National Aeronautics and Space Administration

ALL ABOARD
STS-123
The Station Goes Global

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USA
United Space Alliance

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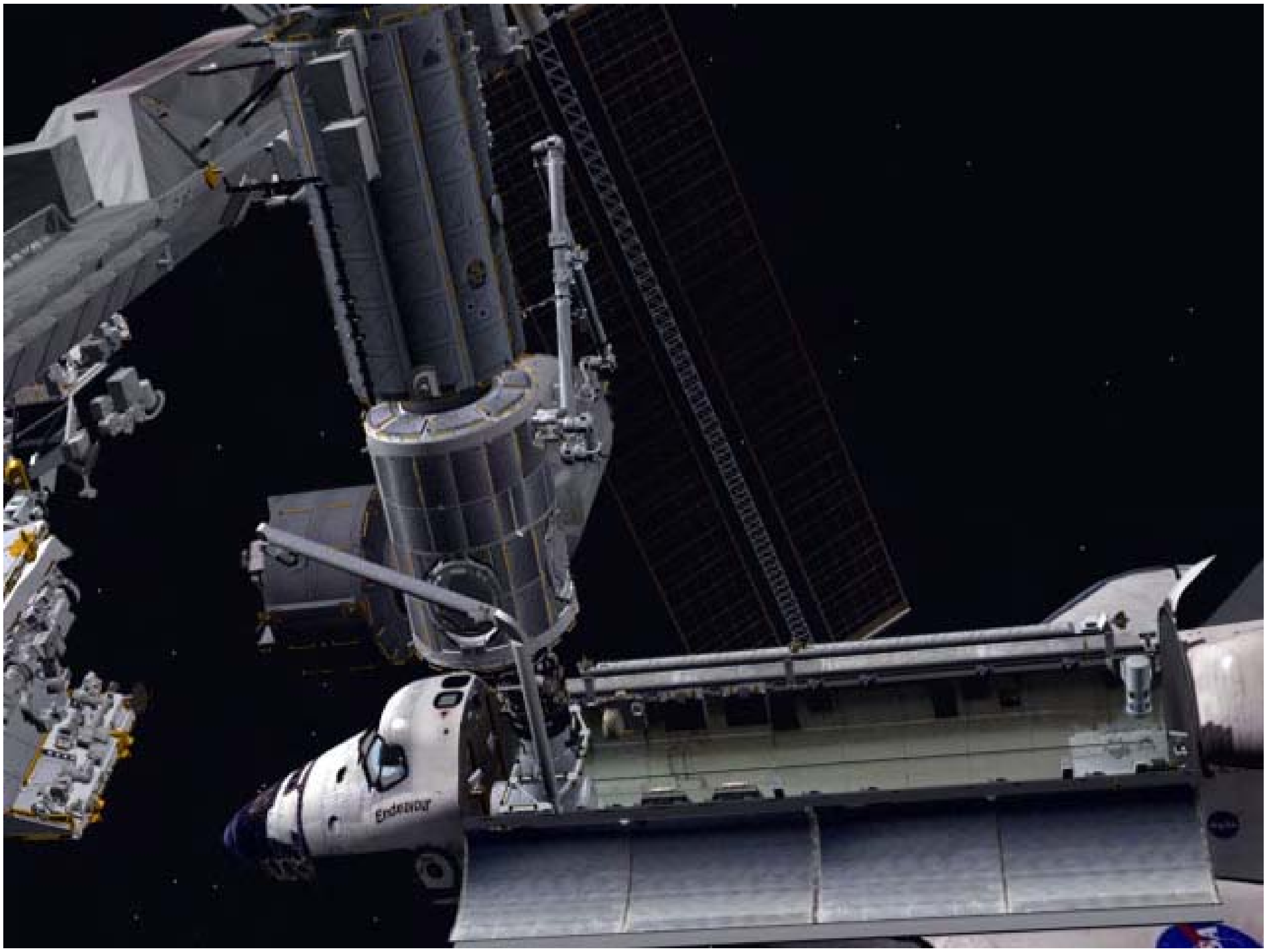
STS-123 MISSION OVERVIEW



This graphic illustrates Endeavour docked to the International Space Station as the shuttle robotic arm grapples a component of the Kibo laboratory.

The first pressurized component of the Japanese Kibo laboratory, a Canadian robotic device called Dextre and five spacewalks are major elements of STS-123. Endeavour's 16-day flight is the longest shuttle mission to the International Space Station (ISS).

The Kibo laboratory will eventually be berthed to the left side of the station's Harmony node. The Japanese Experiment Logistics Module-Pressurized Section (ELM-PS), the smaller of two pressurized modules of Kibo, will be attached temporarily to a docking port on the space-facing side of Harmony.

Kibo is the major Japanese contribution to the station, and will increase its research capability in a variety of disciplines. The name, which means "hope," was chosen by the Japan Aerospace Exploration Agency (JAXA) in a national contest.

STS-123 crew members are attired in training versions of their shuttle launch and entry suits. From the left are astronauts Rick Linnehan, Robert L. Behnken, both mission specialists; Gregory H. Johnson, pilot; Garrett Reisman, mission specialist; Dominic Gorie, commander; Mike Foreman and JAXA's Takao Doi, both mission specialists.

Dextre, the Canadian device, will work with the station's robotic arm, Canadarm2. Designed for station maintenance and service, Dextre is capable of sensing forces and movement of objects it is manipulating. It can automatically compensate for those forces and movements to ensure an object is moved smoothly.

Dextre is the final element of the Mobile Servicing System, part of Canada's contribution to the station. The name was chosen by Canadian students in a national contest. Dextre had been called the Special Purpose Dexterous Manipulator.

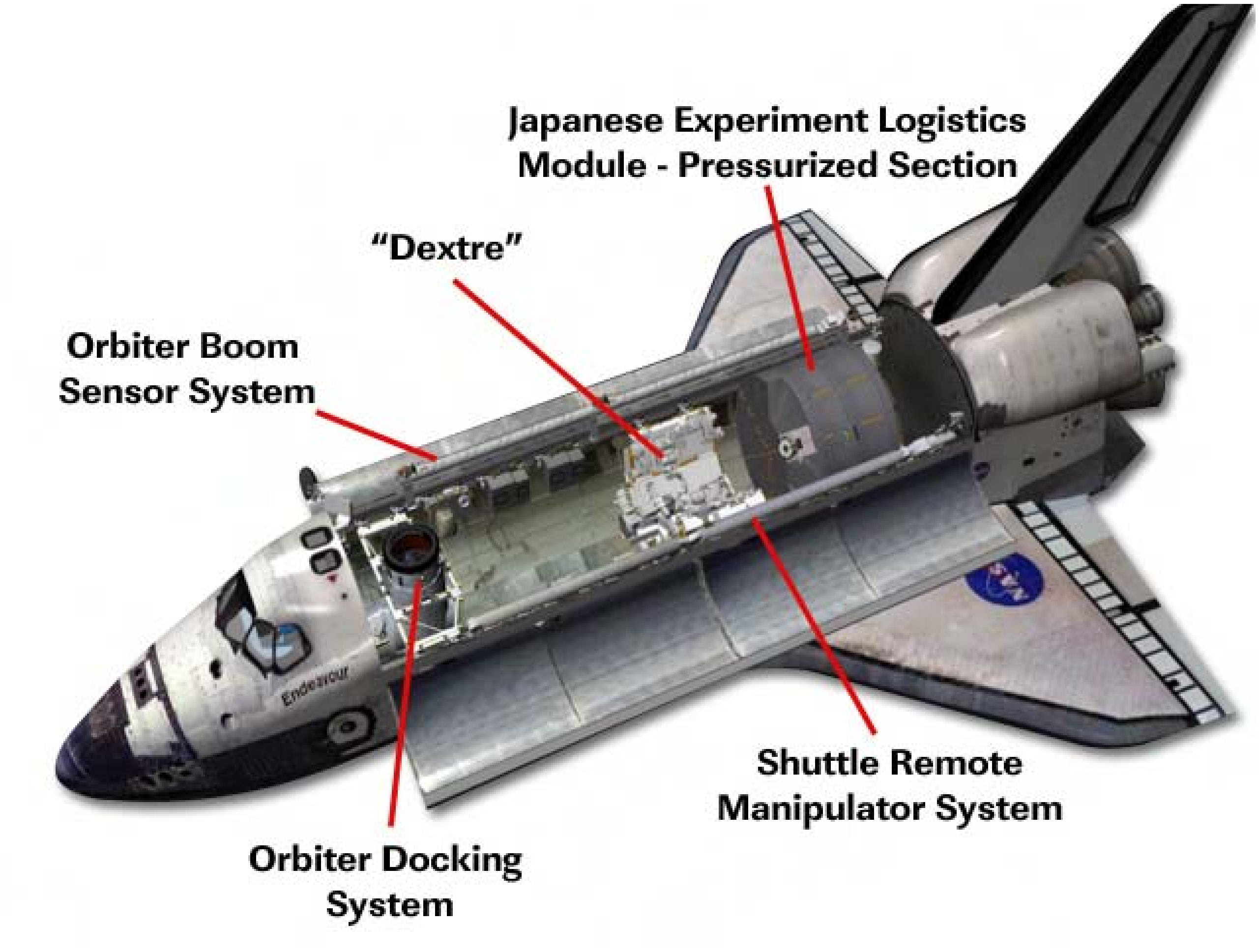
Once assembled, Dextre will look a little like a human upper torso stick figure. It will have two arms, and be capable of performing delicate tasks and using tools. Its four cameras will give crew members inside the station views of its activities. Dextre will be able to work from the end of Canadarm2, or from the orbiting laboratory's mobile base system.

The STS-123 mission, also called assembly flight 1J/A, includes representation of all five station partner interests — the U.S., Japan, Canada, Russia and the European Space Agency.

The flight includes five scheduled spacewalks. Three of them will include tasks devoted to assembly of Dextre and installation of related equipment.

Other spacewalk activities include work to unberth Kibo's ELM-PS, installation of spare parts and tools, installation of a materials experiment, replacement of a circuit-breaker box and demonstration of a repair procedure for tiles of the shuttle's heat shield. Spacewalkers also will stow the Orbiter Boom Sensor System (OBSS), the extension of the shuttle's robotic arm, onto the station's main truss during the fifth spacewalk.

The boom sensor system is being left on the station because the size of the large Japanese pressurized module to be launched on STS-124 won't allow it to be carried in Discovery's cargo bay. The OBSS will be returned to Earth at the end of that mission.



This graphic depicts the location of the STS-123 payload hardware.

Astronaut Dominic Gorie, STS-123 commander, dons a training version of his shuttle launch and entry suit in preparation for a post insertion/de-orbit training session at Johnson Space Center (JSC).

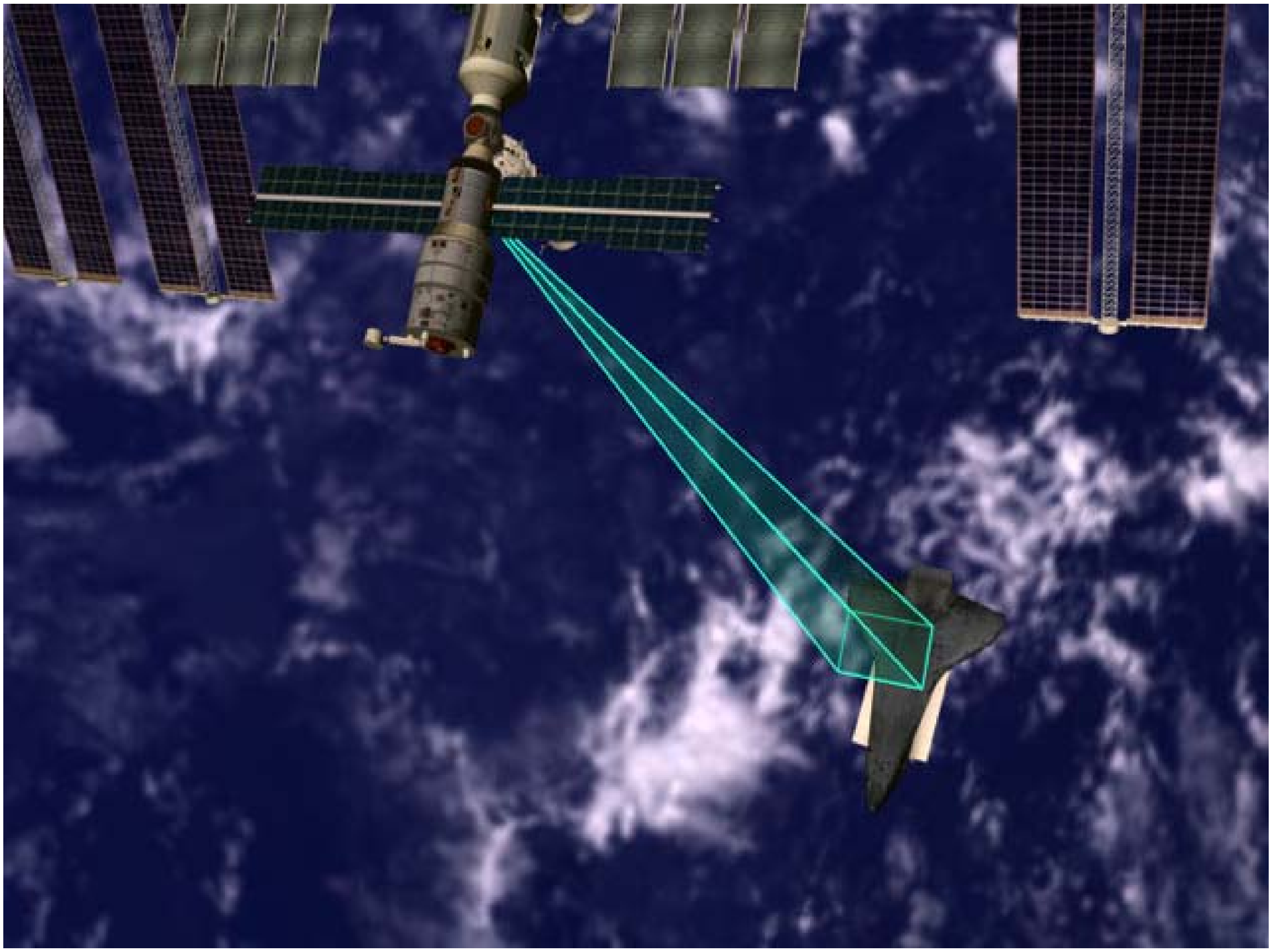
Dominic Gorie (GOR-ee), 50, a veteran of three space flights and a retired Navy captain, will command Endeavour. The spacecraft's pilot is Gregory H. Johnson, 45, an Air Force colonel. STS-123 mission specialists are Robert L. Behnken (BANK-en), 37, an Air Force major; Navy Capt. Mike Foreman, 50; Japanese astronaut Takao (tah-cowe) Doi (DOY), 53; Rick Linnehan (LIN-eh-han), 50, a veteran of three shuttle flights; and Garrett Reisman (REES-man), 39.

Astronauts Robert L. Behnken (left) and Japan Aerospace Exploration Agency's Takao Doi, both STS-123 mission specialists, participate in a training session in the Space Vehicle Mockup Facility at the JSC.

Reisman will remain aboard the station with Commander Peggy Whitson and fellow Flight Engineer Yuri Malenchenko (mal EN chen ko). He will replace Leopold Eyharts (ā-arts), a French Air Force general and European Space Agency astronaut who will return to Earth on Endeavour. Eyharts was launched to the station aboard Atlantis on STS-122.

The day after Endeavour's launch from Kennedy Space Center in Florida, Gorie, Johnson and Doi will use the shuttle's robotic arm and its OBSS for the standard survey of Endeavour's heat-resistant reinforced carbon-carbon and heat shield tiles. Behnken, Linnehan and Reisman will check out the spacesuits on Endeavour.

Flight day 3 is docking day. Once Endeavour reaches a point about 600 feet below the station, Gorie will fly it in a back flip, so station crew members can photograph its heat shield. The digital images will be sent to the ground for analysis. Gorie then will fly Endeavour to a point ahead of the station and maneuver it to a docking with Pressurized Mating Adapter No. 2, at the forward end of the Harmony node.



This graphic depicts the rendezvous pitch maneuver while crew aboard the ISS photograph the orbiter for analysis by specialists on the ground.

Astronauts Gregory H. Johnson (background), STS-123 pilot, and Garrett Reisman, Expedition 16 flight engineer, use the virtual reality lab at JSC to train for some of their duties aboard the space shuttle and space station.

Reisman will become a station crew member with the exchange of his custom Soyuz seatliner with that of Eyharts, who joins the shuttle crew for his flight home. Johnson and Behnken will use the station's Canadarm2 to remove the pallet containing Dextre from the payload bay and attach it to a fixture on the station's main truss. A review of procedures for the first spacewalk will wind up the Endeavour crew's working day.

Flight day 4 focuses on the first spacewalk, by Linnehan and Reisman. Foreman will serve as intravehicular officer, while Behnken and Eyharts will operate the station's Canadarm2. Tasks include preparation for the ELM-PS installation and work on Dextre assembly. Doi and Gorie will subsequently install the ELM-PS on Harmony with the shuttle arm.

Flight day 5 includes outfitting of the ELM-PS vestibule, ELM-PS entry by Doi and Linnehan, transfer of equipment and supplies between shuttle and station, and briefings on station activities for the new station crew member Reisman. An hour-long procedure review looks ahead to the second spacewalk.

Astronaut Rick Linnehan, STS-123 mission specialist, participates in an Extravehicular Mobility Unit spacesuit fit check in the Space Station Airlock Test Article (SSATA) in the Crew Systems Laboratory. Astronaut Robert L. Behnken, mission specialist, assists Linnehan.

The second spacewalk, with Linnehan and Foreman, is scheduled for flight day 6. It will focus on Dextre and include installation of its two arms. Behnken will provide intravehicular support while Johnson and Reisman operate Canadarm2.

Flight day 7 is filled with a variety of activities, including work with the new Japanese module and transfer operations. The standard spacewalk procedures review, this one for the third spacewalk, comes toward the end of the crew day.

EVA-3, by Linnehan and Behnken, will occur on flight day 8, with Foreman providing intravehicular support. Johnson and Reisman will run Canadarm2 to help the spacewalkers stow replacement gear and install a materials experiment and a Dextre platform for spare parts.

Flight day 9 is highlighted by robotics operations, with the station arm manipulating Dextre. The arm first will move Dextre from its pallet to a power and data grapple fixture on the U.S. laboratory Destiny. The arm will return the pallet to Endeavour's payload bay and then move Dextre again, this time to a position where it will be protected during a tile repair test on spacewalk four.

Flight day 10 includes some off-duty time for shuttle crew members and tool configuration for spacewalk four, preparations for the tile repair test, and the standard day-before spacewalk procedures review.

Attired in a training version of his shuttle launch and entry suit, astronaut Mike Foreman, STS-123 mission specialist, takes a moment for a photo during a training session in the Space Vehicle Mockup Facility.

On flight day 11, Behnken and Foreman are scheduled to do EVA-4, with intravehicular support from Linnehan. The spacewalk includes the shuttle tile repair test and change out of an ISS circuit breaker.

An OBSS survey of Endeavour's wings and nose cap by Gorie, Johnson and Doi is scheduled for flight day 12. Once again, spacewalk tools configuration and the end-of-day procedures review for the flight's final spacewalk are also planned.

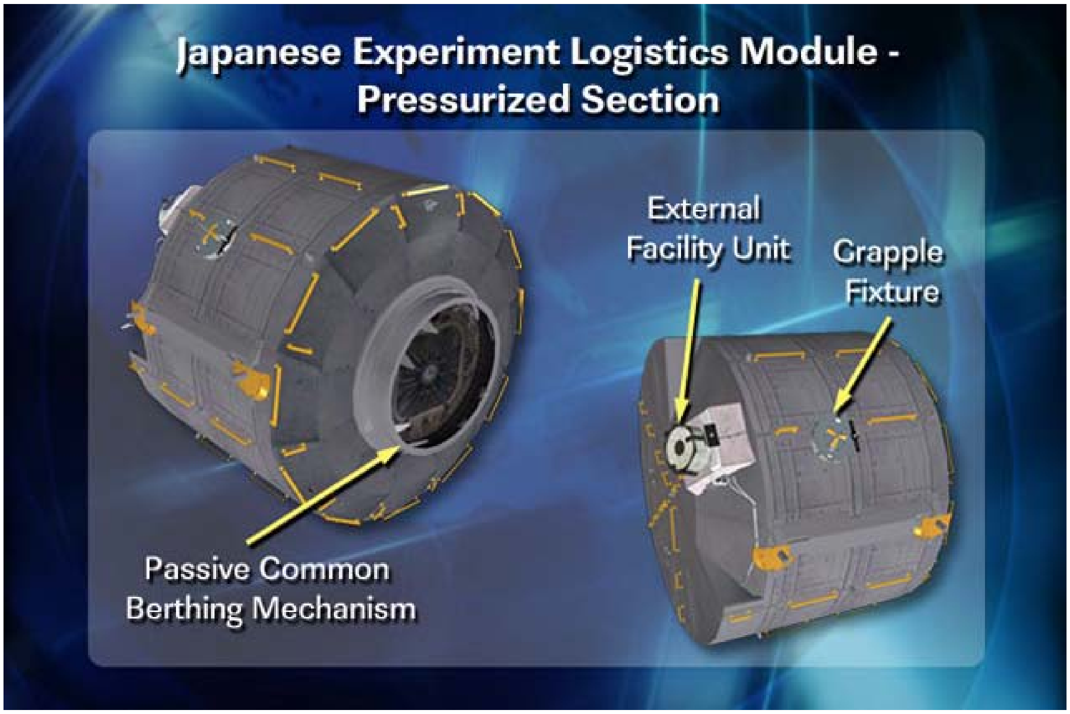
During the fifth and final spacewalk on flight day 13, Behnken and Foreman will stow the OBSS on the station's main truss. With Linnehan as intravehicular officer, they'll also release launch locks on Harmony's left and Earth-facing common berthing mechanisms and perform other tasks including installation of Trundle Bearing Assembly 5 in starboard Solar Alpha Rotary Joint (SARJ) and more SARJ inspection work.

Much of flight day 14's morning will be off-duty time for shuttle crew members. Later they'll also hold the joint crew news conference, wrap up equipment and logistics transfers between the station and shuttle and check out rendezvous tools.

Highlighting flight day 15 are crew farewells, hatch closings, undocking, Endeavour's fly-around of the station with pilot Johnson at the controls, and departure.

Landing preparations, including checkout of the flight control system and the reaction control system, are the focus of flight day 16. Crew members will stow items in the cabin and hold a deorbit briefing just before bedtime.

Deorbit preparations, and landing at the Kennedy Space Center (KSC) on flight day 17 wind up Endeavour's lengthy and demanding STS-123 mission to the ISS.



This image shows the pressurized Kibo Japanese Experiment Logistics Module that will be installed during the STS-123 mission.

TIMELINE OVERVIEW

Flight Day 1

- Launch
- Payload Bay Door Opening
- Ku-band Antenna Deployment
- Shuttle Robotic Arm Activation and Checkout
- Umbilical Well and Handheld External Tank Video and Stills Downlink

2

- Endeavour Thermal Protection System Survey with OBSS
- Extravehicular Mobility Unit Checkout
- Centerline Camera Installation
- Orbiter Docking System Ring Extension
- Orbital Maneuvering System Pod Survey
- Rendezvous Tools Checkout

3

- Rendezvous with the ISS
- Rendezvous Pitch Maneuver Photography by the Expedition 16 Crew
- Docking to Harmony/Pressurized Mating Adapter-2
- Hatch Opening and Welcoming
- Station-to-Shuttle Power Transfer System (SSPTS) Activation
- Canadarm2 Grapple of Spacelab Pallet containing the Dextre Special Purpose Dexterous Manipulator (SPDM) and transfer and mate to the Payload Orbital Replacement Unit Attachment Device (POA) on the Mobile Base System.
- Reisman and Eyharts exchange Soyuz seatliners; Reisman joins Expedition 16, Eyharts joins the STS-123 crew
- Extravehicular Activity (EVA) 1 Procedure Review
- EVA 1 Campout by Linnehan and Reisman

- EVA 1 by Linnehan and Reisman Japanese Experiment Logistics Module-Pressurized Section (ELM-PS) unberth preparations, Orbital Replacement Unit and Tool Changeout Mechanism installation on each of Dextre's two arms
- JEM ELM-PS Grapple, Unberth and Installation on Zenith Port of Harmony

- JEM ELM-PS Ingress Preparations
- JEM ELM-PS Ingress
- Canadarm2 Grapple of OBSS and Handoff to Shuttle Robotic Arm
- EVA 2 Procedure Review
- EVA 2 Campout by Linnehan and Foreman

- EVA 2 by Linnehan and Foreman (Dextre assembly)
- Dextre Joint and Brake Tests and Diagnostics
- JEM ELM-PS Outfitting

- JEM ELM-PS Racks and Systems Outfitting
- Dextre Arm and Brake Tests
- EVA 3 Procedure Review
- EVA 3 Campout by Linnehan and Behnken

8

- EVA 3 by Linnehan and Behnken (Orbital Replacement Unit stowage, MISSE-6 lightweight adapter plate assembly installation and transfer of MISSE-6 experiments to Columbus and Dextre spare part platform and tool handling assembly)
- Dextre End Effector Checkout and Calibration

- Crew Off Duty Periods
- Canadarm2 Grapple of Dextre and Transfer to Power and Data Grapple Fixture on Destiny Laboratory; Dextre's L.C. Arms are Stowed
- T-RAD EVA Hardware Preparation

10

- Crew Off Duty Periods
- EVA 4 Procedure Review
- EVA 4 Campout by Foreman and Behnken

11

- EVA 4 by Foreman and Behnken (T-RAD DTO, Remote Power Control Module replacement including temporary CMG-2 shutdown and spinup)
- Retrieve the JEM TV Electronics Boom from the ELM-PS

12

- OBSS Inspection of Endeavour's Heat Shield
- Mobile Transporter Move from Worksite 6 to Worksite 4
- EVA 5 Procedure Review
- EVA 5 Campout by Foreman and Behnken

13

- EVA 5 by Foreman and Behnken (OBSS stow on station truss, repair and replacement of Destiny Laboratory micrometeoroid debris shields, release of launch locks on Harmony port and nadir Common Berthing Mechanisms)
- Installation of Trundle Bearing Assembly 5 in starboard SARJ
- SARJ Inspection

1

- Joint Crew News Conference
- Crew Off Duty Periods
- Rendezvous Tools Checkout
- Final Transfers

1

- Final Farewells and Hatch Closing
- Undocking
- Flyaround of the ISS
- Final Separation

1

- Flight Control System Checkout
- Reaction Control System Hot-Fire Test
- Cabin Stowage
- European Space Agency’s (ESA’s) PAO Event
- Eyharts’ Recumbent Seat Set Up
- Crew Deorbit Briefing
- Ku-Band Antenna Stowage

1

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

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MISSION PROFILE

CREW

Commander:	Dominic Gorie
Pilot:	Gregory H. Johnson
Mission Specialist 1:	Robert L. Behnken
Mission Specialist 2:	Mike Foreman
Mission Specialist 3:	Takao Doi
Mission Specialist 4:	Rick Linnehan
Mission Specialist 5:	Garrett Reisman (Up)
Mission Specialist 5:	Léopold Eyharts (Down)

LAUNCH

Orbiter:	Endeavour (OV-105)
Launch Site:	Kennedy Space Center Launch Pad 39A
Launch Date:	March 11, 2008
Launch Time:	2:28 a.m. EDT (Preferred In-Plane launch time for 3/11)
Launch Window:	5 Minutes
Altitude:	122 Nautical Miles (140 Miles) Orbital Insertion; 185 NM (213 Miles) Rendezvous
Inclination:	51.6 Degrees
Duration:	15 Days 16 Hours 48 Minutes

VEHICLE DATA

Shuttle Liftoff Weight:	4,521,086 pounds
Orbiter/Payload Liftoff Weight:	269,767 pounds
Orbiter/Payload Landing Weight:	207,582 pounds
Software Version:	OI-32

Space Shuttle Main Engines:

SSME 1:	2047
SSME 2:	2044
SSME 3:	2054
External Tank:	ET-126
SRB Set:	BI-133
RSRM Set:	101

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:	March 26, 2008
Landing Time:	8:35 p.m. EDT
Primary landing Site:	Kennedy Space Center Shuttle Landing Facility

PAYLOADS

Kibo Logistics Module, Dextre Robotics System

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MISSION PRIORITIES

1. Dock Endeavour to Pressurized Mating Adapter-2 and do station safety briefings for all crew members
2. Replace Expedition 16 Flight Engineer Leopold Eyharts with Expedition 16/17 Flight Engineer Garrett Reisman and transfer crew rotation cargo
3. Transfer remaining items on flight ballasting plan
4. Install the ELM-PS, the smaller of two pressurized modules of Kibo, to a temporary position on a docking port on the space-facing side of Harmony
5. Do critical ELM-PS activation
6. Using the station's Canadarm2, unberth the SPDM, or Dextre, on its pallet and install it in a temporary position on the station
7. Do Mobile Base System checkout to ensure the MBS can provide heater power to Dextre
8. Install umbilical for keep-alive power and stow OBSS on station
9. Transfer water from shuttle to space station
10. Transfer critical items
11. Transfer European plant experiment (WAICO) samples from station to shuttle incubator
12. Transfer two double-cold bags with Human Research Program (HRP) nutrition samples and IMMUNO samples to shuttle mid-deck
13. Assemble and deploy SPDM Dextre
14. Use Canadarm2 to berth SPDM Dextre pallet
15. Transfer Canadarm2 yaw joint from shuttle to station External Stowage Platform-2 (ESP-2)
16. Transfer two direct current switching units from shuttle to ESP-2.

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MISSION PERSONNEL

KEY CONSOLE POSITIONS FOR STS-123

	Flt. Director	CAPCOM	PAO
Ascent	Bryan Lunney	Jim Dutton Kevin Ford (Weather)	Kyle Herring
Orbit 1 (Lead)	Mike Moses	Terry Virts	John Ira Petty (Lead)
Orbit 2	Rick LaBrode	Nick Patrick	Kylie Clem
Planning	Matt Abbott	Alvin Drew	Brandi Dean
Entry	Richard Jones	Jim Dutton Kevin Ford (Weather)	Kyle Herring
Shuttle Team 4	Richard Jones/ Tony Ceccacci	N/A	N/A
ISS Orbit 1	Kwatsi Alibaruho	Zach Jones	N/A
ISS Orbit 2 (Lead)	Dana Weigel	Steve Robinson	N/A
ISS Orbit 3	Ginger Kerrick	Mark Vande Hei	N/A
Station Team 4	Heather Rarick	Bob Dempsey	Ron Spencer

Int. Partner FD – Emily Nelson (interfaces with Canadian Space Agency and Japan Aerospace Exploration Agency)

HQ PAO Representative at KSC for Launch – Michael Curie

JSC PAO Representative at KSC for Launch – Rob Lazaro

KSC Launch Commentator – George Diller

KSC Launch Director – Mike Leinbach

NASA Launch Test Director – Steve Payne

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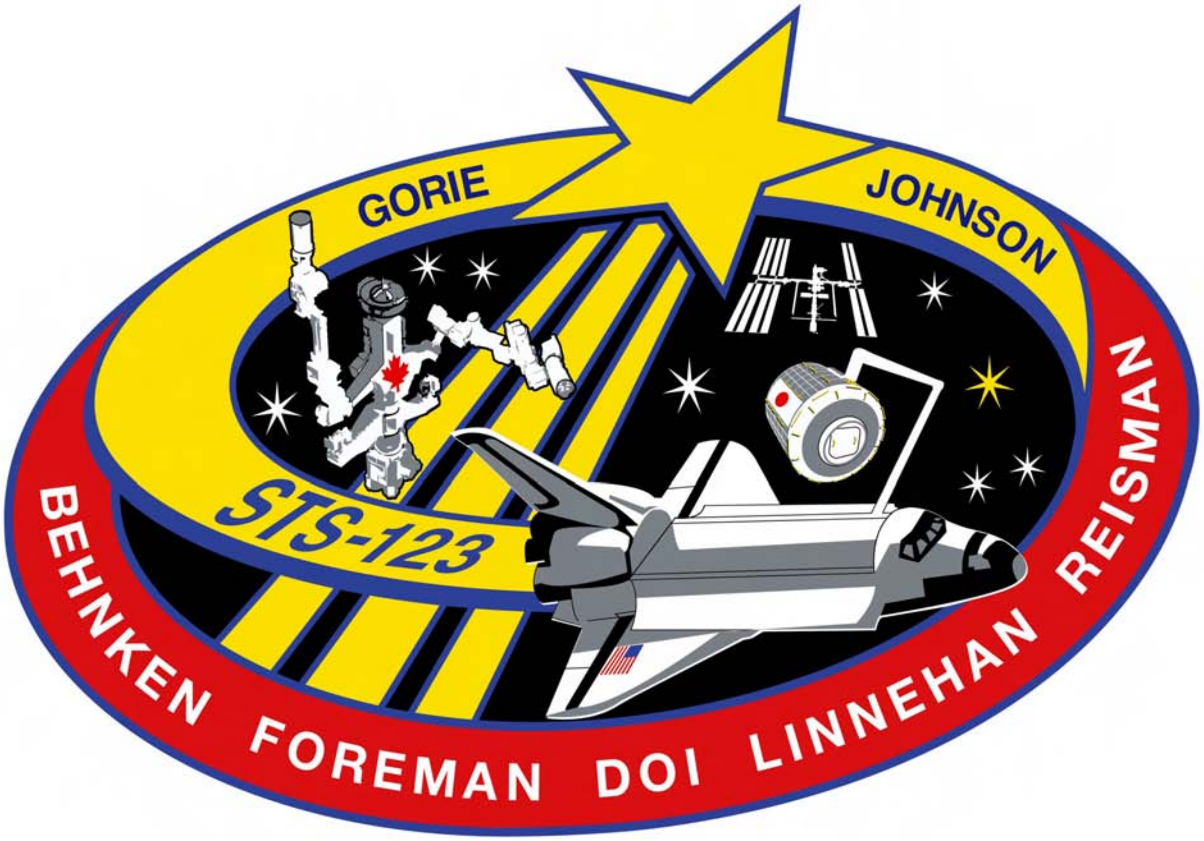
STS-123 ENDEAVOUR CREW

The STS-123 crew patch depicts the shuttle in orbit with the crew names trailing behind. STS 123's major additions to the International Space Station: the Kibo Japanese ELM-PS and the Canadian SPDM, known as Dextre, are both illustrated. The station is shown in the configuration that the STS-123 crew will encounter upon arrival.



These seven astronauts take a break from training to pose for the STS-123 crew portrait. From the right (front row) are astronauts Dominic Gorie, commander; and Gregory H. Johnson, pilot. From the left (back row) are astronauts Rick Linnehan, Robert L. Behnken, Garrett Reisman, Mike Foreman and JAXA's Takao Doi, all mission specialists. The crew members are wearing shuttle launch and entry suits that are used for training.

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

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

STS-123 CREW BIOGRAPHIES

Dominic Gorie

Retired Navy Capt. Dominic Gorie will lead the crew of STS-123 on the 25th shuttle mission to the International Space Station. Gorie served as the pilot of STS-91 in 1998 and STS-99 in 2000. He was the commander of STS-108 in 2001. Making his fourth spaceflight, he has logged more than 32 days in space. He has overall responsibility for the execution of the mission, orbiter systems operations and flight operations, including landing. In addition, Gorie will fly the shuttle in a procedure called the rendezvous pitch maneuver while Endeavour is 600 feet below the station to enable the station crew to photograph the shuttle's heat shield. He then will dock Endeavour to the station.

Gregory H. Johnson

Air Force Col. Gregory H. Johnson has more than 4,000 flight hours in more than 40 different aircraft. He will make his first journey into space as the pilot of Endeavour for the STS-123 mission. Selected by NASA in 1998, Johnson has served as a technical assistant to the director of flight crew operations. He has also worked in the Astronaut Office's space shuttle, safety and exploration branches. He will be responsible for orbiter systems operations, shuttle and station robotic arm operations and will help Gorie in the rendezvous and docking with the station. Johnson will undock Endeavour from the station.

Robert L. Behnken

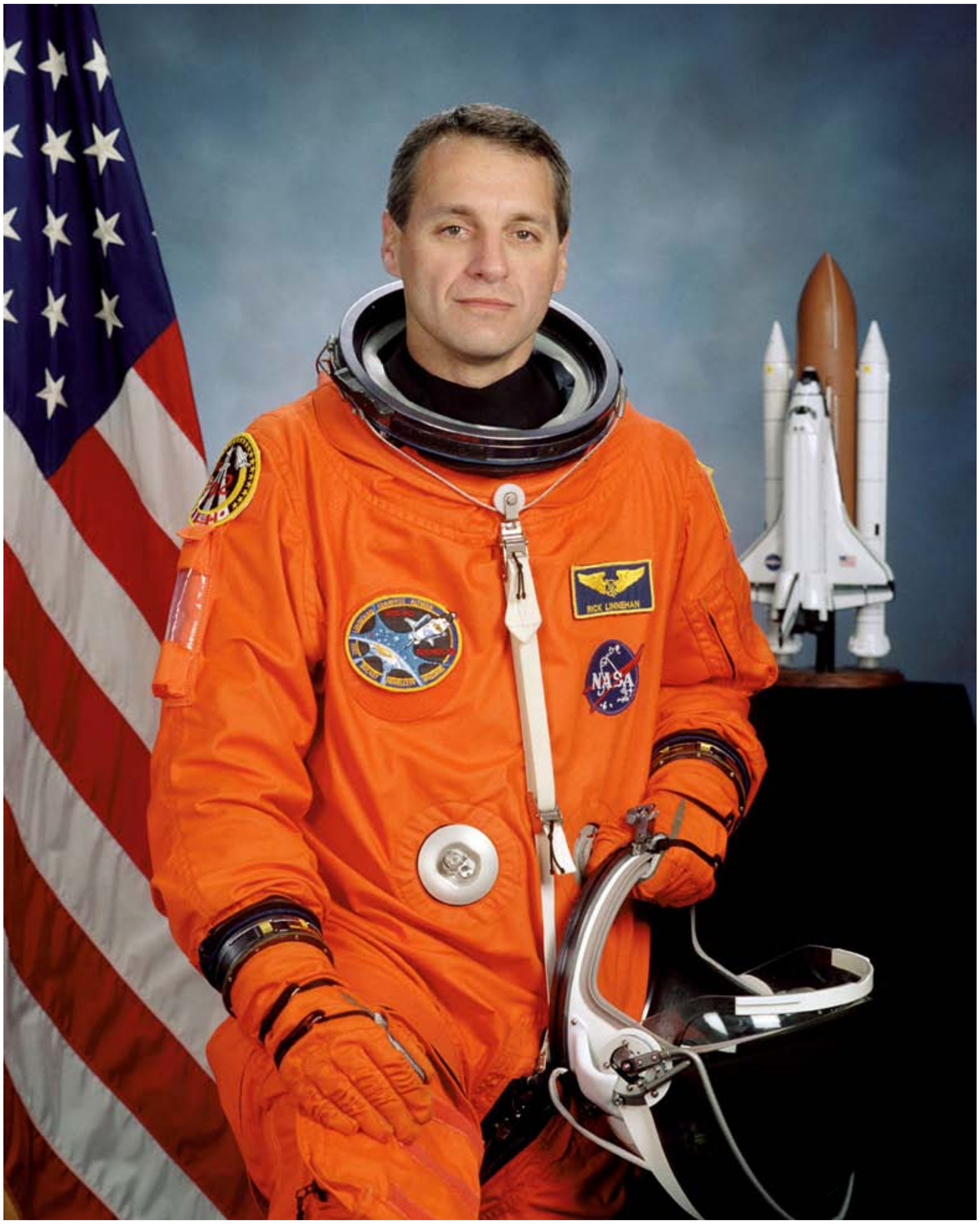
Air Force Maj. Robert L. Behnken will be making his first spaceflight as mission specialist 1 for STS-123. He holds a doctorate in mechanical engineering and has logged more than 1,000 hours in more than 25 different aircraft. Selected as an astronaut in 2000, Behnken has worked in the Astronaut Office shuttle operations branch, supporting launch and landing activities at KSC. During STS-123 he is designated as EV2, or spacewalker 2, and will conduct three spacewalks. He also will serve as an intravehicular coordinator and operator of the station robotic arm for the other spacewalks.

Mike Foreman

Navy Capt. Mike Foreman will be making his first spaceflight as mission specialist 2 for STS-123. He has logged more than 5,000 hours in more than 50 aircraft. Selected as an astronaut in 1998, Foreman has worked in the Astronaut Office space station and space shuttle branches. Foreman will be on the flight deck during launch and landing, serving as the flight engineer to assist Gorie and Johnson. He is designated as EV3 and will conduct three spacewalks. He also will serve as an intravehicular coordinator for the other two spacewalks.

Takao Doi

JAXA astronaut Takao Doi will be making his second trip into space as mission specialist 3 for STS-123. Doi holds doctorates in both aerospace engineering and astronomy. He logged more than 376 hours in space for STS-87 in 1997. He conducted two spacewalks, including the manual capture of a Spartan satellite. Doi was selected as an astronaut in 1985 with the National Space Development Agency (NASDA), currently known as JAXA. He reported to JSC in 1995. During STS-123 Doi will lead the ingress and initial setup of the first element of the Kibo Japanese Experiment Laboratory, the ELM-PS.



Rick Linnehan

Astronaut Rick Linnehan, a doctor of veterinary medicine, will be making his fourth spaceflight as mission specialist 4 for the STS-123 mission. Selected by NASA in 1992, he has logged more than 43 days in space, including three spacewalks to service the Hubble Space Telescope on Servicing Mission 3B. Linnehan flew on STS-78 in 1996, STS-90 in 1998 and STS-109 in 2002. Designated as EV1 for the STS-123 mission, he will oversee the planning and choreography of all five spacewalks. He will conduct the first three and serve as an intravehicular coordinator for the remaining two.

Garrett Reisman

Astronaut Garrett Reisman will be making his first spaceflight for STS-123. He holds a doctorate in mechanical engineering. Selected by NASA in 1998, Reisman has worked in the Astronaut Office robotics and advanced vehicles branches. He was part of the NEEMO V mission, living on the bottom of the sea in the Aquarius habitat for two weeks. He is designated EV4 on STS-123 and will conduct one spacewalk. He also will assist with intravehicular duties during the other spacewalks and operate the station robotic arm. He will serve as a flight engineer during Expedition 16 and the transition to Expedition 17 aboard station. He is scheduled to return on shuttle mission STS-124.

Leopold Eyharts

Leopold Eyharts, a French astronaut from the Center National d'Etudes Spatiales (CNES), will return to Earth on STS-123. He was selected as an astronaut by CNES in 1990 and by the European Space Agency (ESA) in 1992. His first mission was to the Mir Space Station in 1998, where he supported the CNES scientific space mission "Pégase." He performed various French experiments in the areas of medical research, neuroscience, biology, fluid physics and technology. He logged 20 days, 18 hours and 20 minutes in space. In 1998, ESA assigned Eyharts to train at NASA's JSC. He launched to the space station on the STS-122 mission in February. He was aboard station as a flight engineer during Expedition 16 for the commissioning of the European Columbus laboratory.

PAYLOAD OVERVIEW

KIBO OVERVIEW

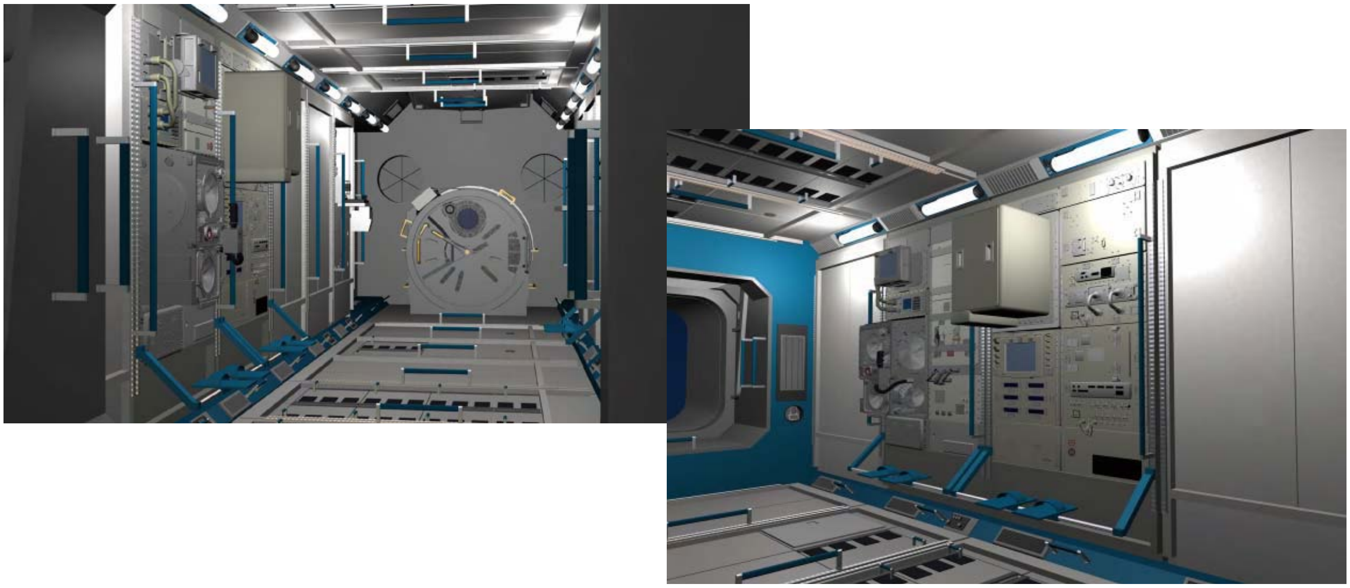
Japan's contribution to the International Space Station Program

The first component of the Japanese experiment module, Kibo, will fly to the International Space Station (ISS) after 23 years of development efforts by the Japan Aerospace Exploration Agency- JAXA. Japan's role in the space station program is to develop and contribute the Japanese Experiment Module (JEM), logistics vehicles, and the H-II Transfer Vehicle (HTV), using accumulated Japanese technologies.

Once in orbit, the Kibo facilities will be used to perform collaborative experiments by all the station partners. In addition, JAXA plans educational, cultural and commercial uses of the Kibo facility which will provide opportunities for expanded utilization of the space environment.

Kibo's contributions are not strictly limited to space utilizations. The actual development and operation of Kibo has great significance in the continued expansion of Japan's accumulated technologies. Acquisition of advanced technologies required to support human life in space enhances both the level of Japan's scientific and technological skill, and contributes to other worldwide space development activities in the future exploration.

This is an artist's concept image of Kibo once fully assembled on the space station.



Graphic images of the Kibo Pressurized Module interior

E M

Kibo (key-boh) means “hope.” It is Japan’s first human-rated space facility. Kibo will be the largest experiment module on the space station, accommodating 31 racks in its pressurized section, including experiment, stowage, and system racks. Kibo is equipped with external facilities that can accommodate 10 exposed experiment payloads.

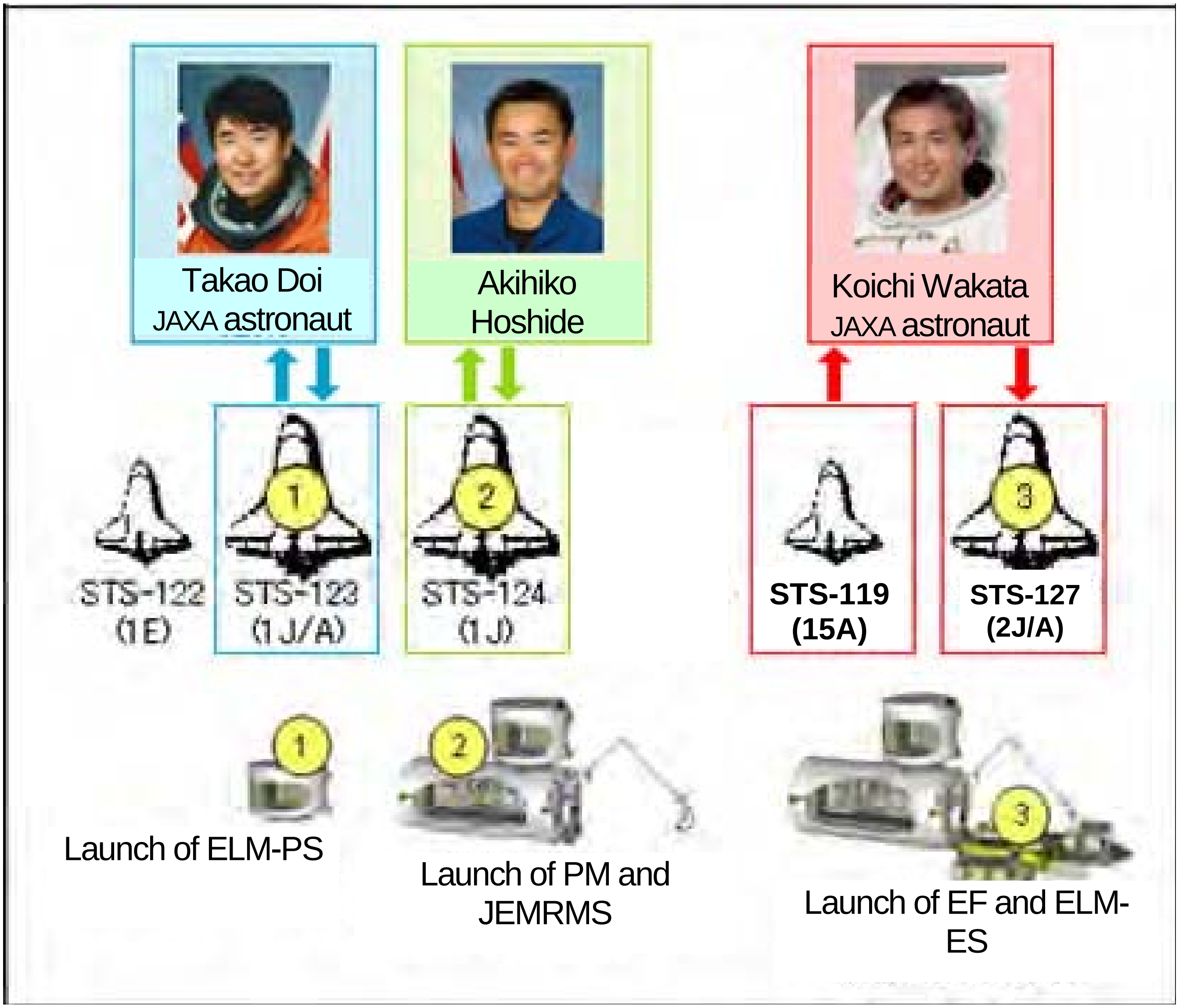
Kibo is a complex facility that enables several kinds of specialized functions. In total, Kibo consists of: Pressurized Module (PM) and Exposed Facility (EF), a logistics module attached to both the PM and EF and a Remote Manipulator System – Japanese Experiment Module Remote Manipulator System (JEMRMS.)

To make maximum use of its limited space, Kibo possesses every function required to perform experiment activities in space: the pressurized and exposed sections, a scientific airlock in the PM, and a remote manipulator system that enables operation of exposed experiments without the assistance of a spacewalking crew.

A

The Kibo elements will be delivered to the space station by three space shuttle flights. STS-123 will deliver the ELM-PS, STS-124 will deliver the PM and JEMRMS, and STS-127 will deliver the EF and the Experiment Logistics Module–Exposed Section (ELM-ES).

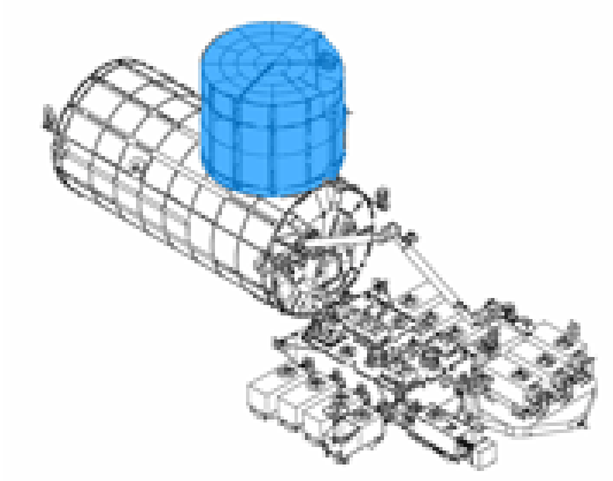
For each of the three missions, a JAXA astronaut will fly to the station to assist with the assembly, activation, and checkout of the Kibo component. Astronaut Takao Doi is assigned as a NASA mission specialist for the STS-123 mission, astronaut Akihiko Hoshide is assigned as a mission specialist for the STS-124 mission, and astronaut Koichi Wakata is assigned as a space station flight engineer for Expedition 18.


Takao Doi
JAXA astronaut
Akihiko
Hoshide
Koichi Wakata
JAXA astronaut
STS-122
(1E)
STS-123
(1J/A)
STS-124
(1J)
STS-119
(15A)
STS-127
(2J/A)
1
2
3
Launch of ELM-PS
Launch of PM and
JEMRMS
Launch of EF and ELM-
ES

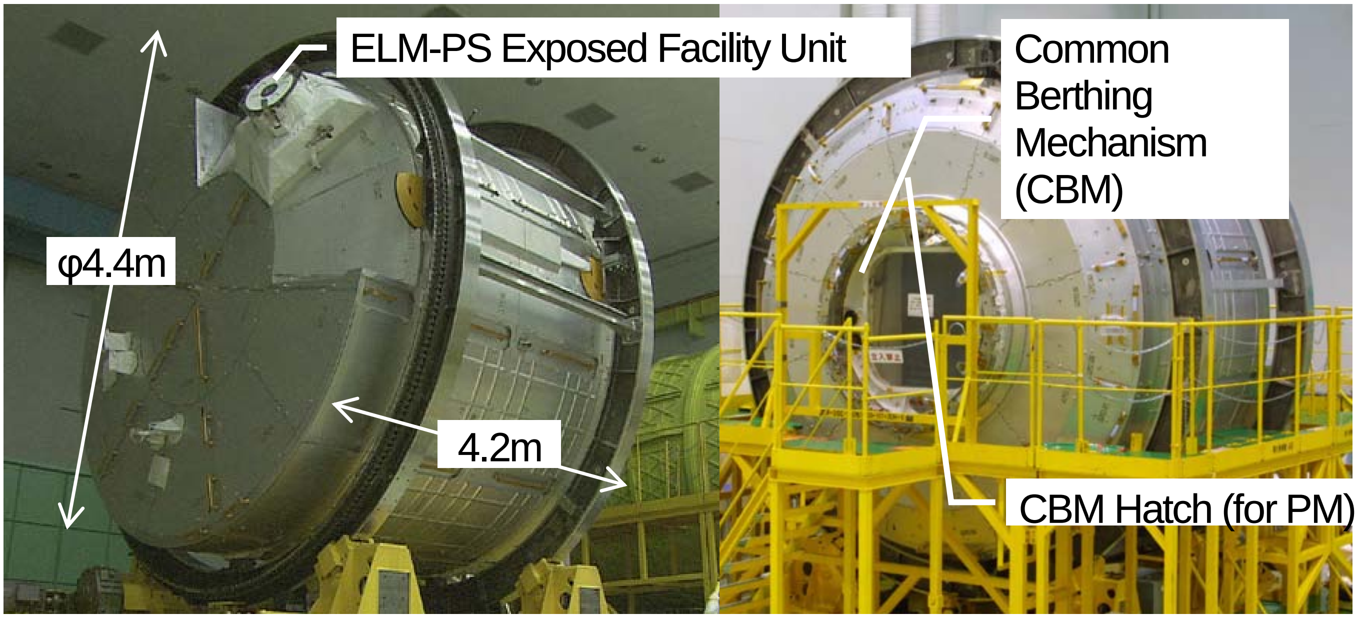
T C E M- S

Kibo's ELM-PS will be launched to the space station aboard the space shuttle Endeavour on the STS-123/1J/A mission, which is the first of the three Kibo-related ISS assembly flights. The ELM-PS is a Kibo storage facility that provides stowage space for experiment payloads, samples, and spare items. The pressurized interior of the ELM-PS is maintained at one atmosphere, thus providing a shirt-sleeve working environment. The crew will be able to freely move between the ELM-PS and the main experiment module, called the Pressurized Module. On the space station, Kibo is the only experiment facility with its own dedicated storage facility.

When the ELM-PS is launched aboard the space shuttle, it will be used as a logistics module for transporting eight Kibo subsystems and experiment racks to the space station. Once the ELM-PS is on orbit, it will be used as a Kibo stowage compartment. Maintenance tools, experiment samples, and other spare items will all be stored inside the ELM-PS. The volume of the ELM-PS is less than that of the PM, and up to eight racks can be housed in the ELM-PS.



ELM-PS structural location



ELM-PS Structure

ELM-PS

ELM-PS Specifications	
Shape:	indrica
Outer Diameter:	eters feet
Inner Diameter:	eters feet
Length:	eters feet
Mass:	18,490 pounds
Number of Racks:	racks
Power Required:	kW D
Environment	
*Temperature:	to de rees e sius to de rees Fahrenheit
*Humidity:	to
Design Life:	More than ears

The ELM-PS will be attached to the zenith port on top of the Harmony Node 2 module on STS-123's fourth flight day. The ELM-PS will remain attached to the Harmony module until the Kibo PM is delivered to the ISS on the following space shuttle mission, STS-124. The final location of the ELM-PS will be on the top port of the PM.

E M- S C

The ELM-PS will carry five Kibo subsystem racks, two experiment racks, and one stowage rack when transported to the space station on the STS-123 mission. This includes some of the Kibo subsystem racks, which must be installed in the PM before activation after its launch on the STS-124 mission.

With the exception of the Inter Orbit Communication System (ICS) –PM rack, the subsystem racks shown below (marked in red outline) are crucial to the activation of the PM.

The racks marked in blue outline house the JAXA experiments. In the SAIBO Rack, cultivation of animal cells, plants, and other microorganisms will be performed in both microgravity and simulated gravity — 0.1 G to 2 G conditions. In the RYUTAI Rack, fluid physics phenomena, solution crystallization, and protein crystallization experiments will be monitored and analyzed.

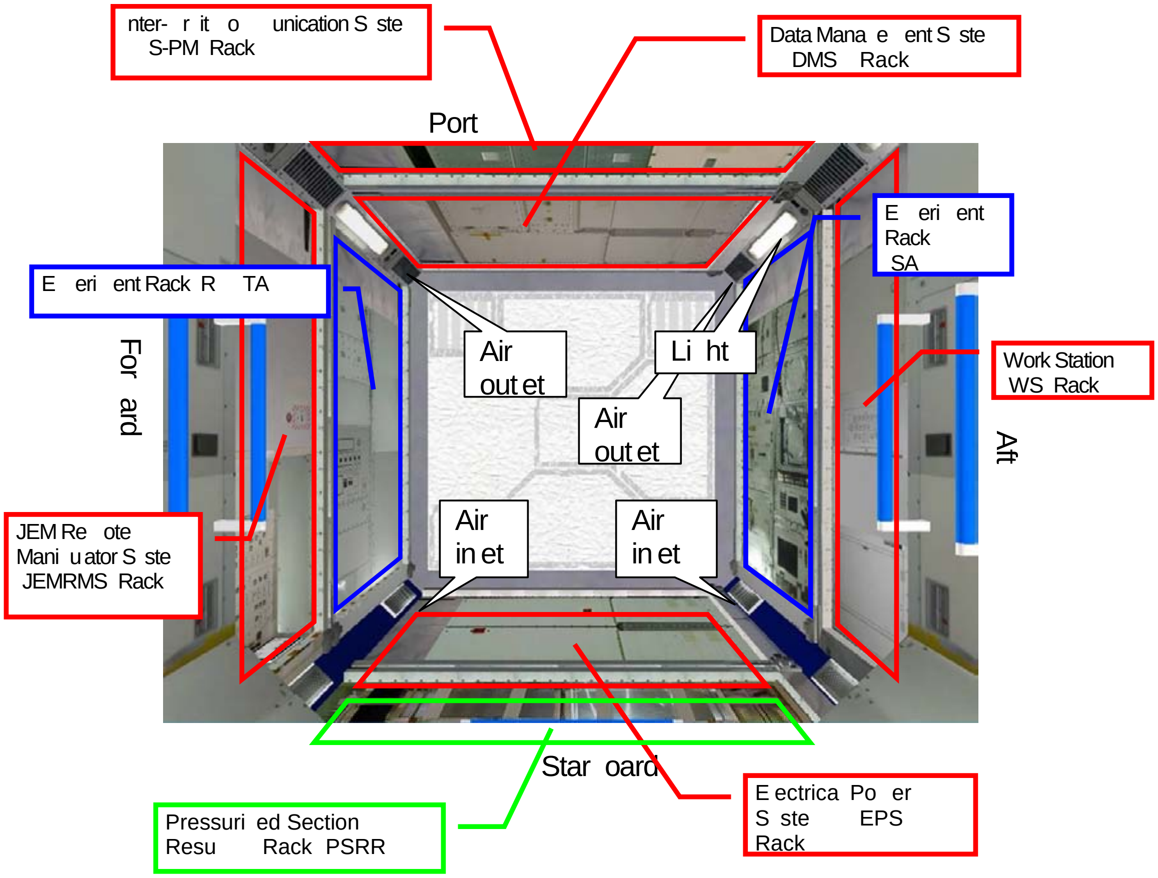
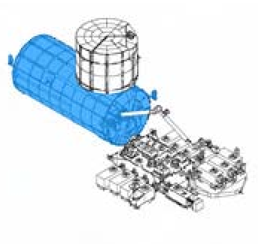


Image above shows rack locations in the ELM-PS as seen from the PM side. Subsystem racks are marked in red outline, experiment racks in blue, and a stowage rack in green.

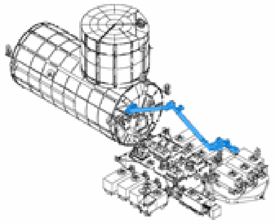
M

Pressurized Module and Japanese Experiment Module Remote Manipulator System (JEMRMS) to be launched on the STS-124/1J Mission

The Pressurized Module (PM) is 11.2 meters, or 36.7 feet in length, and 4.4 meters, or 14.4 feet in diameter. The pressurized interior of the PM is maintained at one atmosphere to provide a shirt-sleeve working environment. The ISS crew will conduct unique microgravity experiments within the PM laboratory. The PM will hold 23 racks, 10 of which are International Standard Payload Racks designed for experiment payloads. The PM will be delivered to the ISS aboard the space shuttle Discovery on the STS-124/1J mission.

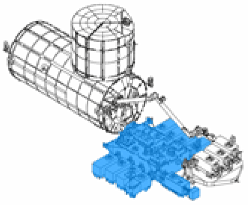


Kibo’s robotic arm, or JEMRMS, serves as an extension of the human hand and arm in manipulating experiments on the EF. The JEMRMS is composed of the Main Arm and the Small Fine Arm, which both have six articulating joints. The Main Arm is used for exchanging EF payloads and for moving large items. The Small Fine Arm, which attaches to the end of the Main Arm, is used for more delicate tasks. The crew will operate these robotic arms from the JEMRMS Console located in the PM. The JEMRMS will be launched, along with the PM, to the ISS aboard the space shuttle Discovery on the STS-124/1J mission.

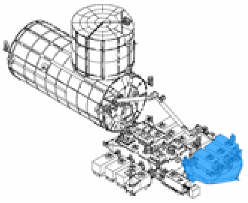


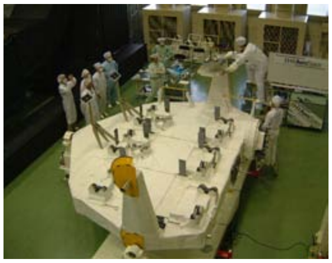
Exposed Facility and Experiment Logistics Module-Exposed Section to be launched on the STS 127/2J/A Mission

The EF provides a multipurpose platform where ten science experiment and system payloads can be deployed and operated in the unpressurized environment of space. The experiment payloads attached to the EF will be exchanged using the JEMRMS. The EF will be delivered to the ISS aboard the space shuttle Endeavour on the STS-127/2J/A mission.



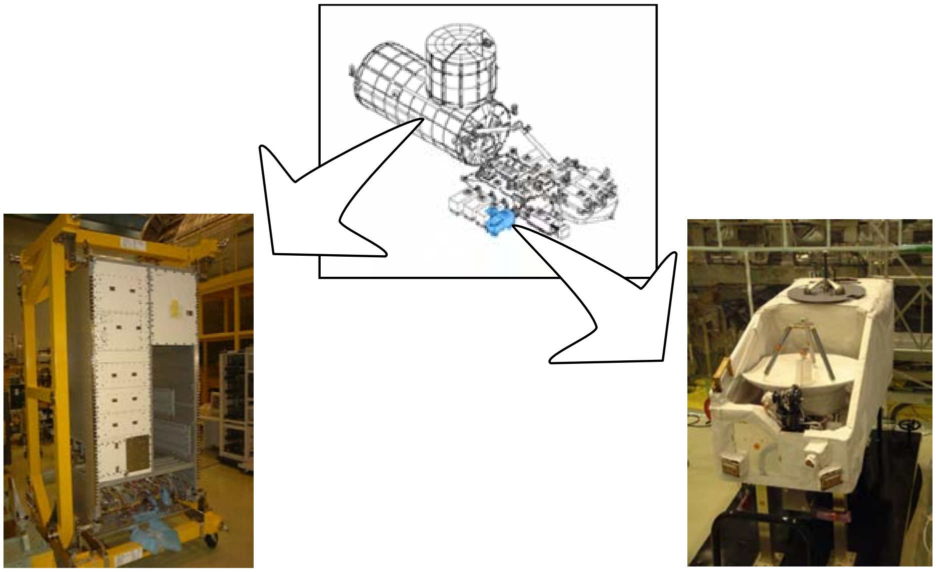
The ELM-ES is attached to the end of the EF and provides a storage space for EF experiment payloads and samples. Up to three experiment payloads can be stored on the ELM-ES. The ELM-ES will be launched, along with the EF and ICS-EF, to the ISS aboard the space shuttle Endeavour on the STS-127/2J/A mission.





Kibo will be capable of independent communications with Tsukuba Space Center (TKSC) once the ICS is installed in both the PM and EF, and fully activated. Through JAXA's Data Relay Test Satellite (DRTS), commands and voice are uplinked from the ground to Kibo, and experiment data, image data or voice are downlinked from Kibo to the ground for scientific payload operations. The ICS-EF has an antenna and a pointing mechanism that will be used to communicate with the DRTS.

The ICS-EF will be launched, along with the EF and ELM-ES, to the ISS aboard the space shuttle Endeavour on the STS-127/2J/A mission, while the Inter-Orbit Communication System -PM Rack will be delivered to the ISS on STS-123/1J/A and installed in the PM during STS-124/1J.



S-PM Rack

S-EF Subsystem S-EF

I O MISSION CONTRO CENTER

After the Kibo element components are fully assembled and activated aboard the ISS, full-scale experiment operations will begin.

Kibo operations will be jointly monitored and controlled from the Space Station Integration and Promotion Center at Tsukuba, in Japan, and the Mission Control Center at NASA's JSC in Houston, where the overall operations of the space station are controlled.

A A C T

The JAXA Flight Control Team (JFCT) consists of flight directors and more than 50 flight controllers assigned to 10 technical disciplines required to support Kibo flight operations. The flight director oversees and directs the team, and the flight controllers possess specialized expertise on all Kibo systems. The team will monitor and control Kibo around the clock in a three-shift per day schedule.

Once operational, the JFCT will monitor the status of command uplinks, data downlinks, system payloads and experiments aboard Kibo. The JFCT will have the capability to make real-time changes to operations, and can communicate directly with the crew aboard Kibo and the various international partner mission control centers located around the world. The team will troubleshoot problems or anomalies that may occur aboard the Kibo during flight operations.

Kibo Mission Control Room

The JFCT organizes and conducts mission-specific training that accurately simulates actual Kibo flight operations. The team is responsible for the preparation and evaluation of all plans and procedures that will be performed by the crew aboard Kibo, and by controllers on the ground. In addition, the JFCT regularly conducts contingency training for all certified flight controllers, and candidate flight controllers.

The roles of the respective sections of JFCT are as follows:

A A

JAXA Flight Director (J-FLIGHT) is the leader of the JFCT. J-FLIGHT will direct the overall operation of Kibo, including operations planning, system and experiment operations, and other tasks performed by the crew aboard Kibo.

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.

Mayumi Matsuura will serve as the lead J-FLIGHT for the STS-123/1J/A mission, and will direct the ELM-PS related operations during the 1J/A stage.


[redacted]

Lead J-FLIGHT for STS-123
Mayumi Matsuura

C N S E ICS C

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

T

Fluid and Thermal officer (FLAT) is responsible for monitoring the status of the Environmental Control and Life Support System and the Thermal Control System which regulate the heat generated by the equipment aboard Kibo. These systems will be monitored through telemetry data downlinked from Kibo on a real-time basis.

R

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

O

Operations Planner (J-PLAN) is responsible for planning the actual flight operations. When Kibo is in a flight operations status, J-PLAN will monitor the status and progress of Kibo operations and, if necessary, will amend or modify the operation plans as required.

S E I I

System Element Investigation and Integration officer (SENIN) is responsible for Kibo's system elements. SENIN will monitor and ensure that each Kibo system is running smoothly and will integrate all systems information provided by each flight control section.

T C

Tsukuba Ground Controller (TSUKUBA GC) 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.

EM C

JEM Communicator (J-COM) is responsible for voice communications with the crew aboard Kibo. J-COM will communicate all essential information to the crew for operating Kibo systems and experiments, and/or respond to Kibo-specific inquiries from the crew. JAXA Astronaut Naoko Yamazaki (who is also assigned as the Crew Support Astronaut for STS-123 Mission Specialist Takao Doi) will serve as a J-COM officer during the STS-123 mission.

JAXA astronaut Naoko Yamazaki will serve as a J-COM officer during the STS-123 mission.

Astronaut Related Intravehicle Activity and Equipment Support

Astronaut Related Intravehicular Activity (IVA) and Equipment Support (ARIES) is responsible for Intra-Vehicular Activity (IVA) operations aboard Kibo. ARIES will manage the tools and other IVA-related support equipment on Kibo.

JEM Payload officer

JEM Payload Officer (JEM PAYLOADS) is responsible for Kibo's experiment payload operations, and will coordinate payload activities with the Primary Investigators of each respective experiment.

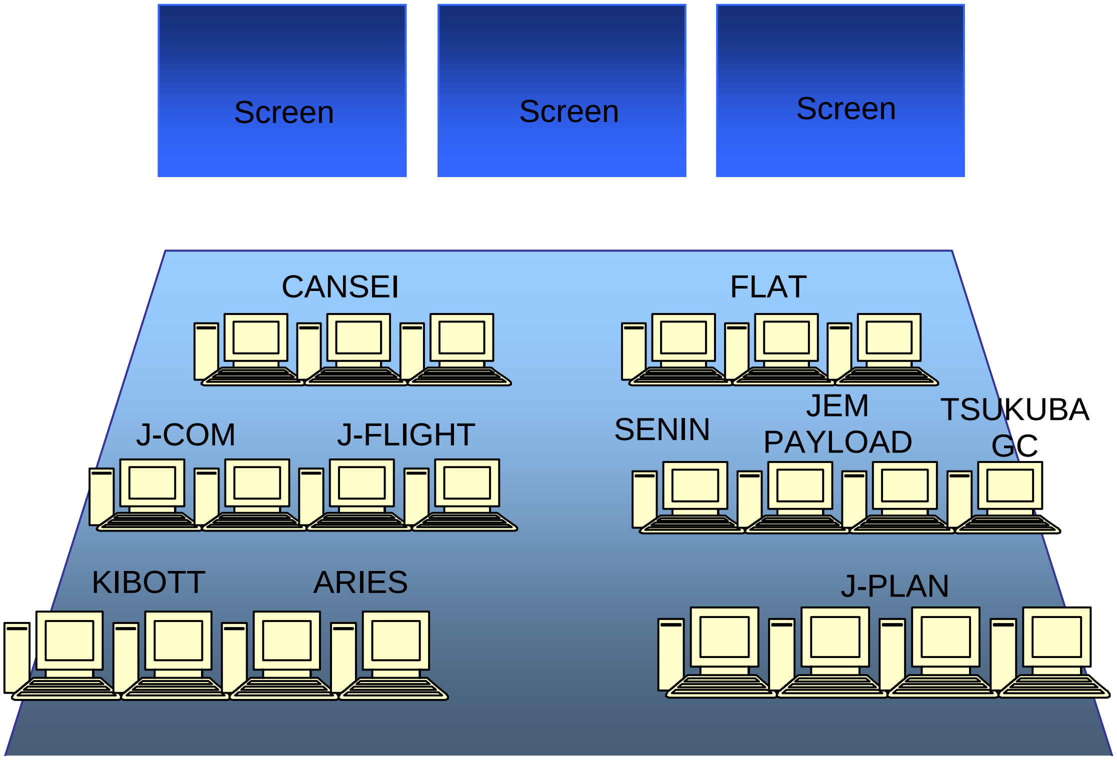
JAXA Extravehicular Activity

JAXA Extravehicular Activity (JAXA EVA) is responsible for Kibo-related EVA operations and will provide technical support to the crew members who perform Kibo-related spacewalks.

Note: The JAXA EVA console will not be located in the Space Station Operations Facility at the Tsukuba Space Center. Instead, the JAXA EVA flight controllers will be stationed at the NASA JSC.

JEM Engineering Team

The JEM Engineering Team (JET) is responsible for providing technical evaluation of real-time data and pre- and post-flight analysis. JET consists of the JET lead and electrical subsystem, fluid subsystem and IVA engineers who are 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.



JEM Mission Control Room

TSUKUBA SPACE CENTER

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

S S T

Comprehensive Kibo system 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: PM, EF, ELM-PS and ELM-ES and JEM-RMS. In addition, subsystems, payloads, and ground support equipment were all tested in this building. Once Kibo operations begin aboard the ISS, engineering support will be provided from this building.

S E

The following activities are conducted in the Space Experiment Laboratory (SEL) building:

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

A T

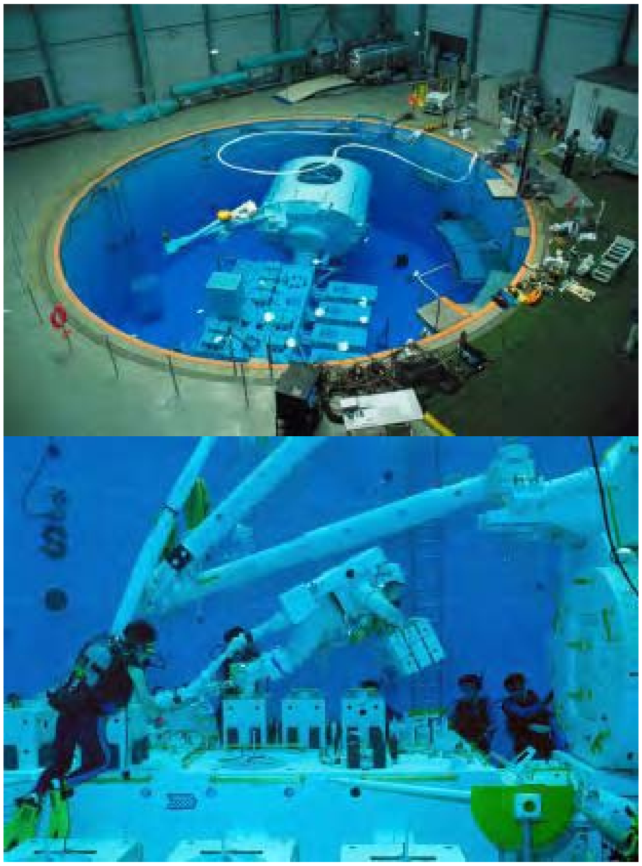
The following activities are conducted in the Astronaut Training Facility (ATF) building:

- JAXA astronaut candidate training
- Astronaut training and health care

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

W E T

The Weightless Environment Test Building (WET) facility provides a simulated weightless environment, using water buoyancy, for astronaut training. Design verification tests on various Kibo components, and development of preliminary spacewalk procedures, were conducted in this facility.



S S I C

SPACE STATION INTEGRATION AND PROMOTION CENTER

The Space Station Integration and Promotion Center is responsible for controlling Kibo operations. At the center, operation of Kibo systems and payloads are supervised and Kibo operation plans are prepared in cooperation with NASA's Mission Control Center and Payload Operation Integration Center.

The center is responsible for the following:

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

The center consists of the following sections:

M C R

The Mission Control Room (MCR) provides real-time Kibo support on a 24-hour basis. This includes monitoring the health and status of Kibo's operating systems, payloads, sending commands, and real-time operational planning.

O A

The User Operations Area (UOA) distributes the status of Japanese experiments and provides collected data to the respective users that are responsible for the experiments and the subsequent analysis.

O R

The Operations Planning Room (OPR) is responsible for the planning of on 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 tandem with the MCR, the User Operations Area and NASA.

O R R

The Operations Rehearsal Room (ORR) provides training for flight controllers, and conducts integrated rehearsals and joint simulations with NASA.

E S R

The Engineering Support Room (ESR) provides engineering support for Kibo operations. In this room, the JEM Engineering Team (JET) monitors the data downlinked to the MCR from Kibo, and provides engineering support as required.

JAPANESE EXPERIMENTS DURING THE 1J/A STAGE

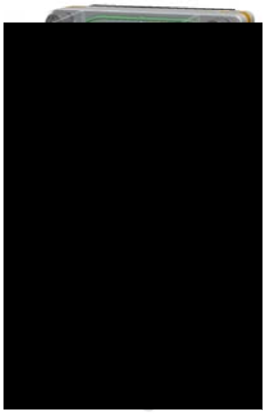
CE WA RESIST WA

Supported by NASA and ESA, JAXA's life science experiment will be performed on board the ISS during the 1J/A Stage. The experiment combines two research themes entitled CELL WALL and RESIST WALL.

Seeds of thale cress, or "mouse-ear cress" — Arabidopsis thaliana — will be launched to the ISS on the STS-123 mission. Using ESA's cultivation chamber, "European Modular Cultivation System: EMCS" located in the Columbus module, half of the seeds will be grown in a microgravity condition and the other half will be grown in an artificial 1G gravity condition. The stems of the thale cress will be collected into sample collection tubes when the stems have grown to 10 cm in height, approximately 43 days after initiation of incubation, and then, will be returned to the ground on the STS-124 mission.

The goal of this research is to uncover the molecular mechanism in plants that are assumed to be regulated by earth's gravitational force, and/or verify the gravity resistance mechanism, which is assumed to be an essential response for plants to develop against the force of gravity on earth.

Thale cress, a.k.a mouse-"ear cress"



PCC and EC (Plant Cultivation Chamber and Experiment Container)

Sample collection tube

A A AEROS ACE O EN A RO RAM

JAXA has been conducting the Aerospace Open Lab Program since June 2004. This program is one of JAXA's space development support measures, aiming for establishing a foundation for easier access to the current or future space development programs. Currently, 25 joint research projects are ongoing as part of the program.

Development of clothing for astronauts aboard spacecraft, known as "crew cabin clothing," is one of the research themes. This research is run by the "Near-Future Space-Living Unit" group led by Prof. Yoshiko Taya of Japan Women's University.

Shirt with short sleeves

The goal of this research group is to develop crew cabin clothing that meets the safety requirements for spaceflight, and that ensures the following functions:

- Thermal comfort
- Cleanliness
- Mobility
- Beautiful clothing contour
- Lightweight and compact design

Clothing developed by this research group will be launched aboard STS-123. During the mission, JAXA astronaut Takao Doi will wear the various clothing types developed by the group to evaluate the comfort and functionality of the clothing.

The group has developed clothing materials with the following properties required for crew cabin clothing:

- Heat insulation
- Water-absorption
- Quick evaporation
- Antibacterial
- Odor elimination
- Antistatic
- Antifouling
- Soft and comfortable to skin

In addition to those properties, non-sewing technology has given the clothing softness and wearable comfort. Cutting technology has improved the way the clothing fits and moves as the crew works in space.

The group has also developed a hook & loop fastener with fire retardant properties and fabricated with soft touch materials.

Shorts

DEXTRE CANADIAN ROBOTICS FOR THE INTERNATIONAL SPACE STATION

Dextre is the third and final component of the Mobile Servicing System developed by Canada for the ISS. The two-armed Special Purpose Dexterous Manipulator, known as "Dextre," complements the mobile base and the robotic arm Canadarm2 already installed and operating on the station. These make the MSS a vital tool for external station maintenance. With advanced stabilization and handling capabilities, Dextre can perform delicate human-scale tasks such as removing and replacing small exterior components. Operated by crew members inside the station or by flight controllers on the ground, it also is equipped with lights, video equipment, a stowage platform, and three robotic tools.

The Special Purpose Dexterous Manipulator can perform delicate human-scale tasks such as removing and replacing small exterior components.

The technology behind Dextre evolved from its famous predecessor Canadarm2. Dextre is the world's first on-orbit servicing robot with an operational mission, and it lays the foundation for future satellite servicing and space exploration capabilities.

W C

While one arm is used to anchor and stabilize the system, the other can perform fine manipulation tasks such as removing and replacing station components, opening and closing covers, and deploying or retracting mechanisms. Dextre can either be attached to the end of Canadarm2 or ride independently on the Mobile Base System. To grab objects, Dextre has special grippers with built-in socket wrench, camera, and lights. The two pan/tilt cameras below its rotating torso provide operators with additional views of the work area.

Currently, astronauts execute many tasks that can only be performed during long, arduous, and potentially dangerous spacewalks. Delivery of this element increases crew safety and reduces the amount of time that astronauts must spend outside the station for routine maintenance. They should therefore have more time for scientific activities.

Some of the many tasks Dextre will perform include:

- Installing and removing small payloads such as batteries, power switching units, and computers
- Providing power to payloads
- Manipulating, installing, and removing scientific payloads

A typical task for Dextre would be to replace a depleted battery (100 kg, 220 pounds) and engage all the connectors. This involves bolting and unbolting, as well as millimetre-level positioning accuracy for aligning and inserting the new battery.

I R S

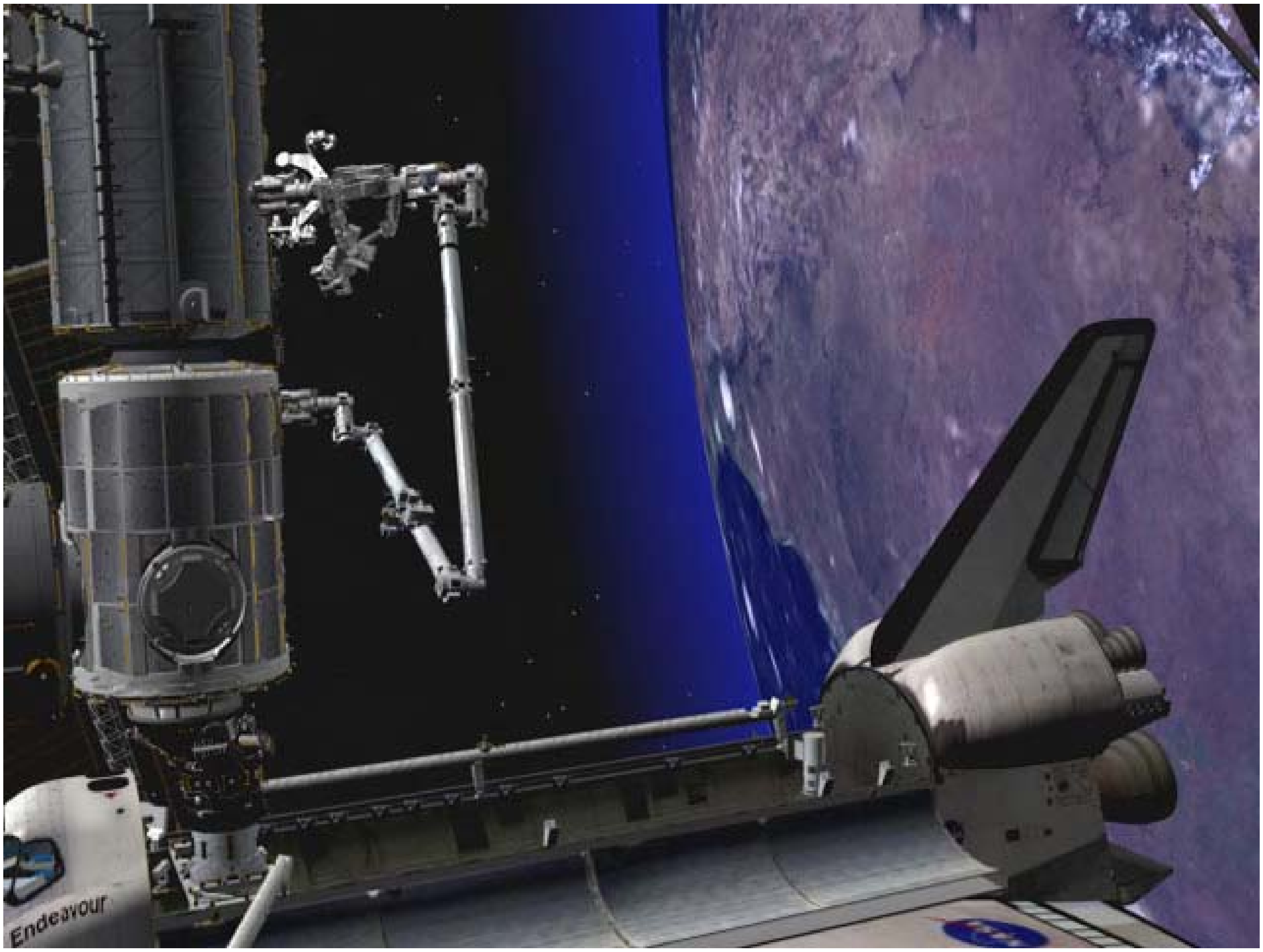
This kind of task demands high precision and a gentle touch. To achieve this, Dextre has a unique technology: precise sensing of the forces and torque in its grip with automatic compensation to ensure the payload glides smoothly into its mounting fixture. Dextre can pivot at the waist, and its shoulders support two identical arms with seven offset joints that allow for great freedom of movement. The waist joint allows the operator to change the position of the tools, cameras, and temporary stowage on the lower body with respect to the arms on the upper body. Dextre is designed to move only one arm at a time for several reasons: to maintain stability, to harmonize activities with Canadarm on the shuttle and Canadarm2 on the station and to minimize the possibility of self-collision.

At the end of each arm is an orbital replacement unit/tool changeout mechanism, or OTCM — parallel jaws that hold a payload or tool with a vice-like grip. Each OTCM has a retractable motorized socket wrench to turn bolts and mate or detach mechanisms, as well as a camera and lights for close-up viewing. A retractable umbilical connector can provide power, data, and video connection feed-through to payloads.

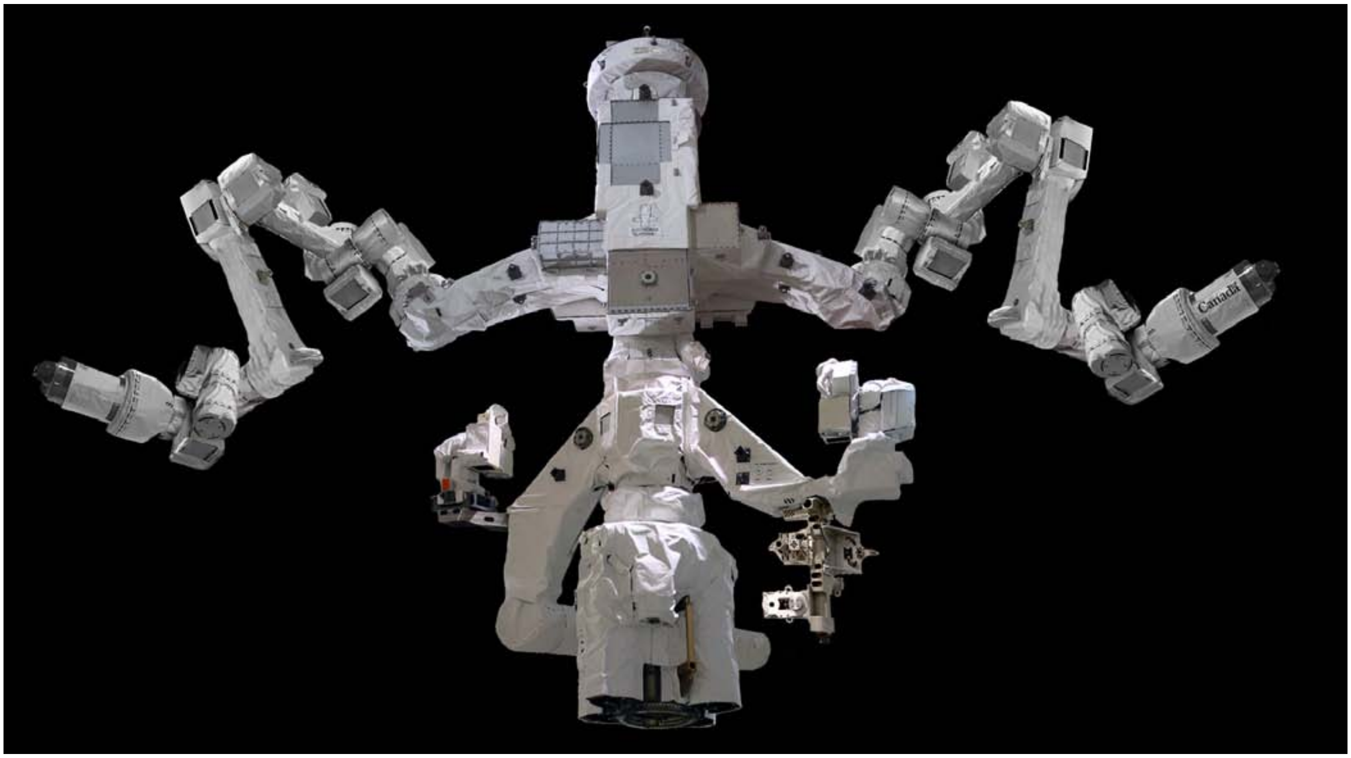
From a workstation aboard the station, astronauts can operate all the Mobile Servicing System components, namely Canadarm2, the mobile base, and Dextre. To prepare for operating each component, astronauts and cosmonauts undergo rigorous training at the Canadian Space Agency's Operations Engineering Training Facility at the John H. Chapman Space Centre in Longueuil, Quebec.

C C I S S

Renowned for its expertise in space robotics, Canada's contribution to the ISS — a unique collaborative project with the United States, Japan, Russia and several European nations — is the Mobile Servicing System. Combining two robotic elements and a mobile platform, they are designed to work together or independently. The first element, Canadarm2, whose technical name is the Space Station Remote Manipulator System, was delivered and installed by Canadian Space Agency astronaut Chris Hadfield in 2001. The mobile base system was added to the station in 2002. Dextre launches aboard space shuttle Endeavour on flight STS-123.



This image illustrates Dextre working at the end of the station's Canadarm2.



Dextre can pivot at the waist and its shoulders support two identical arms with seven offset joints that allow for great freedom of movement.

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For more information, visit:

http://www.space.gc.ca

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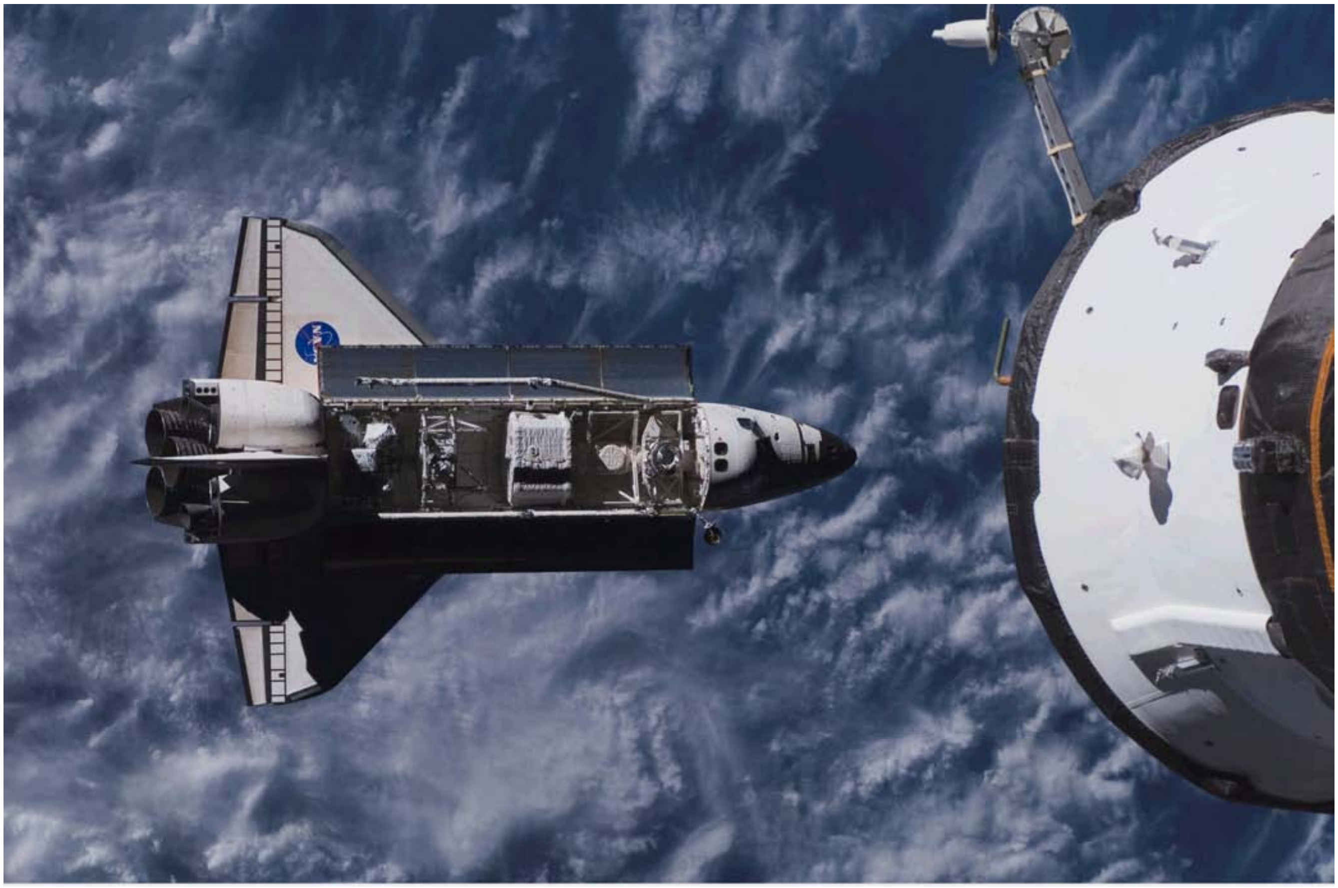
RENDEZVOUS AND DOCKING



Backdropped by a blue and white Earth, space shuttle Endeavour approaches the International Space Station during STS-118 rendezvous and docking operations. A Russian spacecraft, docked to the station, can be seen in the right foreground.

Rendezvous begins with a precisely timed launch of the shuttle on the correct trajectory for its chase of 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. Endeavour will cover the final miles to the station during the next orbit.

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

Commander Dominic Gorie, with help from Pilot Gregory H. Johnson and other crew members, will manually fly the shuttle for the remainder of the approach and docking.

Gorie will stop Endeavour about 600 feet below the station. Once he determines there is proper lighting, he will maneuver the shuttle through a nine-minute back flip 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 will use digital cameras with 400 mm and 800 mm lenses to photograph Endeavour’s upper and bottom surfaces through windows of the Zvezda Service Module. The 400 mm lens provides up to 3 inch resolution and the 800 mm lens up to 1 inch resolution.

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 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 back flip, it will be back where it started, with its payload bay facing the station.

This image illustrates space shuttle Endeavour docking with the International Space Station.

Gorie 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 dock at the Pressurized Mating Adaptor 2 at the forward end of the Harmony module.

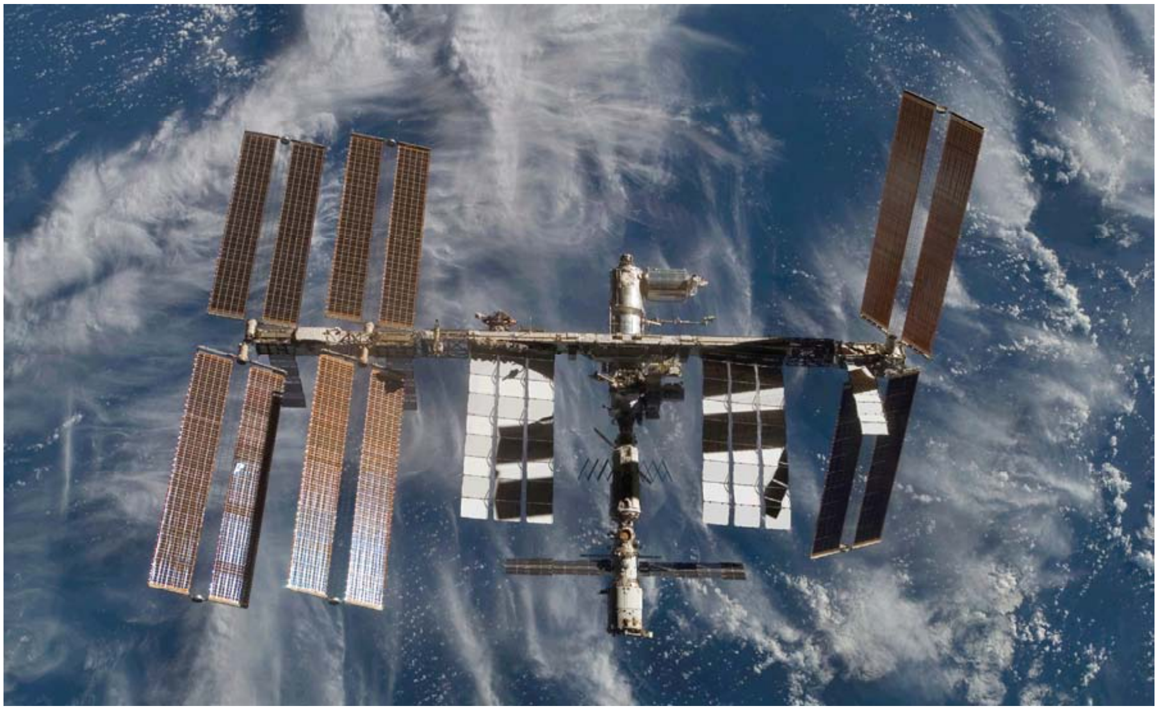
The shuttle crew members operate laptop computers processing the navigational data, the laser range systems and Endeavour's docking mechanism.

Using a video camera mounted in the center of the Orbiter Docking System, Gorie will line up the docking ports of the two spacecraft. If necessary, he will pause 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. He 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.



Backdropped by Earth, the International Space Station is seen from space shuttle Atlantis as the two spacecraft begin separation and the STS-122 mission nears its completion.

UNDOCKING, SEPARATION AND DEPARTURE

At undocking, hooks and latches will be opened and springs will push Endeavour away from the station. The shuttle'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, Johnson will turn the steering jets on and will manually fly Endeavour in a tight corridor as the shuttle moves away from the station.

Endeavour will move away about 450 feet. Then, if propellant and time permit, Johnson will begin to fly the shuttle around the station and its new laboratory. Once Endeavour completes 1.5 revolutions of the station, Johnson will fire Endeavour's jets to leave the area.

This image depicts space shuttle Endeavour undocking from the station following the STS-123 mission.

SPACEWALKS

Five spacewalks performed by four of STS-123's astronauts will help install the Japanese ELM-PS and assemble Dextre, the SPDM.

Spacewalkers also will demonstrate a space shuttle heat shield repair technique, using the Tile Repair Ablator Dispenser (T-RAD), similar to a caulk gun. Foreman and Behnken will use the T-RAD to mix a goo-like substance known as STA-54 and extrude it into holes in several demonstration tiles. They will smooth the material by tamping it with foam-tipped tools. The repaired samples will be stowed in Endeavour's cargo bay for return to Earth, where they will undergo extensive testing.

STS-123's spacewalks will occur on flight days 4, 6, 8, 11, and 13.

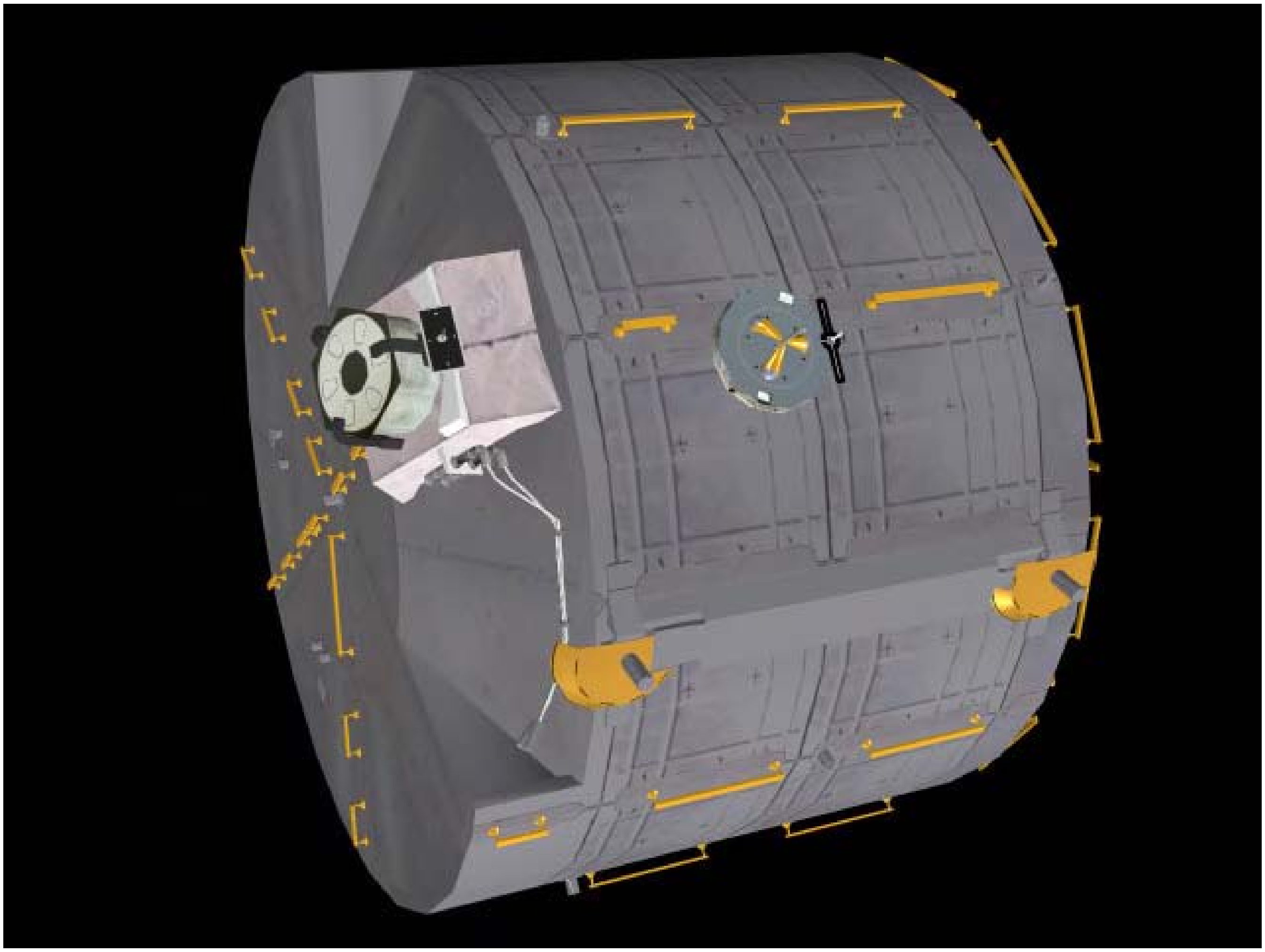
This image illustrates the station's robotic arm grappling the Orbiter Boom Sensor System in preparation for its temporary stowage on the station's S1 truss.

Veteran Rick Linnehan is the mission's lead spacewalker. He conducted three spacewalks in March 2002 during STS-109, the fourth Hubble Space Telescope servicing mission. Linnehan will conduct the first three excursions with three different first-time spacewalkers — Garrett Reisman, Mike Foreman and Robert L. Behnken.

Behnken and Foreman will perform the two final spacewalks, including the heat shield repair demonstration.

The spacewalkers will be identifiable by various markings on their spacesuits. Linnehan will wear the suit bearing solid red stripes. Reisman will wear an all-white spacesuit. Foreman's suit will be distinguished by broken horizontal red stripes, and Behnken's suit will be marked with a diagonal candy cane stripe.

Each spacewalk will start from the station's Quest airlock. The astronauts will prepare by using the campout prebreathe protocol, spending the night before the spacewalk in the airlock. The prebreathe exercise purges nitrogen from the astronauts' systems to prevent decompression sickness, also known as "the bends."



This image depicts the Kibo Japanese Experiment Module that will be installed on the International Space Station during the STS-123 mission.

Mission Specialists Rick Linnehan and Garrett Reisman will conduct the first of the mission's five scheduled spacewalks.

During the campout, the spacewalking crew members isolate themselves in the airlock. The airlock's air pressure is lowered to 10.2 pounds per square inch (psi) while the station is kept at 14.7 psi, or near sea-level pressure. When they wake up, the astronauts don oxygen masks, and the airlock's pressure is raised to 14.7 psi for an hour. After breakfast, the pressure is lowered back to 10.2 psi for an additional hour as the astronauts don their spacesuits. An additional 30 minutes in the suits completes the protocol. The campout procedure enables spacewalks to begin earlier in the crew's day than before the protocol was adopted.

EVA-1

EV1: Linnehan

EV4: Reisman

IV: Foreman

Behnken and Eyharts will operate the station's robotic arm

Duration: 6.5 hours

EVA Operations:

- Prepare the ELM-PS for un erthin fro a oad a
  - Open the Centerline Berthing Camera System on top of the Harmony module. The system provides live video to assist with docking spacecraft and modules together
  - Remove Passive Common Berthing Mechanism, the round flange which can attach to another spacecraft or module. Disconnect the launch-through-activation cables
- Install both the Orbital Replacement Unit (ORU) tool change out mechanisms on Dextre.

EVA-2

EV1: Linnehan

EV3: Foreman

IV: Behnken

Duration: 7 hours

EVA Operations:

Assemble Dextre, removing covers and installing arm components.

Mission specialists Rick Linnehan and Mike Foreman will conduct the second spacewalk on flight day 6.

EVA-3

EV1: Linnehan

EV2: Behnken

IV: Foreman

Duration: 6.5 hours

EVA Operations:

- Outfit Dextre
    1. Install the ORU and tool platform/tool holder assembly
    2. Install the Camera Light Pan Tilt Assembly (CLPA)
    3. Remove the cover
- Prepare the Spacelab Logistics Pallet for landing
- Move the MISSE 6 experiment to the Columbus module
- Transfer a spare Canadarm2 yaw joint
- Transfer two spare Direct Current Switching Units

Mission specialists Rick Linnehan and Robert Behnken will conduct the mission's third spacewalk scheduled for flight day 8.

EVA-

EV2: Behnken

EV3: Foreman

IV: Linnehan

Duration: 6.5 hours

EVA Operations:

- Replace a failed Remote Power Controller Module on the station's truss
- T-RAD Detailed Test Objective (DTO) 848, the heat shield repair demonstration

Mission specialists Robert Behnken and Mike Foreman will conduct the mission's final two spacewalks on flight days 11 and 13.

EVA-

EV2: Behnken

EV3: Foreman

IV: Linnehan

Duration: 6.5 hours

EVA Operations:

- Transfer the OBSS to a temporary stowage location on the S1 truss.
- Install ELM-PS trunnion covers
- Reinstall Trundle Bearing Assembly No. 5 in the starboard SARJ
- Release launch locks on Harmony's port and nadir Common Berthing Mechanisms
- Remove additional covers from the starboard SARJ and perform inspections, capture digital photography and perform debris collection

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EXPERIMENTS

DETAILED TEST OBJECTIVES

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

DTO 848 Tile Repair Ablator Dispenser

The primary purpose of the detailed test objective is to evaluate the Shuttle Tile Ablator-54 (STA-54) material and a tile repair ablator dispenser in a microgravity and vacuum environment for their use as a space shuttle thermal protection system repair technique.

Spacewalkers Robert Behnken and Mike Foreman on flight day 11 will set up for the test on the outside of the Destiny lab.

The Tile Repair Ablator Dispenser (T-RAD) is similar to a caulk-gun. Both spacewalkers will use the T-RAD to mix and extrude the STA-54 material into holes in several demonstration tiles. The spacewalkers will watch for swelling of the material and work it in until it is smooth by tamping the material with foam-tipped tools.

The repaired samples and tools will be stowed in Endeavour's cargo bay for return to Earth. The samples will undergo extensive testing on the ground.

DTO 853 In-Flight Evaluation for Areas of CO_2 Concentration

The purpose of the DTO is to evaluate carbon dioxide (CO_2) levels at specific times during the mission and in shuttle areas that have the potential to contain elevated levels. The DTO is being carried out over four missions: STS-118, STS-120, STS-122 and STS-123. During the missions, the data will be collected over a period of five days, during similar time periods and in similar locations.

The CO_2 levels will be recorded using the Carbon Dioxide Monitor (CDM) – a portable handheld device designed to monitor and quantify CO_2 concentrations.

The test was prompted by the STS-121 and STS-115 mission crews who reported experiencing stuffiness and headaches while sleeping in the middeck area. The symptoms are believed to most likely result from exposure to high levels of CO_2.

For the reported times during STS-121 and STS-115, the CO_2 levels within the crew module, as indicated by the vehicle instrumentation, were within the acceptable range. Additionally, for the course of the docked phase, the CO_2 levels in the shuttle tracked well with the levels in the station. The station crew did not report any symptoms.

Data sampling locations for the test are dependent upon crew sleep locations and high activity locations because the post-sleep activity period and high activity periods are the times when CO_2 symptoms were reported by the two crews.

During the upcoming four missions, the crews will place the CDM in the middeck before they go to sleep so that ground controllers can monitor CO_2 levels continuously. The information will be used to identify CO_2 "hot spots" within the shuttle.

As a result, engineering evaluations will be made to fine-tune air exchange analyses, to determine if any configuration changes are necessary to optimize airflow and to determine if operational improvements are needed or if crew exposure time in identified areas should be limited.

CDM technology was successfully used to determine the existence of CO_2 pockets on the space station. The kit that will be used on the shuttle will include the CDM, filters and several battery packs. The CDM is capable of monitoring CO_2 in a localized area for either long or short durations of time, depending on the operating mode.

TO 80 C
I

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

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

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

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

SHORT- RATION RESEARCH

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:

// / / /
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or

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Detailed information is located at:

// / / /
/ /

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 their immune systems.

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 shuttle fires its engines at night or twilight. A telescope and all-sky imagers will take images and data while the shuttle flies over the Maui site. The images will be analyzed to better understand the interaction between the spacecraft plume and the upper atmosphere.

Test of Midodrine as a Countermeasure Against Post-Flight Orthostatic Hypotension (Midodrine) is a test of the ability of the drug midodrine to reduce the incidence or severity of orthostatic hypotension. If successful, the drug will be employed as a countermeasure to the dizziness caused by the blood-pressure decrease that many astronauts experience upon returning to the Earth's gravity.

Bioavailablity and Performance Effects of Promethazine during Spaceflight (PMZ) will examine the performance-impacting side-effects of promethazine and its bioavailability – the degree to which a drug can be absorbed and used by the parts of the body on which it is intended to have an effect. Promethazine is a medication taken by astronauts to prevent motion sickness.

Sleep-Wake Actigraphy and Light Exposure during Spaceflight - Short (Sleep-Short) will examine the effects of spaceflight on the sleep-wake cycles of the astronauts during shuttle missions. Advancing state-of-the-art technology for monitoring, diagnosing and assessing treatment of sleep patterns is vital to treating insomnia on Earth and in space.

Rigidizable Inflatable Get-Away-Special Experiment (RIGEX) operates in the space shuttle cargo bay and is designed to test and collect data on inflated and rigid structures in space. Inflatable tubes will be heated and cooled to form structurally stiff tubes. It will operate in the U.S. Department of Defense's (DoD) Canister for All Payload Ejections, also known as CAPE.

S R ISS STS-123

Nutritional Status Assessment (Nutrition) is NASA's most comprehensive in-flight study 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. The experiment also will help to understand the impact of countermeasures – exercise and pharmaceuticals – on nutritional status and nutrient requirements for astronauts.

Neuroendocrine and Immune Responses in Humans During and After Long Term Stay at ISS (Immuno) provided an understanding for the development of pharmacological tools to counter unwanted immunological side effects during long-duration missions in space. The aim of this experiment was to determine changes in stress and immune responses, during and after a stay on the space station. This experiment will help better understand the coupling between stress and the functioning of the immune system.

Waving and Coiling of Arabidopsis Roots at Different g-levels (WAICO)l studied the interaction of circumnutation (the successive bowing or bending in different directions of the growing tip of the stems and roots) and gravitropism (a tendency to grow toward or away from gravity) in microgravity and 1-g of *Arabidopsis thaliana* (commonly known as thale cress). This experiment flew on STS-122 and was sponsored by the European Space Agency.

A Comprehensive Characterization of Microorganisms and Allergens in Spacecraft (SWAB) used advanced molecular techniques to comprehensively evaluate microbes on board the space station, including pathogens (organisms that may cause disease). It tracked changes in the microbial community as spacecraft visit the station and new station modules are added. This study allowed an assessment of the risk of microbes to the crew and the spacecraft.

E ISS

The Reverse Genetic Approach to Exploring Genes Responsible for Cell Wall Dynamics in Supporting Tissues of Arabidopsis Under Microgravity Conditions and Role of Microtubule-Membrane-Cell Wall Continuum in Gravity Resistance in Plants (CWRW) is a pair of investigations that will explore the molecular mechanism by which the cell wall (rigid outermost layer) construction in Arabidopsis thaliana (a small plant of the mustard family) is regulated by gravity. The second will determine the importance of the structural connections between microtubule, plasma membrane, cell wall as the mechanism of gravity resistance. The results of these investigations will support future plans to cultivate plants on long-duration exploration missions.

BCAT-4 (Binary Colloidal Alloy Test-4) is a follow-on experiment to BCAT-3. BCAT-4 will study ten colloidal samples. Seven of these samples will determine phase separation rates and add needed points to the phase diagram of a model critical fluid system initially studied in BCAT-3. Three of these samples will use model hard-spheres to explore seeded colloidal crystal nucleation and the effects of polydispersity, providing insight into how nature brings order out of disorder.

Lab-on-a-Chip Application Development-Portable Test System (LOCAD-PTS) is a handheld device for rapid detection of biological and chemical substances aboard the space station. Astronauts will swab surfaces within the cabin, add swab material to the LOCAD-PTS, and within 15 minutes obtain results on a display screen. The study's purpose is to effectively provide an early warning system to enable crew members to take remedial measures if necessary to protect the health and safety of those on the station.

Test of Midodrine as a Countermeasure Against Post-Flight Orthostatic Hypotension – Long (Midodrine-Long) is a test of the ability of the drug midodrine to reduce the incidence or severity of orthostatic hypotension. If successful, it will be employed as a countermeasure to the dizziness caused by the blood-pressure decrease that many astronauts experience upon returning to the Earth's gravity.

Materials International Space Station Experiment- 6A and 6B (MISSE-6A and 6B) is a test bed for materials and coatings attached to the outside of the station being evaluated for the effects of atomic oxygen, direct sunlight, radiation, and extremes of heat and cold. This experiment allows the development and testing of new materials to better withstand the rigors of space environments. Results will provide a better understanding of the durability of various materials when they are exposed to the space environment with applications in the design of future spacecraft.

A E A

Saibo Experiment Rack (Saibo) means "living cell" and is a JAXA multipurpose payload rack system that transports, stores and supports sub-rack facilities aboard the station. Saibo will support the following JAXA sub-rack facilities: Clean Bench (CB) and Cell Biology Experiment Facility (CBEF) by providing structural interfaces, power, data, cooling, water and other items needed to operate science experiments in microgravity aboard the station.

Ryutai Experiment Rack (Ryutai) means "fluid" and is a JAXA multipurpose payload rack system that transports, stores and supports sub-rack facilities aboard the station. Ryutai will support the following JAXA sub-rack facilities: Fluid Physics Experiment Facility (FPEF); Solution Crystallization Observation Facility (SCOF); Protein Crystallization Research Facility (PCRF) and the Image Processing Unit (IPU) by providing structural interfaces, power, data, cooling, water and other items needed to operate science experiments in microgravity aboard the station.

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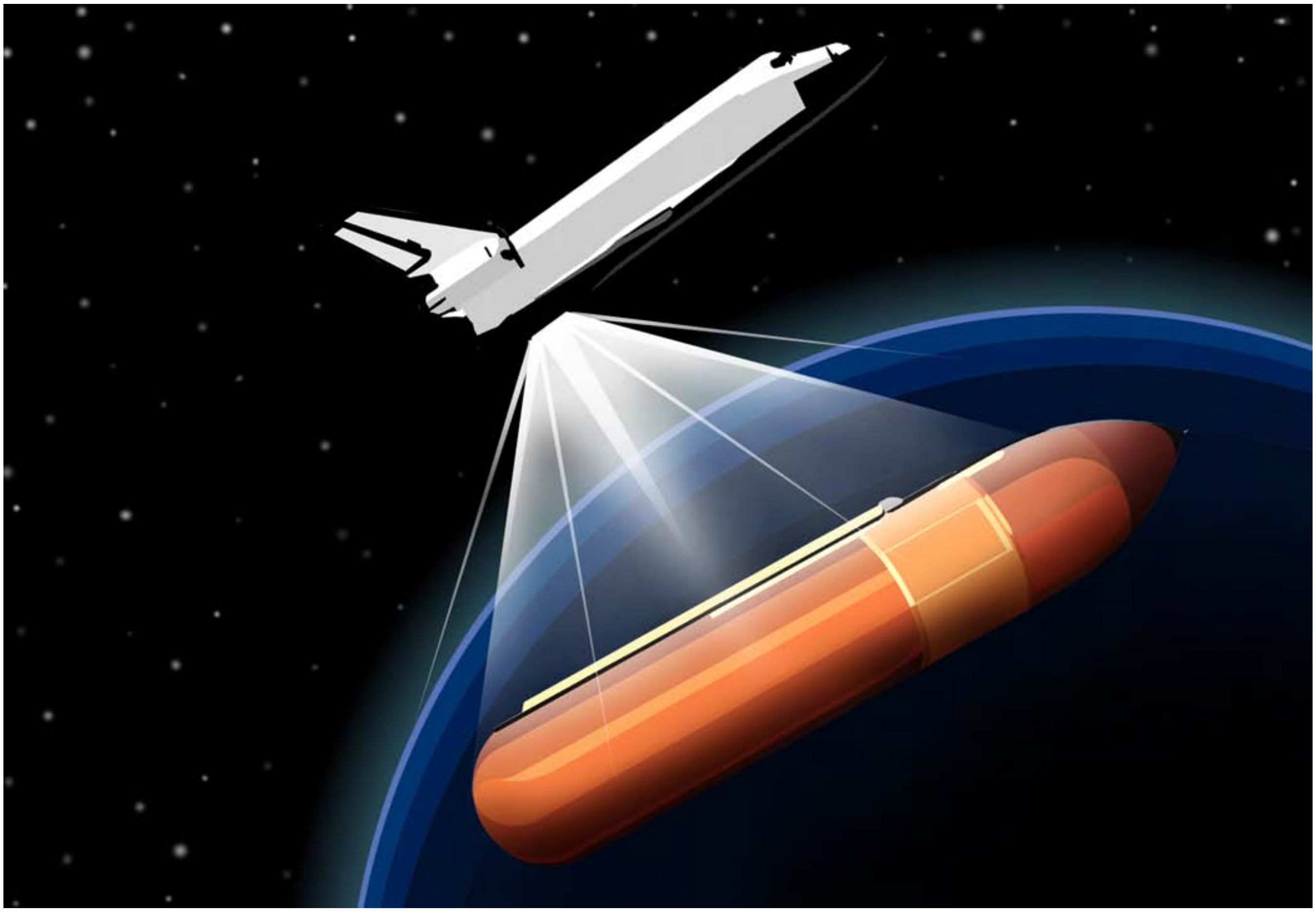
SPACE SHUTTLE CONTINUOUS IMPROVEMENT

ENDEAVOUR'S UMBILICAL WELL DIGITAL CAMERA NOW HAS FLASH CAPABILITY

A lighting system derived from an off-the-shelf flash has been added to the digital camera mounted inside one of the orbiter's umbilical wells to capture 23 illuminated photographs of the tank as it falls away from the shuttle after the main engines shut down 8.5 minutes following launch.

NASA's JSC Engineering Directorate designed and assembled the Digital Umbilical Camera Flash Module, which consists of two modified Nikon SB800 flash units, a charging power system and thermostatically controlled heaters — all mounted inside a single sealed aluminum housing measuring 5 x 9 x 13 inches. A slight modification was made by Nikon to its commercial-off-the-shelf flash units, which involved gluing the internal reflector in the optimum position to focus and project the light.



Shedding new light on space shuttle external fuel tanks takes on a new meaning beginning with Endeavour's launch on the STS-123 mission.

The flash module will provide light to enable photography of the external tank as it separates from the shuttle during darkness or heavy shadowing. The flash module, installed in the left side orbiter external tank umbilical well, begins flashing when signals are sent from the previously flown digital umbilical camera installed in the right side orbiter external tank umbilical well.

The tank separates 19 seconds after the three main engines are shutdown, and the digital camera and new flash start taking photos four seconds later. Both flash units discharge simultaneously in sync with the digital camera, once every two seconds during a 46-second period. The light from the flash will provide adequate lighting for photographs out to the required distance of 130 feet. At that distance, the tip of the external tank will have moved into the field of view, and the camera is capable of detecting damage to the tank insulation as small as 1 to 2 inches in diameter.

The digital umbilical camera system fulfilled a recommendation from the Columbia Accident Investigation Board to provide a capability to downlink high resolution images of the external tank. The digital umbilical camera takes a sequence of digital still photographs as the tank separates from the shuttle. The images are stored in camera memory and are retrieved through 130 feet of firewire cable from a laptop computer on the shuttle's flight deck set up by the crew on the first day of the mission.

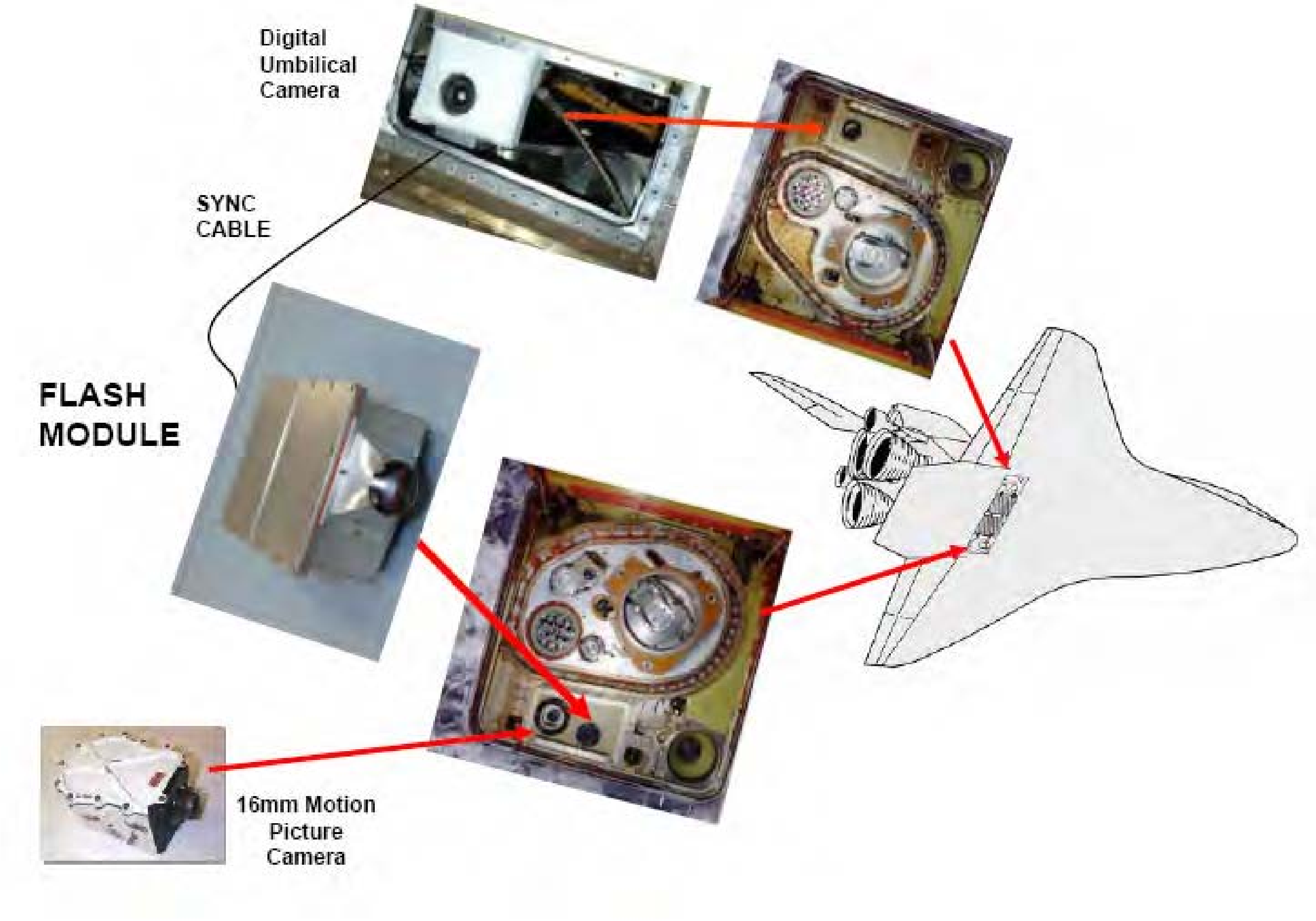
The digital images of the tank's exterior condition are transmitted to the Mission Control Center (MCC) in Houston, and External Tank Project Office in Huntsville, Ala., for analysis. Though there currently is no requirement for lighted imagery of the external tank, it is highly desirable for imagery analysis experts to review and correlate any foam loss seen during launch by ground cameras and those located on the tank itself and on the solid rocket boosters.

Prototype and qualification units were tested over the operational range of 15 to 130 feet. Johnson imagery experts then verified that the design provided sufficient light output to meet resolution requirements and determined optimal camera aperture settings for day or night. The design, fabrication and certification of four flight units cost about $1.2 million.

The new umbilical well flash will fly on remaining shuttle missions and will flash on all pictures — day or night. The camera will have different settings for day or night photography. These settings can be changed remotely from the laptop computer in the crew cabin before launch if the date slips such that the tank separation would occur in day or night, or vice versa.

The camera and flash unit are installed after the shuttle is mated to its tank in KSC's Vehicle Assembly Building. After installation, the camera, flash and image transmission are tested to ensure the system is working properly.

Expectations are that the flash will be visible in the external tank feedline camera view as the tank falls away from the shuttle after separation.



Orbiter Umbilical Cameras and Flash

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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, Kennedy Space Center, approximately 25 minutes after liftoff.

The RTLS profile is designed to accommodate the loss of thrust from one space shuttle main engine between liftoff and approximately four minutes 20 seconds, 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 Kennedy Space Center. 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 Kennedy Space Center and achieve the proper main engine cutoff conditions so the vehicle can glide to the Kennedy Space Center after external tank separation. During the downrange phase, a pitch-around maneuver is initiated (the time depends in part on the time of a space shuttle main engine failure) to orient the orbiter/external tank configuration to a heads-up attitude, pointing toward the launch site. At this time, the vehicle is still moving away from the launch site, but the space shuttle main engines are now thrusting to null the downrange velocity. In addition, excess orbital maneuvering system and reaction control system propellants are dumped by continuous orbital maneuvering system and reaction control system engine thrustings to improve the orbiter weight and center of gravity for the glide phase and landing.

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

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

T A

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.

A O

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

A O A

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.

C A

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.

A

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 on-board methods, such as cue cards, dedicated displays and display information, to determine the abort region. Which abort mode is selected depends on the cause and timing of the failure causing the abort and which mode is safest or improves mission success. If the problem is a space shuttle main engine failure, the flight crew and Mission Control Center select the best option available at the time a main engine fails.

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

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

SH TT E A ORT HISTOR

RS S A H

STS- 1 2 1 8

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- 1 12 1 8

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

STS- M 22 1 3

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

STS- 1 A 12 1 3

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- 8 A 18 1

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

A O H

STS- 1 2 1 8

After an RSLS abort on July 12, 1985, Challenger was launched on July 29, 1985.

Five minutes and 45 seconds after launch, a sensor problem resulted in the shutdown of center engine No. 1, resulting in a safe "abort to orbit" and successful completion of the mission.

SPACE SHUTTLE MAIN ENGINES

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

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

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

The engines operate for about 8-1/2 minutes during liftoff and ascent — burning more than 500,000 gallons (1.9 million liters) of super-cold liquid hydrogen and liquid oxygen propellants stored in the huge external tank attached to the underside of the shuttle. The engines shut down just before the shuttle, traveling at about 17,000 mph (28,000 kilometers per hour), reaches orbit.

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

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

At normal operating level, 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 pre-burners, thus varying the speed of the high-pressure turbopumps and, therefore, the flow of the propellant.

At about 26 seconds into launch, the main engines are throttled down to 316,000 pounds of thrust to keep the dynamic pressure on the vehicle below a specified level — about 580 pounds per square foot or max q. Then, the engines are throttled back up to normal operating level at about 60 seconds. This reduces stress on the vehicle. The main engines are throttled down again at about seven minutes, 40 seconds into the mission to maintain three g's — three times the Earth's gravitational pull — again reducing stress on the crew and the vehicle. This acceleration level is about one-third the acceleration experienced on previous crewed space vehicles.

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

The engine performance has the highest thrust for its weight of any engine yet developed. In fact, one space shuttle main engine generates sufficient thrust to maintain the flight of 2-1/2 747 airplanes.

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

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

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

SPACE SHUTTLE SOLID ROCKET BOOSTERS

The two SRBs provide the main thrust to lift the space shuttle off the pad and up to an altitude of about 150,000 feet, or 24 nautical miles (28 statute miles). In addition, the two SRBs carry the entire weight of the external tank and orbiter and transmit the weight load through their structure to the mobile launcher platform.

Each booster has a thrust (sea level) of about 3,300,000 pounds at launch. They are ignited after the three space shuttle main engines' thrust level is verified. The two SRBs provide 71.4 percent of the thrust at liftoff and during first-stage ascent. Seventy-five seconds after SRB separation, SRB apogee occurs at an altitude of about 220,000 feet, or 35 nautical miles (40 statute miles). SRB impact occurs in the ocean about 122 nautical miles (140 statute miles) downrange.

The SRBs are the largest solid-propellant motors ever flown and the first designed for reuse. Each is 149.16 feet long and 12.17 feet in diameter. Each SRB weighs about 1,300,000 pounds at launch. The propellant for each solid rocket motor weighs about 1,100,000 pounds. The inert weight of each SRB is about 192,000 pounds.

Primary elements of each booster are the motor (including case, propellant, igniter and nozzle), structure, separation systems, operational flight instrumentation, recovery avionics, pyrotechnics, deceleration system, thrust vector control system and range safety destruct system.

Each booster is attached to the external tank at the SRB's aft frame by two lateral sway braces and a diagonal attachment. The forward end of each SRB is attached to the external tank at the forward end of the SRB's forward skirt. On the launch pad, each booster also is attached to the mobile launcher platform at the aft skirt by four bolts and nuts that are severed by small explosives at liftoff.

During the downtime following the Challenger accident, detailed structural analyses were performed on critical structural elements of the SRB. Analyses were primarily focused in areas where anomalies had been noted during postflight inspection of recovered hardware.

One of the areas was the attach ring where the SRBs are connected to the external tank. Areas of distress were noted in some of the fasteners where the ring attaches to the SRB motor case. This situation was attributed to the high loads encountered during water impact. To correct the situation and ensure higher strength margins during ascent, the attach ring was redesigned to encircle the motor case completely (360 degrees).

Previously, the attach ring formed a C and encircled the motor case 270 degrees.

Additionally, special structural tests were done on the aft skirt. During this test program, an anomaly occurred in a critical weld between the hold-down post and skin of the skirt. A redesign was implemented to add reinforcement brackets and fittings in the aft ring of the skirt.

These two modifications added about 450 pounds to the weight of each SRB.

The propellant mixture in each SRB motor consists of an ammonium perchlorate (oxidizer, 69.6 percent by weight), aluminum (fuel, 16 percent), iron oxide (a catalyst, 0.4 percent), a polymer (a binder that holds the mixture together, 12.04 percent), and an epoxy curing agent (1.96 percent). The propellant is an 11-point star-shaped perforation in the forward motor segment and a double-truncated-cone perforation in each of the aft segments and aft closure. This configuration provides high thrust at ignition and then reduces the thrust by about a third 50 seconds after liftoff to prevent overstressing the vehicle during maximum dynamic pressure.

The SRBs are used as matched pairs and each is made up of four solid rocket motor segments. The pairs are matched by loading each of the four motor segments in pairs from the same batches of propellant ingredients to minimize any thrust imbalance. The segmented-casing design assures maximum flexibility in fabrication and ease of transportation and handling. Each segment is shipped to the launch site on a heavy-duty rail car with a specially built cover.

The nozzle expansion ratio of each booster beginning with the STS-8 mission is 7-to-79. The nozzle is gimbaled for thrust vector (direction) control. Each SRB has its own redundant auxiliary power units and hydraulic pumps. The all-axis gimbaling capability is 8 degrees. Each nozzle has a carbon cloth liner that erodes and chars during firing. The nozzle is a convergent-divergent, movable design in which an aft pivot-point flexible bearing is the gimbal mechanism.

The cone-shaped aft skirt reacts the aft loads between the SRB and the mobile launcher platform. The four aft separation motors are mounted on the skirt. The aft section contains avionics, a thrust vector control system that consists of two auxiliary power units and hydraulic pumps, hydraulic systems and a nozzle extension jettison system.

The forward section of each booster contains avionics, a sequencer, forward separation motors, a nose cone separation system, drogue and main parachutes, a recovery beacon, a recovery light, a parachute camera on selected flights and a range safety system.

Each SRB has two integrated electronic assemblies, one forward and one aft. After burnout, the forward assembly initiates the release of the nose cap and frustum, a transition piece between the nose cone and solid rocket motor, and turns on the recovery aids. The aft assembly, mounted in the external tank/SRB attach ring, connects with the forward assembly and the orbiter avionics systems for SRB ignition commands and nozzle thrust vector control. Each integrated electronic assembly has a multiplexer/demultiplexer, which sends or receives more than one message, signal or unit of information on a single communication channel.

Eight booster separation motors (four in the nose frustum and four in the aft skirt) of each SRB thrust for 1.02 seconds at SRB separation from the external tank. Each solid rocket separation motor is 31.1 inches long and 12.8 inches in diameter.

Location aids are provided for each SRB, frustum/drogue chutes and main parachutes. These include a transmitter, antenna, strobe/converter, battery and salt-water switch electronics. The location aids are designed for a minimum operating life of 72 hours and when refurbished are considered usable up to 20 times. The flashing light is an exception. It has an operating life of 280 hours. The battery is used only once.

The SRB nose caps and nozzle extensions are not recovered.

The recovery crew retrieves the SRBs, frustum/drogue chutes, and main parachutes. The nozzles are plugged, the solid rocket motors are dewatered, and the SRBs are towed back to the launch site. Each booster is removed from the water, and its components are disassembled and washed with fresh and deionized water to limit salt-water corrosion. The motor segments, igniter and nozzle are shipped back to ATK Thiokol for refurbishment.

Each SRB incorporates a range safety system that includes a battery power source, receiver/decoder, antennas and ordnance.

H -

Each solid rocket booster has four hold-down posts that fit into corresponding support posts on the mobile launcher platform. Hold-down bolts hold the SRB and launcher platform posts together. Each bolt has a nut at each end, but only the top nut is frangible. The top nut contains two NASA standard detonators (NSDs), which are ignited at solid rocket motor ignition commands.

When the two NSDs are ignited at each hold-down, the hold-down bolt travels downward because of the release of tension in the bolt (pretensioned before launch), NSD gas pressure and gravity. The bolt is stopped by the stud deceleration stand, which contains sand. The SRB bolt is 28 inches long and 3.5 inches in diameter. The frangible nut is captured in a blast container.

The solid rocket motor ignition commands are issued by the orbiter's computers through the master events controllers to the hold-down pyrotechnic initiator controllers on the mobile launcher platform. They provide the ignition to the hold-down NSDs. The launch processing system monitors the SRB hold-down PICs for low voltage during the last 16 seconds before launch. PIC low voltage will initiate a launch hold.

SR I

SRB ignition can occur only when a manual lock pin from each SRB safe and arm device has been removed. The ground crew removes the pin during prelaunch activities. At T minus five minutes, the SRB safe and arm device is rotated to the arm position. The solid rocket motor ignition commands are issued when the three SSMEs are at or above 90 percent rated thrust, no SSME fail and/or SRB ignition PIC low voltage is indicated and there are no holds from the LPS.

The solid rocket motor ignition commands are sent by the orbiter computers through the MECs to the safe and arm device NSDs in each SRB. A PIC single-channel capacitor discharge device controls the firing of each pyrotechnic device. Three signals must be present simultaneously for the PIC to generate the pyro firing output. These signals — arm, fire 1 and fire 2 — originate in the orbiter general-purpose computers and are transmitted to the MECs. The MECs reformat them to 28-volt dc signals for the PICs. The arm signal charges the PIC capacitor to 40 volts dc (minimum of 20 volts dc).

The fire 2 commands cause the redundant NSDs to fire through a thin barrier seal down a flame tunnel. This ignites a pyro booster charge, which is retained in the safe and arm device behind a perforated plate. The booster charge ignites the propellant in the igniter initiator; and combustion products of this propellant ignite the solid rocket motor initiator, which fires down the length of the solid rocket motor igniting the solid rocket motor propellant.

The GPC launch sequence also controls certain critical main propulsion system valves and monitors the engine-ready indications from the SSMEs. The MPS start commands are issued by the on-board computers at T minus 6.6 seconds (staggered start — engine three, engine two, engine one — all about within 0.25 of a second), and the sequence monitors the thrust buildup of each engine. All three SSMEs must reach the required 90 percent thrust within three seconds; otherwise, an orderly shutdown is commanded and safing functions are initiated.

Normal thrust buildup to the required 90 percent thrust level will result in the SSMEs being commanded to the liftoff position at T minus three seconds as well as the fire 1 command being issued to arm the SRBs. At T minus three seconds, the vehicle base bending load modes are allowed to initialize (movement of 25.5 inches measured at the tip of the external tank, with movement towards the external tank).

At T minus zero, the two SRBs are ignited under command of the four on-board computers; separation of the four explosive bolts on each SRB is initiated (each bolt is

28 inches long and 3.5 inches in diameter); the two T-0 umbilicals (one on each side of the spacecraft) are retracted; the on-board master timing unit, event timer and mission event timers are started; the three SSMEs are at 100 percent; and the ground launch sequence is terminated.

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

E

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

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

H

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

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

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

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

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

When the APU speed reaches 100 percent, the APU primary control valve closes, and the

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

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

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

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

THRUST VECTOR CONTROL

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

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

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

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

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

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

SR R A

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

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

SR S

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

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

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

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

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

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

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

S ACE SH TT E S ER I HT WEI HT TAN S WT

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.

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LAUNCH AND LANDING

LAUNCH

As with all previous space shuttle launches, Atlantis has several options to abort its ascent if needed due to 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 orbiter and its payload.

Abort modes include:

ABORT-TO-ORBIT (ATO)

This mode is used if there's 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 shuts down early and there's not enough energy to reach Zaragoza, 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 to be acceptable for a possible RTLS landing at KSC about 20 minutes after liftoff.

ABORT ONCE AROUND (AOA)

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

LANDING

The primary landing site for Atlantis on STS-122 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
AOH	Assembly Operations Handbook
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
ARS	Atmosphere Revitalization System
ASW	Application Software
ATA	Ammonia Tank Assembly
ATCS	Active Thermal Control System
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
BIT	Built-In Test
BM	Berthing Mechanism
BOS	BIC Operations Software
BSS	Basic Software
BSTS	Basic Standard Support Software

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
CAPE	Canister for All Payload Ejections
CAS	Common Attach System
CB	Control Bus
CBCS	Centerline Berthing Camera System
CBM	Common Berthing Mechanism
CCA	Circuit Card Assembly
CCAA	Common Cabin Air Assembly
CCHA	Crew Communication Headset Assembly
CCP	Camera Control Panel
CCT	Communication Configuration Table
CCTV	Closed-Circuit Television
CDR	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
DPG	Differential Pressure Gauge
DPU	Baseband Data Processing Unit
DRTS	Japanese Data Relay Satellite
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
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

EPS	Electrical Power System
ES	Exposed Section
ESA	European Space Agency
ESC	JEF System Controller
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
FOR	Frame of Reference
FPP	Fluid Pump Package
FR	Flight Rule
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
GUI	Graphical User Interface
H&S	Health and Status
HCE	Heater Control Equipment
HCTL	Heater Controller
HEPA	High Efficiency Particulate Acquisition
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
HTV Prox	HTV Proximity
HTVCC	HTV Control Center
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
ICS	Interorbit Communication System
ICS-EF	Interorbit Communication System - Exposed Facility
IDRD	Increment Definition and Requirements Document
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
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
JAL	JEM Air Lock
JAXA	Japan Aerospace Exploration Agency
JCP	JEM Control Processor
JEF	JEM Exposed Facility
JEM	Japanese Experiment Module
JEMAL	JEM Air lock
JEM-PM	JEM – Pressurized Module
JEMRMS	Japanese Experiment Module Remote Manipulator System
JEUS	Joint Expedited Undocking and Separation
JFCT	Japanese Flight Control Team
JLE	Japanese Experiment Logistics Module – Exposed Section
JPM	Japanese Pressurized Module
JPM WS	JEM Pressurized Module Workstation
JSC	Johnson Space Center
JTVE	JEM Television Equipment
Kbps	Kilobit per second
KOS	Keep Out Sphere
KSC	Kennedy Space Center
LB	Local Bus
LCA	LAB Cradle Assembly
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LEE	Latching End Effector
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
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
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
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
NET	No Earlier Than
NLT	No Later 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
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
PBA	Portable Breathing Apparatus
PCA	Pressure Control Assembly
PCBM	Passive Common Berthing Mechanism
PCN	Page Change Notice
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
PIB	Power Interface Box
PIU	Payload Interface Unit
PLB	Payload Bay
PLBD	Payload Bay Door

PLC	Pressurized Logistics Carrier
PLT	Payload Laptop Terminal Pilot
PM	Pressurized Module
PMA	Pressurized Mating Adapter
PMCU	Power Management Control Unit
POA	Payload ORU Accommodation
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
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
SAFER	Simplified Aid for EVA Rescue
SAM	SFA Airlock Attachment Mechanism
SARJ	Solar Alpha Rotary Joint
SCU	Sync and Control Unit
SD	Smoke Detector
SDS	Sample Distribution System
SEDA	Space Environment Data Acquisition equipment
SEDA-AP	Space Environment Data Acquisition equipment - Attached Payload
SELS	SpaceOps Electronic Library System
SEU	Single Event Upset
SFA	Small Fine Arm
SFAE	SFA Electronics
SI	Smoke Indicator
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
SOC	System Operation Control
SODF	Space Operations Data File
SPA	Small Payload Attachment
SPB	Survival Power Distribution Box
SPDA	Secondary Power Distribution Assembly
SPDM	Special Purpose Dextrous Manipulator
SPEC	Specialist
SRAM	Static RAM

SRB	Solid Rocket Booster
SRMS	Shuttle Remote Manipulator System
SSAS	Segment-to-Segment Attach System
SSC	Station Support Computer
SSCB	Space Station Control Board
SSE	Small Fine Arm Storage Equipment
SSIPC	Space Station Integration and Promotion Center
SSME	Space Shuttle Main Engine.
SSOR	Space-to-Space Orbiter Radio
SSP	Standard Switch Panel
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

T-RAD	Tile Repair Ablator Dispenser
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
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
UIL	User Interface Language
ULC	Unpressurized Logistics Carrier
UMA	Umbilical Mating Adapter
UOP	Utility Outlet Panel
UPC	Up Converter
US LAB	United States Laboratory
USA	United Space Alliance
USOS	United States On-Orbit Segment
VAJ	Vacuum Access Jumper
VBSP	Video Baseband Signal Processor
VCU	Video Control Unit
VDS	Video Distribution System
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
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
ZSR	Zero-g Stowage Rack

MEDIA ASSISTANCE

NASA TELEVISION TRANSMISSION

NASA Television is carried on an MPEG-2 digital signal accessed via satellite AMC-6, at 72 degrees west longitude, transponder 17C, 4040 MHz, vertical polarization. For those in Alaska or Hawaii, NASA Television will be seen on AMC-7, at 137 degrees west longitude, transponder 18C, at 4060 MHz, horizontal polarization. In both instances, a Digital Video Broadcast (DVB) -compliant Integrated Receiver Decoder (IRD) (with modulation of QPSK/DBV, data rate of 36.86 and FEC 3/4) will be needed for reception. The NASA Television schedule and links to streaming video are available at:

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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 on-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:

Status Reports

Status reports on launch countdown and mission progress, on-orbit activities and landing operations will be posted at:

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

Briefings

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

Participation in Mission Status Briefings by Phone

During STS-123, JSC will operate a phone bridge for press briefings that take place outside of the normal business hours of 8 a.m. - 5 p.m. CST Monday through Friday. The system will allow media not present at Johnson to ask questions by phone during mission status briefings. To be eligible to use this service, media must possess a valid NASA media credential.

Media planning to use the service must contact the Johnson Newsroom at 281/483-5111 no later than 15 minutes prior to the start of a briefing. Newsroom personnel will verify their credentials and transfer them to the phone bridge. During the briefing, the moderator will call on each participant that has been transferred into the system for questions. The capacity of the phone bridge is limited, and it will be available on a first-come, first-served basis.

M I I

Information on the International Space Station is available at:

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

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Information on other current NASA activities is available at:

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Resources for educators can be found at the following address:

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