National Aeronautics and Space Administration

SPACE SHUTTLE MISSION

STS-127

A Porch in Space

PRESS KIT/JUNE 2009

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STS-127 MISSION OVERVIEW

Against a black sky, the space shuttle Endeavour and its seven-member STS-126 crew head toward Earth orbit and a scheduled link-up with the International Space Station.

There won't be much time for relaxing during the next mission to the International Space Station, despite the fact that space shuttle Endeavour will be delivering the station's porch.

Endeavour, commanded by veteran space flier Mark Polansky, 53, is scheduled to launch at 7:39:33 p.m. EDT on July 11 and arrive at the space station two days later. The shuttle will bring with it the final pieces of the Japanese Kibo complex and a load of large spares to keep the space station going after the shuttle's retirement.

The crew will conduct five spacewalks to install the new space station components and equipment, and to set up some storage locations on the station's truss.

The shuttle will also deliver a new flight engineer – Tim Kopra, 46 – to join the Expedition 20 crew, and return Expedition 20 Flight Engineer Koichi Wakata, 45, of the Japan Aerospace Exploration Agency to Earth. Marine Col. Doug Hurley, 42, will serve as

Endeavour's pilot. The mission specialists are Navy Cmdr. Christopher Cassidy, 39; Tom Marshburn, 49; Dave Wolf, 52; and Julie Payette, 45, of the Canadian Space Agency. STS-127 will be the third space shuttle mission for Polansky, who flew on STS-98 and STS-116; the fourth trip to space for Wolf, who spent 128 days on the Russian Space Station Mir (up on STS-86, down on STS-89) and was a member of the STS-58 and STS-112 crews; and the second for Payette, who served as an STS-96 crew member. This will be the first flight for Hurley, Cassidy, Marshburn and Kopra.

Endeavour's cargo will span a wide range of uses. The big ticket item will be the Japanese Experiment Module – Exposed Facility – the porch for the Japanese Kibo complex, where science experiments will be exposed to the extreme environment of space. To store and transport the experiments that the exposed facility will accommodate, Endeavour will also carry a storage area similar to the logistics module on the Kibo laboratory, but unpressurized – the Experiment Logistics Module – Exposed Section.

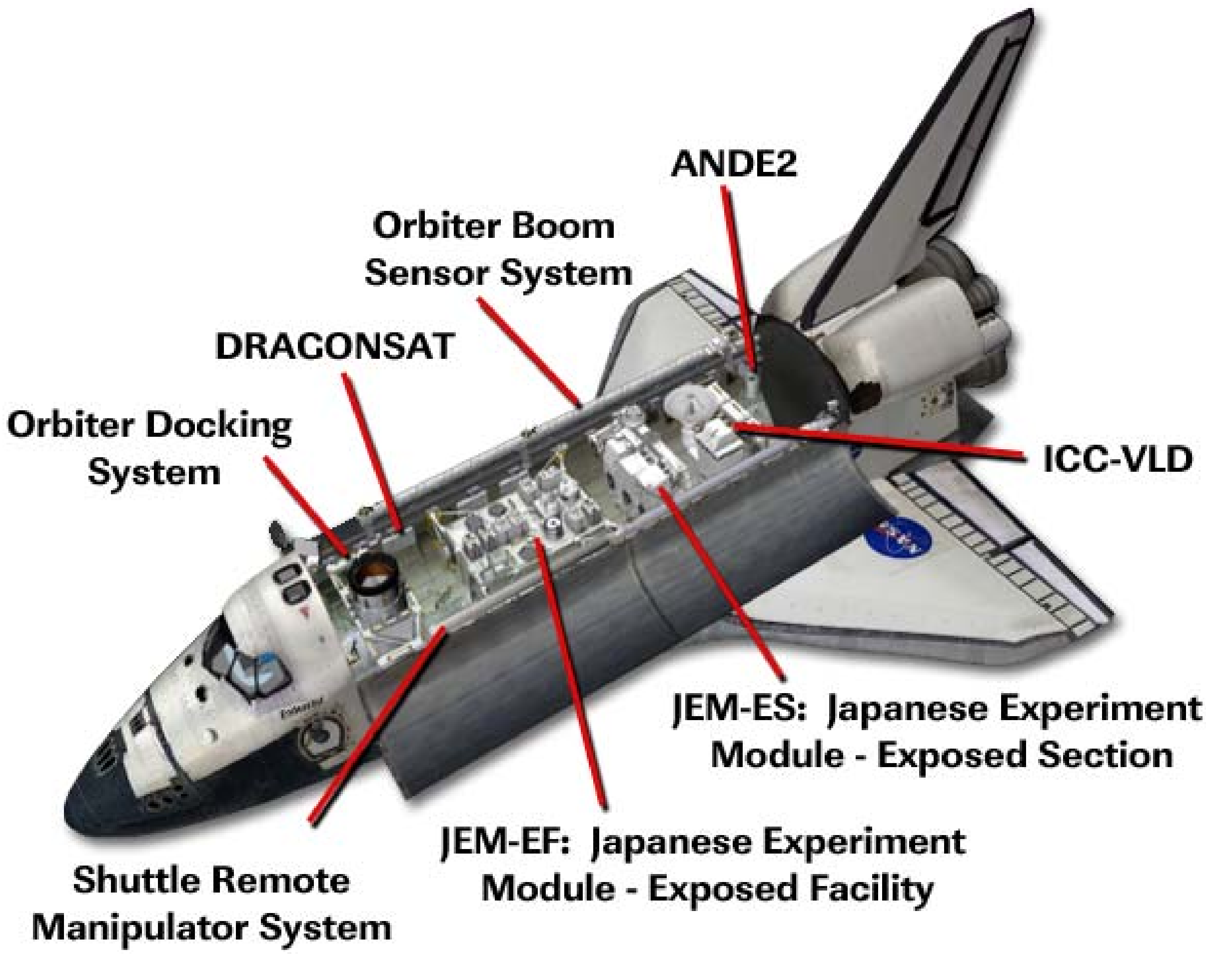
Also inside Endeavour's cargo bay will be an integrated cargo carrier holding several pieces of spare equipment for the space station. Most of it – a spare space-to-ground antenna, a spare linear drive unit and a spare pump module – will be stored on an external storage platform on the station's truss. But six batteries for the station's oldest solar array will be installed over two of the spacewalks.

Astronaut Mark Polansky, STS-127 commander, looks over a checklist during a training session in the Jake Garn Simulation and Training Facility at NASA's Johnson Space Center.

A few hours after Endeavour's docking on the third day of the flight, Kopra and Wakata will exchange custom-made Russian Soyuz spacecraft seat liners. With that exchange, Wakata will become part of Endeavour's crew.

Kopra, meanwhile, will join the Expedition 20 crew – the first space station crew with a full complement of six astronauts. The commander, Russian cosmonaut Gennady Padalka, and NASA Flight Engineer Michael Barratt launched to the station in a Russian Soyuz vehicle in March. The second half of the crew – European Space Agency astronaut Frank De Winne, Russian cosmonaut Roman Romanenko, and Canadian Space Agency astronaut Robert Thirsk – took another Soyuz to the station in May. Wakata arrived aboard space shuttle Discovery during the STS-119 mission in March.

In August, Kopra will return to Earth on shuttle mission STS-128, and Nicole Stott will take his place.



This graphic depicts the location of the STS-127 payload hardware.

The day after Endeavour's launch will be spent inspecting the shuttle's heat shield, using the 50-foot Orbiter Boom Sensor System, or OBSS, extension on the shuttle's robotic arm. The OBSS uses laser devices and cameras to map the shuttle's wings and nose cap. Experts on the ground will analyze the images obtained during the inspection, and if any problems are noticed, a focused inspection of specific areas can be performed on flight day 5.

The shuttle will go through another sort of inspection on flight day 3, just before it docks at the space station. Polansky and Hurley will be at Endeavour's aft flight deck controls as the shuttle approaches the station for docking and fly the shuttle just 600 feet below the space station. There, Endeavour will execute a slow backflip maneuver, presenting its belly and other areas of its heat protective tiles to station residents Barratt and Padalka, who will use digital cameras equipped with 400 and 800 millimeter lenses to acquire detailed imagery. Those photos also will be reviewed by teams on the ground for any signs of damage to the shuttle's heat shield.

Endeavour will then dock to the forward docking port at the end of the station's Harmony module at 3:25 p.m. EDT July 13. About two hours later, hatches will be opened between the two spacecraft to allow the 13 crew members to greet one another for the start of 11 days of docked operations.

Following a standard safety briefing by station Commander Padalka, the crews will exchange Kopra for Wakata as the new station crew member, prepare for the next day's spacewalk, and activate a Station-to-Shuttle Power Transfer System to provide additional electricity for the longer operation of shuttle systems.

Kopra will spend his first night in his new home inside the Quest airlock, along with Wolf, as part of the overnight "campout" procedure that spacewalkers take part in. By spending the night at a pressure of 10.2 pounds per square inch, rather than the 14.7 that the rest of the station stays at, the spacewalkers are able to purge nitrogen from their bloodstreams, preventing decompression sickness once they move out into the vacuum of space. The campout will be repeated on the nights before all spacewalks throughout the mission.

Wolf, who conducted three spacewalks on STS-112 and one aboard the Russian Space Station Mir, will be designated EV 1, or extravehicular crew member 1. He will wear the suit bearing the solid red stripes for the spacewalks he will participate in on flight days 4, 6 and 8. Kopra will act as extravehicular crew member 2, and will wear the solid white suit on flight day 4. Marshburn will serve as extravehicular crew member 3 and will wear the suit with broken red and white stripes for his spacewalks on flight days 6, 10 and 13. The extravehicular crew member 4 spot will be taken by Cassidy, who will wear a spacesuit with horizontal red stripes on flight days 8, 10 and 13. Kopra, Marshburn and Cassidy are all first-time spacewalkers.

Canadian Space Agency astronaut Julie Payette, STS-127 mission specialist, dons a training version of her shuttle launch and entry suit in preparation for a training session in the Space Vehicle Mock-up Facility at NASA's Johnson Space Center. United Space Alliance suit technician Steve Cortinas assists Payette.

On the fourth day of the flight, Wolf and Kopra plan to spend six and a half hours outside the station on the mission's first spacewalk. They'll be preparing the exposed facility for installation, as well as doing some work to get the berthing mechanism on the Kibo laboratory where it will be install-ready. Once that work is done, the robotic arm operators waiting inside the station will get to work. Polansky and Payette, who will be controlling the shuttle's robotic arm from the shuttle's flight deck, will pick up the exposed facility and lift it out of the payload bay to hand off to the station's robotic arm. Hurley and Wakata will be standing by at the robotics workstation inside the Destiny laboratory to take over from there, flying the 9,000-pound porch to its home on the end of the Kibo laboratory.

While that installation is going on, Wolf will spend some time working on one of the station's two Crew Equipment and Translation Aid carts to replace a coupler that's interfering with the station's port solar alpha rotary joint, and both spacewalkers will work together to deploy a cargo attachment system on the port truss that gave the STS-119 spacewalkers trouble. If time permits, they'll also deploy one on the starboard side of the truss before coming in.

Spacewalk activities will take a break on flight day 5, but robotic work will keep the crew busy inside. If a focused inspection is needed, Payette and Kopra will use the station's robotic arm to lift the OBSS out of the shuttle's cargo bay and hand it off to the shuttle's robotic arm – clearances around the station modules prevent the shuttle arm from picking the OBSS up on its own. Polansky and Hurley will be waiting with the shuttle arm for that baton pass, and then Payette will join them to perform the inspection. She'll meet back with Kopra at the station arm controls when it's done to put the OBSS away with the station arm, and Polansky and Hurley will use the shuttle robotic arm to unload the integrated cargo carrier holding the station's newly arrived spare equipment from the cargo bay, in preparation for the following day's spacewalk.

Astronauts Tim Kopra (left), Dave Wolf and Tom Marshburn, all STS-127 mission specialists, attired in training versions of their shuttle launch and entry suits, prepare for a training session in the Mission Simulation Development Facility at NASA's Johnson Space Center. United Space Alliance (USA) suit technician Fred Utley assists the crew members.

After that, Kopra and Wakata will round off the robotics work for the day by spending some time at the robotics workstation in the Kibo laboratory to calibrate the Japanese robotic arm, while the rest of the crew goes over procedures for the second spacewalk.

On flight day 6, Wolf will go out for his second spacewalk of the mission, joined this time by Marshbun. Most of the 6.5-hour spacewalk will be spent transferring spare equipment from the newly unloaded integrated cargo carrier, which will have been handed off to the station's robotic arm that morning and temporarily installed on the station's mobile base system – the railcar that moves along the station's truss. They'll leave the batteries on the cargo carrier for later, and wrap up the spacewalk by installing vision equipment on the exposed facility, to be used as the experiment carrier is installed.

The experiment carrier will be installed the following day, flight day 7, in another complex robotics operation. Polansky and Payette will work together to remove the module from the shuttle's cargo bay using the shuttle's robotic arm, and then hand it off to Hurley and Wakata, at the controls of the station's robotic arm for installation on the end of the exposed facility.

The third spacewalk, on flight day 8, will be performed by Wolf and Cassidy. They'll spend about half an hour removing insulation on the Japanese external science experiments delivered by Endeavour and relocating handrails and worksite interfaces before moving on to the main task of the day. They're scheduled to spend more than 4.5 hours swapping out the batteries on the last solar array on the station's port side – the P6 solar array. The P6 solar array was the first United States solar array added to the station; it's been in space since 2000.

After a relatively slow day on flight day 8, things will pick back up for the robotic arm operators on flight day 9. Wakata and Kopra will become the first to use the Japanese robotic arm for work – as opposed to the testing that's been done up to this point – when they begin to transfer the systems and scientific experiments carried up inside the experiment carrier to the exposed facility. They'll start with the interorbit communication system, which gives station another path for communication with the ground. Then they'll maneuver the Monitor of All-sky X-ray Image, an X-ray camera designed to monitor astronomical objects and the universe, into place.

Flight day 10 will mean more battery swap work, this time for Cassidy and Marshburn during the fourth spacewalk of the mission. There would be about three hours and 40 minutes of battery work left, after which, they'll be installing a second set of vision equipment for the exposed facility. After the spacewalkers come back inside, Polansky and Hurley will use the shuttle's robotic arm to store the integrated cargo carrier back inside the shuttle's cargo bay.

After 10 straight days of hard work, Endeavours' crew will spend flight day 11 enjoying some well-earned off duty time.

Astronaut Christopher Cassidy, STS-127 mission specialist, attired in a training version of his Extravehicular Mobility Unit (EMU) spacesuit, awaits the start of a training session in the waters of the Neutral Buoyancy Laboratory (NBL) near NASA's Johnson Space Center.

Transfer of the exposed facility science experiments will wrap up on flight day 12, with Wakata and Kopra again at the controls of the Japanese robotic arm. Once they've unloaded the Space Environment Data Acquisition Equipment, which measures things like neutrons, plasma, heavy ions, high-energy light particles, atomic oxygen and cosmic dust in the space environment, the experiment carrier will be empty, and Wakata and Hurley can detach it from the exposed facility using the station's robotic arm. They'll then hand it off to Polansky and Payette, at the helm of the shuttle's robotic arm for storage back inside the shuttle's cargo bay.

Marshburn and Cassidy will again venture outside the station on flight day 13 for the fifth and final spacewalk of the mission. Cassidy will start out by swapping some connectors on a patch panel on the station's zenith truss segment, while Marshburn removes one and resecures two thermal covers on the special purpose dexterous manipulator. They'll then work together to deploy two cargo attachment systems on the station's starboard truss and install a video system that supports transmission of video from spacewalkers' helmet cameras. The tasks should take a total of six and a half hours, with about 30 minutes to spare for "get-ahead" work.

They're scheduled to bid farewell to the Expedition 20 crew on flight day 14 after a joint press conference, and undock from the station at 7:33 a.m. EDT on July 25. Hurley, flying the shuttle from the aft flight deck, will make a loop around the station so that the shuttle crew can capture photos of the changes to the station's configuration.

Once the fly around is complete, Endeavour's maneuvering jets will fire to separate it from the station. But before they get too far away, Polansky, Hurley and Payette will use the shuttle's robotic arm and the OBSS to conduct a "late" inspection of the shuttle's heat shield, a final opportunity to confirm Endeavour's readiness to return to Earth.

On flight day 16, Polansky, Hurley and Payette also will conduct the traditional checkout of the orbiter's flight control surfaces and steering jets in preparation for landing the next day. The shuttle crew will stow equipment and supplies that were used during the mission, shut down the robotic arm, check out the spacesuits they will be wearing during re-entry and set up a special recumbent seat in the middeck for Wakata, to make landing easier on him as he readjusts to Earth's gravity after three months of weightlessness.

Cassidy and Marshburn will deploy two satellites. One, the DRAGONSAT – the Dual Autonomous Global Positioning System On-Orbit Navigator Satellite – will collect data on autonomous spacecraft rendezvous and docking capabilities. It actually consists of two picosatellites, the AggieSat2 and PARADIGM, which will acquire GPS data from a device provided by NASA and send it to ground stations at Texas A&M University and the University of Texas at Austin. The two schools are cosponsoring and operating the experiment. The two satellites will collect two orbits of GPS data while remaining in an attached configuration after they're released.

The second, ANDE-2 – Atmospheric Neutral Density Experiment 2 – is part of a Department of Defense project to provide high-quality satellites for calibrating techniques and models for precision orbit determination. They'll also provide data on atmospheric composition for validating Air Force sensors.

Endeavour is scheduled to return to Earth on Monday, July 27, at 12:16 p.m., landing at NASA's Kennedy Space Center in Florida, and bringing to an end its 23rd mission, the 29th shuttle flight to the International Space Station and the 127th flight in shuttle program history.

With its drag chute deployed, space shuttle Endeavour slows to a stop after landing at NASA's Dryden Flight Research Center at Edwards Air Force Base in California, concluding a successful mission to the International Space Station.

STS-127 TIMELINE OVERVIEW

Flight Day 1

- Launch
- Payload Bay Door Opening
- Ku-Band Antenna Deployment
- Shuttle Robotic Arm Activation
- Umbilical Well and Handheld External Tank Photo and TV Downlink

Flight Day 2

- Endeavour Thermal Protection System Survey with Shuttle Robotic Arm/Orbiter Boom Sensor System (OBSS)
- Extravehicular Mobility Unit Checkout
- Centerline Camera Installation
- Orbiter Docking System Ring Extension
- Orbital Maneuvering System Pod Survey
- Rendezvous Tools Checkout

Flight Day 3

- Rendezvous with the International Space Station
- Rendezvous Pitch Maneuver Photography of Endeavour's Thermal Protection System by the Expedition 20 Crew
- Docking to Harmony/Pressurized Mating Adapter-2
- Hatch Opening and Welcoming
- Kopra and Wakata exchange Soyuz seatliners; Kopra joins Expedition 20, Wakata joins the STS-127 crew
- U.S. spacesuit transfer from Endeavour to space station
- Canadarm2 and Kibo robotic arm positioning for Spacewalk 1
- Spacewalk 1 Procedure Review
- Spacewalk 1 Campout by Wolf and Kopra

Flight Day 4

- Shuttle Robotic Arm Grapple and Unberth of Japanese Exposed Facility
- Shuttle Robotic Arm Handoff of Japanese Exposed Facility to Canadarm2
- Canadarm2 installation of Japanese Exposed Facility to Kibo
- Spacewalk 1 by Wolf and Kopra (Japanese Exposed Facility Berthing, Port 3 Nadir Unpressurized Cargo Carrier Attach System (UCCASS) Deploy, Starboard 3 Zenith Outboard Payload Attachment System (PAS) Deploy)

Flight Day 5

- Focused Inspection of Endeavour's Thermal Protection System, if required
- Shuttle Robotic Arm grapple of the Integrated Cargo Carrier-Vertical Light Deploy (ICC-VLD) and handoff to Canadarm2 for installation on the Payload Orbital Replacement Unit Accommodation (POA)
- Spacewalk 2 Procedure Review
- Spacewalk 2 Campout by Wolf and Marshburn

Flight Day 6

- Spacewalk 2 by Wolf and Marshburn (Transfer of critical station spare components from ICC-VLD to External Stowage Platform-3, installation of Japanese Experiment Facility forward camera)

Flight Day 7

- Shuttle Robotic Arm grapple, unberth and handoff of Japanese Logistics Module-Exposed Section to Canadarm2
- Canadarm2 installation of Japanese Exposed Section on Japanese Exposed Facility
- Canadarm2 removal of ICC-VLD from POA and Mobile Transporter move to different worksite
- Spacewalk 3 Procedure Review
- Spacewalk 3 Campout by Wolf and Cassidy

Flight Day 8

- Spacewalk 3 by Wolf and Cassidy (Replacement of four out of six batteries in the Port 6 truss integrated electronics assembly)

Flight Day 9

- Kibo robotic arm transfer of three Japanese science payloads (Monitor of All-sky X-ray Image (MAXI), Space Environment Data Acquisition equipment – Attached Payload, or SEDA-AP and Interorbit Communication System – Exposed Facility, or ICS-EF) from the Japanese Exposed Section to the Japanese Exposed Facility
- Spacewalk 4 Procedure Review
- Spacewalk 4 Campout by Cassidy and Marshburn

Flight Day 10

- Spacewalk 4 by Cassidy and Marshburn (Replacement of the final pair of batteries in the Port 6 truss integrated electronics assembly, installation of the Japanese Experiment Facility aft camera)
- Canadarm2 grapple and handoff of the ICC-VLD to the Shuttle robotic arm for berthing in Endeavour's payload bay

Flight Day 11

- Crew Off Duty Day

Flight Day 12

- Canadarm2 grapple and handoff of Japanese Exposed Section to Shuttle robotic arm for berthing in Endeavour's payload bay
- Transfer of equipment and payloads from Endeavour to space station
- Joint Crew News Conference
- Spacewalk 5 Procedure Review
- Spacewalk 5 Campout by Cassidy and Marshburn

Flight Day 13

- Spacewalk 5 by Cassidy and Marshburn (Zenith 1 Patch Panel reconfiguration, Starboard 3 nadir outboard and inboard PAS deployment, Starboard 3 wireless camera equipment installation, Dextre manipulator insulation removal)

Flight Day 14

- Canadarm2 unberth of OBSS and handoff to Shuttle robotic arm
- Rendezvous tools checkout
- Final Farewells and hatch closure

Flight Day 15

- Endeavour undocking from ISS
- Flyaround of ISS and final separation
- Late inspection of Endeavour's thermal protection system with the OBSS

Flight Day 16

- Flight Control System Checkout
- Reaction Control System hot-fire test
- DRAGONSAT and ANDE-2 payload deployments
- Crew Deorbit Briefing
- Cabin Stowage
- Recumbent Seat Setup for Wakata

Flight Day 17

- Deorbit preparations
- Payload Bay Door closing
- Deorbit burn
- KSC Landing

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MISSION PROFILE

CREW

Commander: Mark Polansky
Pilot: Doug Hurley
Mission Specialist 1: Christopher Cassidy
Mission Specialist 2: Julie Payette
Mission Specialist 3: Tom Marshburn
Mission Specialist 4: Dave Wolf
Mission Specialist 5: Tim Kopra

LAUNCH

Orbiter: Endeavour (OV-105)
Launch Site: Kennedy Space Center Launch Pad 39A
Launch Date: No Earlier Than July 11, 2009
Launch Time: 7:39:33 p.m. EDT
Launch Window: 5 minutes
Altitude: 122 Nautical Miles (140 Miles) Orbital Insertion; 191 NM (220 Miles) Rendezvous
Inclination: 51.6 Degrees
Duration: 15 Days 16 Hours 59 Minutes

VEHICLE DATA

Shuttle Liftoff Weight: 4,519,224 pounds
Orbiter/Payload Liftoff Weight: 264,420 pounds
Orbiter/Payload Landing Weight: 214,707 pounds
Software Version: OI-33

Space Shuttle Main Engines:

SSME 1: 2045
SSME 2: 2060
SSME 3: 2054
External Tank: ET-131
SRB Set: BI-138
RSRM Set: 106

SHUTTLE ABORTS

Abort Landing Sites

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

LANDING

Landing Date: No Earlier Than July 27, 2009
Landing Time: 12:16 p.m. EDT
Primary landing Site: Kennedy Space Center Shuttle Landing Facility

PAYLOADS

2J/A – Kibo Japanese Experiment Module Exposed Facility (JEM EF), Kibo Japanese Experiment Logistics Module – Exposed Section (ELM-ES) ICC-VLD, ANDE-2; DRAGONSAT

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MISSION OBJECTIVES AND PRIORITIES

MAJOR OBJECTIVES

1. Perform space station crew rotation with NASA astronaut Tim Kopra replacing Koichi Wakata of the Japan Aerospace Exploration Agency

2. Install Japanese Experiment Module-Exposed Facility (JEM-EF) to Japanese Experiment Module-Pressurized Module (JEM-PM) and activate (spacewalk)

3. Deliver and install Japanese Experiment Logistics Module Exposed Section (ELM-ES) to JEM-EF

   – Install Japan Aerospace Exploration Agency EF Payloads and Inter-Satellite Communication System (ICS) to JEM-EF

4. Install Integrated Cargo Carrier (ICC) to Payload Orbital Replacement Unit Accommodation (POA)

   – Remove and replace six Port 6 batteries (spacewalk)

   – Transfer PM-2, Linear Drive Unit (LDU) and Space-to-Ground Antenna (SGANT) to External Stowage Platform-3 (spacewalk)

5. Return ICC (with six P6 batteries) to payload bay

6. Return ELM-ES to payload bay

7. Perform H-II Transfer Vehicle (HTV) readiness tasks

8. Install and activate JEM-EF aft camera (spacewalk)

9. Conduct other spacewalk tasks:

   – Perform Crew and Equipment Translation Aid Cart Modifications

   – Open Node 1 (Unity) Port Common Berthing Mechanism Window Flap

   – Reconfigure Grounding Tabs on JEM Robotic Arm End Effector

   – Relocate Grapple Bar to P1 Ammonia Tank Assembly Nadir

   – Deploy Starboard 3 (S3) Inboard Nadir Payload Attachment System (PAS)

   – Install floating connector sleeve

   – Relocate articulating portable foot restraint

10. Deploy Atmosphere Neutral Density Experiment (ANDE) and Space Shuttle Picosat Launcher/Dual RF Autonomous GPS On-Orbit Navigator Satellite

11. Resupply food, water, oxygen

MISSION PRIORITIES SUMMARY

- Rotate Expedition 18/19 Flight Engineer-2 (FE-2) Koichi Wakata with Expedition 19/20 FE-2 crew member Tim Kopra and transfer mandatory crew rotation cargo
- Transfer mandatory quantities of water from shuttle to space station
- Transfer and stow critical items
- Install JEM-EF to Japanese Pressurized Module (JPM)
- Install ICC on the POA
- Install ELM-ES onto JEM-EF
- Remove and replace P6 batteries
- Install ICS on JEM-EF using JEM robotic arm
- Install SGANT, PM, and LDU onto External Stowage Platform-3
- Return ICC to shuttle payload bay
- Install Monitor of All-Sky X-ray Images (MAXI) and Space Environment Data Acquisition equipment – Attached Payload (SEDA-AP) on JEM-EF using JEM robotic arm
- Return ELM-ES to orbiter payload bay
- Perform minimum crew handover of 12 hours
- Transfer remaining cargo items
- Install, activate and check out JEM-EF forward camera
- Open Node 1 Port Centerline Berthing Camera System (CBCS) center disk cover flap
- Perform HTV readiness tasks:
  - Install and activate JEM-EF aft camera
  - Open Node 2 Zenith CBCS center disk cover flap
- Perform daily space station payload status checks as required
- The following tasks are deemed to fit within existing timelines but may be deferred if the spacewalk is behind schedule:
  - Remove grounding tabs on the JEM robotic arm end effector
  - Deploy Port 3 Nadir Unpressurized Cargo Carrier Attach System (UCCAS) (for flight STS-129/ULF3)
  - Deploy Starboard 3 Upper Outboard PAS (for flight STS-129/ULF3)
  - Zenith 1 Patch Panel reconfiguration
  - Install 6 Station-to-Shuttle Power Transfer System (SSPTS) floating power connector grounding sleeves
  - Deploy Starboard 3 Lower Outboard PAS (for flight STS-133/ULF5)
  - Deploy Lower Inboard PAS and open target cover (for flight STS-133/ULF5)
  - Tuck down Lab/Node 2 cables
  - Install JPM spacewalk handrails and worksite interfaces

- Deploy ANDE and DRAGONSAT payloads (post undocking)
- Perform daily middeck activities to support payloads (includes when shuttle crew performs payloads on the space station)
- Perform space station payload research operations tasks
- Transfer nitrogen and oxygen from shuttle to space station airlock high-pressure gas tanks. Quantities shall be consistent with plan to have tanks full at shuttle retirement.
- Perform Detailed Test Objective (DTO) 701, DragonEye
- Perform DTO 695, Thrust Oscillation Seat
- Perform program-approved spacewalk get-ahead tasks
  - Deploy S3 Upper Inboard PAS (for flight STS-133/ULF5)
  - Install Wireless Video System External Transceiver Assembly (WETA) No. 3
  - Install gap spanner to replace handrail on Harmony
  - Retrieve Articulating Portable Foot Restraint (APFR) No. 5, bring inside, remove heat shield, re-install on subsequent spacewalk
- Reboost space station, if needed
- Perform imagery survey during fly around
- Perform an additional four hours of handover per rotating crew member
- Perform Maui Analysis of Upper Atmosphere (MAUI), Shuttle Exhaust Ion Turbulence Experiments (SEITE), and SIMPLEX (payloads of opportunity – not during docked operations)
- Perform Station Detailed Test Objective 13005-U, ISS Structural Life Validation and Extension during Shuttle Mated Reboost and undocking

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MISSION PERSONNEL

KEY CONSOLE POSITIONS FOR STS-127

	Flt. Director	CAPCOM	PAO
Ascent	Bryan Lunney	Alan Poindexter TBD (Wx)	Kylie Clem
Orbit 1 (Lead)	Paul Dye	Greg (Box) Johnson	Brandi Dean
Orbit 2	Kwatsi Alibaruho	Janice Voss	Josh Byerly
Planning	Gary Horlacher Mike Sarafin	Stan Love Shannon Lucid	Kelly Humphries
Entry	Bryan Lunney	Alan Poindexter TBD (Wx)	Kylie Clem
Shuttle Team 4	Richard Jones	N/A	N/A
ISS Orbit 1	Brian Smith	Hal Getzelman	N/A
ISS Orbit 2 (Lead)	Holly Ridings	Akihiko Hoshide	N/A
ISS Orbit 3	Derek Hassmann	Jason Hutt	N/A
Station Team 4	Ron Spencer		

JSC PAO Representative at KSC for Launch – Kyle Herring

KSC Launch Commentator – Mike Curie

KSC Launch Director – Pete Nickolenko

NASA Launch Test Director – Jeff Spaulding

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STS-127 CREW

A crew spokesperson had the following words for the patch. "Bathed in sunlight, the blue Earth is represented without boundaries to remind us that we all share this world. In the center, the golden flight path of the space shuttle turns into the three distinctive rays of the astronaut symbol culminating in the star-like emblem characteristic of the Japanese Space Agency, yet soaring further into space as it paves the way for future voyages and discoveries for all humankind."

Shown on the front row are astronauts Mark Polansky (right), commander, and Doug Hurley, pilot. Remaining crew members, pictured from left to right, are astronauts Dave Wolf, Christopher Cassidy, Canadian Space Agency's Julie Payette, Tom Marshburn and Tim Kopra, all mission specialists. Kopra is scheduled to join Expedition 20 as flight engineer after launching to the International Space Station with the STS-127 crew.

Short biographical sketches of the crew follow with detailed background available at:

http://www.jsc.nasa.gov/Bios/

STS-127 CREW BIOGRAPHIES

Mark Polansky

Mark Polansky will lead the crew of STS-127. He served as the pilot on STS-98 in 2001 and as the commander of STS-116 in 2006. Polansky has overall responsibility for the safety and execution of this mission, orbiter systems operations and flight operations, including landing. He also will fly Endeavour through its rendezvous and docking to the International Space Station.

Doug Hurley

Astronaut Doug Hurley, a Colonel in the Marine Corps, will serve as the pilot for Endeavour's mission. Selected by NASA in 2000, this will be his first journey into space. With more than 3,200 hours in more than 22 aircraft, Hurley will join Polansky on the flight deck and be responsible for orbiter system operations. He'll also assist Polansky with the rendezvous and docking to the station and will perform the flyaround of the space station after undocking. He will also operate all three robotic arms throughout the mission.

Hurley's previous roles within the Astronaut Office have included serving as a lead ASP (Astronaut Support Personnel) for shuttle missions STS-107 and STS-121, served on the Columbia Reconstruction Team, and served on the Exploration Branch in support of the Orion Crew Exploration Vehicle (CEV). More recently, he served as the NASA Director of Operations at the Gagarin Cosmonaut Training Center in Star City, Russia.

Dave Wolf

Veteran astronaut Dave Wolf will serve as the lead spacewalker for this mission. He is tapped to conduct the first three of the five planned spacewalks. On the first, he will join Tim Kopra to prepare Kibo and the exposed facility for installation, then move on to tasks on the truss. For the second spacewalk, he and Marshburn will transport and install parts and hardware. And for the third, Wolf will be joined by Cassidy to work on the exposed facility and replace batteries. Wolf has flown on four prior shuttle flights and a long-duration stay on the Russian Mir Space Station. Wolf flew on STS-58 in 1993 and STS-112 in 2002, where he conducted three spacewalks to help with the installation of the S-1 Truss. He also flew on STS-86, his ride to Mir, where he spent 128 days and conducted an emergency spacewalk in a Russian Orlan suit. He returned on STS-89.

Christopher Cassidy

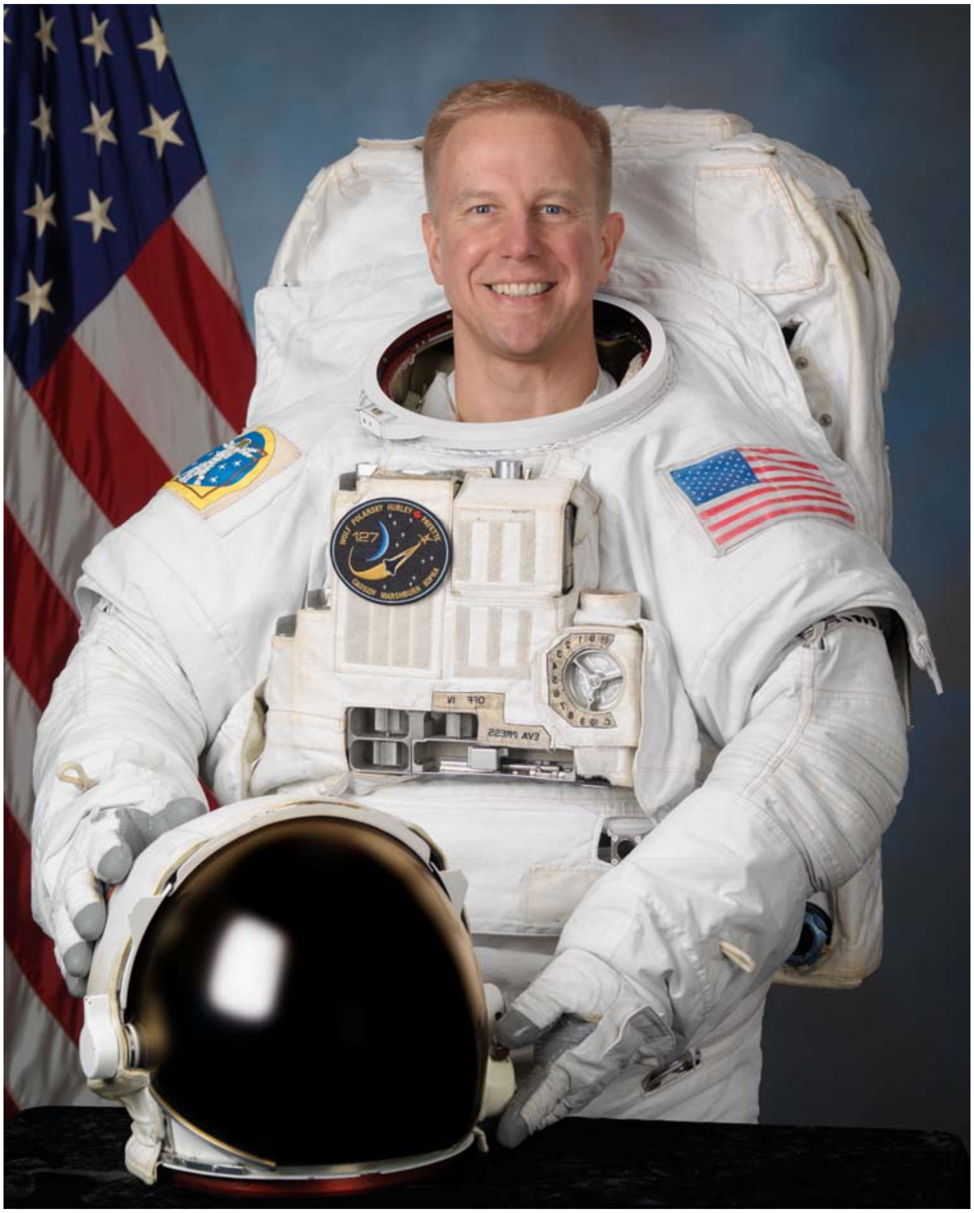
This is the first spaceflight for Navy Cmdr. Christopher Cassidy. He was selected as a NASA astronaut in 2004 and completed his initial training in February 2006. He is slated to perform three spacewalks on this mission. He will pair up with Wolf for the first spacewalk as they prepare the exposed facility for experiment transfers and replace batteries on the truss. He will join Tom Marshburn for his final two spacewalks to replace more batteries, install cameras, remove thermal covers and make electrical configurations.

Julie Payette

This will be the second spaceflight for Julie Payette of the Canadian Space Agency. She reported to NASA's Johnson Space Center for training in 1996 and went on to represent the astronaut corps at the European and Russian space agencies, where she supervised procedure development, equipment verification and space hardware processing for the International Space Station and served as the chief astronaut for the Canadian Space Agency from 2000 to 2007. She flew on STS-96. During this mission, she will lead the intensive robotic arm operations.

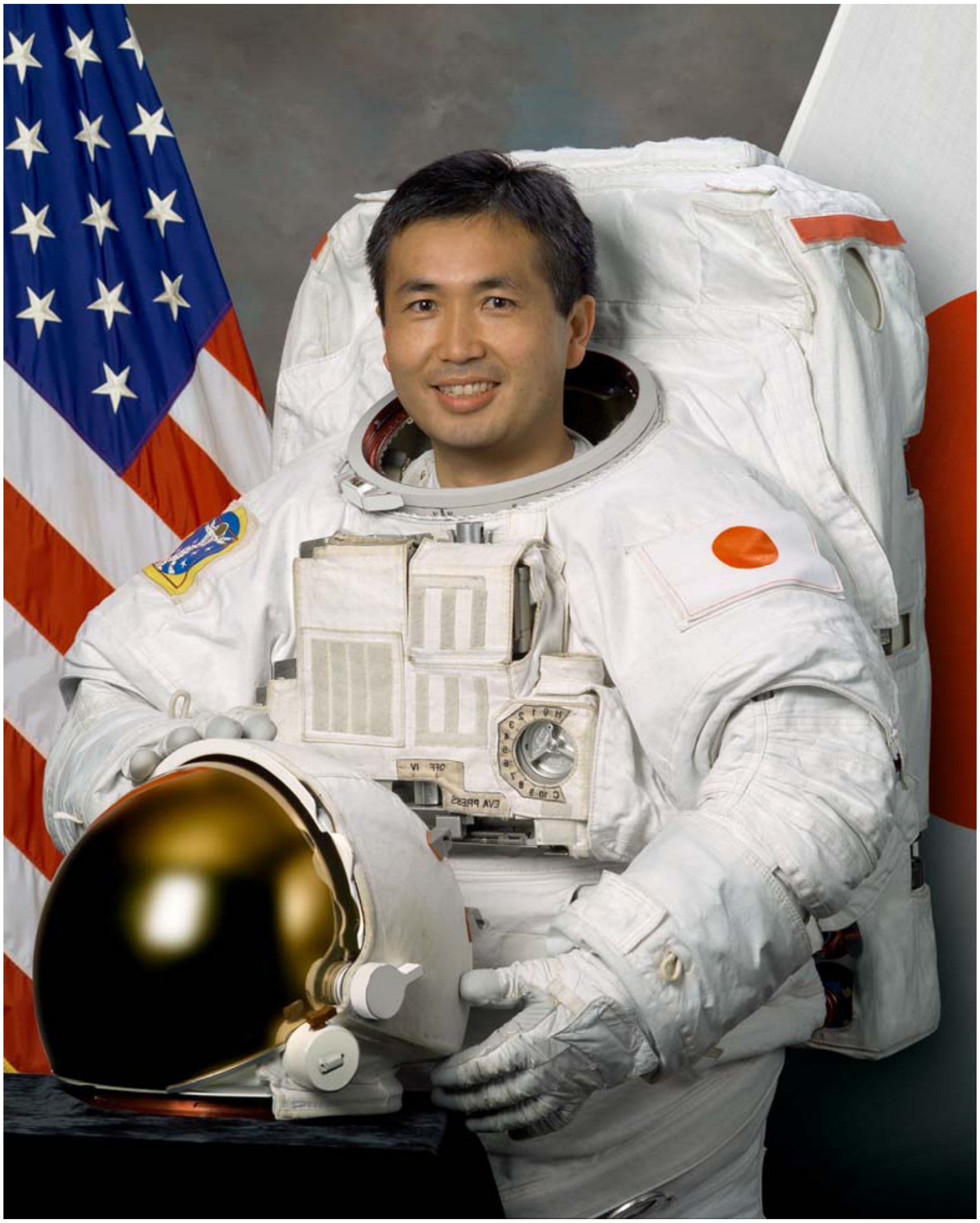
Tom Marshburn

Tom Marshburn will be new to spaceflight but not new to spaceflight medicine. Marshburn holds a medical degree and originally joined NASA back in 1994 as a flight surgeon. For 10 years, he served various roles in NASA's medical operations until he was selected as an astronaut in 2004. After nearly two years of initial training, he will now embark on his first spaceflight, where he will conduct three spacewalks. The first will be with Wolf, as they relocate parts on the station's exterior. He will join his astronaut candidate classmate Cassidy for the final two spacewalks of the mission.



Tim Kopra

Tim Kopra, a colonel in the Army, also has a history at NASA that precedes his joining the astronaut corps. Kopra was assigned to NASA at the Johnson Space Center in September 1998 as a vehicle integration test engineer. In this position, he served as an engineering liaison for space shuttle launch operations and space station hardware testing. He was selected as an astronaut in 2000. Since then, he has completed training at each of the international partner training sites and served as a backup crew member to Expeditions 16 and 17. Kopra will launch to the station with the crew of STS-127 and, once docked, replace Koichi Wakata as the Expedition 20 flight engineer. He will remain on the station and return with the STS-128 shuttle crew.



Koichi Wakata

Koichi Wakata, the first Japanese mission specialist and now the first Japanese long-duration crew member on the space station, will be returning to Earth with the STS-127 crew. He rode up to the station with the STS-119 crew, his third flight, in March to begin his long-duration stay as a flight engineer on the Expedition 18, 19 and 20 crews. When he lands with the STS-127 crew, he'll have spent more than 100 consecutive days in space. Wakata also flew on STS-72 in 1996 and STS-92 in 2000.

PAYLOAD OVERVIEW

The 2J/A mission patch (above) shows the element modules which constitute Kibo's exposed facilities. Inscribed are the names of the element modules and JAXA astronaut Koichi Wakata who will participate in the assembly tasks during the mission.

KIBO JAPANESE EXEPRIMENT MODULE EXPOSED FACILITY

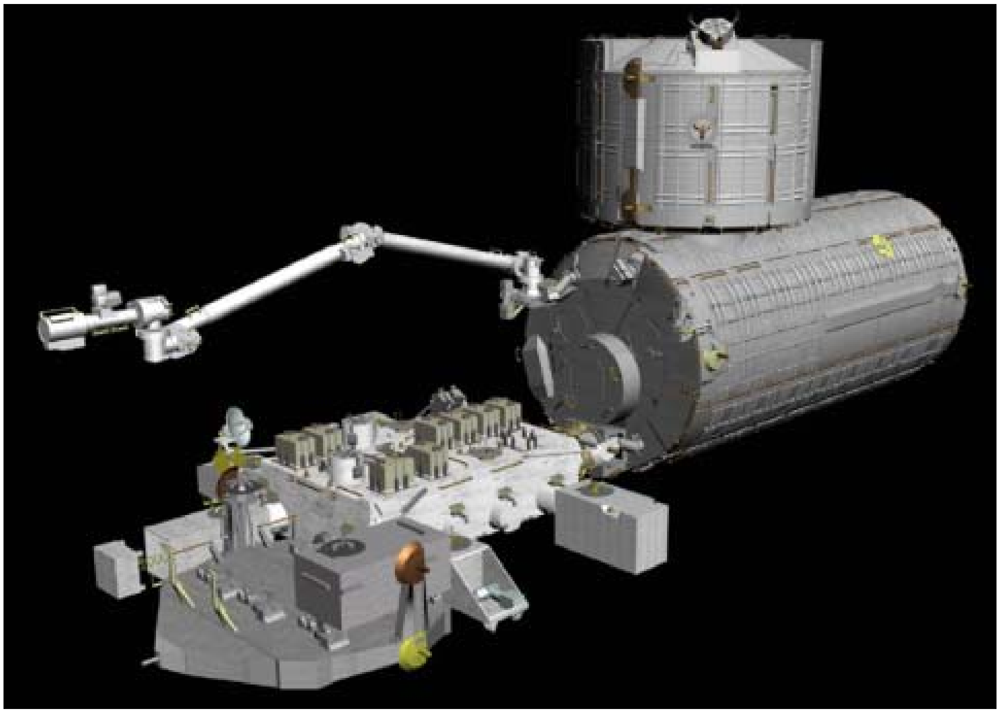
The final components of Kibo will fly to the space station on STS-127. The STS-127 (2J/A) mission concludes the Kibo assembly, paving the way for the full utilization stage of Kibo

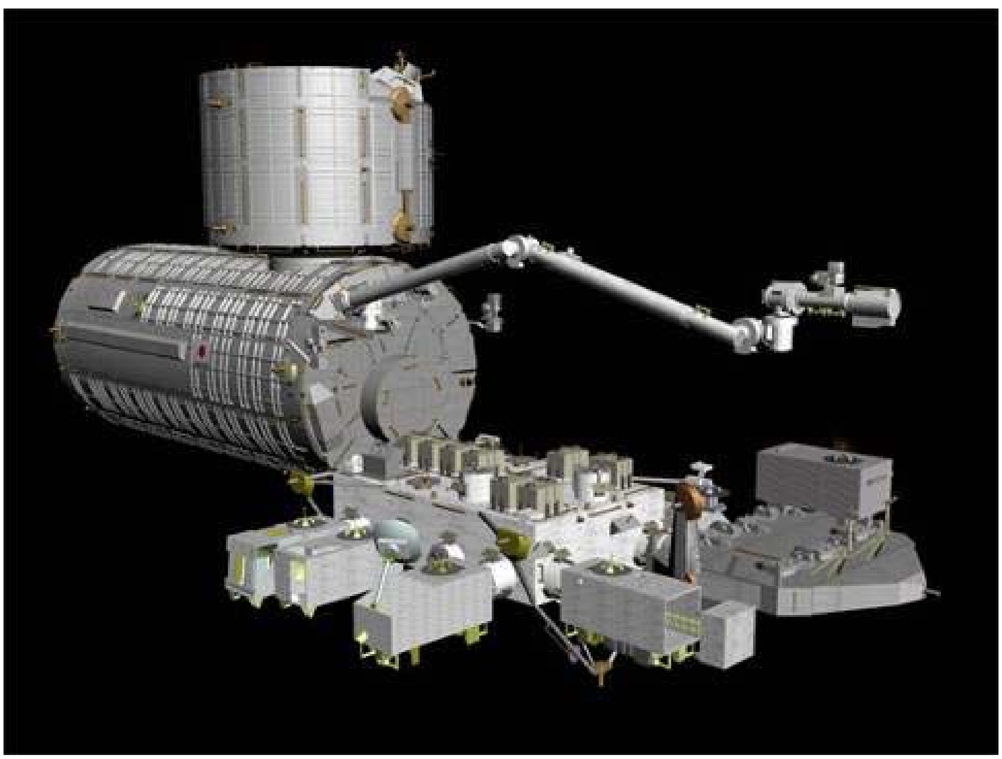
On this third and last Kibo-designated assembly mission, Kibo's final components, the Exposed Facility (EF) and the Experiment Logistics Module – Exposed Section (ELM-ES), will be delivered to the International Space Station. Installation of these components will conclude assembly of the Japanese complex facility on the station.

The EF is a multipurpose experiment platform on which various scientific experiments can be performed using the microgravity and vacuum environment of space.

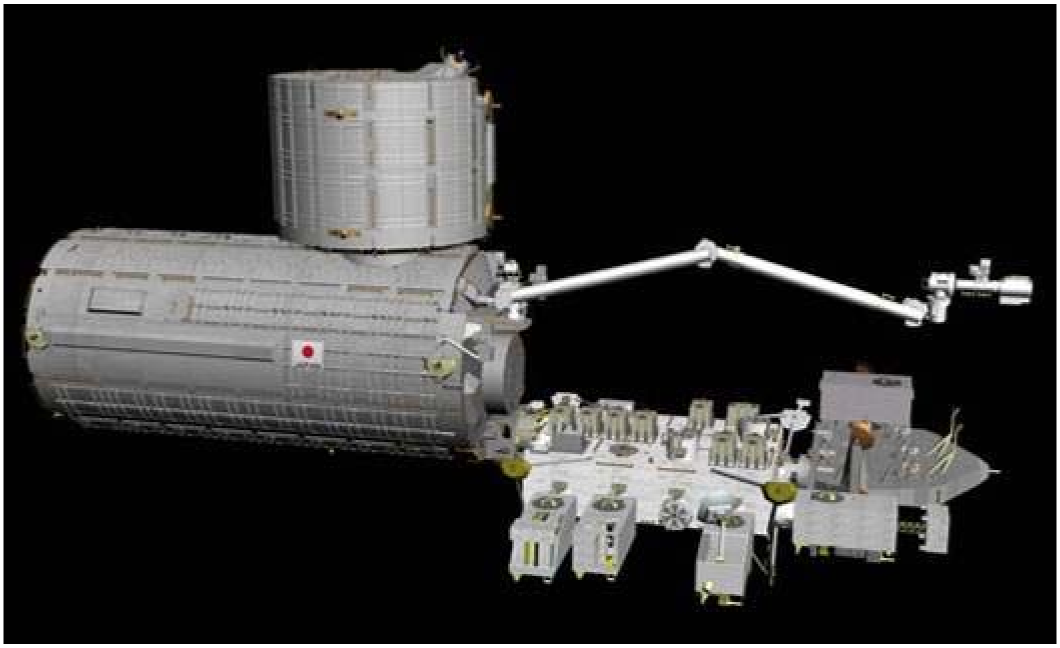
The ELM-ES is a logistics carrier which will be launched and returned on the STS-127 mission. On this flight, the ELM-ES will carry three EF payloads to the station.

The EF will become operational during the STS-127 mission. Kibo's scientific capability will be doubled when the platform for space-exposed experiment activities is ready.





Conceptual images: Kibo



Experiments on Kibo's Exposed Facility (EF) begin

The STS-127 mission will deliver **MAXI** and **SEDA-AP**, two of the three JEM Exposed Facility (EF) payloads developed for Kibo's First Phase Utilization, to the station. These EF experiments will be installed on the EF during the docked mission, and then Kibo external experiment operations can begin.

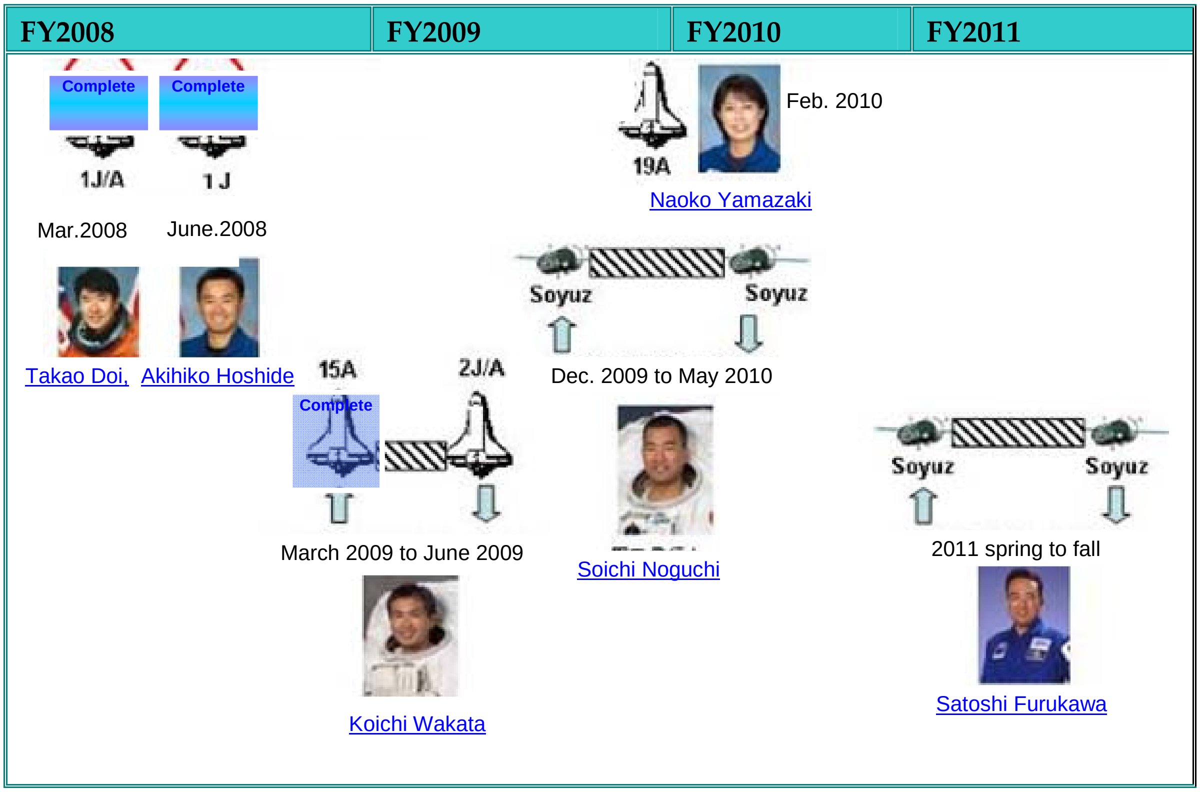
In 2008, the STS-123 mission installed Kibo's pressurized logistics/stowage module, called the Experiment Logistics Module-Pressurized Section (ELM-PS), which carried JAXA's two major experiment racks called the **SAIBO Rack** and the **RYUTAI Rack** along with some of Kibo's system payload racks, to the station.

In the same year, the STS-124 mission installed Kibo's main experiment module, the Pressurized Module (PM) with Kibo's core systems and experiments, onto the station. During the STS-124 mission, the experiment and system racks were installed in the PM, and since then, JAXA's science experiments have been performed using these two scientific experiment racks.

SMILES – Another JAXA EF experiment, will be launched to the station on the H-II Transfer Vehicle (HTV) mission targeted to launch in September 2009.

The KOBAIRO Rack – An additional experiment rack, which will be installed and operated on Kibo, is planned to be launched in 2010 on an HTV mission.

At this point, all the experiment facilities developed and prepared for the Kibo First Phase Utilization will be on board Kibo. After that, Kibo will move into its full utilization stage.



JAXA astronauts' flight schedules *

*These schedules may change depending on the launch schedules of NASA and the Russian Federal Space Agency

JAXA astronauts Takao Doi and Akihiko Hoshide participated on the previous Kibo assembly missions, STS-123 and STS-124, respectively, and completed installation of Kibo's two pressurized component modules.

Wakata is the first Japanese astronaut to serve as a flight engineer for an Expedition mission. When the STS-127 mission arrives at the station delivering Kibo's last components, Wakata will be on board the station and see through the completion of Kibo, the Japanese Experiment Module, in orbit.

Soichi Noguchi and Satoshi Furukawa, assigned to future Expeditions, will spend more time on utilization activities on board the station while performing various station tasks.

Naoko Yamazaki, assigned to the STS-131 mission, will fly to the station in early 2010. When the STS-131 mission arrives at the station, Noguchi will be staying on board the station as a flight engineer for the Expedition 22/23 mission. This will truly be a remarkable event in Japanese space development history because two JAXA astronauts will be on board the station at the same time, participating on missions to set the stage for the final completion of the space station.

In 2008, JAXA selected two JAXA astronaut candidates with the purpose of promoting the next generation of JAXA astronauts for the station missions and future human space exploration. JAXA is contributing to the world's human spaceflight by providing human space development technology as well as human resources.

EXPOSED FACILITY AND EXPERIMENT LOGISTICS MODULE – EXPOSED SECTION

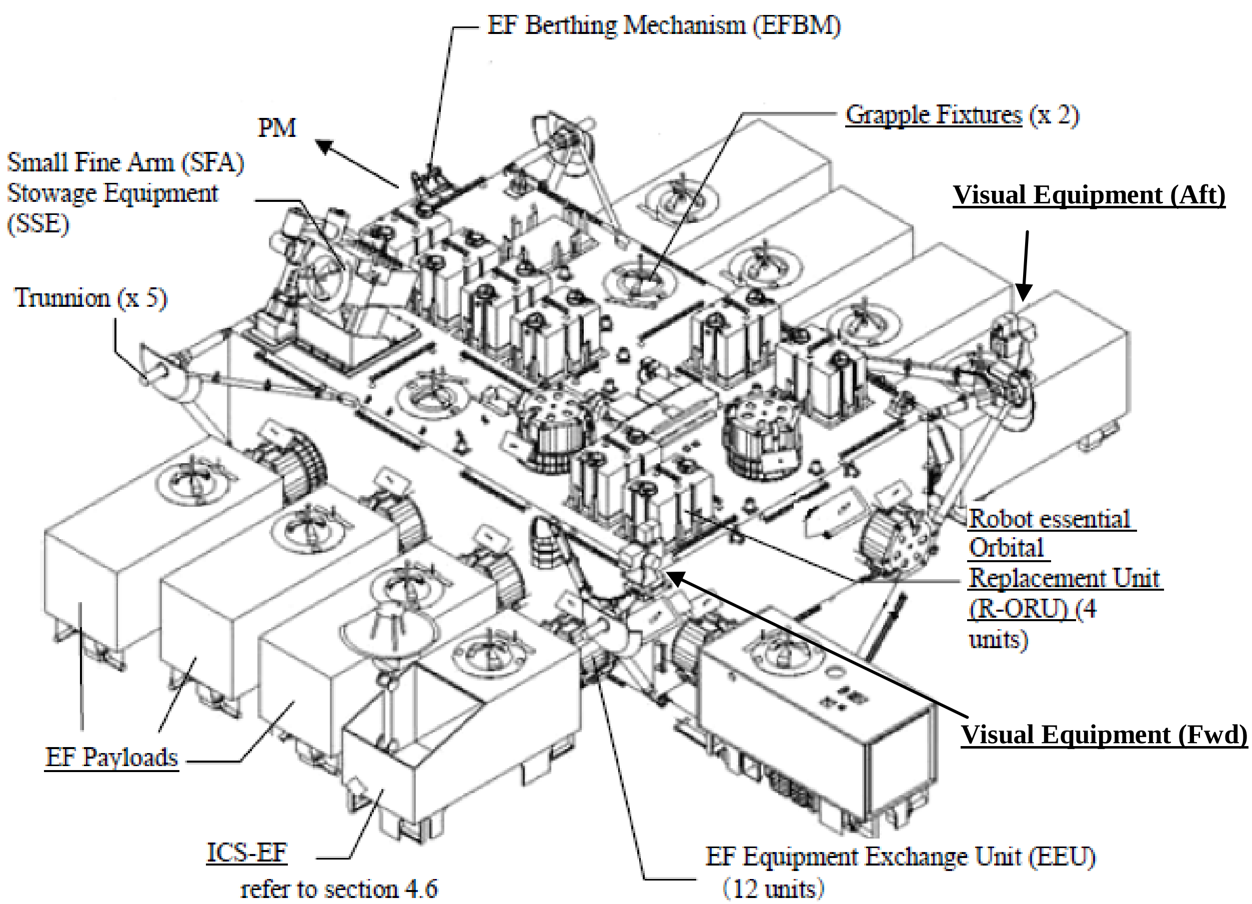
Exposed Facility Overview

Kibo's Exposed Facility (EF) is a multipurpose experiment platform where various scientific activities (including earth observation, space environment monitoring, astronomical observation, data communications and material experiments) can be performed using the microgravity and vacuum environment of space.

There are 12 payload attachment mechanisms called Equipment Exchange Units (EEU) on the EF, and therefore, a maximum of 12 payloads, such as the EF experiments, the ELM-ES, the Inter-orbit Communication System Exposed Facility (ICS-EF) and the HTV Exposed Pallet, can be accommodated on the EF.

The EF experiments are exchangeable in orbit so that several different types of scientific experiments can be conducted on the EF in the future. In order to support space-exposed experiments on the EF, the EF can provide the necessary resources for each payload and experiment, such as power, cooling and communications capabilities.

Exposed Facility (Space Station Testing Building, Tsukuba Space Center (TKSC))



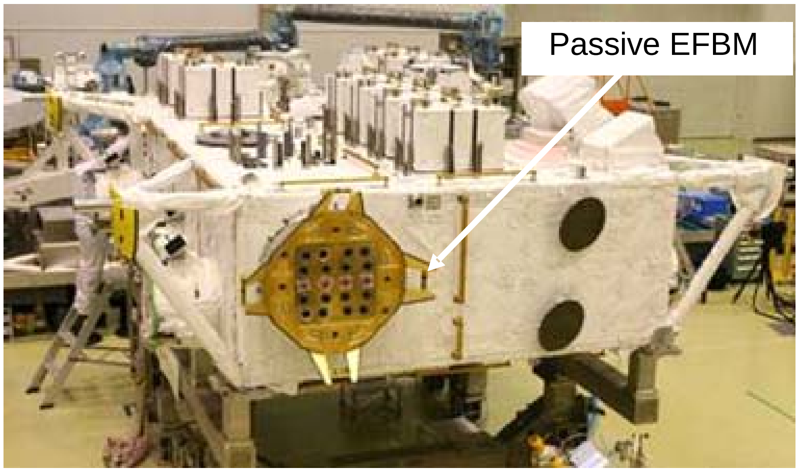
Shape	Box shaped
Size	5.0 m (width) by 5.2 m (length) by 3.8 m (height)
Mass	4.1 t (launch configuration)
Number of payload attachment places	12 (9 for EF experiments, 2 for JEM systems, and 1 for temporary storage)
Electrical power provided	Max. 11 kW (max. 1 kW for systems, 10 kW for EF experiments) 120 V dc
Data management system	16-bit computer system High-speed data link: max.100 Mbps
Environment control	Active thermal control system loop
Life span	More than 10 years

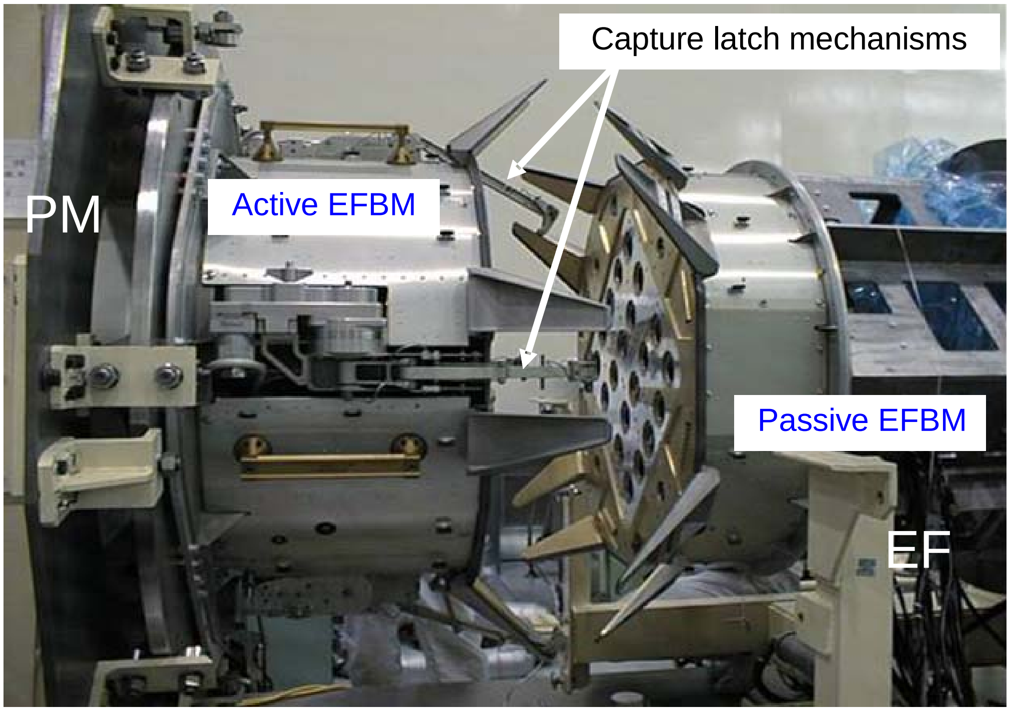
Configuration design and specifications of the EF

Kibo-Unique Mechanisms on EF

Exposed Facility Berthing Mechanism

The EF Berthing Mechanism (EFBM) is a mechanism that connects the EF to the PM. The active half of the EFBM, which has four capture latch mechanisms and four motor-drive bolts (structural latch mechanisms), is located on the PM. The passive half is located on the EF. Once both the active half and passive half of the EFBM are berthed, channels for the electrical power system, data communications system, and thermal control system will be connected, and then power and data transfer will be initiated.





Close-up photo of the EFBM (Space Station Test Building, TKSC)

When the EF arrives at the station, the EFBM (both active and passive) will be covered by Multi-Layer Insulation (MLI) covers. Before the installation of the EF, the covers on the EFBM will be removed by spacewalkers.

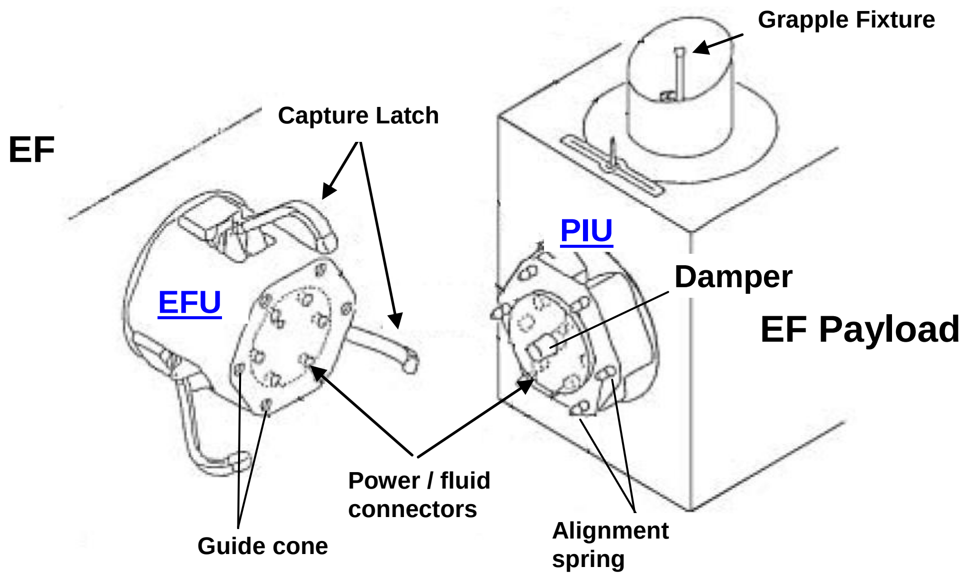
Multi-layer Insulation cover

Equipment Exchange Unit

The EF Equipment Exchange Unit (EEU) is a mechanism to which EF experiments, the Inter-orbit Communication System – Exposed Facility (ICS-EF), the ELM-ES, and the HTV Exposed Pallet are attached. Once a payload is attached to the EEU, power will be provided through the EF, and transmission of commands and telemetries to and from the payload will be enabled.

The EEU consists of an active side and a passive side. The active side of the EEU is called the Exposed Facility Unit (EFU) and is on the EF. The passive side of the EEU is called the Payload Interface Unit (PIU) and is on each EF payload, the ICS-EF, the ELM-ES, and the HTV Exposed Pallet. The EEU enables the exchange (removal and replacement) of the EF payloads in orbit, and thus, several different types of experiments can be conducted in the future.

Close-up photo of the EFU (Space Station Testing Building, TKSC)

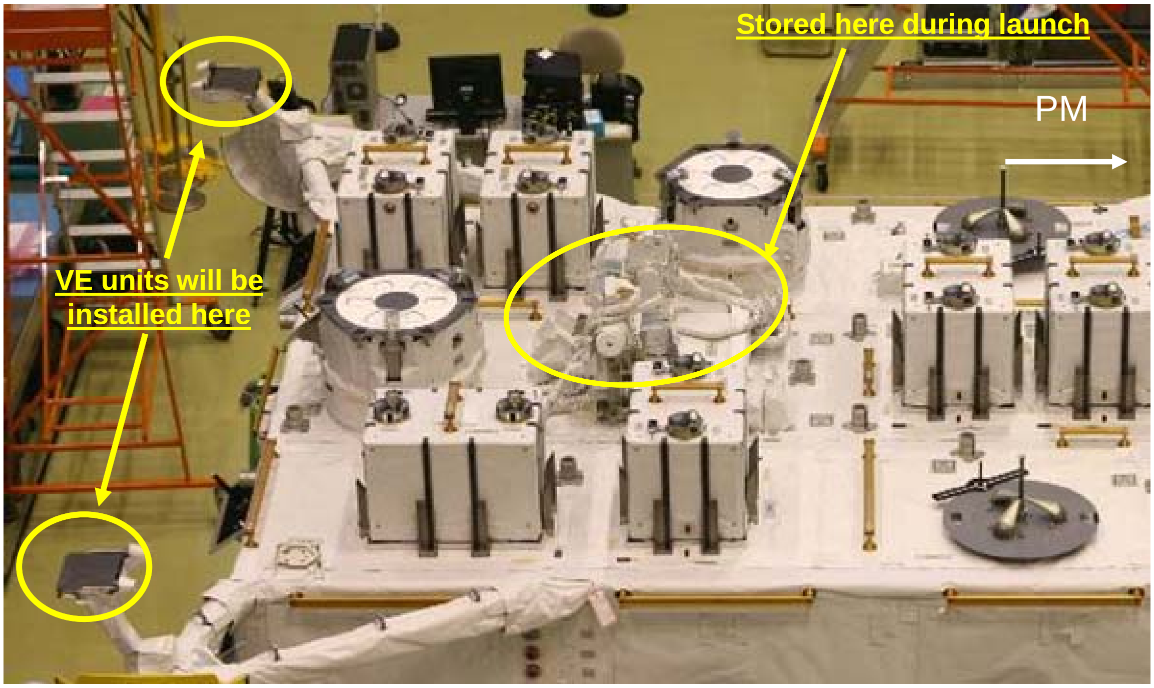


Configuration of the EEU

Visual Equipment

The Visual Equipment (VE) consists of a TV camera, a light, and a Pan/Tilt unit. The VE provides views of the EF experiments, payloads, and Orbital Replacement Units (ORUs) on the EF. Two units of the VE (forward and aft units) are installed on the EF. Locations of the VE units are as shown in the photo. During the launch, the VE units are stored in positions where they can receive heater power.

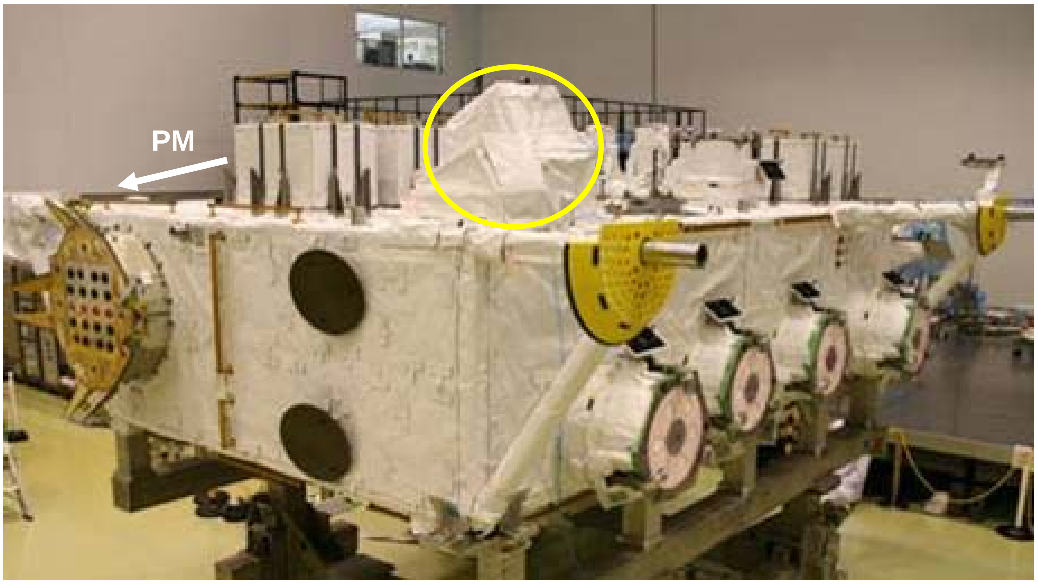
Visual Equipment (Space Station Processing Facility, KSC): The VE is designed as an Orbital Replacement Unit (ORU).



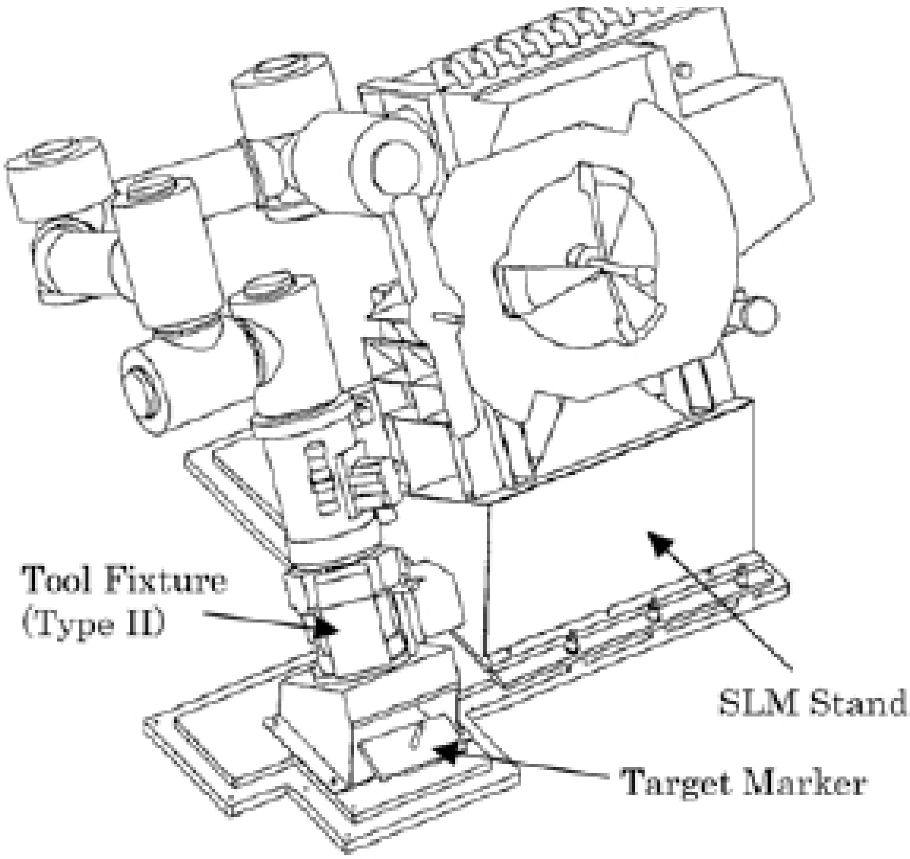
Exposed Facility (Space Station Testing Building, TKSC)

Small Fine Arm Stowage Equipment

The Small Fine Arm (SFA) Stowage Equipment (SSE) is a device that can stow the SFA when the SFA is not in use. The SFA receives heater power from the EF through the SSE when stored on the SSE. The SSE also provides communications interfaces.



Exposed Facility (Space Station Testing Building, TKSC)



The SFA will be attached to the end of Kibo's robotic arm, the JEM Remote Manipulator System (JEMRMS), when it is used for robotics operations.

The SFA is used for exchanging the Orbiter Replacement Units (ORUs) on Kibo's Exposed Facility.

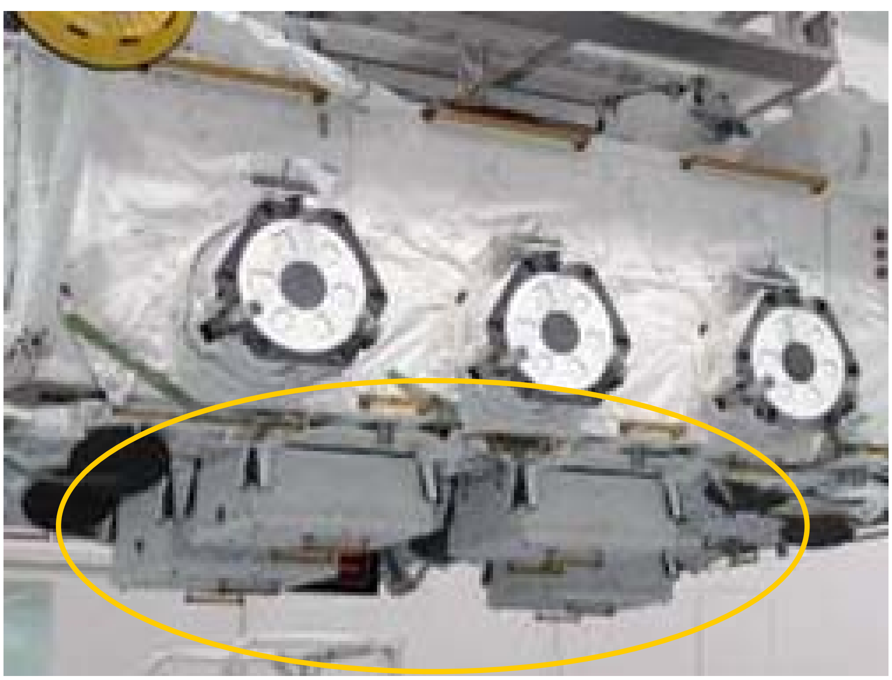
Exposed Facility's Orbital Replacement Units – Extravehicular Activity ORU and Robot Essential ORU

The electrical power system, communication and tracking system, and thermal control system are critical systems for operating the EF. Therefore, these system units are designed as ORUs. In case of failure, these units will be exchanged in orbit. There are three types of ORUs on the EF:

- Extravehicular Activity ORU (E-ORU)
- Robot Essential ORU (R-ORU)
- Visual Equipment (VE), DC/DC converter unit (DDCU)

E-ORU is attached to the nadir side of the EF, and will be exchanged by a spacewalker. R-ORU is attached to the zenith side and will be exchanged with the Small Fine Arm (SFA) attached to the end of Kibo's robotic arm (JEMRMS).

R-ORUs attached on the EF
(Space Station Testing Building, TKSC)



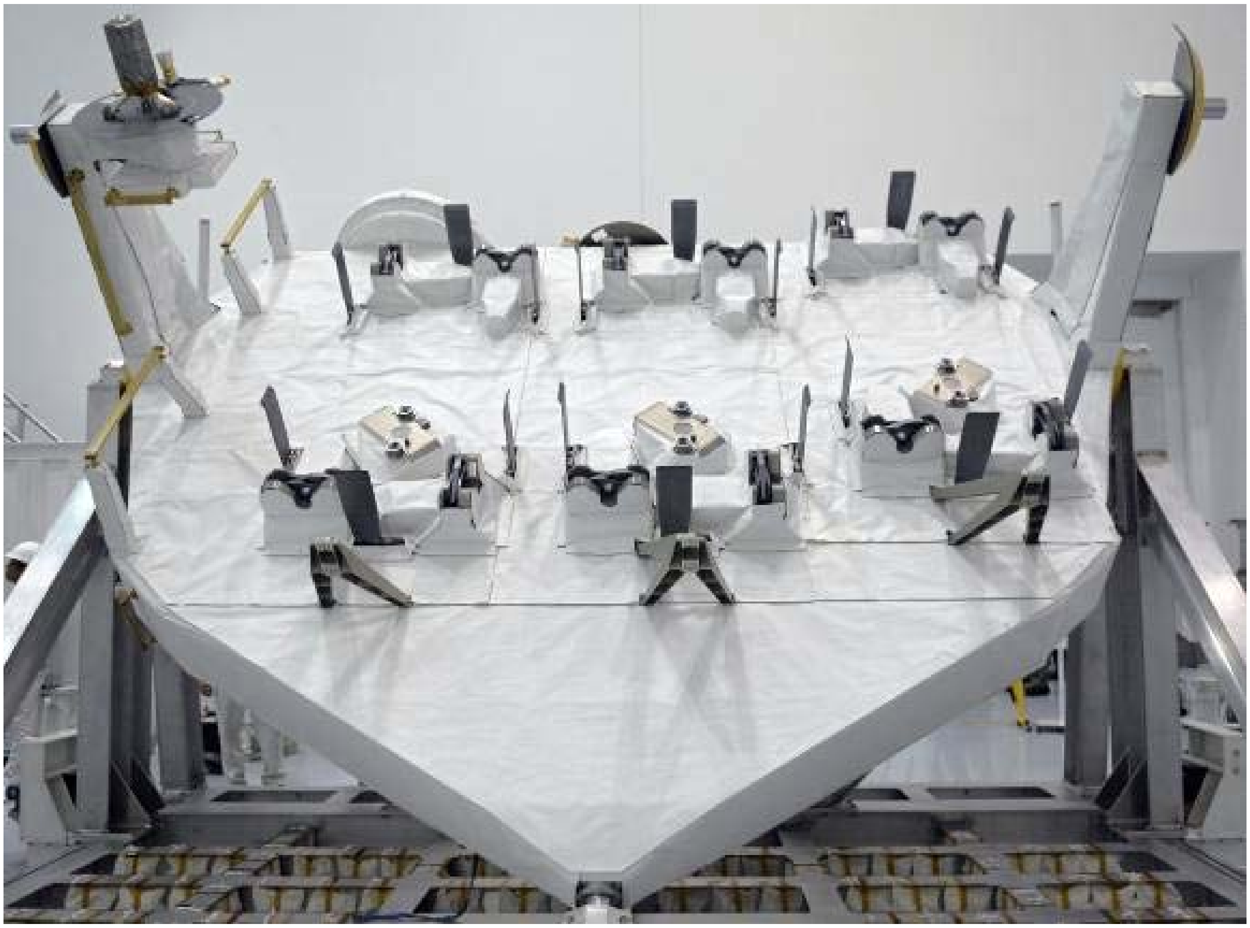
E-ORUs attached below the EF
(Space Station Processing Facility, KSC)

Experiment Logistics Module-Exposed Section Overview

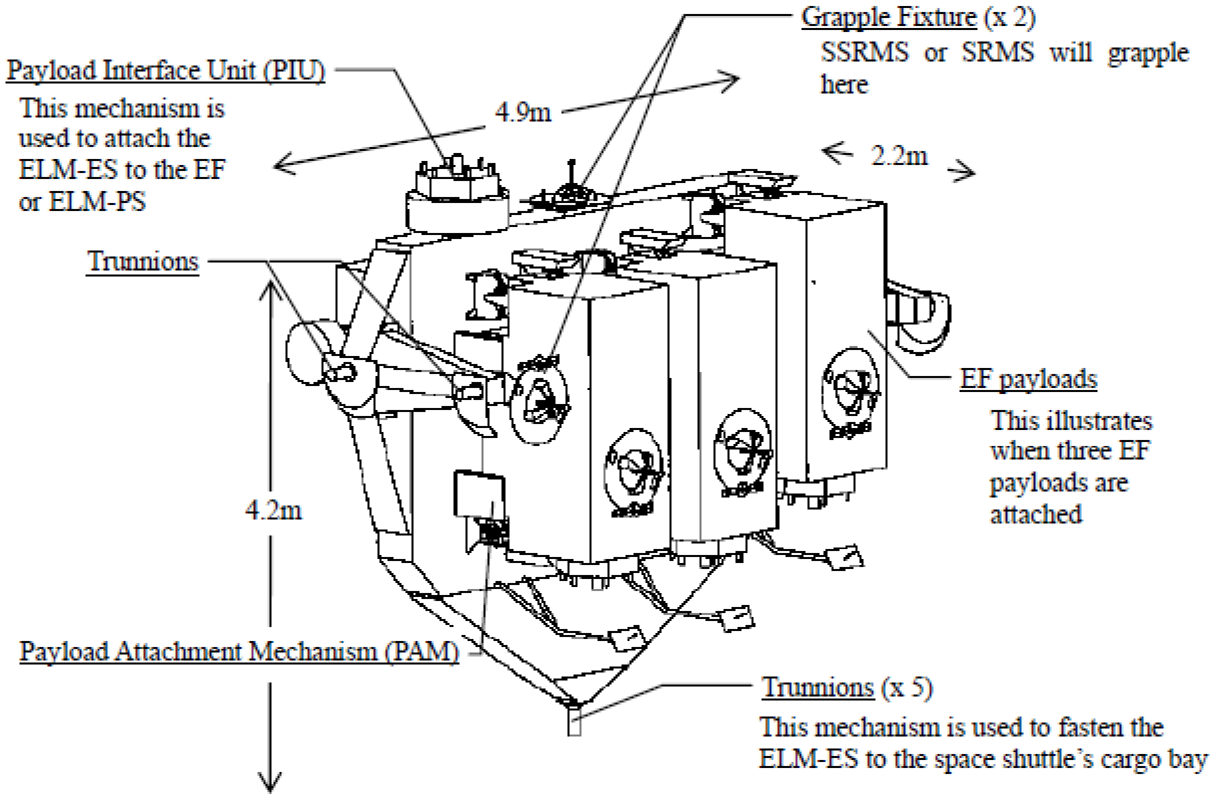
Kibo's Experiment Logistics Module-Exposed Section (ELM-ES) is a logistics carrier which will carry Exposed Facility (EF) payloads.

The ELM-ES is designed to be launched and returned on board the space shuttle. The ELM-ES will be attached to the EF while transferring the carried EF payloads to the EF in order to provide the best access for the robotics transfer operations with Kibo's robotic arm.

On STS-127, the ELM-ES will carry three EF payloads to the station and will return to the ground on board the same flight.



Experiment Logistics Module-Exposed Section (Space Station Processing Facility, KSC)



Structure type	Frame
Width	4.9 m
Height	2.2 m (including the height of the attached payloads)
Length	4.1 m
Mass (dry weight)	1.2 t (excluding payloads)
Number of payload accommodation places	3 EF payloads
Electrical power supply	Max. 1.0 kW 120 V dc
Thermal control	Heater and thermal insulator
Life span	More than 10 years

Configuration design and specifications of the ELM-ES

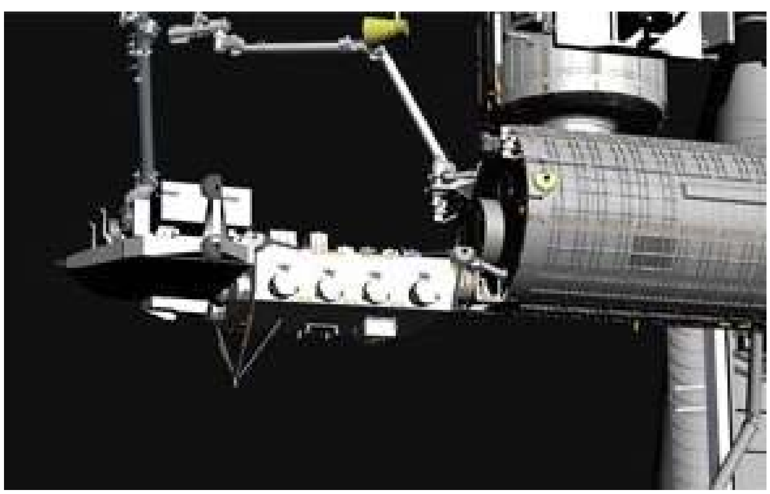
Kibo-Unique Mechanisms on ELM-ES

Payload Interface Unit

The Payload Interface Unit (PIU) is the passive side of the Experiment Exchange Unit (EEU) and will be used to attach the ELM-ES to the active side of the EEU, Exposed Facility Unit (EEU) on the EF.

The heater power necessary for the EF payloads on the ELM-ES will be provided by the EF.

STS-127 crew members checking the PIU during the Crew Equipment Interface Test (CEIT)



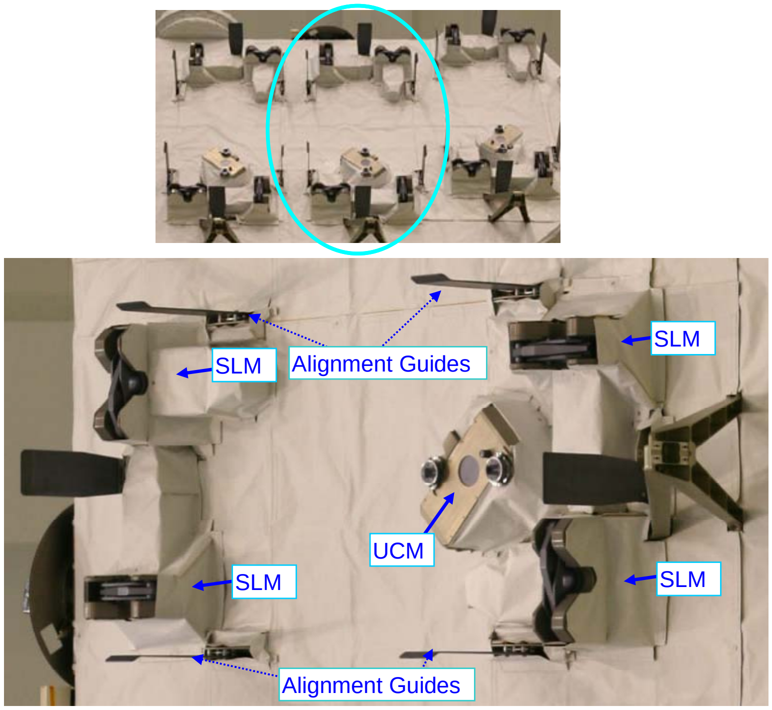
Conceptual images: The ELM-ES being attached to the EF (left)

Payload Attachment Mechanism

The Payload Attachment Mechanism (PAM) is a mechanism which will be used to attach EF payloads to the ELM-ES during launch or travel on board the space shuttle.

The PAM consists of the Structure Latch Mechanisms (SLMs) and the Umbilical Connector Mechanisms (UCMs).

EF payloads can be attached or removed from the PAMs by Kibo's robotic arm (JEMRMS).



Close-up photo of the PAM (Space Station Testing Building, TKSC)

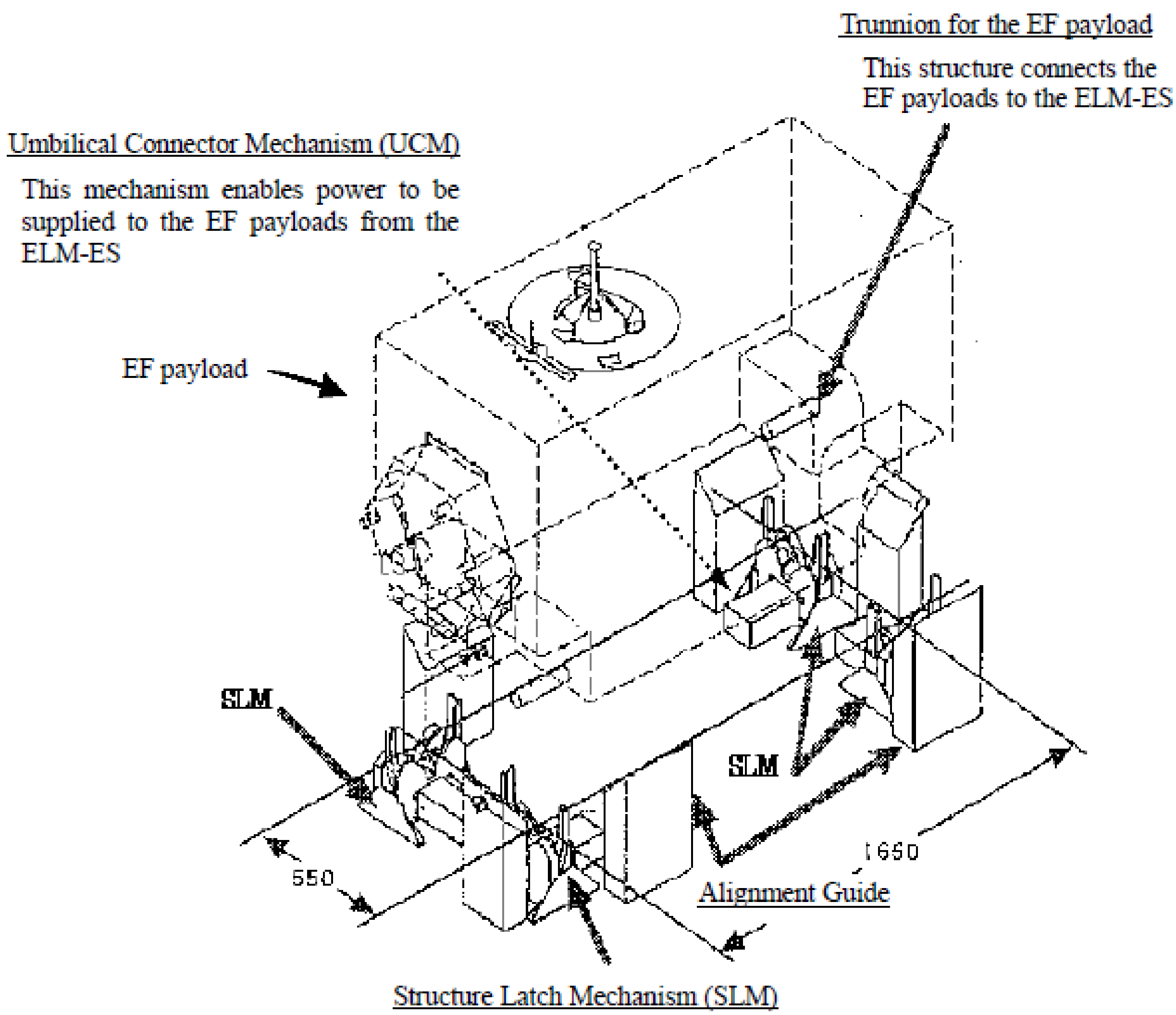
EF payloads attached to the PAM (Space Station Processing Facility, KSC)

Umbilical Connector Mechanism

The Umbilical Connector Mechanism (UCM) will enable heater power to be supplied to the EF payloads from the EF through the ELM-ES, and this will keep the payloads within the required temperature.

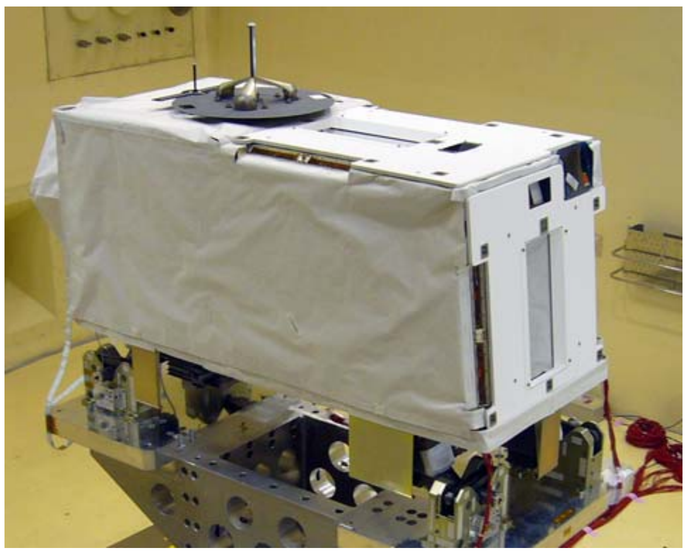
Structure Latch Mechanism

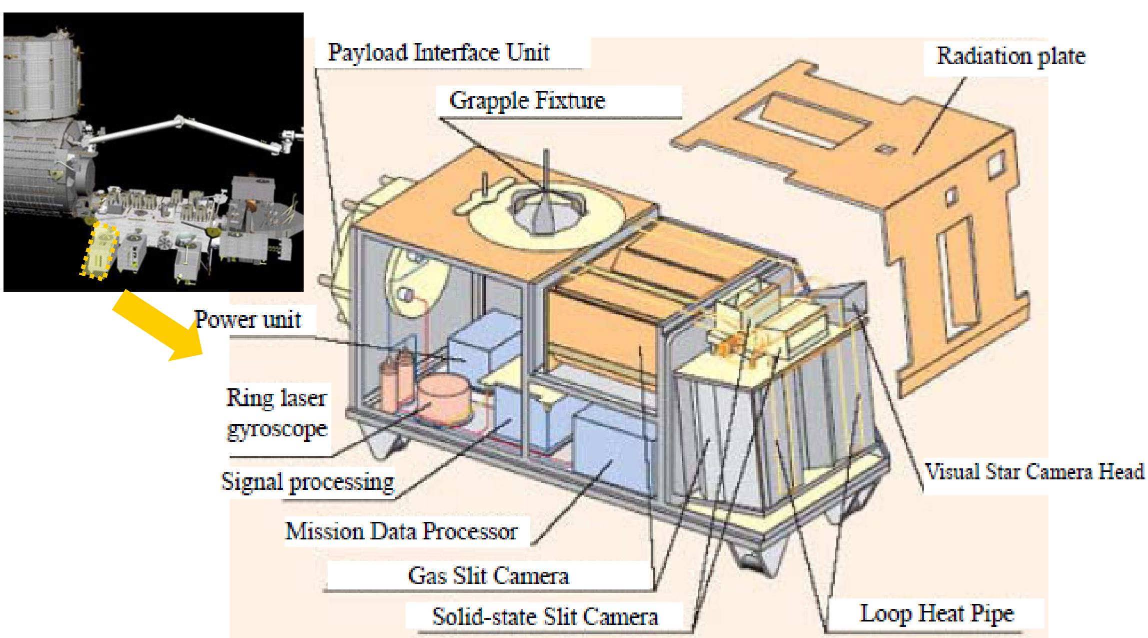
The Structure Latch Mechanisms (SLMs) catch onto and fasten an EF payload with four latches.



EF Experiments and Payload Exposed Facility Experiments Monitor of All-sky X-ray Image

The MAXI is an astronomical observatory which will monitor X-ray spectra from the station. The observations will encompass nearly the entire sky. The MAXI will scan space every 90 minutes with two types of X-ray detectors: a Gas Slit Camera (GSC) with 12 gas proportional counters and a Solid-state Slit Camera (SSC) with a peltier-cooled X-ray sensitive CCD. These slit cameras can scan by using the station's attitude changes and so a pointing mechanism does not need to be used. Observation data can be distributed via the Internet when detecting X-ray transient phenomena so that observatories around the world can promptly receive and respond to the phenomena as well. Following is an overview of the MAXI.

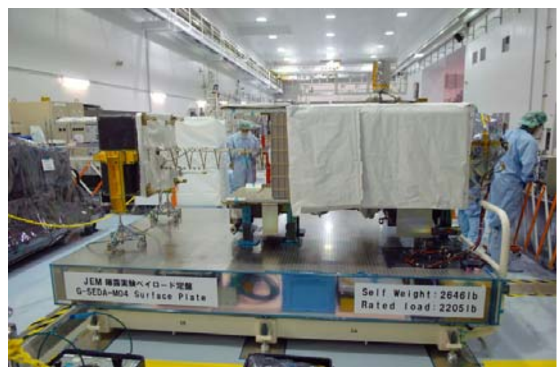


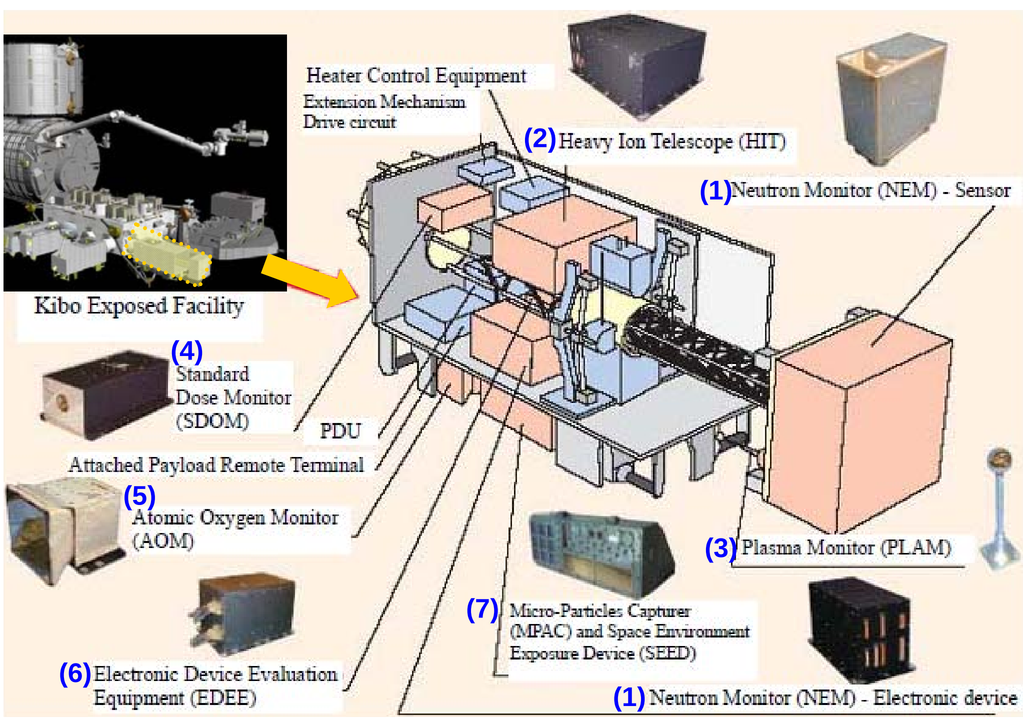


Space Environment Data Acquisition Equipment-Attached Payload

The Space Environment Data Acquisition Equipment-Attached Payload (SEDA-AP) will measure the space environment (neutrons, plasma, heavy ions, high-energy light particles, atomic oxygen, and cosmic dust) in the station's orbit. It will also observe how the space environment affects materials and electronic devices.

The SEDA-AP measurement units include (1) Neutron Monitor (NEM), (2) Heavy Ion Telescope (HIT), (3) Plasma Monitor (PLAM), (4) Standard Dose Monitor (SDOM), (5) Atomic Oxygen Monitor (AOM), (6) Electronic Device Evaluation Equipment (EDEE), and (7) Micro-Particles Capture (MPAC) and Space Environment Exposure Device (SEED). The SEDA-AP will conduct measurement and monitoring by extending a mast, on which the NEM – Sensor and the PLAM-Sensor will be installed. Below is an overview of the SEDA-AP.





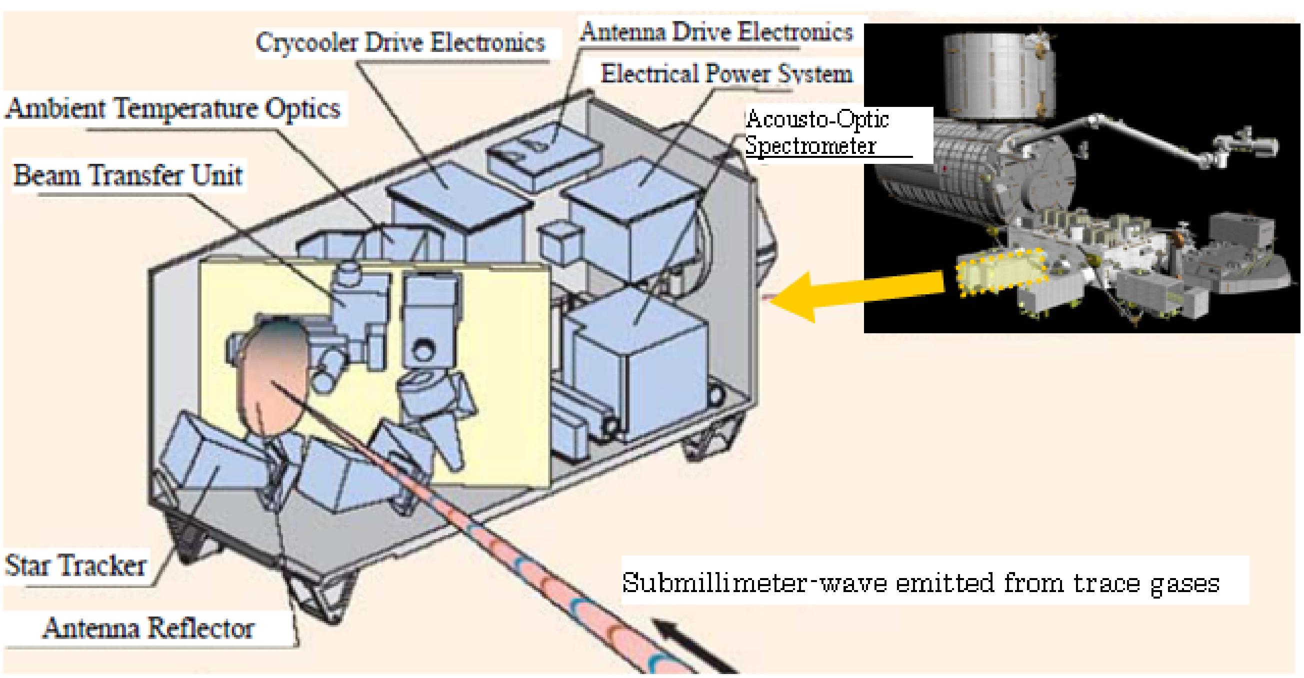
Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES)

This EF experiment will be delivered to the station on the HTV mission targeted to launch in September 2009.

The objective of SMILES is to conduct global mappings of stratospheric trace gases using an extremely sensitive submillimeter receiver. The Superconductor Insulator Superconductor (SIS) mixer in a dedicated cryostat with a mechanical cooler achieves SMILES's super high sensitivity. SMILES will observe ozone-depletion-related molecules such as ClO, HCl, HO2, HNO3, BrO. A scanning antenna will cover tangent altitudes from 10 to 60 km every 53 seconds, while tracing the latitudes from 38 S to 65 N along its orbit.

With global coverage capability, SMILES can observe low- and mid-latitudinal areas as well as the Arctic peripheral region.

SMILES data will enable us to investigate the chlorine and bromine chemistry in the atmosphere and will also provide a database for ozone variations in time and position around the upper troposphere and lower stratosphere.

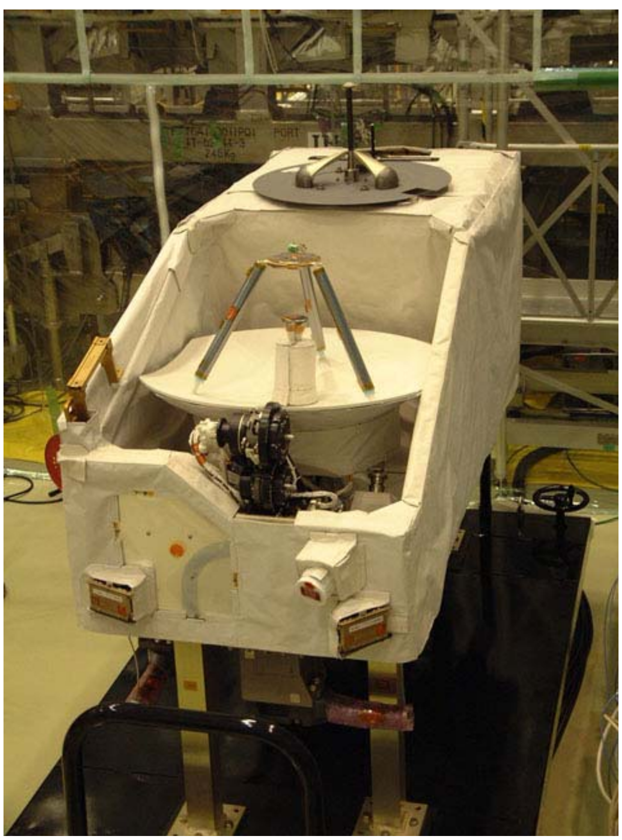


Exposed Facility Payload Inter-orbit Communication System-Exposed Facility (ICS-EF)

The Inter-orbit Communication System (ICS) is the Kibo-specific communications system for uplink/downlink data, images, and voice data between Kibo and the Mission Control Room (MCR) at the Tsukuba Space Center (TKSC) by way of Japan's own relay satellite, the Data Relay Test Satellite (DRTS). The ICS consists of the ICS Pressurized Module (ICS-PM) subsystem installed on the PM (provides data communications) and the ICS Exposed Module (ICS-EF) subsystem to be installed on the EF.

The ICS-EF consists of an antenna, a pointing mechanism, frequency converters, a high-power amplifier, and various sensors including an Earth sensor, a sun sensor, and an inertial reference unit. The ICS antenna can automatically track DRTS using the Antenna Pointing Mechanism by determining the antenna's attitude based on the data from the Earth sensor, sun sensor and Inertial Reference Unit, while at the same time calculating the antenna's direction based on the station and the orbital positions of DRTS.

Installation of the ICS-EF on the EF paves the way for direct communications between Kibo and the Mission Control Room at TKSC through DRTS. It will be an efficient network resource, especially when huge amounts of data (such as experiment video data) are downlinked to the ground from Kibo.



Installations of the EF, the ELM-ES, and EF payloads

Kibo's Exposed Facility (EF) and Experiment Logistics Module-Exposed Section (ELM-ES) will be launched in the space shuttle Endeavour's payload bay.

Heat necessary for the EF and Visual Equipment (VE) will be provided by the Assembly Power Converter Unit (APCU) on the shuttle. Heater power for the ELM-ES and the payloads will be supplied by the Remotely Operated Electrical Unit (ROEU) on the shuttle.

On flight day 4, the EF will be installed on Kibo's PM with the Exposed Facility Berthing Mechanism (EFBM). Prior to the EF installation, several preparation activities will be carried out by spacewalkers: removal of the MLI covers from the EFBM (both the active half and the passive half) and disconnection of the heater cable between the EF and the APCU in the payload bay. Once the EF is berthed to the PM with the EFBM bolts, the EF will be powered and activated; the EF subsystems, such as Command and Data Handling (C&DH), the Electrical Power System (EPS), and the Thermal Control System (TCS), will be activated in that order.

On flight day 7, the ELM-ES will be attached to the EF to provide access for the robotic transfer of the EF payloads on the ELM-ES. Before the space shuttle's robot arm lifts the ELM-ES from the payload bay, the heater power provided by the ROEU on the shuttle will be disconnected. Once the ELM-ES is attached to the EF, the power will be provided by the EF, and channels for commands and telemetries (sending/receiving) will be enabled.

On flight day 9, three EF payloads on the ELM-ES will be transferred to the EF by Kibo's robotic arm. Before this transfer operation, the MLI covers and contamination covers on the EF payloads will have to be removed during a spacewalk on flight day 8.

On flight day 12, the ELM-ES will be unberthed from the EF and returned to the shuttle's payload bay for the trip back to the ground.

KIBO MISSION CONTROL CENTER

Kibo operations are monitored and controlled from the Space Station Operations Facility (SSOF) at JAXA's Tsukuba Space Center (TKSC) and from the Mission Control Center at NASA's Johnson Space Center (JSC), where the overall operations of the space station are controlled.

JAXA FLIGHT CONTROL TEAM

The JAXA Flight Control Team (JFCT) consists of flight directors and flight controllers (a total of more than 60 members) assigned to 10 technical disciplines required to support Kibo flight operations.

The team monitors the status of command uplinks, data downlinks, systems, payloads, and experiment on board Kibo. The team has the capability of making real-time operations planning changes and communicating with the crew on board Kibo and also with the international partners' mission control centers. The team can troubleshoot problems or anomalies that may occur on board Kibo during flight operations.

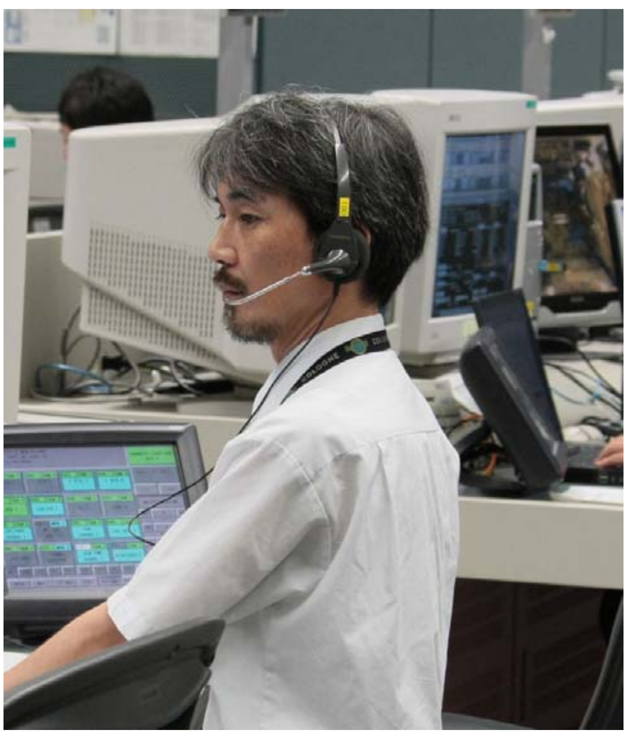
Kibo Mission Control Room

The team is also responsible for the preparation and evaluation of all plans and procedures which will be performed by the crew on board Kibo and by controllers on the ground. The roles of the respective sections of JFCT are as follows:

JAXA Flight Director

The JAXA flight director (J-FLIGHT) is the leader of the team.

The J-FLIGHT directs the overall operations of Kibo, including operations planning, systems, and experiment operations, as well as other tasks performed by the crew on board Kibo.



STS-127 Lead J-FLIGHT Masao Nakai

The flight controllers assigned to each control section must ensure that the J-FLIGHT is given the current status of every detail of Kibo operations.

The lead J-FLIGHT is responsible for the crew safety in the Kibo module and takes the leading role to integrate the mission.

Control and Network Systems, Electrical Power, and ICS Communication Officer

The Control and Network Systems, Electrical Power, and ICS Communication Officer (CANSEI) is responsible for Kibo flight control, network systems, electrical power, and ICS communications. The CANSEI monitors the control status of on-board computers, network systems, and electrical power systems through data downlinked from Kibo on a real-time basis.

Fluid and Thermal Officer

The Fluid and Thermal Officer (FLAT) is responsible for monitoring the status of the ECLSS and the TCS which regulate the heat generated from the equipment on board Kibo. These systems are monitored through telemetry data downlinked from Kibo on a real-time basis.

Kibo Robotics Officer

The Kibo Robotics Officer (KIBOTT) is responsible for the overall operation of Kibo's robotic arm systems, the scientific airlock, and other associated mechanisms. During robotic arm and airlock operations, the KIBOTT will prepare and monitor the related systems necessary for the flight crew to perform the appropriate tasks on board Kibo.

Operations Planner

The Operations Planner (J-PLAN) is responsible for planning the actual flight operations. When Kibo is in a flight operations mode, the J-PLAN monitors the status and progress of Kibo operations and, if necessary, amends or modifies the operation plans as required.

System Element Investigation and Integration Officer

The System Element Investigation and Integration Officer (SENIN) is responsible for Kibo's system elements. The SENIN monitors and ensures that each Kibo system is running smoothly and integrates all systems information provided by each flight control section.

Tsukuba Ground Controller

The Tsukuba Ground Controller is responsible for the overall operation and maintenance of the ground support facilities that are essential for Kibo flight operations. This includes the operations control systems and the operations network systems.

JEM Communicator

The JEM Communicator (J-COM) is responsible for voice communication with the crew on board Kibo. The J-COM communicates all essential information to the crew for operating Kibo systems and experiments and/or responds to Kibo-specific inquiries from the crew.

Astronaut-Related IVA and Equipment Support

Astronaut-Related IVA and Equipment Support (ARIES) is responsible for Intra-Vehicular Activity (IVA) operations on board Kibo. The ARIES manages the tools and other IVA-related support equipment on Kibo.

JEM Payload Officer

The JEM Payload Officer (JEM PAYLOADS) is responsible for Kibo's experiment payload operations and coordinates payload activities with the primary investigators of each experiment.

JAXA Extravehicular Activity

The JAXA Extravehicular Activity (JAXA EVA) team is for Kibo-related EVA operations and provides technical support to the crew members who perform Kibo-related spacewalks.

The JAXA EVA console is not in the Space Station Operations Facility (SSOF) at TKSC. Instead, the JAXA EVA flight controllers are stationed at NASA's JSC.

JEM ENGINEERING TEAM

The JEM Engineering Team (JET) is responsible for providing technical support to the flight control team and technical evaluation of real-time data and pre- and post-flight analysis. JET consists of the JET lead and engineers for Kibo's electrical subsystem, fluid subsystem and IVAs, who are the members of the JEM Development Project Team. JET engineers also work in the NASA Mission Evaluation Room at NASA JSC in order to perform joint troubleshooting and anomaly resolution.

PAYLOAD FLIGHT CONTROL TEAM

All scientific experiments and educational operations on board Kibo are conducted by the Payload Flight Control Team (PL FCT) stationed at the User Operations Area (UOA) under the direction of the JEM PAYLOADS. The PL FCT consists of ten expert groups who have special knowledge in order to support each experiment operation.

JAXA Payload Operations Conductor

The JAXA Payload Operations Conductor (JPOC) is the leader of the PLFCT. The JPOC oversees and manages experiment operations on board Kibo. This role includes evaluating and decision-making concerning experiment planning, operations procedures, readiness, and actual operations.

Fluid Science and Crystallization Science Ops Lead

The Fluid Science and Crystallization Science Ops Lead team (FISICS) is responsible for the operations of the Fluid Physics Experiment Facility (FPEF), the Solution Crystallization Observation Facility (SCOF), the Protein Crystallization Research Facility (PCRF), and the Image Processing Unit (IPU) installed on the RYUTAI Rack.

Biology Ops Lead

The Biology Ops Lead team (BIO) is responsible for overall operations of the Cell Biology Experiment Facility (CBEF) and the Clean Bench (CB) installed on the SAIBO Rack.

RYUTAI Rack User Integrator/Principal Investigator/Engineer (UI/PI/Eng.)

The RYUTAI Rack UI/PI/Eng. team consists of a research team and an engineering team and is responsible for all the experiment operations that use the RYUTAI Rack.

For each experiment program, the team prepares sample specimen and equipment for the experiment in support of the principal investigator (PI) and those who manufacture the experiment. The engineering team includes the User Integrator (UI) and engineers who have been involved in the development of the experiment operated in the RYUTAI Rack.

SAIBO Rack User Integrator/Principal Investigator/Engineer (UI/PI/Eng.)

The SAIBO Rack UI/PI/Eng. team consists of a research team and an engineering team and is responsible for experiment operations that use the SAIBO Rack.

For each experiment program, the team prepares sample specimen and equipment for the experiment in support of the PI and those who manufacture the experiment. The engineering team includes the UI and engineers who have been involved in the development of the experiment operated in the SAIBO Rack.

Education Payload Observation Officer

The Education Payload Observation Officer team (EPO/Medical) is responsible for JAXA's Educational Payload Observation (EPO) and medical research operations.

On board Kibo, educational programs (art and culture) and human space flight technology development programs (the astronauts' health care and medical management) are performed using the space-unique environment.

The team monitors and operates each program in support of the project leader and the researcher/principal investigator of the program, and collaborates with the JEM PAYLOADS and the JPOC.

SEDA-AP, MAXI 1 AND 2, SMILES SPACE ENVIRONMENT DATA ACQUISITION EQUIPMENT – ATTACHED PAYLOAD, MONITOR OF ALL-SKY X-RAY IMAGE, SUPERCONDUCTING SUBMILLIMETER-WAVE LIMB-EMISSION SOUNDER

This team is responsible for the EF experiment operations, namely the SEDA-AP, MAXI and SMILES.

TSUKUBA SPACE CENTER

Tsukuba Space Center is JAXA's largest space development and utilization research complex. As Japan's primary site for human spaceflight research and operations, it operates the following facilities in support of the Kibo mission.

Space Station Test Building

Comprehensive Kibo systems' tests were conducted in this building. The main purpose of the tests was to verify function, physical interface, and performance of the entire Kibo system including all the associated elements. In addition, subsystems, payloads, and ground support equipment were all tested in this building. Currently, this building is used to provide engineering support for Kibo operations.

Space Experiment Laboratory (SEL)

The following activities are conducted in this building:

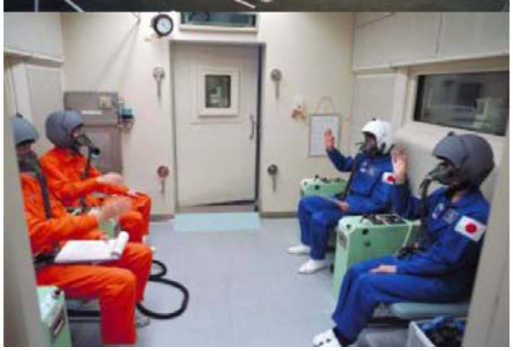
- Development of technologies required for space experiments
- Preparation of Kibo experiment programs
- Experiment data analysis and support

Astronaut Training Facility (ATF)

The following activities are conducted in this building:

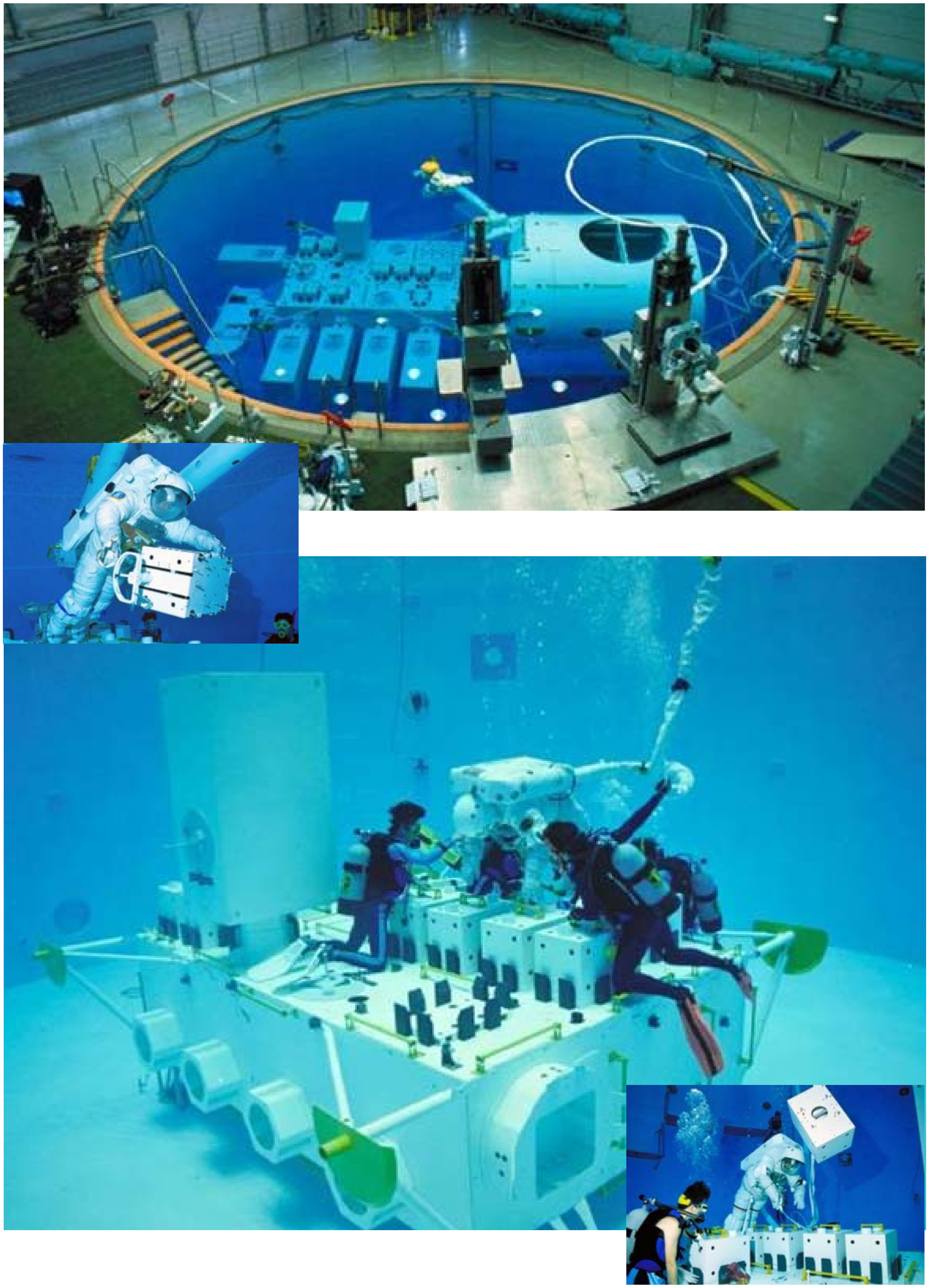
- JAXA astronaut candidate training
- Astronaut training and health care

This building is also the primary site for Japan's space medicine research.



Weightless Environment Test Building (WET)

This facility provides a simulated weightless environment using water buoyancy for astronaut training. Design verification tests on various Kibo element modules and the development of preliminary spacewalk procedures were conducted in this facility.



Exposed Facility Mockup in the WET pool

SPACE STATION OPERATION FACILITY

The Space Station Operation Facility (SSOF) is used for the control of Kibo operations. At the SSOF, operation of Kibo systems and payloads are supervised, and Kibo operation plans are prepared in cooperation with NASA's Space Station Control Center (SSCC) and Payload Operation Integration Center (POIC).

The SSOF is responsible for the following:

- Monitoring and controlling Kibo operating systems
- Monitoring and controlling Japanese experiments on Kibo
- Implementing operation plans
- Supporting launch preparation

The SSOF consists of the following sections:

Mission Control Room

This is the location of real-time Kibo support on a 24-hour basis. This includes monitoring the health and status of Kibo's operating systems and payloads, sending commands, and real-time operational planning.

User Operations Area

The User Operations Area is designated as the distribution point for the status of Japanese experiments, and where collected data is released to the respective users who are responsible for the experiments and their subsequent analyses.

Operations Planning Room

This is the location of the planning of in-orbit and ground operations based on the power distribution, crew resources, and data transmission capacity. If the baseline plans need to be changed, adjustments will be conducted in collaboration with the control room, the User Operations, and NASA.

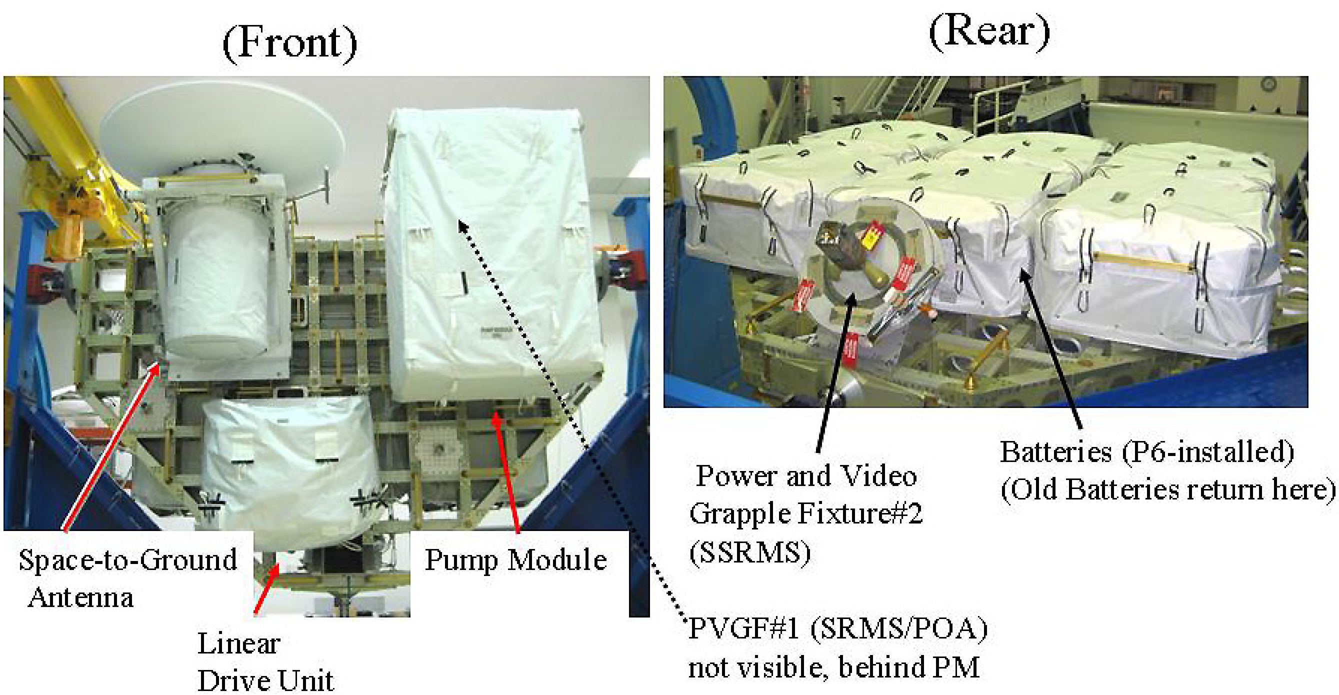
Operations Rehearsal Room

Training for flight controllers, integrated rehearsals, and joint simulations with NASA take place in this room.

Engineering Support Room

This is the location of the engineering support for Kibo operations. In this room, the JEM Engineering Team monitors the data downlinked to the MCR from Kibo and provides engineering support as required.

INTEGRATED CARGO CARRIER – VERTICAL LIGHT DEPLOY (ICC-VLD)

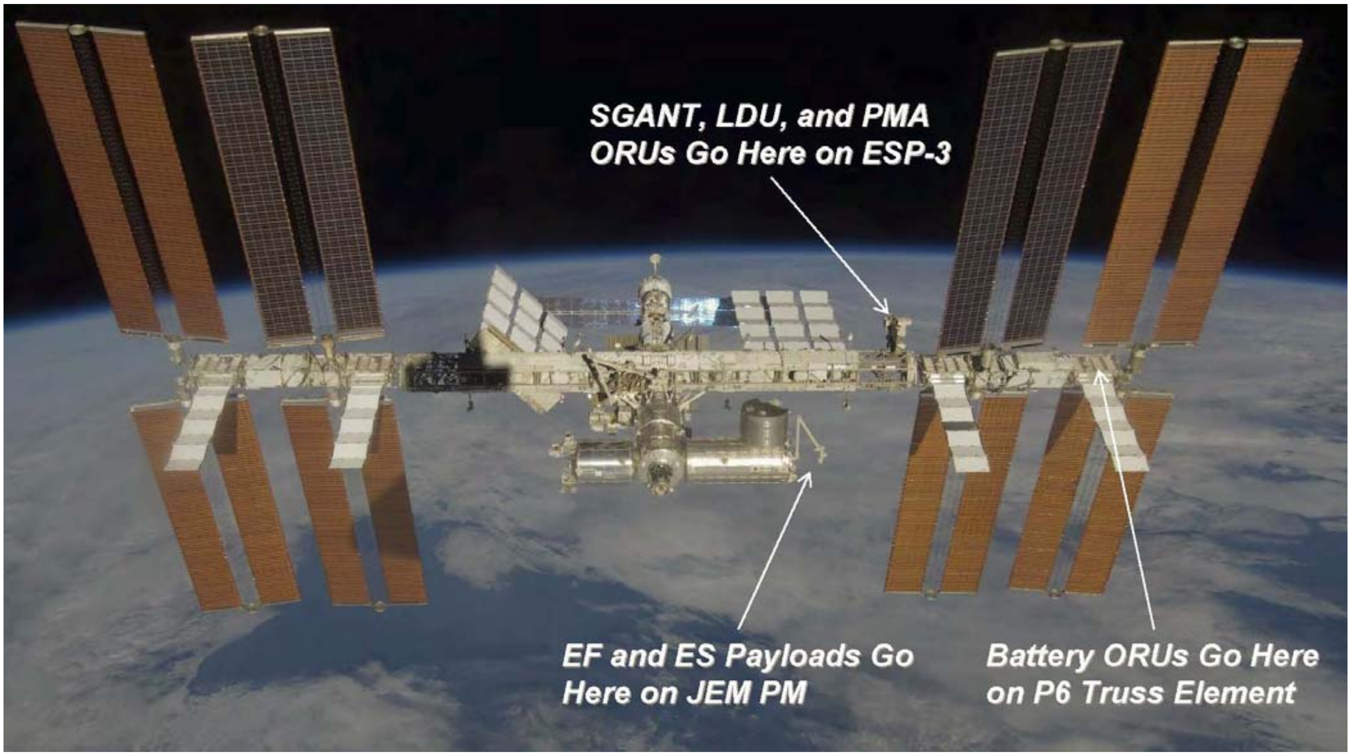


Astronauts use the Integrated Cargo Carrier (ICC) to help transfer unpressurized cargo such as Orbital Replacement Units (ORUs) from the space shuttle to the International Space Station and from the station to worksites on the truss assemblies. The carrier also is used to return items for refurbishment.

The Astrium ICC, formerly provided by SPACEHAB Inc., is an unpressurized flatbed pallet and keel yoke assembly housed in the shuttle's payload bay. Constructed of aluminum, it is approximately 8 feet long (105 inches), 13 feet wide (165 inches), and 10 inches thick, and carries cargo on both the top and bottom faces of the pallet. Using modular elements, several pallet configurations are available, accommodating various mass capabilities and cargo envelopes.

The ICC configuration flown on STS-127 is called the ICC-VLD and provides heater power and electrical connections for the ORUs. The empty weight of the ICC-VLD is 2,645 pounds. The total weight of the ORUs and ICC-VLD is approximately 8,330 pounds. The STS-127/2JA assembly mission ICC-VLD will carry replacement components and spare parts for the space station.

The ICC is grabbed by the space shuttle and the space station robotic arms during its move from the payload bay. It is attached to the station's mobile transporter and can be held at the various worksites by the station's robotic arm while the ORUs are transferred.



The ICC-VLD will carry six batteries for the Port 6 (P6) solar array. Thirty-eight individual pressure vessel (IPV) nickel hydrogen (NiH2) battery cells are connected in series and packaged in a Battery ORU. Two ORUs are connected in series, utilizing a total of 76 cells to form one battery. The P6 Integrated Equipment Assembly (IEA) containing the initial ISS high-power components was launched on Nov. 30, 2000. The IEA contains 12 Battery Subassembly ORUs (6 batteries) that provide station power during eclipse and maintenance periods. Each battery is designed to deliver more than 25 Amps in a low-demand orbit to as high as 75 Amps to meet short peaking load requirements at a battery operating voltage range of 76 to 123 V dc. The batteries will be replaced during two spacewalks and the old ones will be returned. The six batteries weigh 2,204 pounds and have a design life of approximately six and a half years.

In addition to the batteries, the ICC-VLD will have three Flight Releasable Attachment Mechanism (FRAM)-based ORUs called the Space-to-Ground Antenna (SGANT), Pump Module Assembly (PMA) and Linear Drive Unit (LDU). These components will be stored on External Stowage Platform 3 (ESP-3) on the Port 3 truss. When the ICC-VLD with the old batteries is returned to Earth aboard the space shuttle, it will weigh 6,017 pounds.

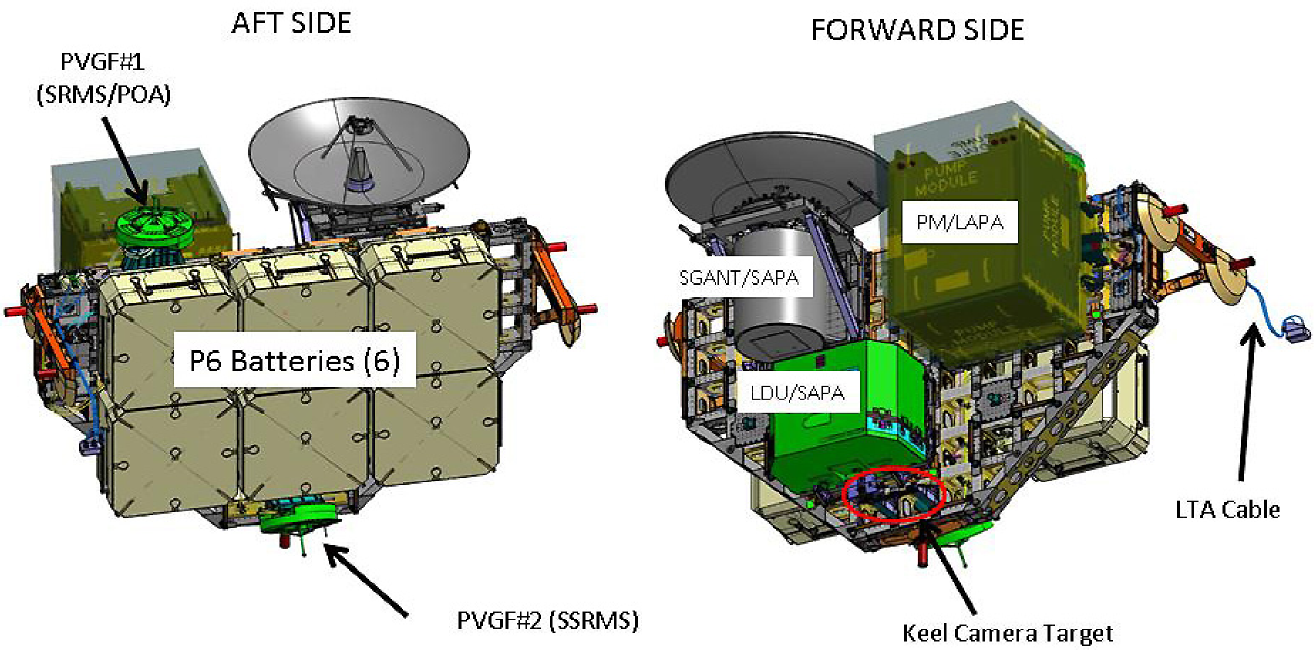
The SGANT provides Ku-band communication between the space station and the Tracking Data and Relay (TDRS) satellites for payload data, video to the ground and the crew Orbiter Communications Adapter (OCA). The OCA allows for telephone calls, emails and other two-way communications services. The

SGANT currently is mounted on top of the Zenith 1 (Z1) truss. Eventually, a second Z1 boom will be mounted with an additional SGANT in a standby backup mode. If ever needed, it could be brought on line quickly. The SGANT launched on flight STS-127/2JA will be a spare for the other two ORUs mounted on the Z1 Truss. The SGANT dish measures 6 feet (72 inches) in diameter, is 6 feet (72 inches) high, including gimbals, and weighs 194 pounds.

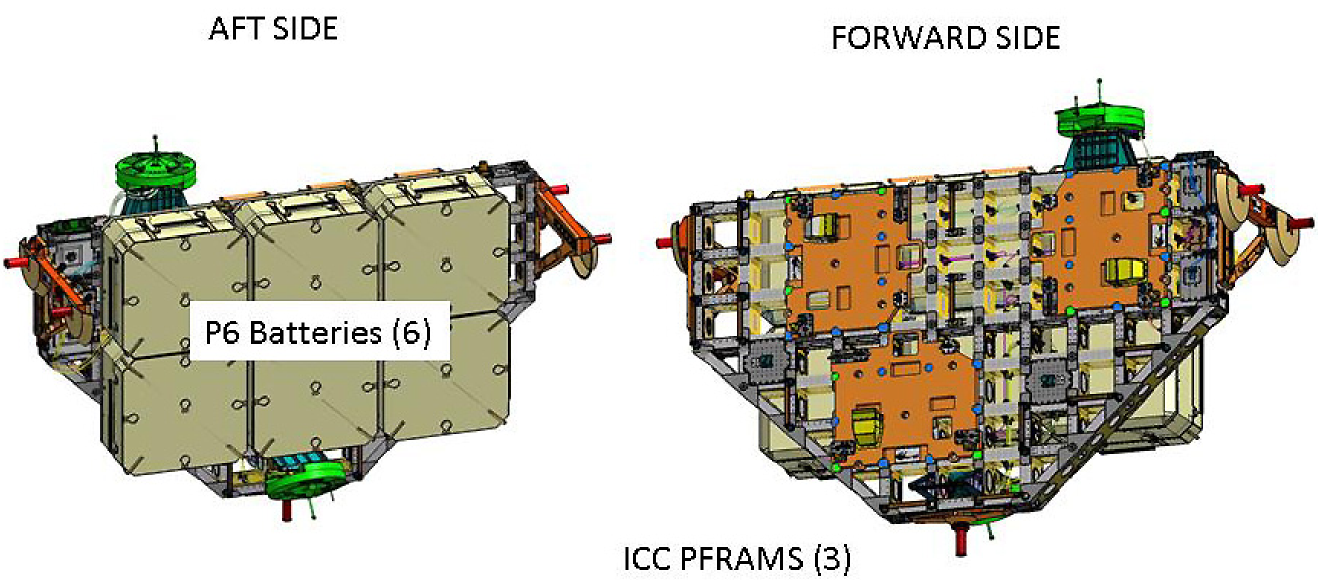
The LDU is the drive system for the mobile transporter that moves back and forth (port to starboard, starboard to port) along the integrated rails on the external structure of the space station (i.e., trusses P3 through S3). The transporter is a movable platform that shifts the space station robotic arm, work carts or massive station components along the main truss. The LDU features two independent drive and engagement systems. Built by Northrop Grumman ASTRO Aerospace in Carpeinteria, Calif., the LDU weighs approximately 255 pounds and measures approximately 4 feet wide by 3 feet high, and just under 2 feet in depth.

The PMA is part of the station's complex Active Thermal Control System (ATCS), which provides vital cooling to internal and external avionics, crew members, and payloads. The station has two independent cooling loops. The external loops use an ammonia-based coolant and the internal loops use water cooling. At the heart of the ATCS is the pump module, which pumps the ammonia through the external system to provide cooling and eventually reject the residual heat into space via the radiators. The heat is generated by the electronic boxes throughout the station. Manufactured by Boeing, the pump module weighs 780 pounds and measures approximately 5 1/2 feet (69 inches) long by 4 feet (50 inches) wide by 3 feet (36 inches) high.

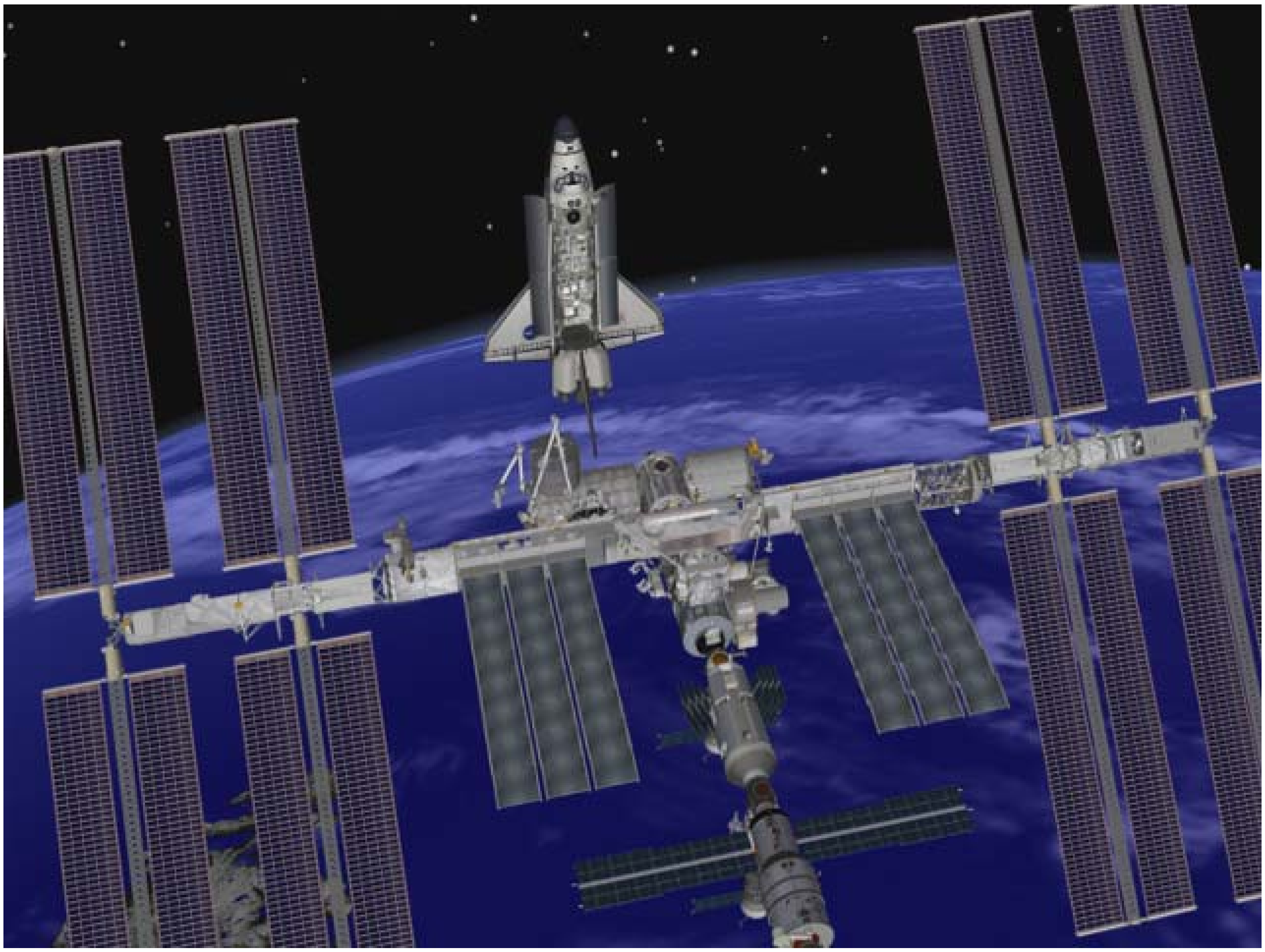
ICC-VLD Launch Configuration



ICC-VLD Return Configuration



RENDEZVOUS & DOCKING



The above image depicts space shuttle Endeavour on final docking approach with the International Space Station.

Rendezvous begins with a precisely timed launch that puts the space shuttle on a trajectory to chase the International Space Station. A series of engine firings over the next two days will bring Endeavour to a point about 50,000 feet behind the station. Once there, Endeavour will start its final approach. About 2.5 hours before docking, the shuttle's jets will be fired during what is called the terminal initiation burn. The shuttle will cover the final miles to the station during the next orbit.

As Endeavour moves closer to the station, its rendezvous radar system and trajectory control sensor will provide the crew with range and closing-rate data. Several small correction burns will place Endeavour about 1,000 feet below the station.

Commander Mark Polansky, with help from Pilot Doug Hurley and other crew members, will manually fly the shuttle for the remainder of the approach and docking.

Polansky will stop Endeavour about 600 feet below the station. Once he determines there is proper lighting, he will maneuver Endeavour through a nine-minute backflip called the Rendezvous Pitch Maneuver. That allows the station crew to take as many as 300 digital pictures of the shuttle's heat shield.

Station crew members Mike Barratt and Gennady Padalka will use digital cameras with 400mm and 800mm lenses to photograph Endeavour's upper and bottom surfaces through windows of the Zvezda Service Module. The 400mm lens provides up to three-inch resolution and the 800mm lens up to one-inch resolution. Padalka will use the 400mm and Barratt will use the 800.

The photography is one of several techniques used to inspect the shuttle's thermal protection system for possible damage. Areas of special interest include the thermal protection tiles, the reinforced carbon-carbon of the nose and leading edges of the wings, landing gear doors and the elevon cove.

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

When Endeavour completes its backflip, it will be back where it started, with its payload bay facing the station. Polansky then will fly Endeavour through a quarter circle to a position about 400 feet directly in front of the station. From that point he will begin the final approach to docking to the Pressurized Mating Adapter 2 at the forward end of the Harmony node.

The shuttle crew members will operate laptop computers that process the navigational data, the laser range systems and Endeavour's docking mechanism.

Using a video camera mounted in the center of the Orbiter Docking System, Polansky will line up the docking ports of the two spacecraft.

If necessary, Polansky will pause Endeavour 30 feet from the station to ensure proper alignment of the docking mechanisms. He will maintain the shuttle's speed relative to the station at about one-tenth of a foot per second, while both Endeavour and the station are moving at about 17,500 mph. Polansky will keep the docking mechanisms aligned to a tolerance of three inches.

When Endeavour makes contact with the station, preliminary latches will automatically attach the two spacecraft. The shuttle's steering jets will be deactivated to reduce the forces acting at the docking interface. Shock absorber springs in the docking mechanism will dampen any relative motion between the shuttle and station.

Once motion between the shuttle and the station has been stopped, the docking ring will be retracted to close a final set of latches between the two vehicles.

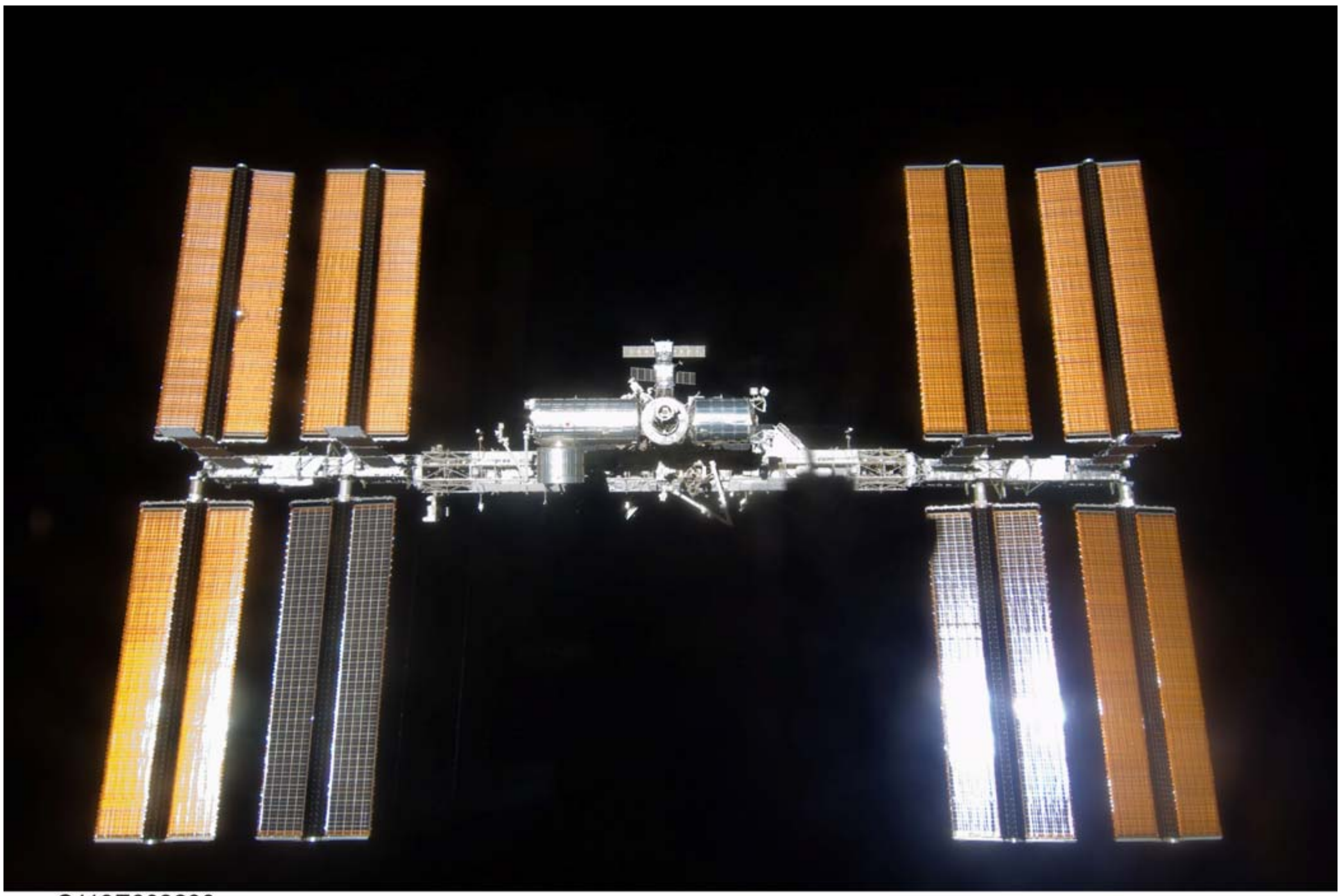
UNDOCKING, SEPARATION AND DEPARTURE

At undocking time, the hooks and latches will be opened and springs will push the shuttle away from the station. Endeavour's steering jets will be shut off to avoid any inadvertent firings during the initial separation.

Once Endeavour is about two feet from the station and the docking devices are clear of one another, Hurley will turn the steering jets back on and will manually control Endeavour within a tight corridor as the shuttle separates from the station.

Endeavour will move to a distance of about 450 feet, where Hurley will begin to fly around the station. This maneuver will occur only if propellant margins and mission timeline activities permit.

Once Endeavour completes 1.5 revolutions of the complex, Hurley will fire Endeavour's jets to leave the area. The shuttle will move about 46 miles from the station and remain there while ground teams analyze data from the late inspection of the shuttle's heat shield. The distance is close enough to allow the shuttle to return to the station in the unlikely event that the heat shield is damaged, preventing the shuttle's safe re-entry.



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Backdropped by the blackness of space, the International Space Station is seen from space shuttle Discovery as the two spacecraft begin their relative separation.

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SPACEWALKS

S112E05324

Dave Wolf, STS-112 mission specialist, his feet secured to a foot restraint on the end of the Space Station Remote Manipulator System or Canadarm2, participates in a six-hour, four-minute session of extravehicular activity.

There are five spacewalks scheduled for the STS-127 mission – only the second time that a crew has gone into a space station mission planning to perform so many. The main event will be the installation of the Japanese Kibo laboratory's exposed section on the first spacewalk, but that's only a small slice of the work to be done. The spacewalkers will also deliver spare equipment, change out batteries and finish up some work that wasn't accomplished during the last shuttle mission to the space station.

Mission Specialists Dave Wolf, Tim Kopra, Tom Marshburn and Christopher Cassidy will spend a combined total of 32.5 hours outside the station on flight days 4, 6, 8, 10 and 13. Wolf, the lead spacewalker for the mission, will suit up for the first, second and third spacewalks in a spacesuit marked with solid red stripes. He is a veteran spacewalker with three extravehicular activities, or EVAs, performed during the STS-112 mission in 2002, and one performed from the Russian Mir space station.

Kopra, Marshburn and Cassidy will perform their first spacewalks. Kopra will participate in the first spacewalk, wearing an all white spacesuit. Marshburn will take part in spacewalks two, four and five and wear a spacesuit marked with a broken red stripe. And Cassidy will wear a spacesuit with a line of horizontal red stripes for spacewalks three, four and five.

On each EVA day, a spacewalker inside the station will act as the intravehicular officer, or spacewalk choreographer. And all but the fifth spacewalk will require at least two crew members inside the station or shuttle to be at the controls of one or more of the robotic arms – the station's 58-foot-long robotic arm or the shuttle's 50-foot-long one – to carry and maneuver equipment and spacewalkers.

Preparations will start the night before each spacewalk, when the astronauts spend time in the station's Quest Airlock. This practice is called the campout prebreathe protocol and is used to purge nitrogen from the spacewalkers' systems and prevent decompression sickness, also known as "the bends."

During the campout, the two astronauts performing the spacewalk will isolate themselves inside the airlock while the air pressure is lowered to 10.2 pounds per square inch, or psi. The station is kept at the near-sea-level pressure of 14.7 psi. The morning of the spacewalk, the astronauts will wear oxygen masks while the airlock's pressure is raised back to 14.7 psi for an hour and the hatch between the airlock and the rest of the station is opened. That allows the spacewalkers to perform their morning routines before returning to the airlock, where the air pressure is lowered again. Approximately 50 minutes after the spacewalkers don their spacesuits, the prebreathe protocol will be complete.

The procedure enables spacewalks to begin earlier in the crew's day than was possible before the protocol was adopted.

EVA-1

Duration: 6 hours, 30 minutes
Crew: Wolf and Kopra
IV Crew: Cassidy
Robotic Arm Operators: Polanksy (shuttle), Hurley (station), Payette (shuttle) and Wakata (station)

EVA Operations

- Kibo/exposed facility berthing mechanism prep
- ICC prep
- CETA cart modification
- Japanese robotic arm maintenance
- Exposed facility experiment prep
- P3 Nadir UCCAS and S3 Zenith Outboard PAS deploy

Although the actual installation of Kibo's exposed facility will be done robotically, Wolf and Kopra will begin the first spacewalk by making preparations for that installation at both ends. Wolf will make his way to the laboratory to remove some insulation currently covering its berthing mechanism that the exposed facility will be attached to. To do so, he'll release four fasteners and jettison the insulation. While he's in the area, he'll also tuck two grounding tabs on the Japanese robotic arm out of the way of the arm's camera – they're currently interfering with the view.

At the same time, Kopra will be working inside the shuttle's cargo bay on the exposed facility end of that preparation. He'll start by removing insulation from its berthing mechanism where it will attach to the Kibo laboratory, by releasing four fasteners and storing the insulation. He'll then disconnect the power cable that keeps the exposed facility running while it's in the cargo bay.

The shuttle's robotic arm will have already latched onto the exposed facility before the spacewalk started, and after the power cable is disconnected, the spacewalkers will have done their part in the preparations for its installation. Afterward, the station robotic arm will maneuver into place, and the shuttle robotic arm will pick up the facility from the shuttle's cargo bay and hand it off to the station robotic arm. The station arm will then fly it to the Kibo laboratory for installation.

Meanwhile, Wolf and Kopra will continue on with their spacewalk activities. Already in the shuttle's cargo bay, Kopra will go ahead and disconnect the power cables providing electricity to the integrated cargo carrier to which the spare station equipment that Endeavour is carrying are attached. And he'll remove a contamination cover on one of the experiments the exposed facility's experiment carrier is carrying – MAXI, or Monitor of All-sky X-ray Image.

After that, Kopra will move to the top of the Harmony node to secure a cover on its common berthing mechanism. He'll move farther aft on station to pick up some tools on the station's zenith truss segment, and then to the left side of the Unity node to open another cover on its common berthing mechanism.

Wolf will move from the Kibo laboratory to the station's port, or left, truss. He'll pause at the innermost section of the truss to loosen four bolts on the grapple bar of an ammonia tank assembly to speed up another task during the second spacewalk, then continue on to the port crew equipment and translation aid, or CETA, cart. There he'll be moving and restraining a foot restraint and brake handles out of the way to prevent them from interfering with the rotating solar alpha rotary joint.

For the rest of the spacewalk, Wolf and Kopra will work together to set up two systems for attaching cargo to the station's truss – an unpressurized cargo carrier attachment system, or UCCAS, and a payload attachment system, or PAS. Though they have different names, the two systems are almost identical. During the last shuttle mission to the space station, spacewalkers ran into problems when they tried to set up the UCCAS on the port 3, or P3, segment of the station's truss. A jammed detent pin kept it from unfolding as it was supposed to. So Wolf and Kopra will come back for another try during their spacewalk. They'll use a specially built detent release tool to help clear the jam and allow them to fully install the UCCAS.

After getting the UCCAS into place, Wolf and Kopra will move to the starboard side of the truss to set up a PAS on the S3 truss segment. If this one goes as planned, the spacewalkers will first remove brackets and pins holding the latch in place, move the latch into position and then reinstall the brackets and pins.

EVA-2

Duration: 6 hours, 30 minutes
Crew: Wolf and Marshburn
IV Crew: Cassidy
Robotic Arm Operators: Hurley, Payette and Wakata (all station)

EVA Operations

- Spare equipment transfer
- Exposed facility vision equipment installation

The second spacewalk will focus primarily on transferring the spare equipment brought up by the shuttle to a storage location on the station's truss segment.

Between the first and second spacewalk, Polansky and Hurley will use the shuttle robotic arm to unpack the integrated cargo carrier that holds all the spare equipment the shuttle is delivering to the space station. On flight day 6, before the second spacewalk starts, Payette and Wakata will take over using the station robotic arm and maneuver the carrier to be installed temporarily on the truss.

This must be done before the spacewalk starts, because Wolf's first task will be to climb into a foot restraint on the station's robotic arm so that he can transfer the equipment from the carrier to an external stowage platform.

Together, Wolf and Marshburn will detach first the spare space-to-ground antenna from the cargo carrier. Wolf will then carry it via the robotic arm to the stowage platform, where he and Marshburn will install it. They'll then repeat the process with the spare pump module and the spare linear drive unit. The process is expected to take about three and a half hours.

They'll spend their remaining time outside adding vision equipment on the newly installed exposed facility, which will help with the installation of the exposed facility's experiment carrier the following day. For launch, it will be locked into a temporary spot on the exposed facility, and Wolf and Marshburn will need to release six bolts, remove some insulation and disconnect a power cable to retrieve it. To install it in its permanent location on the forward end of the exposed facility, they'll use two bolts to secure it and then reconnect its power cable.

EVA-3

Duration: 6 hours, 30 minutes
Crew: Wolf and Cassidy
IV Crew: Marshburn
Robotic Arm Operators: Hurley and Payette (station)

EVA Operations:

- WIF relocation
- Handrail and worksite interface installation
- Safety tether pack relocation
- Exposed facility experiment and communications system preparation
- P6 battery swap, part one

The battery change out work for the port 6, or P6, solar array, will take about 30 minutes of the allotted work time for the third spacewalk of the mission, but Wolf and Cassidy will cram several tasks into that first 30 minutes.

Wolf will relocate a worksite interface and a handrail from their current location on the Harmony node to a new site on the Columbus laboratory. Cassidy, meanwhile, will prepare the experiments and equipment brought up inside the exposed facility's experiment carrier to be transferred to the exposed facility itself by removing insulation. The carrier will have been installed on flight day 7 by Polansky and Payette at the shuttle's robotic arm and Hurley and Wakata at the station's.

Cassidy will start with the interorbit communication system, which has two covers for Cassidy to remove and jettison and one to bring back inside. He'll also need to release the equipment's antenna holding mechanism, which requires removing two bolts. Cassidy will then move on to the space environment data acquisition equipment – attached payload.

From there, both spacewalkers will move to the end of the port side of the station's truss for the battery work. Before the spacewalk starts, Hurley and Payette will use the station's robotic arm to maneuver the integrated cargo carrier, to which the new batteries for the P6 solar array will be attached, as close to Wolf and Cassidy's worksite as possible – almost as far out as the arm can reach.

Wolf and Cassidy will replace four of the six batteries during this spacewalk. The new batteries will be designated by letters A through F, and the old batteries numbered one through six. Cassidy will remove an old battery from the solar array's integrated electrical assembly by installing two "scoops" that will be used by the spacewalkers to maneuver the batteries, and then removing two bolts. He'll then hand it off, get out of the foot restraint he was working in, move closer to Wolf and take hold of the battery. Wolf will release the battery, move slightly further down the truss and position himself to take hold of the battery. Cassidy will hand the battery to Wolf and then move himself closer to once again take hold and control the battery. The process is called "shepherding," and might appear as "inch-worming" the battery along except that one person is always holding a 367-pound battery.

To install the battery in a temporary storage location on the integrated electrical assembly, Wolf will use one of the scoops to attach it to a multi-use tether, or ball-stack, and end effectors. The spacewalkers will then remove battery A from the integrated cargo carrier and shepherd it back to the integrated electrical assembly for installation in slot 1. The next step will be to remove battery 4, shepherd it to the cargo carrier to be installed in slot A, and remove battery B to be installed in slot 4.

The process will continue until four batteries have been installed, then the first battery will be removed from its temporary storage location and installed in the vacant spot on the cargo carrier. The order will be as follows:

Battery 1 to temporary storage
Battery A to Slot 1
Battery 4 to Slot A
Battery B to Slot 4
Battery 3 to Slot B
Battery C to Slot 3
Battery 2 to Slot C
Battery D to Slot 2
Battery 1 to Slot D

EVA-4

Duration: 6 hours, 30 minutes
Crew: Marshburn and Cassidy
IV Crew: Kopra
Robotic Arm Operators: Polansky (shuttle), Hurley (shuttle), Payette (station) and Wakata (station)

EVA Operations:

- Battery swap, part two
- Exposed facility vision equipment installation

Marshburn and Cassidy will spend the first half of spacewalk four finishing up the battery swap work that Wolf and Cassidy started. They'll use the same procedure and perform the work in the following order:

Battery 5 to temporary storage
Battery E to Slot 5
Battery 6 to Slot E
Battery F to Slot 6
Battery 5 to Slot F

The spacewalkers will then wrap up their work by installing the exposed facility's aft vision equipment, in a process similar to that performed by Marshburn and Wolf during the second spacewalk.

EVA-5

Duration: 5 hours, 45 minutes
Crew: Marshburn and Cassidy
IV Crew: Wolf
Robotic Arm Operators: None

EVA Operations:

- SPDM insulation covers reconfiguration
- Z1 patch panel reconfiguration
- S3 PAS deploy (three)
- WETA installation

The last spacewalk of the mission will be devoted primarily to get-ahead tasks that were not able to be finished during the last shuttle mission to the space station. Marshburn's first job will take him to the station's special purpose dexterous manipulator – also known as Dextre – on the exterior of the Destiny laboratory. He'll be resecuring two thermal covers on Dextre's orbital replacement unit tool changeout mechanisms – in other words, one of the robot's wrist joints.

While he does so, Cassidy will swap two connectors on a patch panel on the station's zenith truss segment.

The two will then work together to first set up two more payload attachment systems – on the inboard and outboard sides of the nadir portion of the S3 truss – following the procedure that Wolf and Kopra used during the first spacewalk, and install a wireless video system external transceiver assembly, or WETA, on the same segment. WETAs support the transmission of video from spacewalkers' helmet cameras. To do so, Marshburn will remove a dummy box currently in the location, and then attach the WETA to a stanchion. Cassidy will connect three cables to the assembly.

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EXPERIMENTS

The space shuttle and International Space Station have an integrated research program that optimizes use of shuttle crew members and long-duration space station crew members to address research questions in a variety of disciplines.

For information on science on the station, visit

http://www.nasa.gov/mission_pages/station/science/index.html

or

http://iss-science.jsc.nasa.gov/index.cfm

Detailed information is located at

http://www.nasa.gov/mission_pages/station/science/experiments/Expedition.html

DETAILED TEST OBJECTIVES

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

DTO 701B DRAGONEYE FLASH LIDAR

On behalf of SpaceX of Hawthorne, Calif., NASA's Commercial Crew and Cargo Program Office (C3PO) is sponsoring the investigation of "DragonEye," a pulsed laser navigation sensor that SpaceX's Dragon vehicle would use to approach the International Space Station. The test is to gain confidence and experience with how the DragonEye sensor performs before the system is used on the vehicle's third demonstration which includes rendezvous with the station.

The C3PO office manages the Commercial Orbital Transportation Services (COTS) projects which has a Space Act Agreement with SpaceX. COTS is an effort by NASA to stimulate a commercial market for spaceflight services.

According to SpaceX, its recoverable Dragon spacecraft is being designed to carry both pressurized and unpressurized cargo to the station.

The Advanced Scientific Concepts (ASCs) "DragonEye" flash Light Intensification Detection and Ranging (LIDAR) relative navigation sensor is being tested on this mission. DragonEye has been baselined as SpaceX's primary relative navigation sensor.

The DragonEye will mount to the shuttle's existing Trajectory Control System (TCS) carrier assembly on the Orbiter Docking System (ODS). SpaceX will be taking data in parallel with the shuttle's Trajectory Control Sensor (TCS) system. Both TCS and DragonEye will be "looking" at the retroreflectors that are on the station. After the flight, SpaceX will compare the data DragonEye collected against the data TCS collected and evaluate DragonEye's performance.

The DragonEye will use a flash Light Intensification Detection and Ranging (Range) (LIDAR), which provides a three-dimensional image based on the time of flight of a single laser pulse from the sensor to the target and back. It provides both range and bearing information from targets that can reflect the light back such as the Pressurized Mating Adapter (PMA)2 and those on the nadir side of station's Japanese Experiment Module (JEM).

The DragonEye sensor unit will also be able to operate with retroreflectors in the Field Of View (FOV) even at close range. The DragonEye sensor is eye-safe and will also be unpowered when docked to the station, so there are no safety concerns for spacewalks.

SpaceX also will perform a ground-based space qualification program to ensure the sensor can withstand the rigors of launch and operation in a space environment, including tests such as vibration and thermal-vac.

About SpaceX

SpaceX is developing a family of launch vehicles and spacecraft intended to increase the reliability and reduce the cost of both manned and unmanned space transportation, ultimately by a factor of 10. With the Falcon 1 and Falcon 9 vehicles, SpaceX offers highly reliable/cost-efficient launch capabilities for spacecraft insertion into any orbital altitude and inclination. Starting in 2010, SpaceX's Dragon spacecraft will provide Earth–to-LEO transport of pressurized and unpressurized cargo, including resupply to the space station.

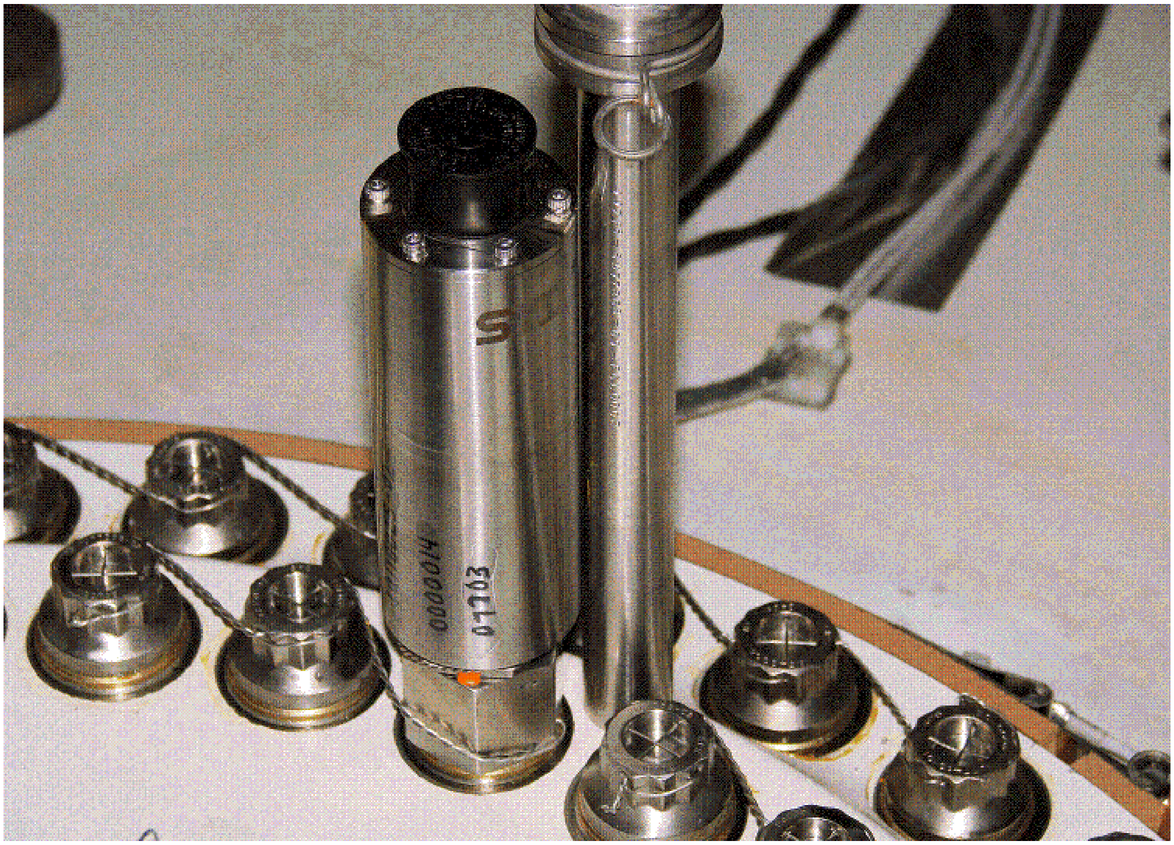
Founded in 2002, the SpaceX team now numbers over 700, with corporate headquarters in Hawthorne, Calif.

Space Shuttle Solid Rocket Motor Pressure Oscillation Data Gathering

The Space Shuttle Program is gathering data on five shuttle flights, beginning with STS-126, to gain a greater understanding of the pressure oscillation, or periodic variation, phenomena that regularly occurs within solid rocket motors. The pressure oscillation that is observed in solid rocket motors is similar to the hum made when blowing into a bottle. At 1.5 psi, or pounds per square inch, a pressure wave will move up and down the motor from the front to the rear, generating acoustic noise as well as physical loads in the structure. These data are necessary to help propulsion engineers confirm modeling techniques of pressure oscillations and the loads they create. As NASA engineers develop alternate propulsion designs for use in NASA, they will take advantage of current designs from which they can learn and measure. In an effort to obtain data to correlate pressure oscillation with the loads it can generate, the shuttle program is using two data systems to gather detailed information. Both systems are located on the top of the solid rocket motors inside the forward skirt.

The Intelligent Pressure Transducer, or IPT, is a stand-alone pressure transducer with an internal data acquisition system that will record pressure data to an internal memory chip. The data will be downloaded to a computer after the booster has been recovered and returned to the Solid Rocket Booster Assembly and Refurbishment Facility at NASA's Kennedy Space Center, Fla. This system has been used on numerous full-scale static test motors in Utah and will provide engineers with a common base to compare flight data to ground test data.

The Enhanced Data Acquisition System, or EDAS, is a data acquisition system that will record pressure data from one of the Reusable Solid Rocket Booster Operational Pressure Transducers, or OPT, and from accelerometers and strain gauges placed on the forward skirt walls. These data will provide engineers with time-synchronized data that will allow them to determine the accelerations and loads that are transferred through the structure due to the pressure oscillation forces.



Intelligent Pressure Transducer

SHORT-DURATION U.S. INTEGRATED RESEARCH TO BE COMPLETED DURING STS-127/2JA (4)

Atmospheric Neutral Density Experiment – 2 (ANDE-2) consists of two microsatellites launched from the shuttle payload bay that will measure the density and composition of the Low-Earth Orbit (LEO) atmosphere while being tracked from the ground. The data will be used to better predict the movement and decay of objects in orbit.

Dual RF Astrodynamic GPS Orbital Navigator Satellite (DRAGONSat) will demonstrate Autonomous Rendezvous and Docking (ARD) in LEO and gather flight data with a Global Positioning System (GPS) receiver strictly designed for space applications. ARD is the capability of two independent spacecraft to rendezvous in orbit and dock without crew intervention. DRAGONSat consists of two picosatellites (one built by the University of Texas and one built by Texas A&M University) and the Space Shuttle Payload Launcher (SSPL).

Maui Analysis of Upper Atmospheric Injections (MAUI) will observe the space shuttle engine exhaust plumes from the Maui Space Surveillance Site in Hawaii. The observations will occur when the space shuttle fires its engines at night or twilight. A telescope and all-sky imagers will take images and data while the space shuttle flies over the Maui site. The images will be analyzed to better understand the interaction between the spacecraft plume and the upper atmosphere of Earth.

Shuttle Exhaust Ion Turbulence Experiments (SEITE) will use space-based sensors to detect the ionospheric turbulence inferred from the radar observations from a previous Space Shuttle Orbital Maneuvering System (OMS) burn experiment using ground-based radar.

Shuttle Ionospheric Modification with Pulsed Localized Exhaust Experiments (SIMPLEX) will investigate plasma turbulence driven by rocket exhaust in the ionosphere using ground-based radars.

Samples Returning from Station on STS-127/2JA

Bisphosphonates as a Countermeasure to Space Flight Induced Bone Loss (Bisphosphonates) will study the effectiveness of bisphosphonates (medications that block the breakdown of bone) used in conjunction with the routine in-flight exercise program to protect space station crew members from the regional decreases in bone mineral density documented on previous station missions.

Long Term Microgravity: A Model for Investigating Mechanisms of Heart Disease with New Portable Equipment (Card) is a European Space Agency experiment that studies blood pressure decreases when the human body is exposed to microgravity. In order to increase the blood pressure to the level it was on Earth, salt is added to the crew members' diet. To monitor this, blood pressure readings and urine samples are performed at different intervals during the mission.

DomeGene Experiment (DomeGene) Two kinds of amphibian cultured cell lines are cultured in DomeGene as part of Japanese Aerospace Exploration Agency research. Cell lines derived from kidney and liver cells are used. They show different types of cell differentiation and morphogenesis. While they are cultured under microgravity, researchers observe the shape and state of the cells and examine the known and unknown gene expression by DNA array assay using fixed and frozen recovery sample.

Validation of Procedures for Monitoring Crew Member Immune Function (Integrated Immune) will assess the clinical risks resulting from the adverse effects of spaceflight on the human immune system and will validate a flight-compatible immune monitoring strategy. Researchers will collect and analyze blood, urine and saliva samples from crew members before, during and after spaceflight to monitor changes in the immune system. Changes in the immune system will be monitored by collecting and analyzing blood and saliva samples from crew members during flight and blood, urine, and saliva samples before and after spaceflight.

Japan Aerospace Exploration Agency – Commercial Payload Program (JAXA-Commercial) is a "to be determined" commercial investigation sponsored by the Japan Aerospace Exploration Agency.

Japan Aerospace Exploration Agency – Education Payload Observation (JAXA-EPO) aims to excite everyone's interest in microgravity research. Activities will include educational events and artistic activities with astronauts in orbit. These Japan Aerospace Exploration Agency-sponsored artistic activities will enlighten the general public about microgravity research and human spaceflight.

Study of Lower Back Pain in Crewmembers during Space Flight (Mus) is a European Space Agency Experiment that will study the details on development of lower back pain during flight in astronauts/cosmonauts. According to biomechanical model, strain on the ilio-lumbar ligaments increases with backward tilt of the pelvis combined with forward flexion of the spine. This is what astronauts may experience due to loss of curvature. The objective is to assess astronaut deep muscle corset atrophy in response to microgravity exposure.

Nutritional Status Assessment (Nutrition) is the most comprehensive in-flight study done by NASA to date of human physiologic changes during long-duration spaceflight; this includes measures of bone metabolism, oxidative damage, nutritional assessments, and hormonal changes. This study will affect both the definition of nutritional requirements and development of food systems for future space exploration missions to the moon and Mars. This experiment also will help to understand the impact of countermeasures (exercise and pharmaceuticals) on nutritional status and nutrient requirements for astronauts.

Protein Crystallization Diagnostics Facility (PCDF) is a multi-user European Space Agency facility for the investigation of protein crystal growth and other biological macro-molecules under microgravity. Crystallization experiments using the dialysis or the batch method can be performed. PCDF is designed for accommodation in the European Drawer Rack (EDR) on the station.

NASA Biological Specimen Repository (Repository) is a storage bank that is used to maintain biological specimens over extended periods of time and under well-controlled conditions. Biological samples from the International Space Station, including blood and urine, will be collected, processed and archived during the preflight, in-flight and post-flight phases of station missions. This investigation has been developed to archive biosamples for use as a resource for future spaceflight-related research.

Sleep-Wake Actigraphy and Light Exposure during Spaceflight – Long (Sleep-Long) examines the effects of spaceflight and ambient light exposure on the sleep-wake cycles of the crew members during long-duration stays on the space station. This experiment uses state-of-the-art ambulatory technology to monitor sleep-wake activity patterns and light exposure in crew members. Subjects will wear a small, light-weight activity and light recording device (Actiwatch) for the entire duration of their mission and record data in log books.

SOdium LOading in Microgravity (SOLO) is a continuation of extensive research into the mechanisms of fluid and salt retention in the body during bed rest and spaceflights. During long-term space missions astronauts will participate in two metabolically controlled study phases, five days each. Subjects follow a diet of constant either low or normal sodium intake, fairly high fluid consumption and isocaloric nutrition.

Mental Representation of Spatial Cues during Space Flight (3D-Space) is a European Space Agency investigation into the effects of exposure to microgravity on the mental representation of spatial cues by astronauts during and after spaceflight. The absence of the gravitational frame of reference during spaceflight could be responsible for disturbances in the mental representation of spatial cues, such as the perception of horizontal and vertical lines, the perception of objects' depth, and the perception of targets' distance.

Experiments Being Delivered to the Station on STS-127/2JA

Dose Distribution Inside ISS – Dosimetry for Biological Experiments in Space (DOSIS-DOBIES) consists of two European Space Agency investigations. The DOSIS portion of the experiment will provide documentation of the actual nature and distribution of the radiation field inside the spacecraft. Integral measurements of energy, charge and spectra of the heavy ion component will be done by the use of different nuclear track detectors. The objective of DOBIES is to develop a standard dosimetric method (as a combination of different techniques) to measure the absorbed doses and equivalent doses in biological samples.

Validation of Procedures for Monitoring Crew Member Immune Function (Integrated Immune) will assess the clinical risks resulting from the adverse effects of spaceflight on the human immune system and will validate a flight-compatible immune monitoring strategy. Researchers collect and analyze blood, urine and saliva samples from crew members before, during and after spaceflight to monitor changes in the immune system.

IRIS (Image Reversal in Space) is a Canadian Space Agency experiment that will investigate whether the perception of three-dimensional ambiguous figures is affected when the observer is in a reduced gravity environment.

Nutritional Status Assessment (Nutrition) is the most comprehensive in-flight study done by NASA to date of human physiologic changes during long-duration spaceflight; this includes measures of bone metabolism, oxidative damage, nutritional assessments, and hormonal changes. This study will impact both the definition of nutritional requirements and development of food systems for future space exploration missions to the moon and Mars. This experiment also will help to understand the effect of countermeasures (exercise and pharmaceuticals) on nutritional status and nutrient requirements for astronauts.

NASA Biological Specimen Repository (Repository) is a storage bank that is used to maintain biological specimens over extended periods of time and under well-controlled conditions. Samples from the International Space Station, including blood and urine, will be collected, processed and archived during the preflight, in-flight and post-flight phases of the space station missions. This investigation has been developed to archive biosamples for use as a resource for future spaceflight-related research.

Tomatosphere-II is a Canadian Space Agency experiment that will send tomato seeds to the station for exposure. The seeds will be returned to Earth for use in classrooms throughout Canada as a learning resource.

SHUTTLE REFERENCE DATA

SHUTTLE ABORT MODES

Redundant Sequence Launch Sequencer (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, KSC, 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, after which 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 KSC. The powered RTLS phase begins with the crew selection of the RTLS abort, 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 KSC and achieve the proper main engine cutoff conditions so the vehicle can glide to the KSC 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 MCC 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, Calif.; or the Kennedy Space Center, Fla). 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 also may 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 are 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 identify which abort mode is (or is not) available. If ground communications are lost, the flight crew has onboard methods, such as cue cards, dedicated displays and display information, to determine the 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 onboard 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 onboard 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 onboard 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, MSFC 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 long, weighs about 7,000 pounds and is 7.5 feet in diameter at the end of its nozzle.

The engines operate for about 8.5 minutes during liftoff and ascent, burning more than 500,000 gallons of super-cold liquid hydrogen and liquid oxygen propellants stored in the external tank attached to the underside of the shuttle. The engines shut down just before the shuttle, traveling at about 17,000 miles 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, 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, 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, and 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, each engine generates 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 preburners, thus varying the speed of the high-pressure turbopumps and, therefore, the flow of the propellant.

At about 26 seconds into ascent, 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, known as 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, 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 until they achieve 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 two and one-half Boeing 747 airplanes.

The space shuttle main engine also is the first rocket engine to use a built-in electronic digital controller, or computer. The controller accepts commands from the orbiter for engine start, change in throttle, shutdown and monitoring of engine operation.

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, 2001 and 2007. 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.

The most recent engine enhancement is the Advanced Health Management System, or AHMS, which made its first flight in 2007. AHMS is a controller upgrade that provides new monitoring and insight into the health of the two most complex components of the space shuttle main engine—the high pressure fuel turbopump and the high pressure oxidizer turbopump. New advanced digital signal processors monitor engine vibration and have the ability to shut down an engine if vibration exceeds safe limits. AHMS was developed by engineers at Marshall.

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 (SRB)

The two solid rocket boosters required for a space shuttle launch and first two minutes of powered flight boast the largest solid-propellant motors ever flown. They are the first large rockets designed for reuse and are the only solid rocket motors rated for human flight. The SRBs have the capacity to carry the entire weight of the external tank, or ET, and orbiter, and to transmit the weight load through their structure to the mobile launch platform, or MLP.

The SRBs provide 71.4 percent of the thrust required to lift the space shuttle off the launch pad and during first-stage ascent to an altitude of about 150,000 feet, or 28 miles. At launch, each booster has a sea level thrust of approximately 3.3 million pounds and is ignited after the ignition and verification of the three space shuttle main engines, or SSMEs.

SRB apogee occurs at an altitude of about 230,000 feet, or 43 miles, 75 seconds after separation from the main vehicle. At booster separation, the space shuttle orbiter has reached an altitude of 24 miles and is traveling at a speed in excess of 3,000 miles per hour.

The primary elements of each booster are nose cap, housing the pilot and drogue parachute; frustum, housing the three main parachutes in a cluster; forward skirt, housing the booster flight avionics, altitude sensing, recovery avionics, parachute cameras and range safety destruct system; four motor segments, containing the solid propellant; motor nozzle; and aft skirt, housing the nozzle and thrust vector control systems required for guidance. Each SRB possesses its own redundant auxiliary power units and hydraulic pumps.

SRB impact occurs in the ocean approximately 140 miles downrange. SRB retrieval is provided after each flight by specifically designed and built ships. The frustums, drogue and main parachutes are loaded onto the ships along with the boosters and towed back to the Kennedy Space Center, where they are disassembled and refurbished for reuse. Before retirement, each booster can be used as many as 20 times.

Each booster is just over 149 feet long and 12.17 feet in diameter. Both boosters have a combined weight of 1,303,314 pounds at lift-off. They are attached to the ET at the SRB aft attach ring by an upper and lower attach strut and a diagonal attach strut. The forward end of each SRB is affixed to the ET by one attach bolt and ET ball fitting on the forward skirt. While positioned on the launch pad, the space shuttle is attached to the MLP by four bolts and explosive nuts equally spaced around each SRB. After ignition of the solid rocket motors, the nuts are severed by small explosives that allow the space shuttle vehicle to perform lift off.

United Space Alliance (USA)

USA, at KSC facilities, is responsible for all SRB operations except the motor and nozzle portions. In conjunction with maintaining sole responsibility for manufacturing and processing of the non-motor hardware and vehicle integration, USA provides the service of retrieval, post flight inspection and analysis, disassembly and refurbishment of the hardware. USA also exclusively retains comprehensive responsibility for the orbiter.

The reusable solid rocket motor segments are shipped from ATK Launch Systems in Utah to KSC, where they are mated by USA personnel to the other structural components – the forward assembly, aft skirt, frustum and nose cap – in the Vehicle Assembly Building. Work involves the complete disassembly and refurbishment of the major SRB structures – the aft skirts, frustums, forward skirts and all ancillary hardware – required to complete an SRB stack and mate to the ET. Work then proceeds to ET/SRB mate, mate with the orbiter and finally, space shuttle close out operations. After hardware restoration concerning flight configuration is complete, automated checkout and hot fire are performed early in hardware flow to ensure that the refurbished components satisfy all flight performance requirements.

ATK Launch Systems (ATK)

ATK Launch Systems of Brigham City, Utah, manufactures space shuttle reusable solid rocket motors, or RSRMs, at their Utah facility. Each RSRM – just over 126 feet long and 12 feet in diameter – consists of four rocket motor segments and an aft exit cone assembly is. From ignition to end of burn, each RSRM generates an average thrust of 2.6 million pounds and burns for approximately 123 seconds. Of the motor's total weight of 1.25 million pounds, propellant accounts for 1.1 million pounds. The four motor segments are matched by loading each 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 KSC on a heavy-duty rail car with a specialty built cover.

SRB Hardware Design Summary

Hold-Down Posts

Each SRB has four hold-down posts that fit into corresponding support posts on the MLP. Hold-down bolts secure the SRB and MLP posts together. Each bolt has a nut at each end, but the top nut is frangible, or breakable. The top nut contains two NASA Standard detonators, or NSDs, that, when ignited at solid rocket motor ignition command, split the upper nut in half.

Splitting the upper nuts allow the hold-down bolts to be released and travel downward because of NSD gas pressure, gravity and the release of tension in the bolt, which is pretensioned before launch. The bolt is stopped by the stud deceleration stand which contains sand to absorb the shock of the bolt dropping down several feet. The SRB bolt is 28 inches long, 3.5 inches in diameter and weighs approximately 90 pounds. The frangible nut is captured in a blast container on the aft skirt specifically designed to absorb the impact and prevent pieces of the nut from liberating and becoming debris that could damage the space shuttle.

Integrated Electronic Assembly (IEA)

The aft IEA, mounted in the ET/SRB attach ring, provides the electrical interface between the SRB systems and the obiter. The aft IEA receives data, commands, and electrical power from the orbiter and distributes these inputs throughout each SRB. Components located in the forward assemblies of each SRB are powered by the aft IEA through the forward IEA, except for those utilizing the recovery and range safety batteries located in the forward assemblies. The forward IEA communicates with and receives power from the orbiter through the aft IEA, but has no direct electrical connection to the orbiter.

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 V dc, with an upper limit of 32 V dc and a lower limit of 24 V dc.

Hydraulic Power Units (HPUs)

There are two self-contained, independent HPUs on each SRB. Each HPU consists of an auxiliary power unit, or APU; Fuel Supply Module, or FSM; 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 APU controller electronics are located in the SRB aft integrated electronic assemblies on the aft ET attach rings. The two separate HPUs and two hydraulic systems are located inside the aft skirt of each SRB between the SRB nozzle and 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 ET. The two independent hydraulic systems are connected to the rock and tilt servoactuators.

The HPUs and their fuel systems are isolated from each other. Each fuel supply module, or tank, contains 22 pounds of hydrazine. The fuel tank is pressurized with gaseous nitrogen at 400 psi to provide the force to expel via positive expulsion the fuel from the tank to the fuel distribution line. A positive fuel supply to the APU throughout its operation is maintained.

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, at which point all the fuel is supplied to the fuel pump.

The APU turbine assembly provides mechanical power to the APU gearbox, which 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 directing it 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. 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 (TVC)

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 TVC. 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 space shuttle ascent TVC portion of the flight control system directs the thrust of the three SSMEs and the two SRB nozzles to control shuttle attitude and trajectory during liftoff and ascent. Commands from the guidance system are transmitted to the ascent TVC, or 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. This permits 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 (RGAs)

Each SRB contains two RGAs mounted in the forward skirt watertight compartment. Each RGA contains two orthogonally mounted gyroscopes – pitch and yaw axes. In conjunction with the orbiter roll rate gyros, they provide angular rate information that describes the inertial motion of the vehicle cluster to the orbiter computers and the guidance, navigation and control system during first stage ascent to SRB separation. At SRB separation, all guidance control data is handed off from the SRB RGAs to the orbiter RGAs. The RGAs are designed and qualified for 20 missions.

Propellant

The propellant mixture in each SRB motor consists of ammonium perchlorate, an oxidizer, 69.6 percent by weight; aluminum, a fuel, 16 percent by weight; iron oxide, a catalyst, 0.4 percent by weight; polymer, a binder that holds the mixture together, 12.04 percent by weight; and epoxy curing agent, 1.96 percent by weight. 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 one-third 50 seconds after liftoff to prevent overstressing the vehicle during maximum dynamic pressure.

SRB Ignition

SRB ignition can occur only when a manual lock pin from each SRB safe and arm device has been removed by the ground crew during prelaunch activities. At T minus 5 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 pyrotechnic initiator controller, or PIC low voltage is indicated; and there are no holds from the launch processing system, or LPS.

The solid rocket motor ignition commands are sent by the orbiter computers through the master events controllers, or MECs, to the NSDs installed in the safe and arm device in each SRB. A pyrotechnic initiation controller, or PIC, is a single-channel capacitor discharge device that 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 V dc signals for the PICs. The arm signal charges the PIC capacitor to 40 V dc, minimum 20 V 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 igniter, which fires down the length of the solid rocket motor igniting the solid rocket motor propellant.

The general purpose computer, or GPC, launch sequence also controls certain critical main propulsion system valves and monitors the engine-ready indications from the SSMEs. The main propulsion system, or MPS, start commands are issued by the on-board computers at T minus 6.6 seconds. There is a staggered start — engine three, engine two, engine one — 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 3 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.

At T minus 0, the two SRBs are ignited by the four orbiter on-board computers; commands are sent to release the SRBs; 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.

SRB Separation

The SRB/ET separation subsystem provides for separation of the SRBs from the orbiter/ET without damage to or recontact of the elements – SRBs, orbiter/ET – during or after separation for nominal modes. 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 ET within 30 milliseconds of the ordnance firing command.

The forward attachment point consists of a ball on the SRB and socket on the 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 range safety system, or 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.

Redesigned Booster Separation Motors (RBSM)

Eight Booster Separation Motors, or BSMs, are located on each booster – four on the forward section and four on the aft skirt. BSMs provide the force required to push the SRBs away from the orbiter/ET at separation. Each BSM weighs approximately 165 pounds and is 31.1 inches long and 12.8 inches in diameter. Once the SRBs have completed their flight, the BSMs are fired to jettison the SRBs away from the orbiter and external tank, allowing the boosters to parachute to Earth and be reused. The BSMs 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.

Redesigned BSMs flew for the first time in both forward and aft locations on STS-125. As a result of vendor viability and manifest support issues, space shuttle BSMs are now being manufactured by ATK. The igniter has been redesigned and other changes include material upgrades driven by obsolescence issues and improvements to process and inspection techniques.

SRB Cameras

Each SRB flies with a complement of four cameras, three mounted for exterior views during launch, separation and descent; and one mounted internal to the forward dome for main parachute performance assessment during descent.

The ET observation camera is mounted on the SRB forward skirt and provides a wide-angle view of the ET intertank area. The camera is activated at lift off by a G-switch and records for 350 seconds, after which the recorder is switched to a similar camera in the forward skirt dome to view the deployment and performance of the main parachutes to splash down. These cameras share a digital tape recorder located within the data acquisition system.

The ET ring camera is mounted on the ET attach ring and provides a view up the stacked vehicle on the orbiter underside and the bipod strut attach point.

The forward skirt camera is mounted on the external surface of the SRB forward skirt and provides a view aft down the stacked vehicle of the orbiter underside and the wing leading edge reinforced carbon-carbon, or RCC, panels.

The ET attach ring camera and forward skirt camera are activated by a global positioning system command at approximately T minus 1 minute 56 seconds to begin recording at approximately T minus 50 seconds. The camera images are recorded through splash down. These cameras each have a dedicated recorder and are recorded in a digital format. The cameras were designed, qualified, and implemented by USA after Columbia to provide enhanced imagery capabilities to capture potential debris liberation beginning with main engine start and continuing through SRB separation.

The camera videos are available for engineering review approximately 24 hours following the arrival of the boosters at KSC.

Range Safety Systems (RSS)

The RSS consists of two antenna couplers; command receivers/decoders; a dual distributor; a safe and arm device with two NSDs; two confined detonating fuse manifolds; seven confined detonator fuse, or CDF assemblies; and one linear-shaped charge.

The RSS provides for destruction of a rocket or part of it with on-board explosives by remote command if the rocket is out of control, to limit danger to people on the ground from crashing pieces, explosions, fire, and poisonous substances.

The space shuttle has two RSSs, one in each SRB. Both are capable of receiving two command messages – arm and fire – which are transmitted from the ground station. The RSS is only used when the space shuttle violates a launch trajectory red line.

The antenna couplers provide the proper impedance for radio frequency and ground support equipment commands. The command receivers are tuned to RSS command frequencies and provide the input signal to the distributors when an RSS command is sent. The command decoders use a code plug to prevent any command signal other than the proper command signal from getting into the distributors. The distributors contain the logic to supply valid destruct commands to the RSS pyrotechnics.

The NSDs provide the spark to ignite the CDF that in turn ignites the linear shaped charge for space shuttle destruction. The safe and arm device provides mechanical isolation between the NSDs and the CDF before launch and during the SRB separation sequence.

The first message, called arm, allows the onboard logic to enable a destruct and illuminates a light on the flight deck display and control panel at the commander and pilot station. The second message transmitted is the fire command. The SRB distributors in the SRBs are cross-strapped together. Thus, if one SRB received an arm or destruct signal, the signal would also be sent to the other SRB.

Electrical power from the RSS battery in each SRB is routed to RSS system A. The recovery battery in each SRB is used to power RSS system B as well as the recovery system in the SRB. The SRB RSS is powered down during the separation sequence, and the SRB recovery system is powered up.

Descent and Recovery

After separation and at specified altitudes, the SRB forward avionics system initiates the release of the nose cap, which houses a pilot parachute and drogue parachute; and the frustum, which houses the three main parachutes. Jettison of the nose cap at 15,700 feet deploys a small pilot parachute and begins to slow the SRB decent. At an altitude of 15,200 feet the pilot parachute pulls the drogue parachute from the frustum. The drogue parachute fully inflates in stages, and at 5,500 feet pulls the frustum away from the SRB, which initiates the deployment of the three main parachutes. The parachutes also inflate in stages and further slow the decent of the SRBs to their final velocity at splashdown. The parachutes slow each SRB from 368 mph at first deployment to 52 mph at splashdown, allowing for the recovery and reuse of the boosters.

Two 176-foot recovery ships, Freedom Star and Liberty Star, are on station at the splashdown zone to retrieve the frustums with drogue parachutes attached, the main parachutes and the SRBs. The SRB nose caps and solid rocket motor nozzle extensions are not recovered. The SRBs are dewatered using an enhanced diver operating plug to facilitate tow back. These plugs are inserted into the motor nozzle and air is pumped into the booster, causing it to lay flat in the water to allow it to be easily towed. The boosters are then towed back to the refurbishment facilities. Each booster is removed from the water and components are disassembled and washed with fresh and deionized water to limit saltwater corrosion. The motor segments, igniter and nozzle are shipped back to ATK in Utah for refurbishment. The nonmotor components and structures are disassembled by USA and are refurbished to like-new condition at both KSC and equipment manufacturers across the country.

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.

EXTERNAL TANK

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 more than 530,000 gallons of liquid hydrogen and liquid oxygen in two separate tanks, the forward liquid oxygen tank and the aft liquid hydrogen tank. An unpressurized intertank unites the two propellant tanks.

Liquid hydrogen (fuel) and liquid oxygen (oxidizer) are used as propellants for the shuttle's three main engines. The external tank weighs 58,500 pounds empty and 1,668,500 pounds when filled with propellants.

The external tank is the "backbone" of the shuttle during launch, providing structural support for attachment with the solid rocket boosters and orbiter. It is the only component of the shuttle that is not reused. Approximately 8.5 minutes after reaching orbit, with its propellant used, the tank is jettisoned and falls in a preplanned trajectory. Most of the tank disintegrates in the atmosphere, and the remainder falls into the ocean.

The external tank is manufactured at NASA's Michoud Assembly Facility in New Orleans by Lockheed Martin Space Systems.

Foam Facts

The external tank is covered with spray-on foam insulation that insulates the tank before and during launch. More than 90 percent of the tank's foam is applied using an automated system, leaving less than 10 percent to be applied manually.

There are two types of foam on the external tank, known as the Thermal Protection System, or TPS. One is low-density, closed-cell foam on the tank acreage and is known as Spray-On-Foam-Insulation, often referred to by its acronym, SOFI. Most of the tank is covered by either an automated or manually applied SOFI. Most areas around protuberances, such as brackets and structural elements, are applied by pouring foam ingredients into part-specific molds. The other is a denser composite material made of silicone resins and cork and called ablator. An ablator is a material that dissipates heat by eroding. It is used on areas of the external tank subjected to extreme heat, such as the aft dome near the engine exhaust, and remaining protuberances, such as the cable trays. These areas are exposed to extreme aerodynamic heating.

Closed-cell foam used on the tank was developed to keep the propellants that fuel the shuttle's three main engines at optimum temperature. It keeps the shuttle's liquid hydrogen fuel at -423 degrees Fahrenheit and the liquid oxygen tank at near -297 degrees Fahrenheit, even as the tank sits under the hot Florida sun. At the same time, the foam prevents a buildup of ice on the outside of the tank.

The foam insulation must be durable enough to endure a 180-day stay at the launch pad, withstand temperatures up to 115 degrees Fahrenheit, humidity as high as 100 percent, and resist sand, salt, fog, rain, solar radiation and even fungus. Then, during launch, the foam must tolerate temperatures as high as 2,200 degrees Fahrenheit generated by aerodynamic friction and radiant heating from the 3,000 degrees Fahrenheit main engine plumes. Finally, when the external tank begins reentry into the Earth's atmosphere about 30 minutes after launch, the foam maintains the tank's structural temperatures and allows it to safely disintegrate over a remote ocean location.

Though the foam insulation on the majority of the tank is only 1-inch thick, it adds 4,823 pounds to the tank's weight. In the areas of the tank subjected to the highest heating, insulation is somewhat thicker, between 1.5 to 3 inches thick. Though the foam's density varies with the type, an average density is about 2.4 pounds per cubic foot.

Application of the foam, whether automated by computer or hand-sprayed, is designed to meet NASA's requirements for finish, thickness, roughness, density, strength and adhesion. As in most assembly production situations, the foam is applied in specially designed, environmentally controlled spray cells and applied in several phases, often over a period of several weeks. Before spraying, the foam's raw material and mechanical properties are tested to ensure they meet NASA specifications. Multiple visual inspections of all foam surfaces are performed after the spraying is complete.

Most of the foam is applied at NASA's Michoud Assembly Facility in New Orleans when the tank is manufactured, including most of the "closeout" areas, or final areas applied. These closeouts are done either by hand pouring or manual spraying. Additional closeouts are completed once the tank reaches Kennedy Space Center, Fla.

The super lightweight external tank, or SLWT, made its first shuttle flight in June 1998 on mission STS-91. The SLWT is 7,500 pounds lighter than previously flown tanks. 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 previously.

Beginning with the first Return to Flight mission, STS-114 in June 2005, several improvements were made to improve safety and flight reliability.

Forward Bipod

The external tank's forward shuttle attach fitting, called the bipod, was redesigned to eliminate the large insulating foam ramps as a source of debris. Each external tank has two bipod fittings that connect the tank to the orbiter through the shuttle's two forward attachment struts. Four rod heaters were placed below each forward bipod, replacing the large insulated foam Protuberance Airload, or PAL, ramps.

Liquid Hydrogen Tank & Liquid Oxygen Intertank Flange Closeouts

The liquid hydrogen tank flange located at the bottom of the intertank and the liquid oxygen tank flange located at the top of the intertank provide joining mechanisms with the intertank. After each of these three component tanks, liquid oxygen, intertank and liquid hydrogen, are joined mechanically, the flanges at both ends are insulated with foam. An enhanced closeout, or finishing, procedure was added to improve foam application to the stringer, or intertank ribbing, and to the upper and lower area of both the liquid hydrogen and liquid oxygen intertank flanges.

Liquid Oxygen Feedline Bellows

The liquid oxygen feedline bellows were reshaped to include a “drip lip” that allows condensate moisture to run off and prevent freezing. A strip heater was added to the forward bellow to further reduce the potential of high density ice or frost formation. Joints on the liquid oxygen feedline assembly allow the feedline to move during installation and during liquid hydrogen tank fill. Because it must flex, it cannot be insulated with foam like the remainder of the tank.

Other tank improvements include:

Liquid Oxygen & Liquid Hydrogen Protuberance Airload (PAL) Ramps

External tank ET-119, which flew on the second Return to Flight mission, STS-121, in July 2006, was the first tank to fly without PAL ramps along portions of the liquid oxygen and liquid hydrogen tanks. These PAL ramps were extensively studied and determined to not be necessary for their original purpose, which was to protect cable trays from aeroelastic instability during ascent. Extensive tests were conducted to verify the shuttle could fly safely without these particular PAL ramps. Extensions were added to the ice frost ramps for the pressline and cable tray brackets, where these PAL ramps were removed to make the geometry of the ramps consistent with other locations on the tank and thereby provide consistent aerodynamic flow. Nine extensions were added, six on the liquid hydrogen tank and three on the liquid oxygen tank.

Engine Cutoff (ECO) Sensor Modification

Beginning with STS-122, ET-125, which launched on Feb. 7, 2008, the ECO sensor system feed through connector on the liquid hydrogen tank was modified by soldering the connector’s pins and sockets to address false readings in the system. All subsequent tanks after ET-125 have the same modification.

Liquid Hydrogen Tank Ice Frost Ramps

ET-128, which flew on the STS-124 shuttle mission, May 31, 2008, was the first tank to fly with redesigned liquid hydrogen tank ice frost ramps. Design changes were incorporated at all 17 ice frost ramp locations on the liquid hydrogen tank, stations 1151 through 2057, to reduce foam loss. Although the redesigned ramps appear identical to the previous design, several changes were made. PDL* and NCFI foam have been replaced with BX* manual spray foam in the ramp’s base cutout to reduce debonding and cracking; Pressline and cable tray bracket feet corners have been rounded to reduce stresses; shear pin holes have been sealed to reduce leak paths; isolators were primed to promote adhesion; isolator corners were rounded to help reduce thermal protection system foam stresses; BX manual spray was applied in bracket pockets to reduce geometric voids.

*BX is a type of foam used on the tank's "loseout," or final finished areas; it is applied manually or hand-sprayed. PDL is an acronym for Product Development Laboratory, the first supplier of the foam during the early days of the external tank's development. PDL is applied by pouring foam ingredients into a mold. NCFI foam is used on the aft dome, or bottom, of the liquid hydrogen tank.

Liquid Oxygen Feedline Brackets

ET-128 also was the first tank to fly with redesigned liquid oxygen feedline brackets. Titanium brackets, much less thermally conductive than aluminum, replaced aluminum brackets at four locations, XT 1129, XT 1377, Xt 1624 and Xt 1871. This change minimizes ice formation in under-insulated areas, and reduces the amount of foam required to cover the brackets and the propensity for ice development. Zero-gap/slip plane Teflon material was added to the upper outboard monoball attachment to eliminate ice adhesion. Additional foam has been added to the liquid oxygen feedline to further minimize ice formation along the length of the feedline.

LAUNCH AND LANDING

LAUNCH

As with all previous space shuttle launches, Endeavour has several options to abort its ascent if needed after engine failures or other systems problems. Shuttle launch abort philosophy is intended to facilitate safe recovery of the flight crew and intact recovery of the shuttle and its payload.

Abort modes include:

ABORT-TO-ORBIT (ATO)

This mode is used if there is a partial loss of main engine thrust late enough to permit reaching a minimal 105 by 85 nautical mile orbit with the orbital maneuvering system engines. The engines boost the shuttle to a safe orbital altitude when it is impossible to reach the planned orbital altitude.

TRANSATLANTIC ABORT LANDING (TAL)

The 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)

If one or more engines shut down early and there is not enough energy to reach the TAL sites, the shuttle would pitch around toward Kennedy until within gliding distance of the Shuttle Landing Facility. For launch to proceed, weather conditions must be forecast as 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 Endeavour on STS-127 is the Kennedy Space Center's Shuttle Landing Facility. Alternate landing sites that could be used if needed because of weather conditions or systems failures are at Edwards Air Force Base, Calif., and White Sands Space Harbor, N.M.

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ACRONYMS AND ABBREVIATIONS

A/G	Alignment Guides
A/L	Airlock
AAA	Avionics Air Assembly
ABC	Audio Bus Controller
ACBM	Active Common Berthing Mechanism
ACDU	Airlock Control and Display Unit
ACO	Assembly Checkout Officer
ACS	Atmosphere Control and Supply
ACU	Arm Control Unit
ADS	Audio Distribution System
AE	Approach Ellipsoid
AEP	Airlock Electronics Package
AI	Approach Initiation
AJIS	Alpha Joint Interface Structure
AM	Atmosphere Monitoring
AMOS	Air Force Maui Optical and Supercomputing Site
ANDE	Atmosphere Neutral Density Experiment
AOA	Abort Once Around
AOH	Assembly Operations Handbook
AOM	Atomic Oxygen Monitor
APAS	Androgynous Peripheral Attachment
APCU	Assembly Power Converter Unit
APE	Antenna Pointing Electronics
	Audio Pointing Equipment
APFR	Articulating Portable Foot Restraint
APM	Antenna Pointing Mechanism
APS	Automated Payload Switch
APV	Automated Procedure Viewer
AR	Atmosphere Revitalization
ARCU	American-to-Russian Converter Unit
ARD	Autonomous Rendezvous and Docking
ARIES	Astronaut-Related IVA and Equipment Support
ARS	Atmosphere Revitalization System
ASC	Advanced Scientific Concepts
ASW	Application Software
ATA	Ammonia Tank Assembly
ATCS	Active Thermal Control System

ATF	Astronaut Training Facility
ATU	Audio Terminal Unit
BAD	Broadcast Ancillary Data
BC	Bus Controller
BCDU	Battery Charge/Discharge Unit
	Berthing Mechanism Control and Display Unit
BEP	Berthing Mechanism Electronics Package
BGA	Beta Gimbal Assembly
BIC	Bus Interface Controller
BIO	Biology Ops Lead team
BIT	Built-In Test
BM	Berthing Mechanism
BOS	BIC Operations Software
BSS	Basic Software
BSTS	Basic Standard Support Software
C3PO	Commercial Crew and Cargo Program Office
C&C	Command and Control
C&DH	Command and Data Handling
C&T	Communication and Tracking
C&W	Caution and Warning
C/L	Crew Lock
C/O	Checkout
CAM	Collision Avoidance Maneuver
CANSEI	Control and Network Systems, Electrical Power, and ICS Communication Office
CAPE	Canister for All Payload Ejections
CAS	Common Attach System
CB	Clean Bench
	Control Bus
CBCS	Centerline Berthing Camera System
CBEF	Cell Biology Experiment Facility
CBM	Common Berthing Mechanism
CCA	Circuit Card Assembly
CCAA	Common Cabin Air Assembly
CCHA	Crew Communication Headset Assembly
CCD	
CCP	Camera Control Panel
CCT	Communication Configuration Table
CCTV	Closed-Circuit Television
CDR	Space Shuttle Commander
CDRA	Carbon Dioxide Removal Assembly

CETA	Crew Equipment Translation Aid
CHeCS	Crew Health Care System
CHX	Cabin Heat Exchanger
CISC	Complicated Instruction Set Computer
CLA	Camera Light Assembly
CLPA	Camera Light Pan Tilt Assembly
CMG	Control Moment Gyro
COTS	Commercial Off the Shelf
CPA	Control Panel Assembly
CPB	Camera Power Box
CR	Change Request
CRT	Cathode-Ray Tube
CSA	Canadian Space Agency
CSA-CP	Compound Specific Analyzer
CVIU	Common Video Interface Unit
CVT	Current Value Table
CZ	Communication Zone
DB	Data Book
DC	Docking Compartment
DCSU	Direct Current Switching Unit
DDCU	DC-to-DC Converter Unit
DEM	Demodulator
DFL	Decommutation Format Load
DIU	Data Interface Unit
DMS	Data Management System
DMS-R	Data Management System-Russian
DOSIS-DOBIES	Dose Distribution Inside ISS – Dosimetry for Biological Experiments in Space
DPG	Differential Pressure Gauge
DPU	Baseband Data Processing Unit
DRAGONSat	Dual RF Astrodynamic GPS Orbital Navigator Satellite
DRTS	Data Relay Test Satellite Japanese Data Relay Satellite
DTO	Detailed Test Objective
DYF	Display Frame
E/L	Equipment Lock
EATCS	External Active Thermal Control System
EBCS	External Berthing Camera System
ECC	Error Correction Code
ECLSS	Environmental Control and Life Support System
ECS	Environmental Control System

ECU	Electronic Control Unit
EDAS	Enhanced Data Acquisition System
EDEE	Electronic Device Evaluation Equipment
EDR	European Drawer Rack
EDSU	External Data Storage Unit
EDU	EEU Driver Unit
EE	End Effector
EETCS	Early External Thermal Control System
EEU	Experiment Exchange Unit
EF	Exposed Facility
EFBM	Exposed Facility Berthing Mechanism
EFHX	Exposed Facility Heat Exchanger
EFU	Exposed Facility Unit
EGIL	Electrical, General Instrumentation, and Lighting
EIU	Ethernet Interface Unit
ELM-ES	Japanese Experiment Logistics Module – Exposed Section
ELM-PS	Japanese Experiment Logistics Module – Pressurized Section
ELPS	Emergency Lighting Power Supply
EMGF	Electric Mechanical Grapple Fixture
EMI	Electro-Magnetic Imaging
EMU	Extravehicular Mobility Unit
E-ORU	EVA Essential ORU
EP	Exposed Pallet
EPO	Educational Payload Observation
EPS	Electrical Power System
ES	Exposed Section
ESA	European Space Agency
ESC	JEF System Controller
ESP-3	External Stowage Platform 3
ESW	Extended Support Software
ET	External Tank
ETCS	External Thermal Control System
ETI	Elapsed Time Indicator
ETRS	EVA Temporary Rail Stop
ETVCG	External Television Camera Group
EV	Extravehicular
EVA	Extravehicular Activity
EXP-D	Experiment-D
EXT	External
FA	Fluid Accumulator
FAS	Flight Application Software

FCT	Flight Control Team
FD	Flight Day
FDDI	Fiber Distributed Data Interface
FDIR	Fault Detection, Isolation, and Recovery
FDS	Fire Detection System
FE	Flight Engineer
FET-SW	Field Effect Transistor Switch
FGB	Functional Cargo Block
FISICS	Fluid Science and Crystallization Science Ops Lead team
FLAT	Fluid and Thermal Officer
FOR	Frame of Reference
FOV	Field of View
FPEF	Fluid Physics Experiment Facility
FPP	Fluid Pump Package
FR	Flight Rule
FRAM	Flight Releasable Attachment Mechanism
FRD	Flight Requirements Document
FRGF	Flight Releasable Grapple Fixture
FRM	Functional Redundancy Mode
FSE	Flight Support Equipment
FSEGF	Flight Support Equipment Grapple Fixture
FSW	Flight Software
GAS	Get-Away Special
GCA	Ground Control Assist
GLA	General Lighting Assemblies
	General Luminaire Assembly
GLONASS	Global Navigational Satellite System
GNC	Guidance, Navigation, and Control
GPC	General Purpose Computer
GPS	Global Positioning System
GPSR	Global Positioning System Receiver
GSC	Gas Slit Camera
GUI	Graphical User Interface
H&S	Health and Status
HCE	Heater Control Equipment
HCTL	Heater Controller
HEPA	High Efficiency Particulate Acquisition
HIT	Heavy Ion Telescope
HPA	High Power Amplifier
HPP	Hard Point Plates

HRDR	High Rate Data Recorder
HREL	Hold/Release Electronics
HRFM	High Rate Frame Multiplexer
HRM	Hold Release Mechanism
HRMS	High Rate Multiplexer and Switcher
HTV	H-II Transfer Vehicle
HTVCC	HTV Control Center
HTV Prox	HTV Proximity
HX	Heat Exchanger
I/F	Interface
IAA	Intravehicular Antenna Assembly
IAC	Internal Audio Controller
IBM	International Business Machines
ICB	Inner Capture Box
ICC	Integrated Cargo Carrier
ICC-PM	ICC Pressurized Module
ICC-VLD	Integrated Cargo Carrier – Vertical Light Deploy
ICS	Interorbit Communication System
ICS-EF	Interorbit Communication System - Exposed Facility
IDRD	Increment Definition and Requirements Document
IEA	Integrated Equipment Assembly
IELK	Individual Equipment Liner Kit
IFHX	Interface Heat Exchanger
IMCS	Integrated Mission Control System
IMCU	Image Compressor Unit
IMV	Intermodule Ventilation
INCO	Instrumentation and Communication Officer
IP	International Partner
IP-PCDU	ICS-PM Power Control and Distribution Unit
IP-PDB	Payload Power Distribution Box
IPT	Intelligent Pressure Transducer
IPU	Image Processing Unit
ISP	International Standard Payload
ISPR	International Standard Payload Rack
ISS	International Space Station
ISSSH	International Space Station Systems Handbook
ITCS	Internal Thermal Control System
ITS	Integrated Truss Segment
IVA	Intravehicular Activity
IVSU	Internal Video Switch Unit

J–COM	JEM Communicator
J–FLIGHT	JAXA Flight Director
J–PLAN	Operations Planner
JAXA	Japan Aerospace Exploration Agency
JAXA EVA	JAXA Extravehicular Activity
JCP	JEM Control Processor
JEF	JEM Exposed Facility
JEM	Japanese Experiment Module
JEMAL	JEM Airlock
JEM-EF	Japanese Experiment Module Exposed Facility
JEM-PM	Japanese Experiment Module – Pressurized Module
JEM PAYLOADS	JEM Payload Officer
JEMAL	JEM Airlock
JEMRMS	Japanese Experiment Module Remote Manipulator System
JET	JEM Engineering Team
JEUS	Joint Expedited Undocking and Separation
JFCT	Japanese Flight Control Team
JLE	Japanese Experiment Logistics Module – Exposed Section
JLP	Japanese Experiment Logistics Module – Pressurized Section
JLP-EDU	JLP-EFU Driver Unit
JLP-EFU	JLP Exposed Facility Unit
JPM	Japanese Pressurized Module
JPM WS	JEM Pressurized Module Workstation
JPOC	JAXA Payload Operations Conductor
JSC	Johnson Space Center
JTVE	JEM Television Equipment
Kbps	Kilobit per second
KIBOTT	Kibo Robotics Officer
KOS	Keep Out Sphere
Ku-Band	15.250 to 17.250 Gigahertz
LB	Local Bus
LCA	LAB Cradle Assembly
LCD	Liquid Crystal Display
LDU	Linear Drive Unit
LED	Light Emitting Diode
LEE	Latching End Effector
LEO	Low-Earth Orbit
LIDAR	Light Intensification Detection and Ranging (Range?)
LMC	Lightweight MPESS Carrier
LSW	Light Switch

LTA	Launch-to-Activation
LTAB	Launch-to-Activation Box
LTL	Low Temperature Loop
MA	Main Arm
MAUI	Main Analysis of Upper-Atmospheric Injections
MAXI	Monitor of All-sky X-ray Image
Mb	Megabit
Mbps	Megabit per second
MBS	Mobile Base System
MBSU	Main Bus Switching Unit
MCA	Major Constituent Analyzer
MCC	Mission Control Center
MCC-H	Mission Control Center – Houston
MCC-M	Mission Control Center – Moscow
MCDS	Multifunction Cathode-Ray Tube Display System
MCR	Mission Control Room
MCS	Mission Control System
MDA	MacDonald, Dettwiler and Associates Ltd.
MDM	Multiplexer/Demultiplexer
MDP	Management Data Processor
MELFI	Minus Eighty-Degree Laboratory Freezer for ISS
MGB	Middle Grapple Box
MIP	Mission Integration Plan
MISSE	Materials International Space Station Experiment
MKAM	Minimum Keep Alive Monitor
MLE	Middeck Locker Equivalent
MLI	Multi-layer Insulation
MLM	Multipurpose Laboratory Module
MMOD	Micrometeoroid/Orbital Debris
MOD	Modulator
MON	Television Monitor
MPAC	Micro Particles Capture
MPC	Main Processing Controller
MPESS	Multipurpose Experiment Support Structure
MPEV	Manual Pressure Equalization Valve
MPL	Manipulator Retention Latch
MPLM	Multipurpose Logistics Module
MPM	Manipulator Positioning Mechanism
MPV	Manual Procedure Viewer
MSD	Mass Storage Device
MSFC	Marshall Space Flight Center

MSP	Maintenance Switch Panel
MSS	Mobile Servicing System
MT	Mobile Tracker
MTL	Moderate Temperature Loop
MUX	Data Multiplexer
n.mi.	nautical mile
NASA	National Aeronautics and Space Administration
NCS	Node Control Software
NEM	Neutron Monitor
NET	No Earlier Than
NiH2	Nickel Hydrogen
NLT	No Less Than
NPRV	Negative Pressure Relief Valve
NSV	Network Service
NTA	Nitrogen Tank Assembly
NTSC	National Television Standard Committee
OBSS	Orbiter Boom Sensor System
OCA	Orbital Communications Adapter
OCAD	Operational Control Agreement Document
OCAS	Operator Commanded Automatic Sequence
ODF	Operations Data File
ODS	Orbiter Docking System
OI	Orbiter Interface
OIU	Orbiter Interface Unit
OMS	Orbital Maneuvering System
OODT	Onboard Operation Data Table
OPT	Operational Pressure Transducer
ORCA	Oxygen Recharge Compressor Assembly
ORU	Orbital Replacement Unit
OS	Operating System
OSA	Orbiter-based Station Avionics
OSE	Orbital Support Equipment
OTCM	ORU and Tool Changeout Mechanism
OTP	ORU and Tool Platform
P/L	Payload
PAL	Planning and Authorization Letter
PAM	Payload Attach Mechanism
PAO	Public Affairs Office

PAS	Payload Attachment System
PBA	Portable Breathing Apparatus
PCA	Pressure Control Assembly
PCBM	Passive Common Berthing Mechanism
PCDF	Protein Crystallization Diagnostics Facility
PCN	Page Change Notice
PCRF	Protein Crystallization Research Facility
PCS	Portable Computer System
PCU	Power Control Unit
PDA	Payload Disconnect Assembly
PDB	Power Distribution Box
PDGF	Power and Data Grapple Fixture
PDH	Payload Data Handling unit
PDRS	Payload Deployment Retrieval System
PDU	Power Distribution Unit
PEC	Passive Experiment Container
PEHG	Payload Ethernet Hub Gateway
PFE	Portable Fire Extinguisher
PGSC	Payload General Support Computer
PI	Principal Investigator
PIB	Power Interface Box
PIU	Payload Interface Unit
PL FCT	Payload Flight Control Team
PLAM	Plasma Monitor
PLB	Payload Bay
PLBD	Payload Bay Door
PLC	Pressurized Logistics Carrier
PLT	Payload Laptop Terminal Space Shuttle Pilot
PM	Pressurized Module
PMA	Pressurized Mating Adapter Pump Module Assembly
PMCU	Power Management Control Unit
POA	Payload ORU Accommodation
POIC	Payload Operation Integration Center
POR	Point of Resolution
PPRV	Positive Pressure Relief Valve
PRCS	Primary Reaction Control System
PREX	Procedure Executor
PRLA	Payload Retention Latch Assembly
PROX	Proximity Communications Center

psia	Pounds per Square Inch Absolute
PSP	Payload Signal Processor
PSRR	Pressurized Section Resupply Rack
PTCS	Passive Thermal Control System
PTR	Port Thermal Radiator
PTU	Pan/Tilt Unit
PVCU	Photovoltaic Controller Unit
PVGF	Power and Video Grapple Fixture
PVM	Photovoltaic Module
PVR	Photovoltaic Radiator
PVTCS	Photovoltaic Thermal Control System
QD	Quick Disconnect
R&MA	Restraint and Mobility Aid
RACU	Russian-to-American Converter Unit
RAM	Read Access Memory
RBVM	Radiator Beam Valve Module
RCC	Range Control Center
RCT	Rack Configuration Table
RF	Radio Frequency
RGA	Rate Gyro Assemblies
RHC	Rotational Hand Controller
RIGEX	Rigidizable Inflatable Get-Away Special Experiment
RIP	Remote Interface Panel
RLF	Robotic Language File
RLT	Robotic Laptop Terminal
RMS	Remote Manipulator System
ROEU	Remotely Operated Electrical Umbilical
ROM	Read Only Memory
R-ORU	Robotics Compatible Orbital Replacement Unit
ROS	Russian Orbital Segment
RPC	Remote Power Controller
RPCM	Remote Power Controller Module
RPDA	Remote Power Distribution Assembly
RPM	Roll Pitch Maneuver
RS	Russian Segment
RSP	Return Stowage Platform
RSR	Resupply Stowage Rack
RT	Remote Terminal
RTAS	Rocketdyne Truss Attachment System

RVFS	Rendezvous Flight Software
RWS	Robotics Workstation
S3	Starboard 3
SAFER	Simplified Aid for EVA Rescue
SAM	SFA Airlock Attachment Mechanism
SARJ	Solar Alpha Rotary Joint
SCOF	Solution Crystallization Observation Facility
SCU	Sync and Control Unit
SD	Smoke Detector
SDOM	Standard Dose Monitor
SDS	Sample Distribution System
SEDA	Space Environment Data Acquisition equipment
SEDA-AP	Space Environment Data Acquisition equipment - Attached Payload
SEED	Space Environment Exposure Device
SEITE	Shuttle Exhaust Ion Turbulence Experiments
SEL	Space Experiment Laboratory
SELS	SpaceOps Electronic Library System
SENIN	System Investigation and Integration Officer
SEU	Single Event Upset
SFA	Small Fine Arm
SFAE	SFA Electronics
SGANT	Space-to-Ground Antenna
SI	Smoke Indicator
SIMPLEX	Shuttle Ionispheric Modification with Pulsed Localized Exhaust Experiments
SIS	Superconductor Insulator Superconductor
SLM	Structural Latch Mechanism
SLP-D	Spacelab Pallet – D
SLP-D1	Spacelab Pallet – Deployable
SLP-D2	Spacelab Pallet - D2
SLT	Station Laptop Terminal
	System Laptop Terminal
SM	Service Module
SMDP	Service Module Debris Panel
SMILES	Superconducting Submillimeter Wave Limb – Emission Sounder
SOC	System Operation Control
SODF	Space Operations Data File
SOLO	SOdium Loading in Microgravity
SPA	Small Payload Attachment
SPB	Survival Power Distribution Box
SPDA	Secondary Power Distribution Assembly
SPDM	Special Purpose Dexterous Manipulator

SPEC	Specialist
SRAM	Static RAM
SRB	Solid Rocket Booster
SRMS	Shuttle Remote Manipulator System
SSAS	Segment-to-Segment Attach System
SSC	Solid-state Slit Camera
	Station Support Computer
SSCB	Space Station Control Board
SSCC	Space Station Control Center
SSE	Small Fine Arm Storage Equipment
SSIPC	Space Station Integration and Promotion Center
SSME	Space Shuttle Main Engine
SSOF	Space Station Operations Facility
SSOR	Space-to-Space Orbiter Radio
SSP	Standard Switch Panel
SSPL	Space Shuttle Payload Launcher
SSPTS	Station-to-Shuttle Power Transfer System
SSRMS	Space Station Remote Manipulator System
STC	Small Fire Arm Transportation Container
STR	Starboard Thermal Radiator
STS	Space Transfer System
STVC	SFA Television Camera
SVS	Space Vision System
TA	Thruster Assist
TAC	TCS Assembly Controller
TAC-M	TCS Assembly Controller - M
TCA	Thermal Control System Assembly
TCB	Total Capture Box
TCCS	Trace Contaminant Control System
TCCV	Temperature Control and Check Valve
TCS	Thermal Control System
	Trajectory Control Center
TCV	Temperature Control Valve
TDK	Transportation Device Kit
TDRS	Tracking and Data Relay Satellite
THA	Tool Holder Assembly
THC	Temperature and Humidity Control
	Translational Hand Controller
THCU	Temperature and Humidity Control Unit
TIU	Thermal Interface Unit
TKSC	Tsukuba Space Center (Japan)

TLM	Telemetry
TMA	Russian vehicle designation
TMR	Triple Modular Redundancy
TPL	Transfer Priority List
TRRJ	Thermal Radiator Rotary Joint
TUS	Trailing Umbilical System
TVC	Television Camera
UCCAS	Unpressurized Cargo Carrier Attach System
UCM	Umbilical Connect Mechanism
UCM-E	UCM – Exposed Section Half
UCM-P	UCM – Payload Half
UHF	Ultrahigh Frequency
UI	User Investigator
UIL	User Interface Language
ULC	Unpressurized Logistics Carrier
UMA	Umbilical Mating Adapter
UOA	User Operations
UOP	Utility Outlet Panel
UPC	Up Converter
USA	United Space Alliance
US LAB	United States Laboratory
USOS	United States On-Orbit Segment
VAJ	Vacuum Access Jumper
VBSP	Video Baseband Signal Processor
VCU	Video Control Unit
VDS	Video Distribution System
VE	Visual Equipment
VLD	Vertical Light Display
VLU	Video Light Unit
VRA	Vent Relief Assembly
VRCS	Vernier Reaction Control System
VRCV	Vent Relief Control Valve
VRIV	Vent Relief Isolation Valve
VSU	Video Switcher Unit
VSW	Video Switcher
WAICO	Waiving and Coiling
WCL	Water Cooling Loop
WET	Weightless Environment Test Building
WETA	Wireless Video System External Transceiver Assembly

WIF	Work Interface
WRM	Water Recovery and Management
WRS	Water Recovery System
WS	Water Separator
	Work Site
	Work Station
WVA	Water Vent Assembly
Z1	Zenith 1
ZSR	Zero-g Stowage Rack

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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, or DVB-compliant Integrated Receiver Decoder, or IRD, with modulation of QPSK/DBV, data rate of 36.86 and FEC 3/4 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 De-coder, or IRD, to participate in live news events and interviews, media 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.

Television Schedule

A schedule of key in-orbit events and media briefings during the mission will be detailed in a NASA TV schedule posted at the link above. The schedule will be updated as necessary and will also be available at:

http://www.nasa.gov/multimedia/nasatv/mission_schedule.html

Status Reports

Status reports on launch countdown and mission progress, in-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.

More Internet Information

Information on the ISS is available at:

http://www.nasa.gov/station

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

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

Information on other current NASA activities is available at:

http://www.nasa.gov

Resources for educators can be found at the following address:

http://education.nasa.gov

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