National Aeronautics and Space Administration

STS-122
The Voyage of Columbus

Shuttle Atlantis brings Columbus to the International Space Station

Columbus docks to Harmony's starboard side

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United Space Alliance

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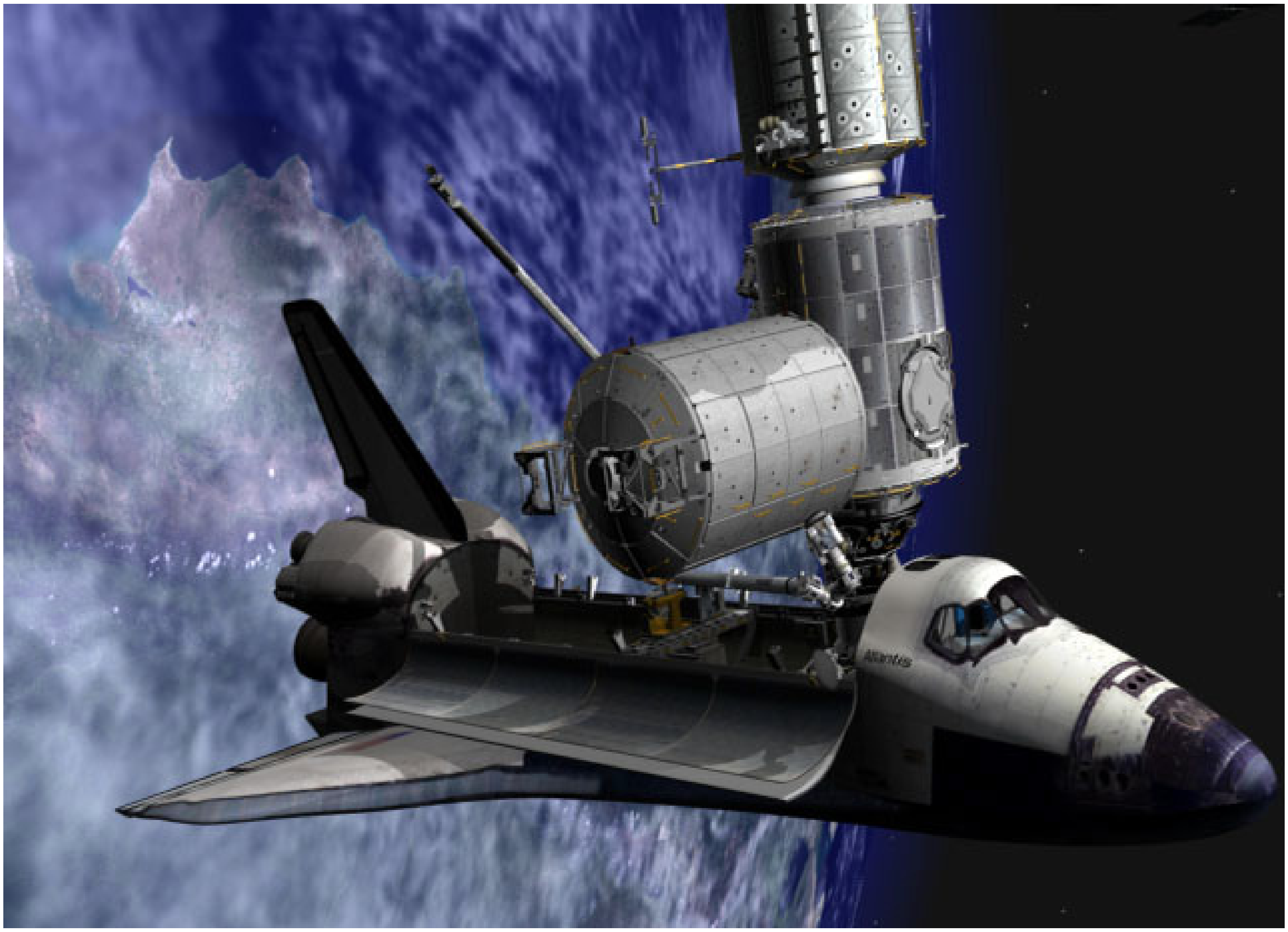
STS-122 MISSION OVERVIEW: THE VOYAGE OF COLUMBUS



This graphic illustrates Atlantis docked to the International Space Station as the Shuttle Robotic Arm grapples the Columbus module.

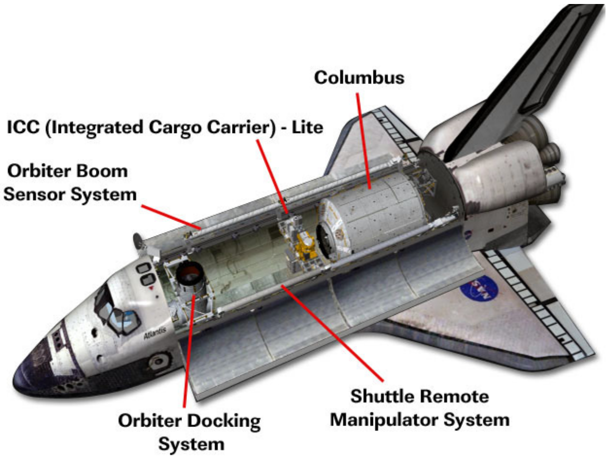
Scientific research will take on a new look aboard the International Space Station when the space shuttle Atlantis launches on the STS-122 mission. The mission, also known as assembly flight 1E, will deliver the newest research module to the orbiting complex, the European Space Agency's Columbus laboratory.

The addition of Columbus will expand the science capabilities of the space station. Columbus will be Europe's largest contribution to the construction of the station. Twenty-three feet long and 15 feet in diameter, the module will house experiments in life sciences, materials science, fluid physics and other disciplines. In addition to the Columbus module, Atlantis will deliver experiments to be performed in orbit and two ESA astronauts, one of whom will remain on the station to do them.

The STS-122 crew members, attired in training versions of their shuttle launch and entry suits, pose for a crew photo prior to a training session in the Space Vehicle Mockup Facility at Johnson Space Center. From the left are European Space Agency (ESA) astronauts Hans Schlegel and Leopold Eyharts and NASA astronaut Stanley G. Love, all mission specialists; Stephen N. Frick, commander; Alan G. Poindexter, pilot; Leland D. Melvin and Rex J. Walheim, both mission specialists.

Two Navy captains will lead the mission. Veteran astronaut Steve Frick, 43, will command the mission and Alan Poindexter, 46, will serve as the pilot. Mission specialists Leland Melvin, 43; Air Force Col. Rex Walheim (WALL-hime), 45, Stanley Love, 42; and ESA astronauts Hans Schlegel (SHLAY-guhl), 56, and French Air Force Gen. Léopold Eyharts (ā-arts), 50, round out the crew.

Expedition 16 Flight Engineer Daniel Tani (TAW-nee), who traveled to the space station on the STS-120 mission, will return home with the STS-122 crew. Eyharts will join the Expedition 16 crew, serving with Commander Peggy Whitson and Flight Engineer Yuri Malenchenko.

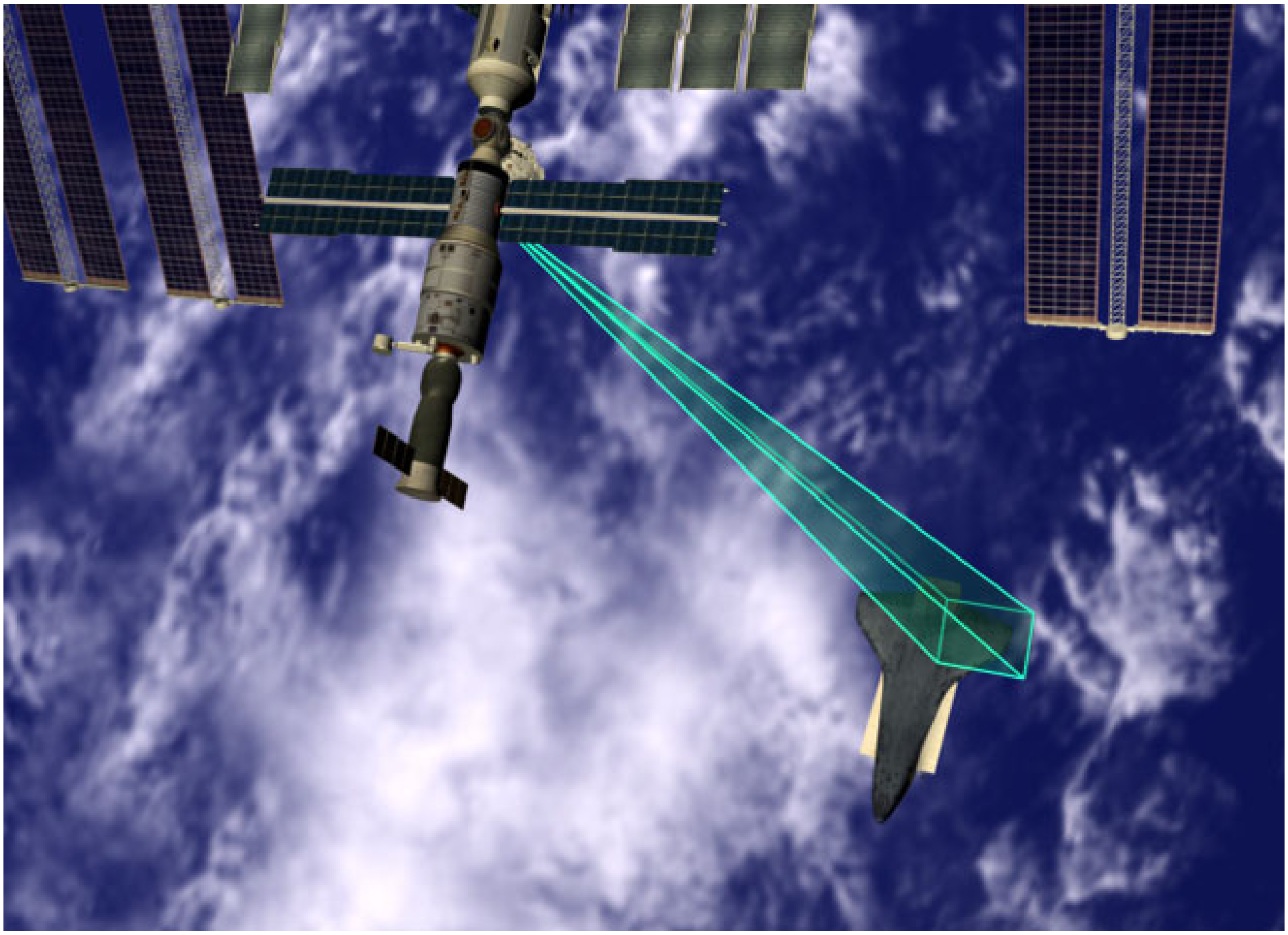


This graphic depicts the location of STS-122 payload hardware.

The 11-day mission begins with the targeted liftoff of Atlantis from NASA's Kennedy Space Center at 2:45 p.m. EST Feb. 7. The next day includes the close inspection of Atlantis' heat shield using the shuttle's robotic arm and the Orbiter Boom Sensor System (OBSS) to check for any ascent-imposed damage to the reinforced-carbon carbon panels on the shuttle's wings and nose cap. Crew members also will perform a checkout of the spacesuits to be used during the mission's spacewalks.

Atlantis arrives at the International Space Station on the third day of the mission. As the shuttle approaches the space station, Frick will perform the rendezvous pitch maneuver with Atlantis about 600 feet below the station, a slow backflip that will allow Whitson and Malenchenko to use cameras to take hundreds of detailed images of the shuttle's protective tiles. The images will be downlinked for analysis by specialists on the ground. With the pitch maneuver complete, Frick will fly the shuttle ahead of the station and slowly ease the orbiter back to a docking with the complex.

After the requisite leak checks, the hatches between the two vehicles will be opened, kicking off six days of joint operations between the shuttle and station crews.



This illustration depicts the rendezvous pitch maneuver while crew aboard the International Space Station photograph the orbiter for analysis by specialists on the ground.

Astronaut Rex J. Walheim, STS-122 mission specialist, dons a training version of the Extravehicular Mobility Unit (EMU) spacesuit prior to being submerged in the waters of the Neutral Buoyancy Laboratory (NBL) near Johnson Space Center. United Space Alliance suit technician Greg Pavelko assists Walheim.

Later in flight day 3, preparations will begin for the first of three planned spacewalks to install and outfit the Columbus laboratory. Walheim and Schlegel will transfer spacesuits to be used during the mission's spacewalks from the shuttle to the Quest Airlock and begin configuring them for the next day's extravehicular activity. The two will spend the night in the Quest Airlock in preparation for the first spacewalk.

Early on flight day 4, one of the first tasks will be the exchange of Tani's and Eyharts' custom seatliners used in the Soyuz spacecraft. With this exchange, Eyharts will become an Expedition 16 crew member.

Installation of Columbus to its new home on the space station will highlight the first spacewalk. First Walheim and Schlegel will prepare the module to be removed from the shuttle's payload bay by installing a Power and Data Grapple Fixture (PDGF) on it. Once complete, Melvin and Love will use the station's robotic arm to grab the PDGF on the module and remove Columbus from the shuttle's cargo bay, delicately maneuvering it to its docking port on the starboard side of the Harmony module.

The spacewalkers will then demate nitrogen lines and begin work to remove the Nitrogen Tank Assembly. Meanwhile, the robotics operators will proceed with the capture and latching of Columbus to Harmony.

Attired in training versions of their shuttle launch and entry suits, astronauts Rex J. Walheim, European Space Agency's Hans Schlegel and Stanley G. Love, all STS-122 mission specialists, await the start of a training session in the Space Vehicle Mockup Facility at the Johnson Space Center.

Flight day 5 will be dedicated to continued setup, activation and ingress of the new laboratory. Columbus has five payload racks, three of which will be relocated. That activity will include a number of umbilical connections and individual umbilical power downs. Supplies and equipment also will be transferred. Eyharts and Whitson will be the first crew members to enter ESA's new laboratory.

A focused inspection of the shuttle's heat shield, or thermal protection system, will be conducted if needed. Late in the crew's day, Walheim and Schlegel will camp out in Quest in preparation for the next day's spacewalk.

On flight day 6, Walheim and Schlegel will begin the mission's second spacewalk. They will replace the Nitrogen Tank Assembly. While the spacewalk is under way, Eyharts and his new station crewmates will continue the internal activation and outfitting of Columbus' systems.

The STS-122 crewmembers participate in a tool training session in the Space Vehicle Mockup Facility at the Johnson Space Center. From the left are European Space Agency astronaut Hans Schlegel, Leland D. Melvin, both mission specialists; Stephen N. Frick, commander; Rex J. Walheim, mission specialist; Alan G. Poindexter, pilot; and Stanley G. Love, mission specialist. United Space Alliance crew trainer Dave Mathers (seated right) assists the crewmembers.

Flight day 7 is a light-duty day for the crew members. It will include preparation for the third planned spacewalk. Walheim and Love will camp out in Quest.

On flight day 8, Walheim and Love will add science facilities to the exterior of Columbus. The two spacewalkers will assist Melvin and Tani, who will use the station's robotic arm, to install two external research suites on Columbus: the Sun Monitoring on the External Payload Facility, or SOLAR, which will be used to study the sun, and the European Technology Exposure Facility (EuTEF).

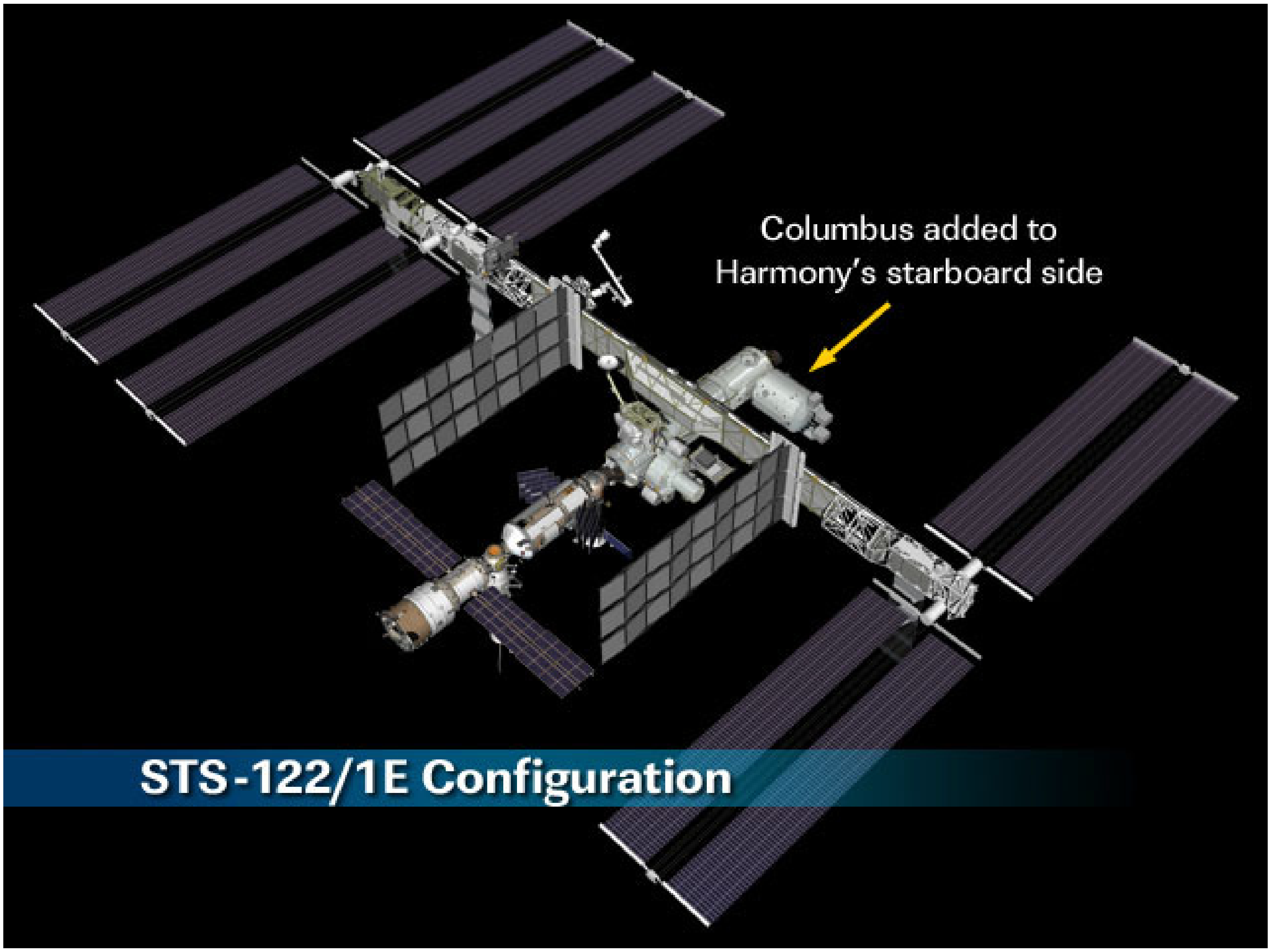
Walheim and Love also will transfer a failed Control Moment Gyroscope from its storage location on the station to the shuttle for return to Earth. This gyroscope, one of four that help maintain the station's orientation, was removed and replaced during the STS-118 mission.

If consumables allow, mission managers may add an additional day to the flight after the third spacewalk that would be dedicated to activating Columbus module systems and experiment racks

Flight day 9 will be dedicated to post-spacewalk tasks and final transfer work. The crews also will say farewell to one another before the hatch closure that evening, in preparation for undocking.

For the undocking, scheduled for flight day 10, Poindexter will back the shuttle away about 400 feet ahead of the station, then maneuver to a position above the station to perform a flyaround so that his crewmates can capture video and digital still photography of the complex in its new configuration. Later that day, the crew will perform a requisite late inspection using the cameras on the OBSS to ensure no orbital debris impact might have occurred to cause any critical damage to the shuttle.

Landing is scheduled for the morning of flight day 12 at the Kennedy Space Center to kick off a busy year of space flight.



This image depicts the configuration of the International Space Station following the installation of the Columbus module.

While seated at the commander's and pilot's stations, astronauts Stephen N. Frick (left) and Alan G. Poindexter, STS-122 commander and pilot, respectively, participate in a post insertion/de-orbit training session in the crew compartment trainer (CCT-2) in the Space Vehicle Mockup Facility at Johnson Space Center. Frick and Poindexter are wearing training versions of their shuttle launch and entry suits.

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

FLIGHT DAY 2

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

FLIGHT DAY 3

- Rendezvous with the International Space Station
- Rendezvous Pitch Maneuver Photography by the Expedition 16 Crew
- Docking to Harmony (Node 2)/Pressurized Mating Adapter-2
- Hatch Opening and Welcoming
- OBSS Unberth by Canadarm2
- Extravehicular Activity (EVA) 1 Procedure Review
- EVA-1 Campout by Walheim and Schlegel

FLIGHT DAY 4

- Soyuz Seat Liner Swap and Expedition Crew Exchange by Tani and Eyharts
- EVA-1 by Walheim and Schlegel (Columbus Grapple Fixture Installation, P1 Truss Nitrogen Tank Assembly Preparation)
- Temporary Shuttle Ku-band Antenna Stowage for Columbus Module Unberth
- Columbus Module Grapple, Unberth and Installation on Starboard Side of Harmony

FLIGHT DAY 5

- Atlantis Thermal Protection System Focused Inspection with OBSS (if required)
- Shuttle Ku-band Antenna Redeployment
- Columbus Module Ingress Preparations
- Columbus Module Ingress
- EVA-2 Procedure Review
- EVA-2 Campout by Walheim and Schlegel

FLIGHT DAY 6

- EVA-2 by Walheim and Schlegel (P1 Truss Nitrogen Tank Assembly Installation, Stowage of Old N2 Tank Assembly)
- Columbus Module Outfitting

FLIGHT DAY 7

- Columbus Module Racks and Systems Outfitting
- Off Duty Periods
- EVA-3 Procedure Review
- EVA-3 Campout by Walheim and Love

FLIGHT DAY 8

- EVA-3 by Walheim and Love (SOLAR and EuTEF Facility Installation, Failed Control Moment Gyroscope Transfer to Atlantis' Payload Bay)

FLIGHT DAY 9

- Shuttle and Station Transfers
- Joint Crew News Conference
- ISS Reboost
- Columbus Module Outfitting
- Farewells and Hatch Closure

FLIGHT DAY 10

- Undocking from Harmony Node 2/Pressurized Mating Adapter-2 and Flyaround
- Final Separation from the International Space Station
- OBSS Unberth and Late Inspection of Atlantis' Thermal Protection System
- OBSS Final Berthing

FLIGHT DAY 11

- Cabin Stow
- Flight Control System Checkout
- Reaction Control System Hot-Fire Test
- Crew Deorbit Briefing
- Launch and Entry Suit Checkout
- Recumbent Seat Set Up for Tani
- Ku-Band Antenna Stow

FLIGHT DAY 12

- Deorbit Preparations
- Payload Bay Door Closing
- Deorbit Burn
- Kennedy Space Center Landing

MISSION PROFILE

CREW

Commander:	Steve Frick
Pilot:	Alan Poindexter
Mission Specialist 1:	Leland Melvin
Mission Specialist 2:	Rex Walheim
Mission Specialist 3:	Hans Schlegel
Mission Specialist 4:	Stanley Love
Mission Specialist 5:	Leopold Eyharts (up)
Mission Specialist 5:	Daniel Tani (down)

LAUNCH

Orbiter:	Atlantis (OV-104)
Launch Site:	Kennedy Space Center Launch Pad 39A
Launch Date:	Feb. 7, 2008
Launch Time:	2:45 p.m. EST (Preferred In-Plane launch time for 12/6)
Launch Window:	5 Minutes
Altitude:	122 Nautical Miles (140 Miles) Orbital Insertion; 185 NM (213 Miles) Rendezvous
Inclination:	51.6 Degrees
Duration:	10 Days, 19 Hours, 12 Minutes

VEHICLE DATA

Shuttle Liftoff Weight:	4,523,508 pounds
Orbiter/Payload Liftoff Weight:	267,341 pounds
Orbiter/Payload Landing Weight:	206,212 pounds
Software Version:	OI-32

Space Shuttle Main Engines:

SSME 1:	2059
SSME 2:	2052
SSME 3:	2057
External Tank:	ET-125
SRB Set:	BI-132
RSRM Set:	99

SHUTTLE ABORTS

Abort Landing Sites

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

LANDING

Landing Date:	No earlier than Feb. 18, 2008
Landing Time:	9:57 a.m. EST
Primary landing Site:	Kennedy Space Center Shuttle Landing Facility

PAYLOADS

Columbus Laboratory

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MISSION PRIORITIES

1. Dock Atlantis to Pressurized Mating Adapter-2 port and perform mandatory station safety briefing for all crew members

2. Rotate Expedition 15/16 flight engineer with Expedition 16 flight engineer and transfer mandatory crew rotation cargo

3. Configure, mate and safe Columbus module to Harmony starboard location using the space station robotic arm

4. Transfer water of mandatory quantities from the shuttle to the space station

5. Perform minimum crew handover of 12 hours per rotating crew member

6. Remove and replace the space station's Port 1 Nitrogen Tank Assembly

7. Complete purge of Harmony's oxygen system

8. Install and perform mandatory activation of the Columbus SOLAR external payload on the External Payload Facility (EPF). (SOLAR, the Sun Monitoring on the External Payload Facility of Columbus, is a monitoring observatory to measure the sun’s spectral irradiance.)

9. Return failed control moment gyroscope from External Stowage Platform-2

10. Install and perform mandatory activation of the Columbus European Technology Exposure Facility (EuTEF) on the EPF. (EuTEF will carry experiments requiring exposure to the space environment.)

11. Transfer mandatory items

12. Activate Columbus module systems required for sustained crew presence including removal of negative pressure relief valves and installation of inter-module ventilation valves

13. Perform requested public affairs event with top level European government leader as soon after initial ingress into the Columbus module and activation as practical

14. Install trunnion and keel thermal covers

15. Activate and initiate checkout/commissioning activities for SOLAR and EuTEF payloads and the EPF

16. Transfer remaining items

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MISSION PERSONNEL

KEY CONSOLE POSITIONS FOR STS-122

	Flt. Director	CAPCOM	PAO
Ascent	Norm Knight	Jim Dutton Terry Virts (Weather)	Rob Navias
Orbit 1 (Lead)	Mike Sarafin	Kevin Ford	Nicole Lemasters (Lead)
Orbit 2	Tony Ceccacci	Steve Robinson	Pat Ryan
Planning	Paul Dye	Shannon Lucid	Lynnette Madison
Entry	Bryan Lunney	Jim Dutton Terry Virts (Weather)	Rob Navias
Shuttle Team 4	Matt Abbott	N/A	N/A
ISS Orbit 1	Bob Dempsey	Hal Getzelman	N/A
ISS Orbit 2 (Lead)	Sally Davis	Chris Cassidy	N/A
ISS Orbit 3	Ron Spencer	Chris Zajac	N/A
Station Team 4	Kwatsi Alibaruho	N/A	N/A

Int. Partner FD – Annette Hasbrook (interfaces with Columbus Control Center in Oberpfaffenhofen, Germany

JSC PAO Representative at KSC for Launch – Brandi Dean

KSC Launch Commentator – George Diller

KSC Launch Director – Doug Lyons

NASA Launch Test Director – Jeff Spaulding

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STS-122 ATLANTIS CREW

The STS-122 patch depicts the continuation of the voyages of the early explorers to today's frontier, space. The ship denotes the travels of the early expeditions from the East to the West. The space shuttle shows the continuation of that journey along the orbital path from West to East.

A little more than 500 years after Columbus sailed to the new world, the STS-122 crew will bring the Columbus European laboratory module to the International Space Station to usher in a new era of scientific exploration.

Atlantis' crew takes a break from training to pose for the STS-122 crew portrait. From the left (front row) are Commander Steve Frick, European Space Agency's (ESA) Mission Specialist Leopold Eyharts and Pilot Alan Poindexter. From the left (back row) are Leland Melvin, Rex Walheim, Stanley Love and ESA's Hans Schlegel, all mission specialists. The crew members are attired in training versions of their shuttle launch and entry suits.

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

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

STS-122 CREW BIOGRAPHIES

Steve Frick

A Navy captain, Steve Frick will lead the crew of STS-122 on the 24th shuttle mission to the International Space Station. Frick served as the pilot of STS-110 in 2002. Making his second spaceflight, he has logged more than 259 hours in space. He has overall responsibility for the execution of the mission, orbiter systems operations and flight operations, including landing. In addition, Frick will fly the shuttle in a procedure called the rendezvous pitch maneuver while Atlantis is 600 feet below the station to enable the station crew to photograph the shuttle's heat shield. He will then dock Atlantis to the station.

Alan Poindexter

A Navy captain, Alan Poindexter has 3,500 flight hours in more than 30 different aircraft. He will make his first journey into space as the pilot of Atlantis for the STS-122 mission. Selected by NASA in 1998, Poindexter has served as the lead support astronaut at NASA's Kennedy Space Center. He will be responsible for orbiter systems operations and will help Frick in the rendezvous and docking with the station. Poindexter will coordinate the three spacewalks from inside the spacecraft and undock Atlantis from the station at the end of the joint mission.

Leland Melvin

Astronaut Leland Melvin will be making his first spaceflight for STS-122 as mission specialist 1. Before being selected as an astronaut in 1998, he worked at NASA's Langley Research Center on advanced fiber optic sensor and laser research for spacecraft and civil aviation health monitoring systems. Melvin has worked in the Astronaut Office Space Station Operations and Robotics branches and for the Education Department at NASA Headquarters. He will be the primary operator of the space station robotic arm and will use the shuttle robotic arm to inspect Atlantis' heat shield.

Rex Walheim

An Air Force colonel, Rex Walheim will be making his second flight into space for STS-122 as mission specialist 2. He flew with Frick on STS-110 in 2002, during which he conducted two spacewalks to install the S0 truss segment. He has logged more than 259 hours in space, including 14 hours and five minutes during the spacewalks. Walheim will be on the flight deck during launch and landing, serving as the flight engineer to assist Frick and Poindexter. He also will assist them with rendezvous with the space station and be the lead spacewalker for the three excursions.

Hans Schlegel

ESA astronaut Hans Schlegel, of Germany, will be making his second trip into space as mission specialist 3 for STS-122. He logged more than 239 hours in space for STS-55 in 1993 during the German-sponsored Spacelab D-2 mission. Schlegel trained as an astronaut at the German Aerospace Center (DLR) beginning in 1988. He was integrated into the ESA astronaut corps and began training as part of NASA's 1998 astronaut class. He worked as the lead space station CAPCOM for Expedition 10 and as ESA lead astronaut at NASA's Johnson Space Center. He will conduct the first two spacewalks with Walheim during STS-122.

Stanley Love

Astronaut Stanley Love, who holds a doctorate in astronomy, will be making his first spaceflight during STS-122 as mission specialist 4. Selected by NASA in 1998, he has served as a space station CAPCOM for Expeditions 1 through 7 and three space shuttle missions. He served in the Astronaut Office Exploration Branch, helping develop future space vehicles and missions. Love will conduct the third spacewalk with Walheim and operate the station robotic arm with Melvin during the first two spacewalks.

Leopold Eyharts

This will be the second spaceflight for Leopold Eyharts, a French astronaut from the Center National d'Etudes Spatiales (CNES). He was selected as an astronaut by CNES in 1990 and by 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 Johnson Space Center. He will launch to the space station on the STS-122 mission and will return on STS-123, targeted for February 2008. He will remain aboard station for the commissioning of the European Columbus laboratory.

Daniel Tani

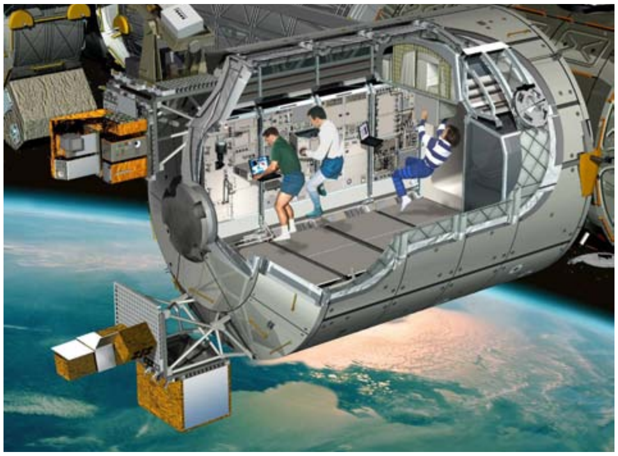
Expedition 16 Flight Engineer Daniel Tani traveled to the station on STS-120 in October and is scheduled to return to Earth on Atlantis during STS-122. Tani flew on STS-108 in 2001 and has logged more than 11 days in space, including a spacewalk to wrap thermal blankets around ISS Solar Array Gimbals. During STS-120, Tani performed the second spacewalk and operated the station robotic arm for the P6 relocation, Harmony Node 2 installation and various spacewalk activities. He conducted two additional spacewalks during the Expedition 16 mission with Commander Peggy Whitson to continue the external outfitting of Harmony.

PAYLOAD OVERVIEW

The International Space Station photographed from space shuttle Endeavour after undocking during the STS-118 mission on Aug. 19, 2007.

THE EUROPEAN COLUMBUS LABORATORY

The Columbus laboratory is the cornerstone of the European Space Agency's contribution to the International Space Station (ISS) and is the first European laboratory dedicated to long-term research in space. Named after the famous explorer from Genoa, the Columbus laboratory will give an enormous boost to current European experiment facilities in weightlessness and to the research capabilities of the ISS once it becomes an integral part of the space station.



Artist's impression of Columbus laboratory, cutaway view

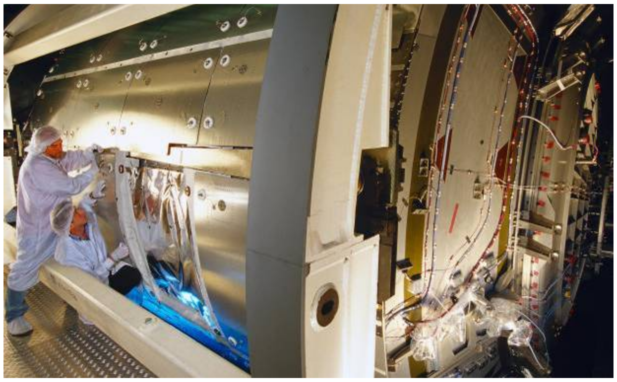
During its projected lifespan of 10 years, Columbus will support sophisticated research in weightlessness, having internal and external accommodation for numerous experiments in life sciences, fluid physics and a host of other disciplines. The laboratory marks a significant enhancement in European space experimentation and hardware development when compared to the missions of the European-developed Spacelab in the 1980s and 1990s.

Multi-purpose logistics module 'Leonardo' in the space shuttle cargo bay on March 10, 2001, during the STS-102 mission to the ISS. The Columbus Laboratory shares its basic structure with the multi-purpose logistics modules.

The 7-meter-long (23-foot-long) Columbus laboratory consists of a pressurised cylindrical hull 4.5 meters (15 feet) in diameter, closed with welded end cones. To reduce costs and maintain high reliability, the laboratory shares its basic structure and life-support systems with the European-built multi-purpose logistics modules (MPLMs): pressurized cargo containers, which travel in the space shuttle's cargo bay.

The primary and internal secondary structures of Columbus are constructed from aluminum alloys. These layers are covered with a multi-layer insulation blanket for thermal stability and a further two tons of paneling constructed of an aluminium alloy together with a layer of Kevlar and Nextel to act as protection from space debris.

The Columbus Laboratory has a mass of 10.3 tons and an internal volume of 75 cubic meters (98 cubic yards), which can accommodate 16 racks arranged around the circumference of the cylindrical section in four sets of four racks. These racks have standard dimensions with standard interfaces, used in all non-Russian modules, and can hold for example experimental facilities or subsystems.



Columbus Laboratory at EADS Astrium in Bremen with debris protection panels. Insulation material exposed under one section of paneling. July 2004.

Ten of the 16 are International Standard Payload Racks fully outfitted with resources (such as power, cooling, video and data lines), to be able to accommodate an experiment facility with a mass of up to 700 kilograms (1,543 pounds). This extensive experiment capability of the Columbus laboratory has been achieved through a careful and strict optimization of the system configuration, making use of the end cones for housing subsystem equipment. The central area of the starboard cone carries system equipment such as video monitors and cameras, switching panels, audio terminals and fire extinguishers.

International standard payload rack into which experiment facilities, subsystems or storage racks can be fitted.

Columbus laboratory in Integration hall of EADS in Bremen. Primary structure exposed. June 2002

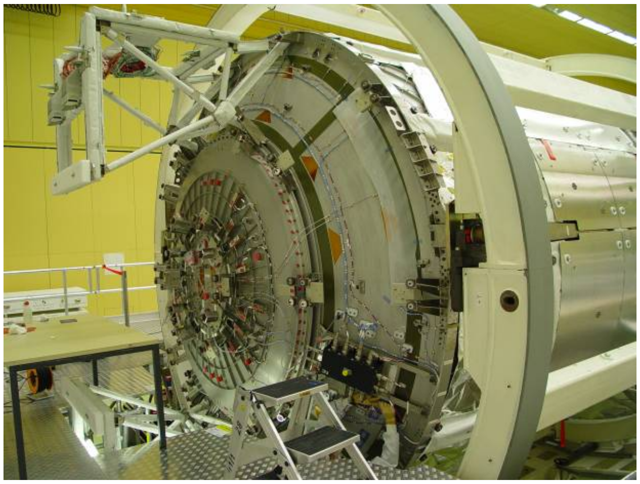
Although it is the station's smallest laboratory module, the Columbus laboratory offers the same payload volume, power, and data retrieval, for example, as the station's other laboratories. A significant benefit of this cost-saving design is that Columbus will be launched already outfitted with 2,500 kilograms (5,511 pounds) of experiment facilities and additional hardware. This includes the ESA-developed experiment facilities:

Biolab, which supports experiments on micro-organisms, cell and tissue culture, and even small plants and animals;

Biolab experiment facility during payload integration.

Fluid Science Laboratory, looking into the complex behavior of fluids, which could lead to improvements in energy production, propulsion efficiency and environmental issues;

European Physiology Modules Facility, which supports human physiology experiments concerning body functions such as bone loss, circulation, respiration, organ and immune system behavior in weightlessness; and the European Drawer Rack, which provides a flexible experiment carrier for a large variety of scientific disciplines.



Columbus laboratory with External Payload Facility attached. August 2004

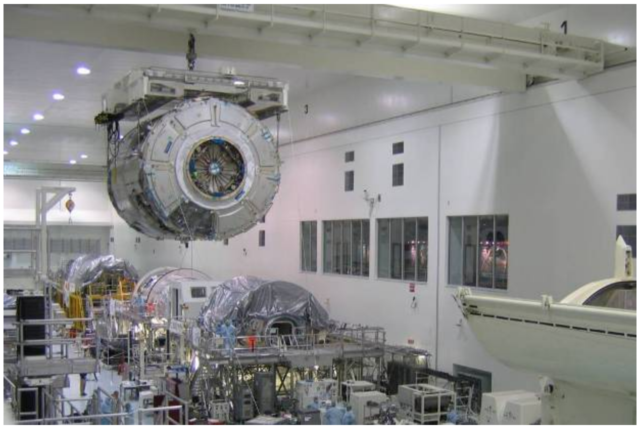
These multi-user facilities will have a high degree of autonomy in order to maximize the use of astronauts' time in orbit.

Outside its pressurized hull, Columbus has four mounting points for external payloads related to applications in the field of space science, Earth observation, technology and innovative sciences from space. Two external payloads will be installed after the Columbus is attached to the ISS: the European Technology Exposure Facility (EuTEF) will carry a range of experiments, which need exposure to space, and the SOLAR observatory, which will carry out a spectral study of the sun for at least 18 months.

These will be followed in the first instance by the Atomic Clock Ensemble in Space (ACES), which will test a new generation of microgravity cold-atom clock in space and the Atmosphere Space Interaction Monitor, which will study the coupling of thunderstorms processes to the upper atmosphere, ionosphere and radiation belts and energetic space particle precipitation effects in the mesosphere and thermosphere.

In addition to the accommodation for experiment facilities, three rack positions contain Columbus subsystems such as water pumps, heat exchanger and avionics, and three racks are for general storage purposes. When fully outfitted Columbus will provide a shirt sleeve environment of 25 cubic meters (33 cubic yards) in which up to three astronauts can work. The laboratory will receive a supply of up to 20 kW of electricity of which 13.5 kW can be used for experimental facilities.

Columbus subsystem racks during testing



European-built Node 2 being moved on an overhead crane in preparation for leak testing in the Space Station Processing Facility at the Kennedy Space Center in Florida, USA. Node 2, also known as Harmony, was attached to the station during the STS-120 mission in October 2007.

For the internal environment, Columbus is ventilated by a continuous airflow from Node 2, the European-built ISS module where the Columbus Laboratory will be permanently attached. The air returns to Node 2 for refreshing and carbon dioxide removal. This air content is monitored by Columbus subsystems for contamination.

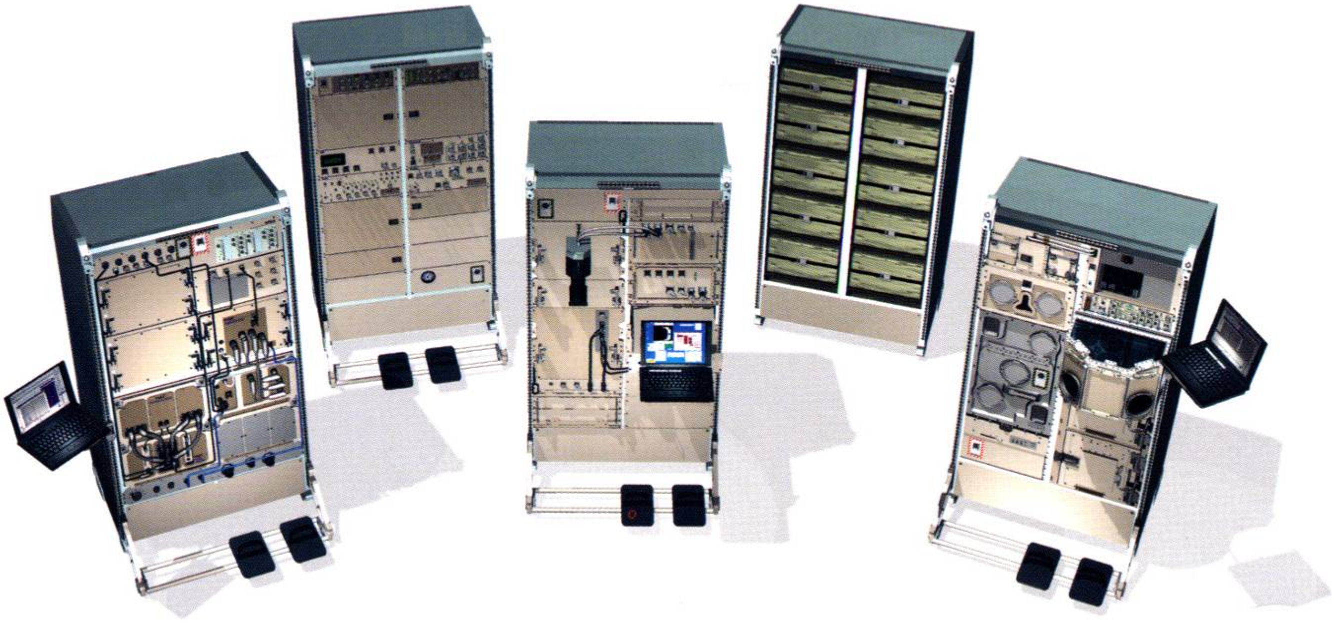
The crew can also control the temperature (16 to 30 degrees C) (61 to 86 degrees F) and humidity in Columbus. A water loop system, connected to the ISS heat removal system, serves all experimental facility and system locations for removal of heat and thus stopping equipment from overheating. In addition, there is an air/water heat exchanger to remove condensation from the cabin air. A system of electrical heaters also helps to combat the extreme cold possible at some station attitudes.

Once it is attached to the ISS, the Columbus Control Center (Col-CC) in Oberpfaffenhofen, Germany, on the premises of the DLR's German Space Operations Center will be responsible for the control and operation of the Columbus laboratory. All the European payloads on Columbus will transfer data, via the ISS data transfer system, directly to Col-CC.

Col-CC will coordinate European experiment (payload) operations. Relevant data will be distributed from Col-CC to the different User Support and Operations Centers across Europe, responsible for either complete facilities, subsystems of facilities or individual experiments.

Col-CC also will be in close contact with the Mission Control Center in Houston, which has overall responsibility for the ISS, together with the Mission Control Center in Moscow. In addition, Col-CC coordinates operations with the ISS Payload Operations and Integration Center at the Marshall Space Flight Center in Huntsville, Ala., which has overall responsibility for ISS experiment payloads.

Control Room at the Columbus Control Center in Oberpfaffenhofen, Germany



European facilities to be launched inside Columbus. Front row from left: European Drawer Rack, Fluid Science Laboratory and Biolab. Back row from left: European Physiology Modules and European Transport Carrier.

Columbus Internal Facilities

ESA has developed a range of payload racks for the Columbus laboratory, all tailored to acquire the maximum amount of research from the minimum of space and to offer European scientists across a wide range of disciplines full access to a weightless environment that is not possible on Earth. When STS-122 is launched, Columbus will be outfitted with the five pressurized (internal) payloads: Biolab, the Fluid Science Laboratory, the European Physiology Modules facility, the European Drawer Rack, and the European Transport Carrier. The first three were developed within ESA's Microgravity Facilities for Columbus Program, while the last two fall under ESA's Utilization Program.

The above ISS experiment facilities represent a first in European research and hardware development by providing the scientific community with a European platform for running long-term experiments in weightlessness on the ISS rather than the short-term experiments typical of the earlier Spacelab missions.

The multi-user facilities are modular in design to allow for upgrading and easy refurbishment and repair because of the long-term operations foreseen in the space station era, beyond the retirement of the space shuttle in 2010. This modularity provides the opportunity and flexibility to be used over again with different experiment containers, to allow for shorter mission preparation times and contributes to a faster scientific development in the specific field.

The research facilities have been designed to be compact enough to fit into the restricted space of an International Standard Payload Rack, durable enough to withstand years of service, able to accommodate multiple users, and largely automatic and fully controllable from ground stations since the station crew has only a limited amount of time to supervise ongoing experiments.

Experiment containers to be processed in the facilities will be transported separately within the Multi-Purpose Logistics Modules (MPLMs), which are pressurized cargo transportation modules that travel inside the space shuttle cargo bay. Experiments requiring late access also can be transported within the shuttle middeck lockers. Experiment containers will also be transported using the European Automated Transfer Vehicle (ATV) or the H-II Transfer Vehicle (HTV) or the Russian Progress vehicles. This includes certain biological and medical samples that will need to be thermally conditioned in storage in the Minus Eighty degrees Laboratory Freezer for the ISS (MELFI), which serves as the major permanent ISS refrigerator/freezer.

Internal Facilities: Biolab

Biolab is a facility designed to support biological experiments on micro-organisms, cells, tissue cultures, small plants and small invertebrates. The major objective of performing life sciences experiments in space is to identify the role that weightlessness plays at all levels of an organism, from the effects on a single cell up to a complex organism including humans.

The first experiment to take place in Biolab, when Columbus arrives at the ISS, will investigate the effect of weightlessness on the growth of seeds and will aim to better understand the cellular mechanism which impairs the immune functions and aggravates the radiation response under spaceflight conditions. This experiment is important in view of future, long-term human space missions. Further experiments will try to unravel the influence of gravity on cellular mechanisms such as signal transduction and gene expression. These two effects are important steps in the reaction of a cell to changes in its environment, so the results are important for finding causes or treatments for diseases on Earth.

Biolab is divided physically and functionally into two sections: the automatic section in the left side of the rack, and the manual section in the right side of the rack. In the automatic section, known as the Core Unit, all activities are performed automatically by the facility, after manual sample loading by the crew. By implementing such a high level of automation, the demand on crew time is drastically reduced. The manual section, in which all activities are performed by the crew themselves, is mainly devoted to sample storage and specific crew activities of experiment handling.

The main element of the Core Unit is the large Incubator, a thermally controlled volume where the experiments take place. Inside the incubator are two centrifuges that can each hold up to six experiment containers, which contain the biological samples, and can be independently spun to generate artificial gravity in the range from 10-3 g to 2 g. This allows for the simultaneous performance of 0g experiments with 1g reference experiments in the facility.

During processing of the experiment, the facility handling mechanism will transport the samples to the facility’s diagnostic instrumentation where, through teleoperations, the scientist on the ground can actively participate in the preliminary in-situ analyses of the samples. The handling mechanism also provides transport of samples into the ambient and temperature-controlled automatic stowage units for preservation or for later analysis. The typical Biolab experiment durations range from one day to three months.

Biolab's manual section carries a laptop for crew control, two temperature control units for sample storage and a BioGlovebox. The temperature control units are cooler/freezers (+10 degrees C to -20 degrees C) (50 degrees F to -4 degrees F) for storing larger items and experiment containers. The BioGlovebox is an enclosed container for handling toxic materials and delicate biological samples that must be protected against contamination by the space station environment. An ozone generator ensures sterilization of the BioGlovebox working volume.

The Biolab facility will be launched inside the European Columbus laboratory.

Biolab

Internal Facilities: European Drawer Rack

There is a need in the scientific community for medium-sized, dedicated experiment equipment for space research to reduce research costs and development times. ESA's solution is the European Drawer Rack, which provides a flexible experiment carrier for a large variety of scientific disciplines. It provides the accommodation and resources to experiment modules in two types of standard ISS housings called International Subrack Interface Standard (ISIS) drawers and ISS Lockers. The facility can accommodate up to three of these drawers, each with a payload volume of 72 liters and four lockers, each with a payload volume of 57 liters.

This approach allows a quick turn-around capability, and provides increased flight opportunities for the user community wishing to fly payloads that do not require a complete rack. The overall design of the facility is optimized for the parallel accommodation of three to four payloads, i.e., an average experiment payload accommodating two drawers/lockers, but both larger and smaller payloads may be accommodated.

The resource management covers the monitoring of resource allocations to individual payloads, but the operating concept of the European Drawer Rack assumes that payloads are largely autonomous. The facility computer distributes ISS data to payloads and routes payload data to ground and the European Drawer Rack laptop. The European Drawer Rack data management system supports all modes of payload operation, ranging from fully automatic to step-by-step control by an astronaut.

European Drawer Rack with clear view of 3 drawer and 4 locker locations

In addition to distributing Columbus resources to the experiment modules, the European Drawer Rack provides services such as an air cooling loop and conversion of the 120 volt Columbus power standard to 28 volts.

The first configuration of the European Drawer Rack will include one experiment module. This is the Protein Crystallization Diagnostics Facility and is a multi-user material science instrument, which will tackle the problems of protein crystallization in space. This facility will help to establish the conditions under which good zeolite crystals can be grown. This can only be determined in weightlessness. The results generated will hold benefits in various industrial applications.

A second module will be launched with a later flight. This is the Facility for Adsorption and Surface Tension (FASTER), which will establish a link between emulsion stability and characteristics of droplet interfaces. This research has a lot of application links in industrial domains and is linked to investigations like foam stability/ drainage/rheology.

Internal Facilities: European Physiology Modules Facility

The European Physiology Modules Facility is designed to investigate the effects of long-duration spaceflight on the human body, with typical research areas including neuroscience, cardiovascular and respiratory system, bone and muscle physiology and endocrinology and metabolism. The research into human physiology under weightless conditions also will contribute to an increased understanding of terrestrial problems such as the ageing process, osteoporosis, balance disorders, and muscle deterioration.

A selection of the first set of experiments to take place in the European Physiology Modules, when Columbus arrives at the ISS, relate to neuroscience, mechanisms of heart disease, weightless effects on human skeletal muscle function, and sodium retention in weightlessness.

The facility consists of a set of up to eight science modules mounted in a carrier infrastructure. The carrier provides these modules with data handling, thermal control and housing. It interfaces directly with Columbus and provides support for both rack-mounted and external science modules. In addition to science modules mounted in the carrier, it is possible for instruments deployed in the Columbus center aisle to interface to the carrier via a Utility Distribution Panel.

Three science modules have been selected for the first launch configuration of the European Physiology Modules Facility. These are:

Cardiolab: This is a facility for investigating the different systems that are involved in the regulation of arterial blood pressure and the heart rate. Data from Cardiolab also will be used to maintain the crew in good health during their stay on board, and to prepare the astronauts for their return to Earth. Cardiolab, developed by CNES and DLR has been added to the European Physiology Modules through cooperative agreements.

MEEMM (Multi Electrodes Encephalogram Measurement Module): MEEMM will be used to study brain activity by measuring electrical signals from electrodes mounted on the experiment subject.

PORTEEM (Portable Electroencephalogram Module): This instrument is a flexible, modular and portable digital recorder for ambulatory and sleep studies. The instrument is outfitted with a 16-channel EEG/polysomnography module for EEG sleep studies, but can be easily reconfigured for a wide variety of other applications.

ESA's European Physiology Modules Facility is closely linked to NASA's Human Research Facility racks in the U.S. Laboratory where even some of ESA's physiology science modules like the Pulmonary Function System are accommodated. The Pulmonary Function System is now in orbit and is functioning successfully.

New science modules and other necessary items will be transported to the station on the STS-122 flight and on future flights for use in conjunction with the European physiology modules. This will mainly comprise counter-measures equipment like the FlyWheel Exercise Device, a Portable Pulmonary Function System radiation monitors, etc. This European physiology modules equipment can be brought to the ISS by the European Automated Transfer Vehicle (ATV), the Russian Progress and Soyuz vehicles or the space shuttle. Samples are returned using the MPLM, the shuttle's middeck lockers and the Soyuz spacecraft.

European Physiology Modules Facility

Internal Facilities: Fluid Science Laboratory

The Fluid Science Laboratory is a multi-user facility designed to study the dynamics of fluids in the absence of gravitational forces. The major objective of performing fluid science experiments in space is to study dynamic phenomena in the absence of gravitational forces. Under weightless conditions, as on the ISS, such forces are almost entirely eliminated, resulting in significant reductions in gravity-driven convection, sedimentation, stratification and fluid static pressure. This allows the study of fluid dynamic effects normally masked by gravity.

The first experiments to take place in the Fluid Science Laboratory, when Columbus arrives at the ISS, include the heat and mass transfer from free surfaces in binary liquids, a study of emulsion stability, an investigation of geo-physical flow in weightlessness, which can have importance in areas such as global-scale flow in the atmosphere and oceans, studies of electric fields on the boiling process, and a study to improve the processing of peritectic alloys.

The Fluid Science Laboratory is modular in design and based on the use of drawer elements. This facilitates the removal and transport of components, either to upgrade them or to repair defective parts. It can be operated in fully-automatic or semi-automatic mode and can be controlled on board by the ISS astronauts, or from the ground in telescience mode.

The right side of the Fluid Science Laboratory contains functional subsystems for power distribution, environmental conditioning and data processing and management. The core element on the left side of the Fluid Science Laboratory consists of the Optical Diagnostics Module and Central Experiment Module, into which the experiment containers are inserted for operation.

The Optical Diagnostics Module houses the equipment for visual, velocimetric and interferometric observation, the related control electronics, and the attachment points and interfaces for special front mounted cameras.

The Central Experiment Module is divided into two parts. The first contains the suspension structure for the experiment containers, including all the functional interfaces and optical equipment. This structure is designed to be pulled out from the rack to allow insertion and removal of the standard dimension experiment containers into which the experiments are integrated. The second part contains all of the diagnostic and illumination equipment, together with the control electronics to command and monitor the electromechanical and opto-mechanical components.

The Fluid Science Laboratory

Cooperative agreements have added to the facility the Microgravity Vibration Isolation System developed by the Canadian Space Agency. This system will provide good isolation for experiments from disturbances in the weightless environment from the station.

An experiment container also may be equipped with dedicated experiment diagnostics to complement the standard diagnostics provided by the Fluid Science Laboratory itself.

A facility like Fluid Science Lab, which can be used over and over again with different experiment containers, allows shorter individual mission preparation times and contributes to a faster scientific development in the specific field.

Internal Facilities: European Transport Carrier

The European Transport Carrier accommodates items for transport and stowage based on standardized cargo transfer bags that are compatible for transportation with the European-built Multi-Purpose Logistics Module (MPLM) and ATV, and for use on board ISS modules such as Columbus. The modular European Transport Carrier design, based on rigid stowage containers, offers maximum flexibility for handling different cargo transfer bag sizes. All European payload items will be transported and stored in ISS cargo transfer bags. These are Nomex® bags in four standard sizes with removable, reconfigurable dividers.

The European Transport Carrier's rigid stowage containers are optimized in size for accommodation of the different sized cargo transfer bags. There are two smaller containers for accommodating full- and half-size cargo transfer bags, each one equivalent in volume to 1.5 shuttle middeck lockers. There are four containers, which offer about three times the volume of a shuttle middeck locker. They can be filled with any combination of cargo transfer bags, up to the triple-size. All stowage containers are designed to withstand the launch and landing loads while carrying their stowage contents.

European Transport Carrier

The European Transport Carrier will carry payload items that cannot be launched within the ESA facilities because of stowage or transport limitations. In orbit, it will serve as a workbench and stowage facility to support experiments with Biolab, Fluid Science Lab, European Physiology Modules and European Drawer Rack. One piece of equipment that will be brought to the ISS inside the European

Transport Carrier will be the European Flywheel Exercise Device. This is a resistance exercise device that acts to countermeasure muscle atrophy, bone loss, and impairment of muscle function in astronauts. It will be transported within two of the triple-sized cargo transfer bags.

The European Transport Carrier's secondary use is within the MPLM after it is eventually replaced in Columbus by an active experiment rack. (ESA currently 'owns' five rack positions, all are active/powered positions). The European Transport Carrier may then act as a logistics carrier between Earth and the ISS for the Columbus ESA payload racks. It is designed for 15 launches, and can be reconfigured on the ground to the specific stowage needs of each flight.

In general, the European Transport Carrier will stow and transport commissioning items, complementary instruments, consumables, flight and orbital support equipment, orbital replaceable units, resupply items and science items like experiment containers and consumables.

In addition, European Transport Carrier's Zero-g Stowage Pockets (two upper, one lower) allow on-orbit use of the remaining internal volume. They can only be filled in orbit and cannot be used for launch and descent transportation.

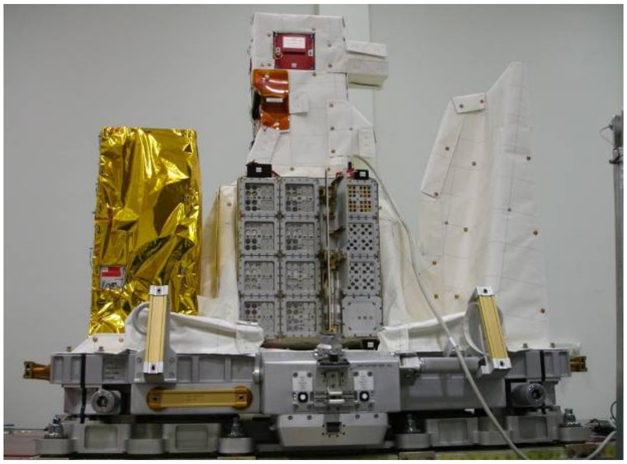
The European Transport Carrier can carry more than 400 kilograms (882 pounds) of payload and experiment items, totaling up to about 800 liters. On-board the ISS, Zero-g Stowage Pockets extend capacity to about 1,000 liters.

Columbus External Facilities

We usually think of astronauts aboard the International Space Station performing experiments inside the pressurized laboratory modules, but external payloads offer the choice of experimentation in the open space environment with the major advantages of long duration exposure and return to Earth thereafter for examination and analysis. One noticeable example of this is the ESA Matroshka radiation dosimetry facility, which was located on the external surface of the ISS for 1.5 years following installation in March 2004.

ESA has equipped the Columbus module with the External Payload Facility, which provides four locations (platforms) to accommodate research payloads. It is a framework mounted on the module's end-cone and provides power, data and command links.

The Columbus External Payload Facility offers the opportunity for classical space science and technology experiments in a diverse array of disciplines. The External Payload Facility will enhance the station's return without significantly increasing the infrastructure cost by exploiting automated operations, with almost no crew intervention.



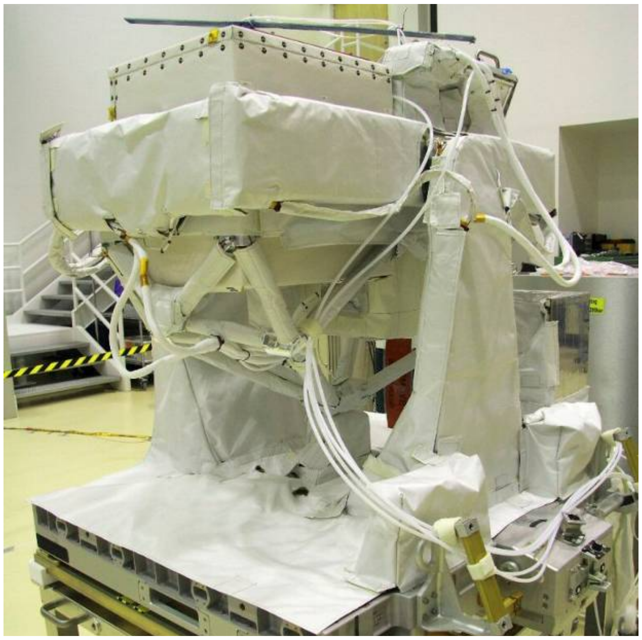
EuTEF External Payload Facility

The External Payload program consists of two elements: early utilization (before station assembly is complete) and routine exploitation (after assembly completion). Each payload is mounted on an adaptor able to accommodate small instruments and experiments totaling up to 227 kilograms (500 pounds). Following an Announcement of Opportunity and peer review, five payloads were selected, of which four entered development. They were originally planned to use the NASA external sites but will now be located on Columbus.

Two of the payloads: The European Technology Exposure Facility (EuTEF) and SOLAR are flying on the STS-122 flight with Columbus and will be attached to the outside of Columbus during the last mission spacewalk. The Atomic Clock Ensemble in Space (ACES) and the Atmosphere Space Interaction Monitor (ASIM) will be flown to the ISS on a later flight.

This first batch of external Columbus payloads will be replaced by new payloads in the future. One such payload is ASIM, (Atmosphere/Space Interactions Monitor), payload composed of optical instruments for the observation of high altitude emission from the stratosphere and mesosphere related to thunderstorms.

In the future, the in-orbit transfer of the unpressurized payloads from the shuttle to the External Payload Facility, and vice-versa, will be performed by the Space Station Robotic Manipulator System. For SOLAR and EuTEF, however the transfer will be carried out by astronauts with robotic arm assistance, as part of EVA tasks. Future payloads like ASIM and ACES could be uploaded with the HTV; smaller/modular ones with the ATV or Progress as well.



SOLAR External Payload Facility

External Facilities: European Technology Exposure Facility (EuTEF)

The European Technology Exposure Facility (EuTEF) will be mounted outside the Columbus module and carry experiments requiring exposure to the space environment. It is a programmable, fully automated, multi-user facility with modular and flexible accommodation for a variety of technology payloads. EuTEF is specifically designed to facilitate the rapid turnaround of experiments and for its first configuration on orbit will accommodate nine different instruments.

The experiments and facility infrastructure are accommodated on the Columbus External Payload Adaptor, consisting of an adapter plate, the Active Flight Releasable Attachment Mechanism and the connectors and harness. The experiments are mounted either directly on the adapter plate or a support structure that elevates them for optimum exposure to the direction of flight or pointing away from the Earth.

In total, the payload mass is under 350 kilograms (771 pounds), and requires less than 450 watts of power. The suite of experiments consists of:

- MEDET, the Material Exposure and Degradation Experiment (CNES, ONERA, University of Southampton, ESA);
- DOSTEL, radiation measurements (DLR Institute of Flight Medicine);
- TRIBOLAB, a testbed for the tribology properties of materials in space (INTA, INASMET);
- EXPOSE, photobiology and exobiology (Kayser-Threde, under ESA contract);
- DEBIE-2, a micrometeoroid and orbital debris detector (Patria Finavitec, under ESA contract). Shares a standard berth with FIPEX. DEBIE-1 flew on the Proba satellite;
- FIPEX, an atomic oxygen detector (University of Dresden). Shares a standard berth with DEBIE-2;
- PLEGPAY, plasma electron gun payload for plasma discharge in orbit (Thales Alenia Space, under ASI contract);
- EuTEMP, an experiment candidate to measure EuTEF’s thermal environment during unpowered transport from the shuttle to the Columbus External Payload Facility (EFACEC, under ESA contract).

EVC: an Earth Viewing Camera, developed by ESA/Carlo Gavazzi Space for outreach activities.

EuTEF

External Facilities: SOLAR

Apart from contributing to solar and stellar physics, knowledge of the interaction between the solar energy flux and Earth's atmosphere is of great importance for atmospheric modeling, atmospheric chemistry and climatology. SOLAR, will study the sun with unprecedented accuracy across most of its spectral range. This is currently scheduled to last two years. It will be located on the Columbus External Payload Facility zenith position (i.e., pointing away from the Earth).

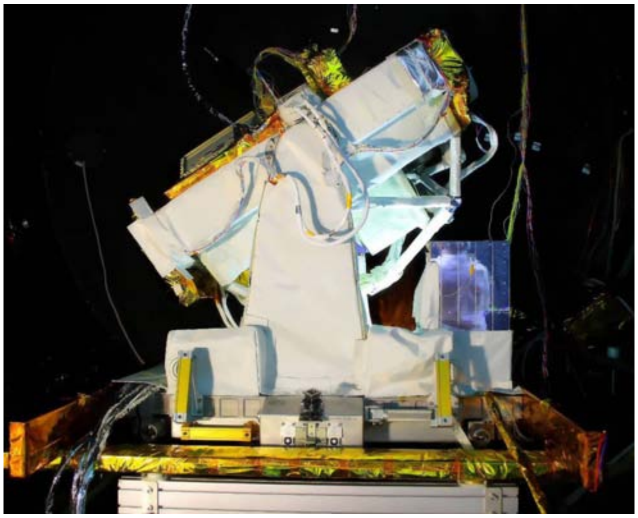
The SOLAR payload consists of three instruments complementing each other to allow measurements of the solar spectral irradiance throughout virtually the whole electromagnetic spectrum - from 17 nm to 100 µm - in which 99% of the solar energy is emitted. The three complementary solar science instruments are:

SOVIM (SOlar Variable & Irradiance Monitor), which covers near-UV, visible and thermal regions of the spectrum (200 nm – 100 µm) is developed by PMOD/WRC (Davos, Switzerland) with one of the instrument's radiometers provided by IRM (Brussels, Belgium).

SOLSPEC (SOLar SPECctral Irradiance measurements) covers the 180 nm - 3,000 nm range. SOLSPEC is developed by CNRS (Verrières-le-Buisson, France) in partnership with IASB/BIRA (Belgium) and LSW (Germany).

SOL-ACES (SOLar Auto-Calibrating Extreme UV/UV Spectrophotometers) measures the EUV/UV spectral regime. SOL-ACES is developed by IPM (Freiburg, Germany).

SOVIM and SOLSPEC are upgraded versions of instruments that have already accomplished several space missions. SOL-ACES is a newly developed instrument.



SOLAR External Payload Facility in March 2007

Future External Facilities

Atomic Clock Ensemble in Space (ACES)

ACES will test a new generation of atomic clock in space. PHARAO (Projet d'Horloge Atomique par Refroidissement d'Atomes en Orbite) developed by CNES in France and the Space Hydrogen Maser developed in Switzerland will be characterized and their output signals compared with each other and with national frequency standards worldwide using a dedicated microwave link. The ultimate performance of PHARAO in microgravity will be explored and a number of fundamental physics experiments will be performed.

ACES is a complex payload involving state-of-the-art instruments and subsystems. The atomic clocks are extremely sensitive to their operating environment, so the particularly harsh environment of space provides new challenges to the clock and payload designs. Thermal and electromagnetic sensitivity places particularly severe constraints on the payload.

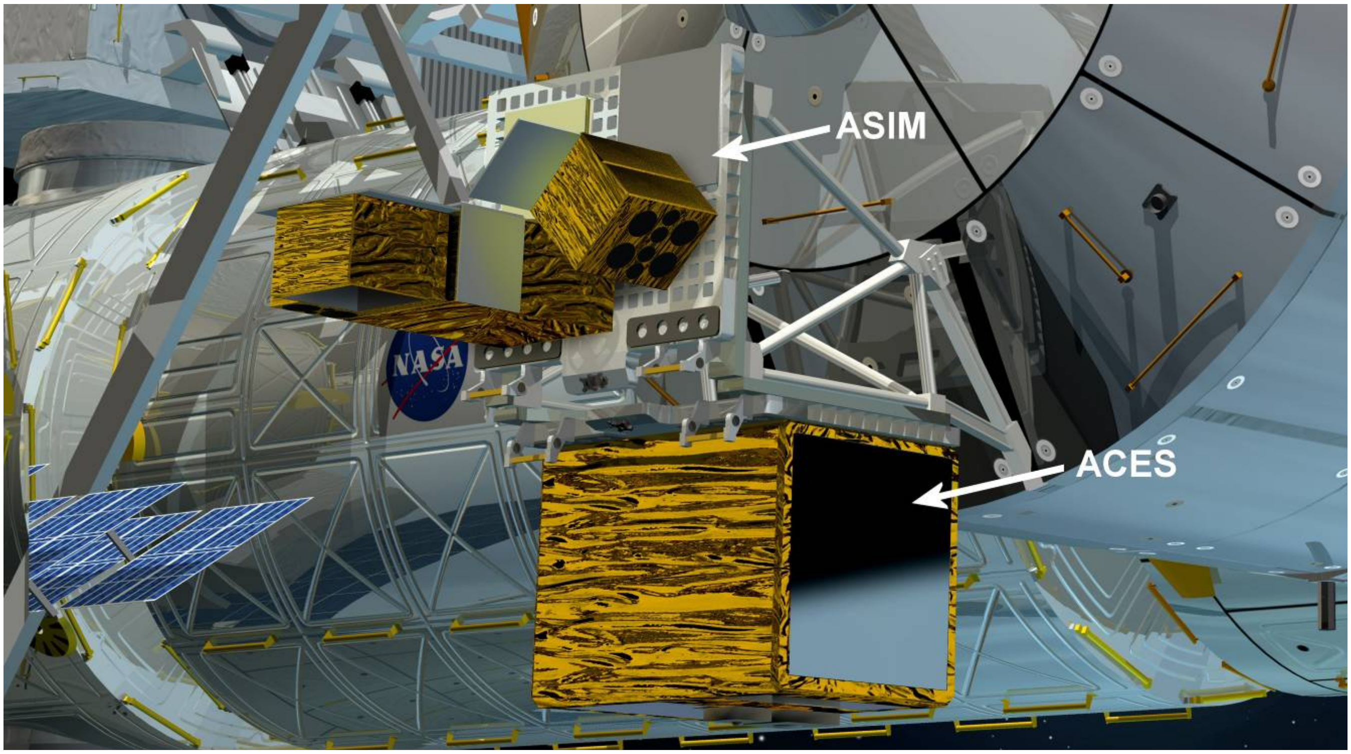
PHARAO uses six orthogonal laser beams to cool caesium atoms to a few µK. The combination of these slow atoms and their low acceleration in microgravity allows observation times significantly longer than on Earth, providing better stability and accuracy of the frequency.

Atmosphere Space Interactions Monitor (ASIM)

The mesosphere and lower thermosphere are the regions of the atmosphere about which the least is known. They are too low for in situ spacecraft observations, and remote sensing is hampered by low densities and a high degree of variability over a range of time and spatial scales.

ASIM (Atmosphere Space Interactions Monitor) will study the interaction of thunderstorms with the upper regions of the atmosphere, reaching into the ionosphere and magnetosphere and energetic space particle radiation effects on the mesosphere and thermosphere. The scientific objectives of this payload are complementary to the ones of the Taranis satellite mission developed by CNES.

The ASIM payload consists of two instrument units, the Miniature Multispectral Imaging Array (MMIA) and the Miniature X- and Gamma-Ray Sensor (MXGS) and subsystems. The MMIA incorporates two CCD cameras and a photometer. Two MMIA are dedicated to limb observation with a field of view of 20 degrees. A third MMIA in conjunction with the Miniature X- and Gamma-Ray Sensor will be nadir pointing with a field of view of 80 degrees. The nadir-pointing instruments will keep track of X-ray and gamma-ray bursts.



Artist's impression of future external payload facilities ASIM and ACES located on the Columbus laboratory

MOTION CONTROL SUBSYSTEM

The International Space Station control system is composed of Russian and U.S. segments that maintain attitude control. When the Russian segment is in control, it uses thrusters, which burn propellant. When the U.S. segment is in control, Control Moment Gyroscopes (CMGs), manufactured by L3 Communications, are used. Four CMGs are mounted on the Z1 truss, an exterior framework that houses the gyroscopes and some communications equipment. A shuttle crew installed the Z1 truss on orbit with four gyros pre-installed in October 2000.

To maintain the station in the desired attitude, the CMG system must cancel or absorb the torque generated by the disturbances acting on the station. The CMGs rely on electrical power readily available from the solar powered electrical subsystem.

Each CMG weighs approximately 600 pounds. A CMG consists of a large, flat, 220-pound stainless steel flywheel that rotates at a constant speed (6,600 rpm) and develops an angular momentum of 3,600 ft-lb-sec (4,880 Newton-meter-sec) about its spin axis. This rotating wheel is mounted in a two-degree-of-freedom gimbal system that can point the spin axis (momentum vector) of the wheel in any direction. Control motors on the CMG gimbals change the orientation of the spinning rotors to produce torque on the station to balance the effects of gravity and aerodynamics, maintaining the station at an equilibrium attitude without using propellant.

At least two CMGs are needed to provide attitude control and are the minimum necessary to steer and steady the station as it travels around the Earth every 90 minutes at a speed of more than five miles each second.

There are four CMGs operating on orbit. The original CMG 1 was removed, replaced, and returned from orbit in August 2005. The original CMG 3 was removed and replaced in August 2007, and it will be returned on STS-122.

CMG Statistics:

Primary integrator: Boeing

Manufacturer: L3 Communications, Space and Navigation Division, Budd Lake, N.J.

Weight: 600 pounds

Purpose: Control the attitude of the International Space Station without use of propellant.

Structure: Each CMG contains a 220-pound stainless steel flywheel that spins at 6,600 rpm.

Removal and Installation: Six bolts and four power/data connectors need to be detached to remove the Control Moment Gyroscope from the station’s Z1 Truss.

Control Moment Gyroscope

NITROGEN TANK ASSEMBLY (NTA)

Built at The Boeing Company's Houston manufacturing facility, the Nitrogen Tank Assembly (NTA) Orbital Replacement Unit (ORU) on the International Space Station's Port 1 (P1) truss segment will be replaced during space shuttle Atlantis STS-122 and ISS Assembly Sequence 1E mission.

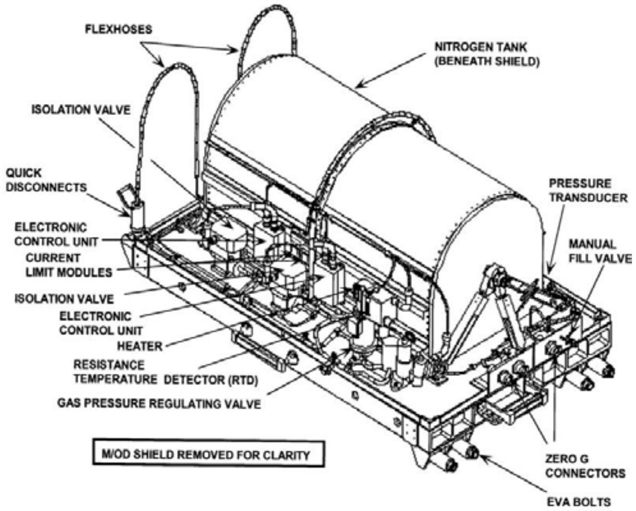
The NTA provides a high-pressure gaseous nitrogen supply to control the flow of ammonia out of the Ammonia Tank Assembly (ATA). The ATA contains two flexible, chambers incorporated into its ammonia tanks that expand as pressurized nitrogen expels liquid ammonia out of them. There are four NTA ORUs, three of which will be on-orbit at the conclusion of STS-122.

The NTA controls ammonia pressure in the ATA as a key part of the External Active Thermal Control System, an external system that circulates ammonia to cool ISS segments, including the newly installed Columbus module which was also flown on STS-122.

Mounted to both the Starboard 1 (S1) and P1 truss segments, the NTA is equipped with a Gas Pressure Regulating Valve (GPRV) and isolation valves as well as survival heaters. The GPRV and isolation valves provide control function and over pressure protection of downstream components. The heaters prevent the electronic equipment from getting too cold.

The NTA's support structure is made largely of aluminum, and the tank is a carbon composite. The NTA ORU currently in place on P1 will have the majority of its usable nitrogen mass depleted due to assembly operations since its initial installation on Nov. 23, 2002, as part of the P1 truss during STS-113 and ISS Assembly Sequence 11A. Its replacement ORU has a full tank with a weight of about 80 pounds of nitrogen at approximately 2,500 pounds per square inch (psi) of pressure — nearly 80 times the pressure of an average automotive tire at 30 psi. It also provides the capability to be refilled while on orbit through its nitrogen fill quick disconnect (QD).

The replaced NTA will be returned to Houston for modification and refurbishment, which includes redesigning heaters and installing an on-orbit capable fill quick disconnect. The refurbished NTA will be returned to ISS on a future mission.



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COLUMBUS CONTROL CENTER, OBERPFAFFENHOFEN, GERMANY

Room K4 of the Columbus Control Center in Oberpfaffenhofen, near Munich, Germany. Aug. 9, 2004.

ESA's Columbus Control Center (Col-CC) will support the European Columbus laboratory once it becomes an integral part of the station after the STS-122 launch. The center is situated at the German Aerospace Center (DLR) facility in Oberpfaffenhofen, near Munich, Germany.

The control center will be the direct link to the Columbus laboratory when in orbit. Its main functions will be to command and control the Columbus laboratory systems, to coordinate operations of the European payloads aboard the ISS and to operate the European ground communications network.

In its main function of commanding and controlling the systems of the Columbus laboratory, the Col-CC will be making sure that astronauts working within Columbus have a safe and comfortable environment in which to work and that the payload facilities have the necessary system support in order to function properly. This will include monitoring and configuring, by remote command, the life support systems to maintain air quality, the power supply to experiment facilities, and systems for removal of heat from experiment facilities.

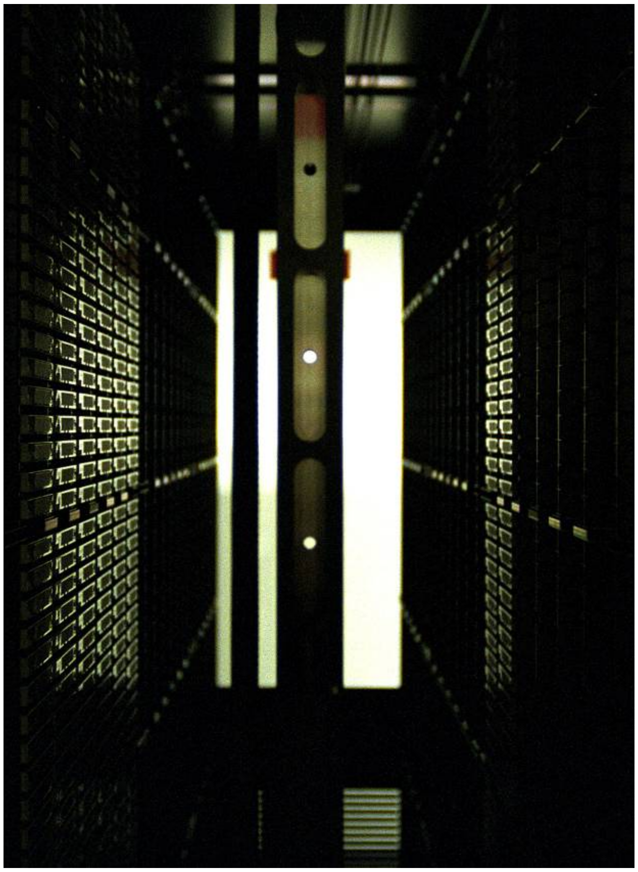
European and non-European astronaut activities inside Columbus will be monitored and coordinated from the Col-CC. The Control Center also will hold overall responsibility for such issues as safety in the Columbus laboratory under the overall authority of the ISS Mission Control Center in Houston. The Col-CC will react to any changes during the mission, coordinating decisions and establishing priorities should any change interfere with the European experiments inside Columbus.

Columbus will have experimental facilities both internally and externally covering a multitude of experiments over the course of its lifetime. The involvement of the astronauts with these experiments could range from a high degree of interaction to only some activity limited to the integration and removal of the experiment from its processing location.

Any autonomous activities of the Columbus systems and experiment facilities will be monitored and coordinated through the Col-CC. The Columbus systems will be configured as and when necessary to account for alterations in procedures or a change within the payload facilities. All data coming from Columbus will be routed by the Col-CC, exercising its role as network operations center. The engineering data will be archived at Col-CC whereas the scientific and relevant experiment and facility data will be distributed to de-centralized User Support and Operations Centers or USOCs, where these will be processed and archived.

The USOCs are based in national centers distributed throughout Europe and will be responsible for the specific operations of the ESA payload and experiment facilities within Columbus. At these centers scientific investigators can monitor, or be linked to, their experiments.

The Col-CC is responsible for distributing data to the USOCs and receiving information from them such as requests for resources and reconfiguration of Columbus systems in support of experiments and payload facility operations. Such information is fed into the mission planning process that generates timelines for flight controllers and astronauts.



Long-term storage library at the Columbus Control Center

The European Astronaut Center in Cologne, Germany

The Col-CC also will be linked to the European Astronaut Center in Cologne, Germany, which is responsible for medical support, monitoring, and safety of ESA astronauts during missions.

Since Columbus itself will host non-European experiments such as U.S. payload facilities, decisions such as changes in scheduling are coordinated with the ISS international partners. For this reason the Col-CC is connected to the ISS Mission Control Center at the Johnson Space Center in Houston, the Huntsville Operations Support Center in Huntsville, Ala., and to the Mission Control Center in Moscow.

Further to its functions of command and control of Columbus systems as well as the coordination of the Columbus payload operations, the Col-CC is responsible for operating the ground communications network that provides communication services (voice, video and data) to a large number of sites: ESA Operations Management at ESA/ESTEC; the USOCs; the European Astronaut Center; industrial engineering support sites; and to the Automated Transfer Vehicle (ATV) Control Center in Toulouse, France. The ATV is the European-built ISS re-supply ship, the first of which (Jules Verne) is due for launch early in 2008 by an Ariane 5 rocket from Kourou, French Guiana. The ATV Control Center will coordinate and support all ATV operations for ESA.

The ISS Flight Control Room at the Mission Control Center in Houston

The Col-CC has two control rooms: one for real-time operation control and one for preparation activities, such as the training of controllers, simulations, etc. The second control room also acts as a backup for the first control room. A back-up control center, which can take over operations in case of a major disaster such as fire in the control facility, is provided on site of DLR but not located in the same building.

The ATV Control Center in Toulouse, France will receive communications services from the Columbus Control Center.

The integrated Col-CC flight control team is a joint DLR and EADS Astrium team. This mission control service is provided as part of the overall end-to-end operations service delivered by EADS Astrium as the ISS industrial operator. The flight control team will be led by DLR flight directors and will be under the overall supervision of an ESA mission director based at DLR Oberpfaffenhofen. The Col-CC operations teams will be capable of supporting seven day/week, 24 hours/day operations during the Columbus launch and assembly mission. Thereafter, the Col-CC operations will be tailored to the payload operations needs.

Network Equipment Room at the Columbus Control Center

RENDEZVOUS AND DOCKING

Backdropped by a blue and white Earth, space shuttle Discovery approaches the International Space Station during STS-120 rendezvous and docking operations.

About 2.5 hours before docking, Atlantis' jets will be fired during what is called the Terminal Initiation burn to begin the final phase of the rendezvous. Atlantis will close the final miles to the station during the next orbit.

As Atlantis moves closer to the station, the shuttle's rendezvous radar system and trajectory control sensor will track the complex and provide range and closing rate data to the crew. During the final approach, Atlantis will execute several small mid-course correction burns that will place the shuttle about 1,000 feet directly below the station. STS-122 Commander Steve Frick then will manually control the shuttle for the remainder of the approach and docking.

Frick will stop the approach 600 feet beneath the station to ensure proper lighting for imagery prior to initiating the standard Rendezvous Pitch Maneuver (RPM), or backflip.

Frick will maneuver Atlantis through a 9-minute, 360-degree backflip that allows the station crew to take as many as 300 digital pictures of the shuttle's heat shield.

On verbal cue from Pilot Alan Poindexter to the station crew, Frick will command Atlantis to begin a nose-forward, three-quarter of a degree per second rotational backflip.

Both 400 and 800 mm digital camera lenses will be used to photograph Atlantis by station crew members. The 400 mm lens provides up to 3-inch resolution and the 800 mm lens can provide up to 1-inch resolution. The imagery includes the upper surfaces of the shuttle as well as Atlantis' underside, capturing pictures of the nose landing gear door seals, the main landing gear door seals and the elevon cove.

The photos will be taken out of windows in the Zvezda Service Module using Kodak DCS 760 digital cameras. The imagery is one of several inspection techniques to determine the health of the shuttle's thermal protection system, including the tiles and reinforced carbon-carbon wing leading edges and nose cap.

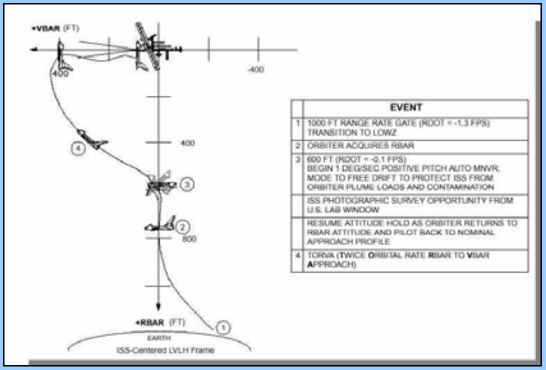
The photos will be downlinked through the station's Ku-band communications system for analysis by systems engineers and mission managers.

When Atlantis completes its rotation, its payload bay will be facing the station.

Frick then will move Atlantis to a position about 400 feet directly in front of the station in preparation for the final approach to docking to the PMA-2, newly located at the end of the Harmony module.

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

Rendezvous Approach Profile



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

Space Shuttle Rendezvous Maneuvers

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

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

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

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

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

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

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

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

Using a view from a camera mounted in the center of the Orbiter Docking System, Frick will precisely match 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.

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

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

Backdropped by a blue and white Earth, space shuttle Discovery approaches the International Space Station during STS-120 rendezvous and docking operations. A Russian spacecraft, docked to the station, is visible at left.

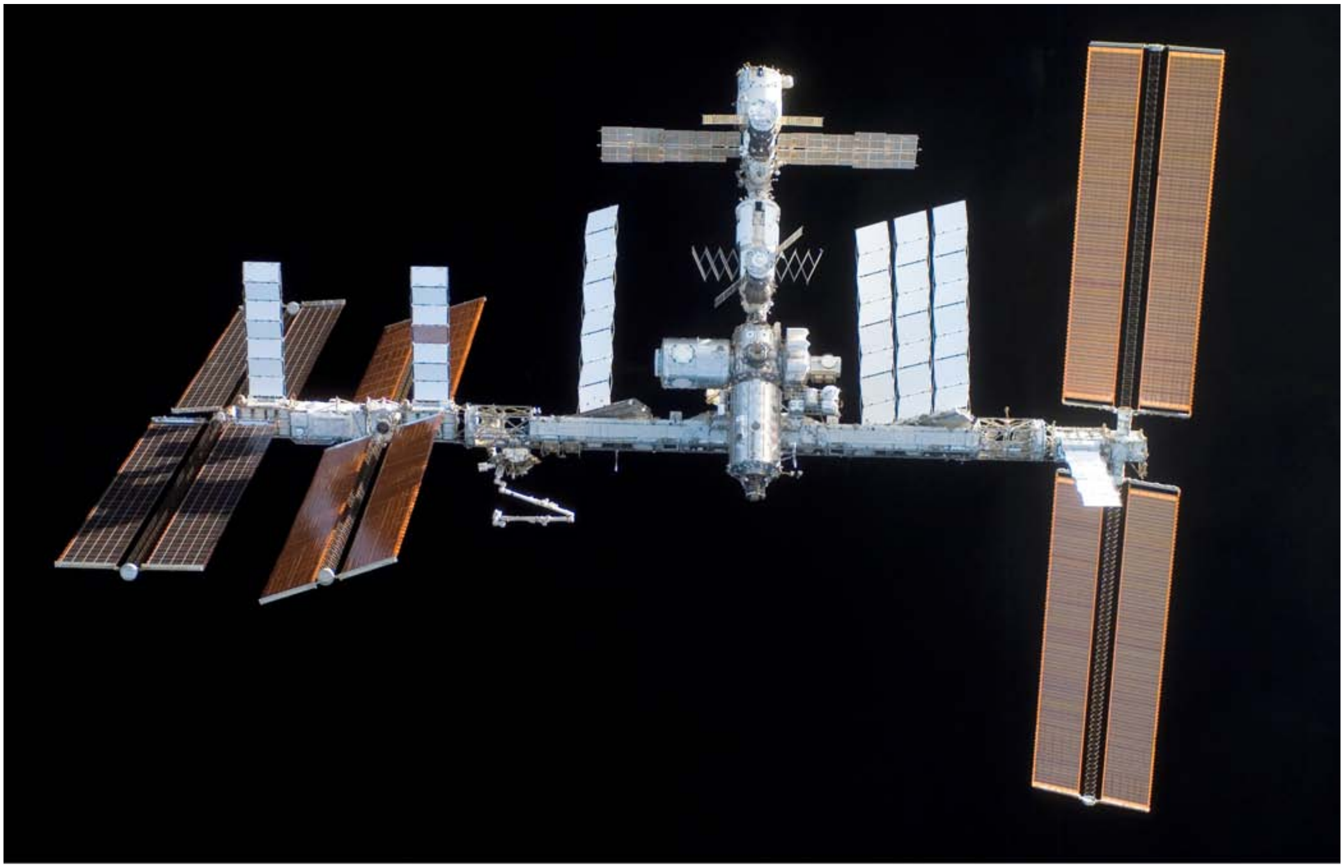
UNDOCKING, SEPARATION, AND DEPARTURE

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

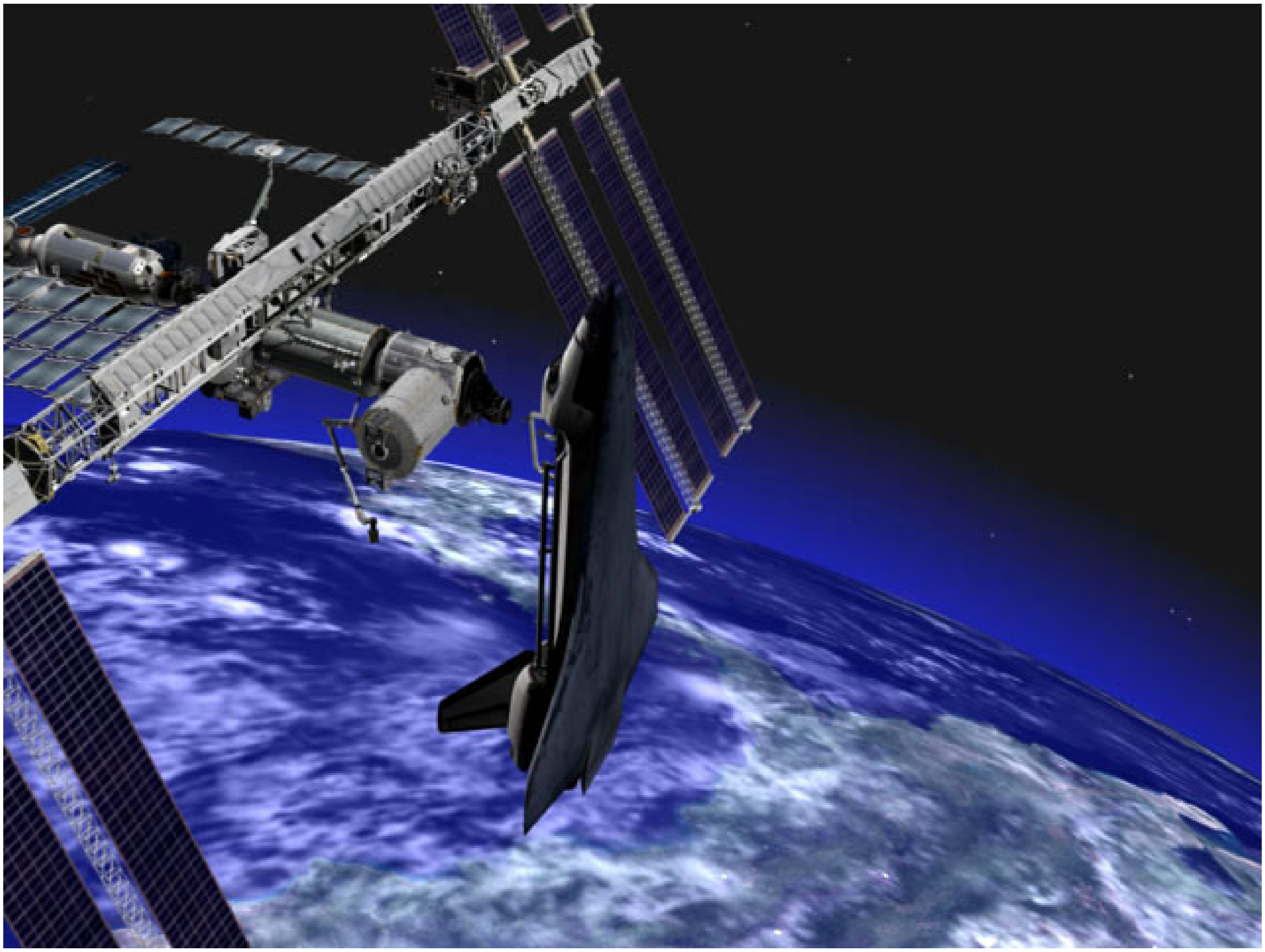
Once Atlantis is about two feet from the station and the docking devices are clear of one another, Poindexter will turn the steering jets back on and will manually control Atlantis within a tight corridor as the shuttle separates from the station.

Atlantis will move to a distance of about 450 feet, where Poindexter will begin to fly around the station in its new configuration. This maneuver will occur only if propellant margins and mission timeline activities permit.

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



Backdropped by the blackness of space, the International Space Station is seen from space shuttle Discovery as the two spacecraft begin their relative separation. Earlier the STS-120 and Expedition 16 crews concluded 11 days of cooperative work onboard the shuttle and station.



This image depicts the space shuttle undocking from the orbital outpost during the STS-120 mission.

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SPACEWALKS

The objective of the spacewalks during the STS-122 mission is to install and prepare the European Space Agency's Columbus research laboratory for use. The three spacewalks, known as extravehicular activities or EVAs, are planned on flight days 4, 6, and 8.

Mission Specialist Rex Walheim is the lead spacewalker for all three excursions. He will be joined by first time spacewalkers European Space Agency Astronaut Hans Schlegel on the first and second spacewalks and Mission Specialist Stanley Love on the third.

Pilot Alan Poindexter will be the intravehicular lead, assisting the spacewalkers with their tasks from inside the spacecraft.

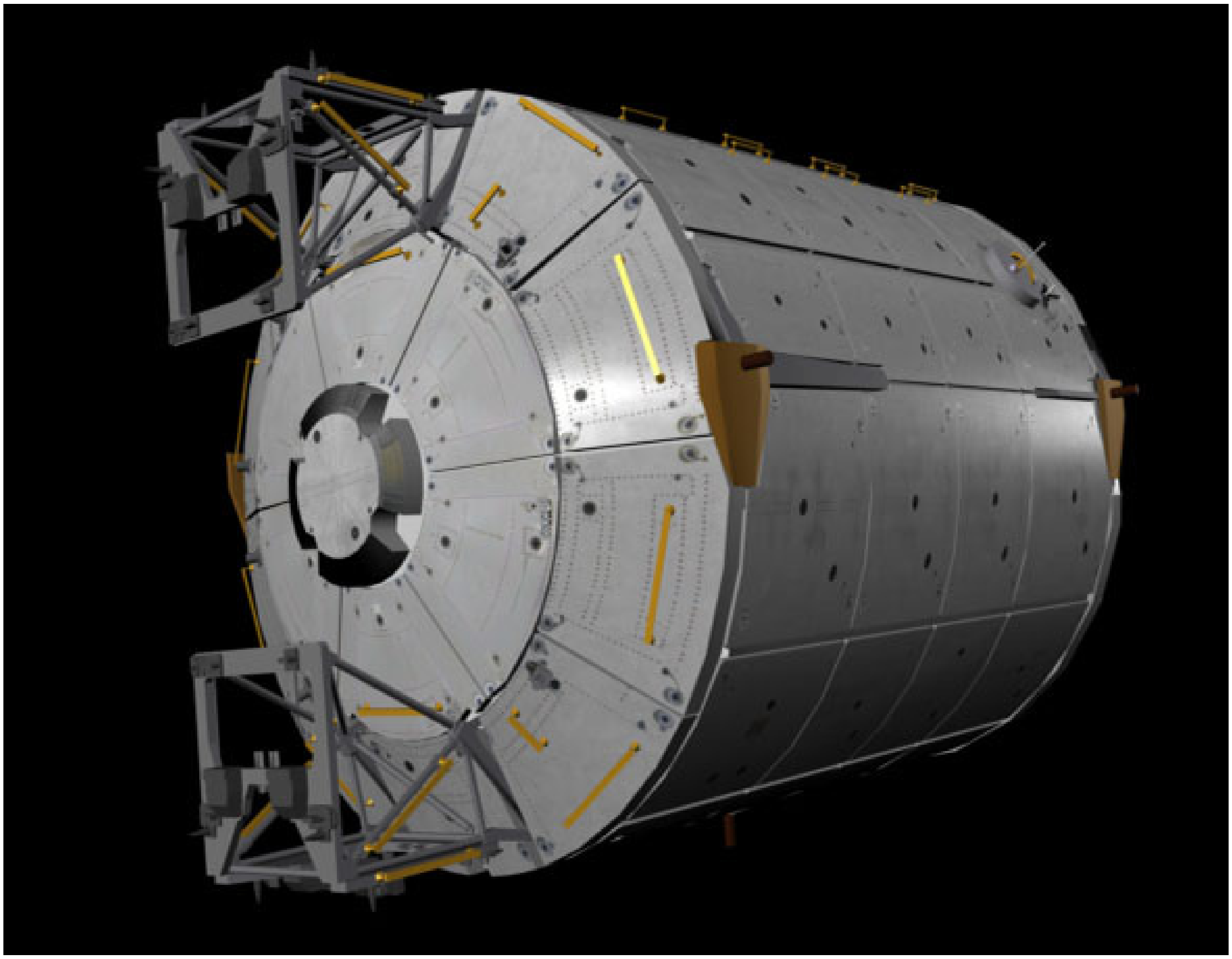
Mission Specialists Leland Melvin and Love will operate the space station's robotic arm for the Columbus installation.

This image illustrates the Columbus laboratory being grappled by the Station Robotic Arm, Canadarm2, in preparation for its relocation to its permanent location.

The spacewalkers will be identifiable by markings on their spacesuits. Walheim's suit will have solid red stripes. Schlegel will wear an all-white spacesuit. Love's suit will have broken red stripes.

The spacewalks will start from the station's Quest airlock. As in recent missions, the astronauts will prepare for the EVA by using the "campout" prebreathe protocol, spending the night before the spacewalk in the airlock. The prebreathe exercise purges nitrogen from the astronauts' systems so they avoid the condition known as the bends.

During the campout, the spacewalking crew members isolate themselves in the airlock. The airlock's air pressure is lowered to 10.2 psi while the station is kept at 14.7 psi, or near sea-level pressure. Upon rising, the astronauts don oxygen masks, and the airlock's pressure is raised again to 14.7 psi for an hour. After breakfast, the pressure is lowered back to 10.2 psi for an additional hour as the spacesuits are donned. An additional 50 minutes in the suits completes the protocol. As a result, the crew can get outside earlier to perform the day's tasks.



Columbus laboratory

Spacewalkers Rex Walheim and Hans Schlegel will conduct the first two extravehicular activities.

EVA-1

EV1: Walheim (MS2)

EV2: Schlegel (MS3)

IV: Poindexter (PLT)

Robotics: Melvin (MS1) and Love (MS4)

Flight day 4

Duration: 6.5 hours

Overview:
The main task will be to prepare the Columbus module for installation on Harmony. They will install the Power Data Grapple Fixture on Columbus, which will allow the space station's robotic arm to grab the module and move it from the shuttle's payload bay to Harmony. The spacewalkers also will begin work to remove the Nitrogen Tank Assembly, a part of the station's thermal control system, from the P1 truss. The assembly needs to be replaced because the nitrogen is running low.

- Stow the shuttle's Ku Band antenna before egress
- Open Harmony (Node 2) starboard Centerline Berthing Camera System (CBCS) Flap

- Demate Columbus Launch To Activation (LTA) cable
- Prepare and remove Meteoroid and Debris Protective Shield (MDPS) panels
- Retrieve the Power Data Grapple Fixture (PDGF) from sidewall carrier
- Remove Columbus Passive Common Berthing Mechanism (PCBM) seal covers
- Set up and install PDGF on Columbus
- Reinstall MDPS panels
- Configure Multi-use Tether End Effector (MUT/EE) ballstack combinations for use on the second spacewalk
- Demate nitrogen lines and break torque on Port 1 (P1) Nitrogen Tank Assembly (NTA)
- Stow On-orbit Replacement Unit Temporary Stowage Device (possible get-ahead task)

EVA-2

EV1: Walheim (MS2)

EV2: Schlegel (MS3)

IV: Poindexter (PLT)

Robotics: Melvin (MS1) and Love (MS4)

Flight day 6

Duration: 6.5 hours

Overview:
Walheim and Schlegel will remove the old NTA and temporarily store it on an equipment cart. They will then install the new one. The old NTA will be transferred to the shuttle's payload bay for return home.

- Release new Nitrogen Tank Assembly (NTA) from Integrated Cargo Carrier (ICC) and stow on Crew and Equipment Translation Aid (CETA) cart
- Remove old P1 NTA, temporarily stow on CETA cart
- Install new P1 NTA
- Maneuver to payload bay (PLB) and install old NTA on Integrated Cargo Carrier
- Install Columbus trunnion covers

EVA-3

EV1: Walheim (MS2)

EV2: Love (MS4)

IV: Poindexter (PLT)

Robotics: Melvin (MS1) and Eyharts (FE2)

Flight day 8

Duration: 6.5 hours

Overview:
Walheim and Love will install two payloads on Columbus' exterior: SOLAR, an observatory to monitor the sun; and the European Technology Exposure Facility (EuTEF) that will carry eight experiments requiring exposure to the space environment. The spacewalkers also will move a failed control moment gyroscope from its storage location on the station to the shuttle's payload bay for return to Earth.

- Release SOLAR from Integrated Cargo Carrier
- Maneuver to External Payload Facility (EPF) and install SOLAR
- Install Keel Pin Cover

- Engage adjustable shims on Control Moment Gyroscope (CMG) Flight Support Equipment (FSE)
- Release and maneuver CMG to payload bay/ integrated cargo carrier
- Install CMG on Integrated Cargo Carrier
- Release European Technology Exposure Facility (EuTEF) from Integrated Cargo Carrier
- Maneuver to EPF and install EuTEF
- Install Columbus worksite interfaces and handrails

Spacewalkers Rex Walheim and Stanley Love will conduct the mission's third scheduled extravehicular activity.

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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 853 In-Flight Evaluation for Areas of CO2 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.

DTO 805 Crosswind Landing Performance (If opportunity)

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

1. 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 with 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.

SDTO 13005-U ISS Structural Life and Life Validation and Extension

The purpose of this Station Development Test Objective (SDTO) is to guarantee safety of the station structure and crew by validating the on-orbit math models that were created for the space station. The test will be used to validate critical interface load and to help improve fatigue life prediction on the station.

The test will provide dynamic loads information for engineers to use in creating precise models that can be used for analysis. On-orbit data may aid in detecting structural anomalies, and the station's response to actual loading events aids in post-flight reconstruction of loads that help determine structural life usage.

The test requires actual or educated estimates of input (forcing function) and actual output (on-orbit sensor measurements) of the station response. Measurement of the force input (i.e., thruster firing sequences, video of crew activity, etc.) and station response will aid reconstruction of station loads and structural life usage over the life of the station, thus allowing life extension of the structure.

All of the on-orbit dynamic tests were also performed on the ISS-Orbiter mated configuration models.

SHORT-DURATION 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 International Space Station:

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

or

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

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.

Samples Returning

Molecular and Plant Physiological Analyses of the Microgravity Effects on Multigeneration Studies of Arabidopsis thaliana (Multigen) will grow Arabidopsis thaliana, a small flowering plant related to cabbage and mustard, in orbit for three generations. The results of this investigation will support future plans to grow plants on the long-duration transit to Mars. This is a cooperative investigation with the European Space Agency, ESA

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.

The Optimization of Root Zone Substrates (ORZS) for Reduced Gravity Experiments Program was developed to provide direct measurements and models for plant rooting media that will be used in future Advanced Life Support (ALS) plant growth experiments. The goal of this investigation is to develop and optimize hardware and procedures to allow optimal plant growth to occur in microgravity.

Stability of Pharmacotherapeutic and Nutritional Compounds (Stability) will study the effects of radiation in space on complex organic molecules, such as vitamins and other compounds in food and medicine. This could help researchers develop more stable and reliable pharmaceutical and nutritional countermeasures suitable for future long-duration missions to the moon and Mars.

European Space Agency Short-Duration Experiments

The Study of Lower Back Pain in Crewmembers During Space Flight (Mus) investigation will study the development of lower back pain in crew members during space flight and determine if there is a relationship to muscle atrophy. Lower back pain on Earth is result of the amount of pressure that is placed on the spinal column by gravity. During missions in microgravity, crew members experience back pain which could be the result of muscle atrophy in the lower back.

EUROPEAN SPACE AGENCY EXPERIMENTS

The **Debris in Orbit Evaluator – 2 (DEBIE-2)** is used to determine the parameters of space debris and micrometeoroids in situ by their impacts with a detecting surface. Knowledge of impacts, their seasonal variations and long-term evolution is required for a reliable spacecraft risk assessment and the design of protective shielding.

DOSimetry TELescopes (DOSTEL) is designed to measure time dependent fluence rates of charged particles and their corresponding dose rates. The experiment uses two sensor types planar Silicon detectors (PIPS) and PIN diodes.

EuTEF Thermometer (EuTemp) will record temperatures across EuTEF (European Technology Exposure Facility) after ascent and for 30 days and will download the data to Earth.

The **Earth Viewing Camera (EVC)** is a fixed-pointed Earth-observing camera, located on the European Technology Exposure Facility (EuTEF). The main goal of the system is to capture color images of the Earth surface, to be used as a communication tool to increase the awareness of the general public on the ISS and as a promotional tool to demonstrate the use of the ISS for observation purposes to the potential user community.

Exposure Experiment (Expose) is a multi-user facility accommodating experiments in several disciplines. Expose allows short and long-term exposure of experiments to space conditions and solar UV-radiation on the International Space Station.

Flux (Phi) Probe Experiment (FIPEX) is a system which is able to distinguish and measure molecular and atomic oxygen at very low ambient pressures. It is based on solid oxide electrolyte microsensors.

Fly Wheel Exercise Device (FWED) is an in-flight exercise countermeasure system, to prevent muscle atrophy, bone loss and impairment of muscle function in human beings in response to long-duration spaceflight.

Simulation of Geophysical Fluid Flow under Microgravity (Geoflow) is an ESA investigation planned for the Fluid Science Laboratory (FSL) on the ISS. Geoflow will study thermal convection in the gap between two concentric rotating (full) spheres to model Earth’s liquid core.

Material Exposure and Degradation Experiment (MEDET) will actively monitor material degradation dynamics in low Earth orbit and acquire a better knowledge of the International Space Station environment in terms of contamination, atomic oxygen, ultraviolet radiation and microparticles.

Motion Perception: Vestibular Adaptation to G-Transitions (MOP) will provide insight in the process of vestibular adaptation to a gravity transition. Adaptation will be assessed by rating motion perception as a result of body movements. MOP will also correlate susceptibility to space adaptation syndrome (SAS) with susceptibility to sickness induced by centrifugation (SIC). The experimental results will allow the team to establish the time course of the adaptation process and thereby set a further step in the determination of key parameters in vestibular adaptation.

Particle Flux Demonstrator (Particle Flux) is an experiment designed to measure ionizing particle radiation inside of ISS. The device is constructed for educational purposes and will be used to demonstrate the basic properties of the ionizing radiation environment aboard the ISS. Activities will be filmed and included in a media package for high school and university students throughout Europe.

Plasma Electron Gun Payload (PLEGPAY) will validate the plasma contactor as an active device on the International Space Station for the prevention/control of electrostatic charging phenomena on large space structures orbiting at low Earth orbit.

SOL-ACES (SOLar Auto-Calibrating EUV/UV Spectrophotometers) measures the extreme-ultraviolet/ultraviolet (EUV/UV) spectrum (17 nm to 220 nm) with moderate spectral resolution.

SOLSPEC (SOLar SPECtral Irradiance Measurements) will operate at high spectral resolution in the range 180-3000 nm, with an accuracy of 2% in ultravaiolet (UV) and 1% in visible and infrared (IR).

SOVIM (SOlar Variable and Irradiance Monitor) will measure solar spectral irradiance via filter-radiometers in the near-UV (402 nanometers), visible (500 nanometers) and near-IR (862 nanometers) regions, together with the total solar irradiance, using two types of radiometers covering the range from 200 nanometers to 100 micrometers.

Tribology Laboratory (Tribolab) is an investigation of the tribological (science of mechanisms of friction, lubrication, and wear of interacting surfaces that are in motion) behavior of different lubricants in microgravity which can not be simulated on Earth.

Waving and Coiling of Arabidopsis Roots: Interaction of Circumnutation and Gravitropism in 1-g and Uncoupling at Microgravity (WAICO) will observe Arabidopsis root growth in space, to predict that without interfering gravity they will grow in spirals, verifying the endogenous nature of circumnutation-like growth imbalances in this plant root.

Facilities Delivered

Biological Experiment Laboratory in Columbus (BioLab) is a multi-user research facility located in the European Columbus laboratory. It will be used to perform space biology experiments on microorganisms, cells, tissue cultures, small plants and small invertebrates. BioLab will allow a better understanding of the effects of microgravity and space radiation on biological organisms.

The **European Drawer Rack (EDR)** will provide room for European Space Agency (ESA) class 2 (compact and low mass) experiments. EDR can accommodate seven experiment modules (EM). One class 2 payload may be composed of several EM's. Each class 2 payload will have its own cooling, power, and data communications, as well as vacuum, venting and nitrogen supply if required. The EDR is designed to be multi-discipline facility accommodating investigations from all any science discipline.

The **European Physiology Modules Facility (EPM)** is designed to investigate the effects of short-term and long-duration space flights on the human body. The research into human physiology under microgravity conditions will also contribute to an increased understanding of terrestrial problems such as the aging process, osteoporosis, balance disorders and muscle deterioration.

The purpose of the **European Technology Exposure Facility (EuTEF)** is to provide investigators a way to gather scientific and technological data. EuTEF is providing facility resources like power and data sharing, thermal control and accommodation to a number of different disciplines of scientific and technology investigations. EuTEF is installed on a CEPA (Columbus External Payload Adapter), which is providing the interface of the facility infrastructure and the EuTEF investigations to the Columbus external payload facilities (CEPF).

The **Fluid Science Laboratory (FSL)** is a multi-user facility, designed by the European Space Agency (ESA) for conducting fluid physics research in microgravity conditions. It can be operated in fully- or in semi-automatic mode and can be controlled on-board by the International Space Station (ISS) crew members, or from the ground in telescience mode.

Sun Monitoring on the External Payload Facility of Columbus (Solar) is a monitoring observatory that will allow one to measure with unprecedented accuracy the solar spectral irradiance. Apart from scientific contributions for solar and stellar physics, the knowledge of the solar energy irradiance into the Earth's atmosphere and its variations is of great importance for atmospheric modeling, atmospheric chemistry and climatology.

EUROPEAN EXPERIMENT PROGRAM

Columbus will immediately support a full European experiment program in a host of different scientific areas with many utilizing the internal and external experiment facilities of the Columbus laboratory after its arrival on the STS-122 flight. European experiments will be undertaken by members of the Expedition 16 crew, including ESA astronaut Léopold Eyharts and Russian cosmonaut Yuri Malenchenko. Other experiments will include those carried out by ESA astronaut Hans Schlegel who will be a mission specialist on the STS-122/1E assembly flight.

Human Physiology

Chromosome-2

During spaceflights crew members are exposed to different types of ionizing radiation. To assess the genetic impact of these radiations, this experiment will study chromosome changes and sensitivity to radiation in lymphocytes (white blood cells) of ISS crew members. The Chromosome-2 experiment is planned to be carried out using eight subjects: four subjects from short-duration flights and four Expedition crew members.

Science Team:

C. Johannes (DE), M. Horstmann (DE)

Early Detection of Osteoporosis in Space

The mechanisms underlying the reduction in bone mass, which occurs in astronauts in weightlessness, are still unclear. The Early Detection of Osteoporosis in Space (EDOS) experiment will evaluate the structure of weight and non-weight bearing bones of cosmonauts/astronauts pre and post-flight using the method of computed tomography (pQCT) together with an analysis of bone biochemical markers in blood samples.

Computed tomography (pQCT) measurement during second campaign of the WISE bed rest study in Toulouse, France.

The objective of the project is to demonstrate the efficiency of this technique as an early detection of impairment in bone remodeling and ultimately to provide information on the mechanics underlying bone loss and to accurately evaluate the efficiency of relevant countermeasures.

EDOS should significantly contribute to the development of a reference technique to perform an early detection of osteoporosis on Earth. The ground experiment with the ISS increment crews will take place at Star City near Moscow and is scheduled to use 10 to 12 short- and long-term subjects.

Science Team:
C. Alexandre (FR), L. Braak (FR), L. Vico (FR),
P. Ruegsegger (CH), M. Heer (DE)

Eye Tracking Device

The working of our balance system and our eyes are strongly interconnected and understanding their adaptation to weightlessness can help with our understanding of the occurrence of space sickness. Our eyes can rotate around three axes whereas normally only two are used. The name of the coordinate framework which describes the movement of the eyes in the head is called Listing's plane. This experiment centers on the evaluation of Listing's plane under different gravity conditions using the Eye Tracking Device (ETD), which is able to record horizontal, vertical and rotational eye movements and measure head movement.

Science Team:
A. Clarke (DE), T. Haslwanter (CH),
E. Tomilovskaya (RU), I. Koslovkaya (RU)

Immuno

The aim of this experiment is to determine changes in stress and immune responses, during and after a stay on the ISS. This will include the sampling of saliva, blood and urine to check for hormones associated with stress response and for carrying out white blood cell analysis and a questionnaire to be filled out by the astronaut. There will also be a focus on the adaptation of cellular energy metabolism, which can affect immune response.

Science Team:
A. Chouker (DE), F. Christ (DE), M. Thiel (DE),
I. Kaufmann (DE), B. Morukov (RU)

Low Back Pain

The deep muscle corset plays an important role in posture when in the upright position. It is thought that this deep muscle corset atrophies during spaceflight leading to strain and hence pain in certain ligaments, in particular in the iliolumbar region in the back. The objective of this experiment is to assess the back pain in response to exposure to weightlessness.

Science Team:
A. Pool-Goudzwaard (NL), C. Richardson (AU),
J. Hides (AU), L. Danneels (BE)

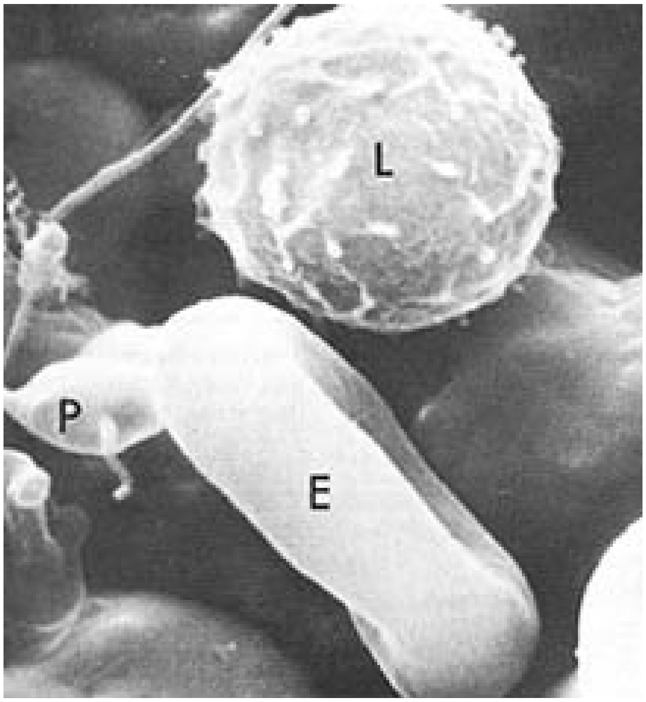
MOP

When entering weightlessness, astronauts suffer from a phenomenon called space motion sickness, which has symptoms comparable to seasickness. This disturbance in the body's orientation and balance is similar to the disturbances experienced by subjects who have undergone rotation in a human centrifuge having experienced two to three times Earth's gravity for up to several hours. This experiment aims to obtain an insight into this process and could help in developing countermeasures to space motion sickness.

Science Team:

E. Groen (NL), J. Bos (NL), S. Nooij (NL),
W. Bles (NL), R. Simons (NL), T. Meeuwsen (NL)

Neocytolysis



Constituents of blood. E is an erythrocyte or red blood cell, L is a lymphocyte or white blood cell and P is a blood platelet.

This experiment covers the effects of weightlessness on the hemopoietic system: the system of the body responsible for the formation of blood cells. The experiment will study a process called neocytolysis, the selective destruction of young red blood cells. The experiment will analyze the physical and functional characteristics of young red blood cells taken from astronaut blood samples before and after spaceflight.

Science Team:

A. Risso (IT), G. Antonutto (IT), M. Cosulich (IT),
G. Minetti (IT)

Spin

This experiment is a comparison between preflight and post-flight testing of astronaut subjects using a centrifuge and a standardized tilt test. Orthostatic tolerance, i.e., the ability to maintain an upright posture (without fainting) will be correlated with measures of otolith-ocular function, i.e., the body's mechanism linking the inner ear with the eyes that deals with maintaining balance.

Science Team:

F. Wuyts (BE), S. Moore (US),
H. MacDougall (AU), G. Clement (FR),
B. Cohen (US), N. Pattyn (BE), A. Diedrich (US).

ZAG

ZAG, which stands for Z-axis Aligned Gravito-inertial force is an investigation into the effect that weightlessness has on an astronaut's perception of motion and tilt as well as his level of performance during and after spaceflight. Different tests will take place pre and post flight including an analysis of the astronaut's motion perception and eye movements whilst using a track-and-tilt chair.

Science Team:

G. Clement (FR), S. Wood (US),
M. F. Reschke (US), P. Denise (FR).

Radiation Dosimetry

EuCPD

The European Crew Personal Dosimeters (EuCPDs) will be worn by the ESA astronauts onboard the ISS to measure the radiation exposure during their flights. The dosimeters are worn around the waist and the left ankle for astronauts inside the station and at the same locations above the liquid cooling garment inside the spacesuit for astronauts undertaking spacewalks. Each dosimeter is only 8 mm thick and consists of a stack of five different passive radiation sensors. The different sensors will measure different radioactive particles such as a range of neutrons and heavy ions as well as measuring particle impact angles and energy transfer from particles.

Science Team:
U. Straube – ESA, C. Fuglesang - ESA

Project Team:
J. Dettmann – ESA, G. Reitz – DLR (DE)

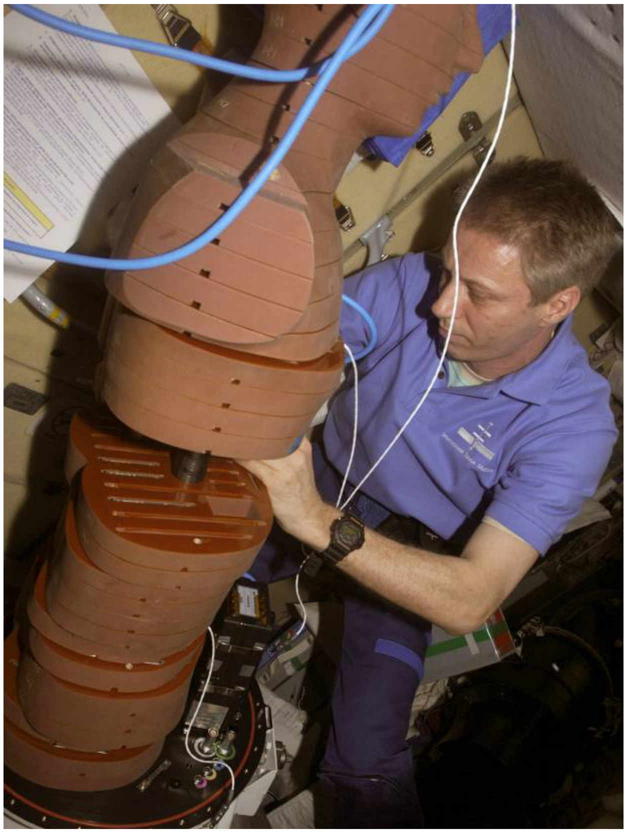
Matroshka 2B

The ESA Matroshka facility was initially installed on the external surface of the ISS on Feb. 27, 2004 with the aim of studying radiation levels experienced by astronauts during spacewalk activities. It consists of a human shape (head and torso) called the Phantom equipped with several active and passive radiation dosimeters. This is mounted inside an outer container of carbon fiber and reinforced plastic to simulate a spacesuit. The facility was brought back inside the ISS on Aug. 18, 2005, to continue the experiment for radiation measurements inside the ISS.

For the Matroshka 2B experiment, new passive radiation sensors uploaded on Soyuz 15S on Oct. 10, 2007 will be installed inside the Phantom. The active radiation dosimeters will be activated in early 2008. The Matroshka facility will be installed inside the ISS to taking similar measurements related to the internal ISS radiation environment.

Science Team:
G. Reitz (DE), R. Beaujean (DE),
W. Heinrich (DE), M. Luszik-Bhadra (DE),
M. Scherkenbach (DE), P. Olko (PL),
P. Bilski (PL), S. Derne (HU), J. Palvalvi (HU),
E. Stassinopoulos (US), J. Miller (US),
C. Zeitlin (US), F. Cucinotta (US),
V. Petrov (RU).

Project Team:
ESA: J. Dettmann, DLR: G. Reitz, J. Bossler,
Kayser Italia: M. Porciani, F. Granata



ESA astronaut Thomas Reiter, works with the Matroshka experiment Phantom in the Zvezda Service Module of the International Space Station in December 2006.

Education Activities

The ESA views education as an important facet of all human spaceflight missions, promoting and fostering the important role of science and technology in the younger generation. For primary school children there will be an animated web lesson about the Columbus Laboratory with a cut out model of Columbus while for secondary school children there will be a video podcast focusing on Columbus as a unique, European science laboratory in space with accompanying biology and physics lessons online.

For university students an essay contest was launched in September 2007, the winner of which will attend the launch of the Columbus Laboratory at the Kennedy Space Center in Florida. The topic of the essay is the "Value of Human Spaceflight for European Citizens". University course material related to engineering aspects of Columbus will also be available on the ESA Web portal. National web chats with ESA astronauts Hans Schlegel and Léopold Eyharts either pre- or post-flight are also being organized.

Project Team
ESA-HME Education Office (NL)

External Experiments: EuTEF Facility

The European Technology Exposure Facility (EuTEF) is one of the first two external facilities to be attached to the Columbus laboratory and houses the following experiments requiring either exposure to the open space environment or a housing on the external surface of the ISS:

EXPOSE-E
EXPOSE-E is a subsection of EuTEF and consists of five individual exobiology experiments:

LIFE – The ***Lichens and Fungi Experiment (LIFE)*** experiment will test the limits of survival of Lichens, Fungi and symbionts under space conditions. Some of the organisms being exposed for approximately 1.5 years include the black Antarctic fungi (*Cryomyces antarcticus* and *Cryomyces minteri*), the fungal element (mycobiont) of the lichen *Xanthoria elegans*, and the complete lichens (*Rhizocarpon geographicum* and *Xanthoria elegans*) in situ on rock samples.

Previous results from the Biopan exposure facility on the Foton-M2 mission in 2005 showed the ability for lichens to survive in exposed space conditions for 15 days.

**Top: Lichen Xanthoria elegans.
Bottom: mycobiont**

Science Team:
S. Onofri (IT), L. Zucconi (IT),
L. Selbmann (DE), S. Ott (DE), J-P.de Vera (ES),
R. de la Torre (ES)

ADAPT – This experiment concerns the molecular adaptation strategies of micro-organisms to different space and planetary UV climate conditions.

Science Team:
P. Rettberg (DE), C. Cockell (UK),
E. Rabbow (DE), T. Douki (FR), J. Cadet (FR),
C. Panitz (DE), R. Moeller (DE),
G. Horneck (DE), H. Stan-Lotter (AT)

PROCESS – The main goal of the PROCESS (PRebiotic Organic ChEmistry on Space Station) experiment is to improve our knowledge of the chemical nature and evolution of organic molecules involved in extraterrestrial environments.

Science Team:
H. Cottin (FR), P. Coll (FR), D. Coscia (FR),
A. Brack (FR), F. Raulin (FR)

PROTECT – The aim of this experiment is to investigate the resistance of spores, attached to the outer surface of spacecraft, to the open space environment. Three aspects of resistance are of importance: the degree of resistance; the types of damage sustained; and the spores repair mechanisms.

Science Team:
G. Horneck (DE), J. Cadet (FR), T. Douki (FR),
R. Mancinelli (FR), R. Moeller(DE),
J. Pillinger (UK), W. Nicholson (US),
E. Rabbow (DE), J. Sprey (UK),
P. Rettberg (DE), E. Stackebrandt (DE),
K. Venkateswaren (US)

SEEDS – This experiment will test the plant seed as a terrestrial model for a panspermia vehicle, i.e., a means of transporting life through the universe and as a source of universal UV screens.

Science Team:
D.Tepfer (FR), A. Zalar (HR),
S. Leach (UK), S. Hoffmann (DK),
P. Ducrot (FR), F. Corbineau (FR)

DEBIE-2

DEBIE, which stands for 'DEBris In orbit Evaluator' is designed to be a standard in-situ space debris and micrometeoroid monitoring instrument which requires low resources from the spacecraft. It measures sub-mm sized particles and has three sensors facing in different directions. The scientific results from several DEBIE instruments onboard different spacecraft will be compiled into a single database for ease of comparison.

Science Team:
G. Drolshagen – ESA, A. Menicucci – ESA

Dostel

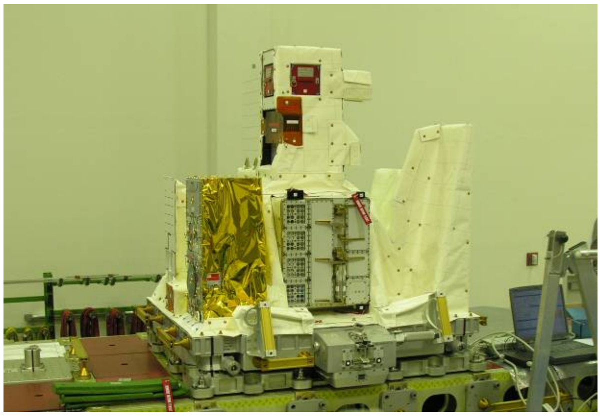
Dostel (DOSimetric radiation TELescope) is a small radiation telescope that will measure the radiation environment outside the ISS.

Science Team:
G. Reitz -DLR (DE)

EuTEMP

EuTEMP is an autonomous and battery-powered multi-input thermometer for measuring EuTEF temperatures during the unpowered transfer from the shuttle cargo bay to the Columbus External Payload Facility to which EuTEF is attached.

Science Team:
J. Romera – ESA



EuTEF facility at the Kennedy Space Center with external payloads attached

EVC

The Earth Viewing Camera (EVC) payload is a fixed-pointed Earth-observing camera. The main goal of the system is to capture color images of the Earth's surface, to be used as a tool to increase general public awareness of the station and promote the use of the ISS to the potential user community for observation purposes.

Science Team:
M. Sabbatini – ESA

FIPEX

It is important to build up a picture of the varying atmospheric conditions in low Earth orbit where orbiting spacecraft are still affected by atmospheric drag. The density of the atmosphere is the major factor affecting drag and this is affected by solar radiation and the earth's magnetic and gravitational fields. The flux of atomic oxygen is important as it shows different interactions with spacecraft surfaces, e.g., surface erosion. With the FIPEX micro-sensor system, it is intended to measure the atomic oxygen flux as well as the oxygen molecules in the surrounding area of the International Space Station.

Science Team:
Prof. Fasoulas, University of Dresden (DE)

MEDET

The aims of the Materials Exposure and Degradation Experiment (MEDET) are: to evaluate the effects of open space on materials currently being considered for utilization on spacecraft in low earth orbit; to verify the validity of data from the space simulation currently used for materials evaluation; and to monitor solid particles impacting spacecraft in low Earth orbit.

Science Team:
V. Inguimbert – ONERA (FR), A. Tighe – ESA

PLEGPLAY

The scientific objective of PLEGPAY (PLasma Electron Gun PAYload) is the study of the interactions between spacecraft and the space environment in low earth orbit, with reference to electrostatic charging and discharging. Understanding these mechanisms is very important as uncontrollable discharge events can adversely affect the functioning of spacecraft electronic systems.

Science Team:
G. Noci – Laben-Proel (IT)

Tribolab

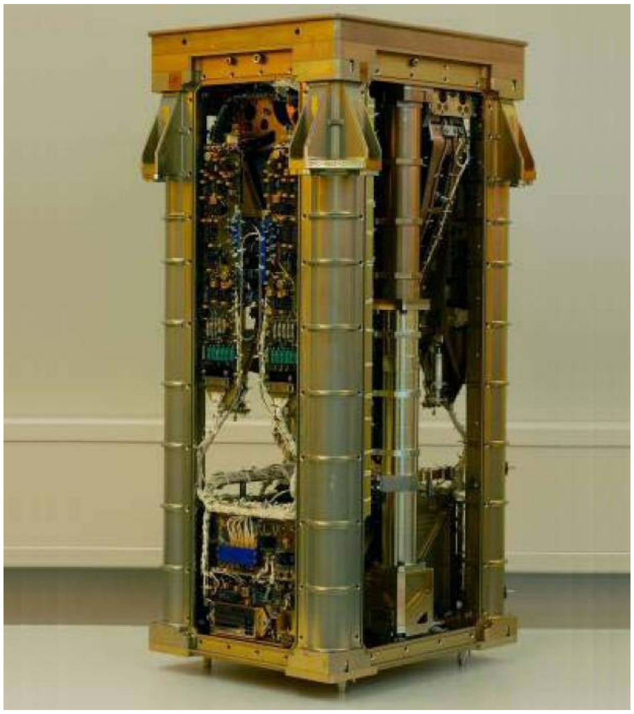
This series of experiment covers research in tribology, i.e., the science of friction and lubrication thereof. This is of major importance for spacecraft systems. The Tribolab experiments will cover both experiments in liquid and solid lubrication such as the evaluation of fluid losses from surfaces and the evaluation of wear of polymer and metallic cages weightlessness.

Science Team:
R. Fernandez – INTA (ES)

External Experiments: SOLAR Facility

The SOLAR (Sun Monitoring on the External Payload Facility of Columbus) facility will study the sun with unprecedented accuracy across most of its spectral range. This study is currently scheduled to last for two years. SOLAR is expected to contribute to the knowledge of the interaction between the solar energy flux and the Earth's atmosphere chemistry and climatology. This will be important for Earth observation predictions. The payload consists of three instruments complementing each other, which are:

SOL-ACES



The Solar Auto-Calibrating Extreme UV-Spectrometer (SOL-ACES)

The goal of the Solar Auto-Calibrating Extreme UV-Spectrometer (SOL-ACES) is to measure the solar spectral irradiance of the full disk from 17 to 220 nm at 0.5 to 2 nm spectral resolution. Solar EUV radiation strongly influences the propagation of electromagnetic signals such as emitted from navigation satellites. Providing the variability of solar EUV radiation with the accuracy of SOL-ACES will contribute to improving the accuracy of navigation data as well as the orbit forecasts of satellites and debris. By an auto-calibration capability, SOL-ACES is expected to gain long-term spectral data with a high absolute resolution. In its center, it contains four Extreme Ultra-Violet spectrometers. SOL-ACES is a new instrument that has never flown.

Science Team:
G. Schmidtke (DE)

SOLSPEC

The purpose of SOLSPEC (SOLar SPECtral irradiance measurements) experiment is to measure the solar spectrum irradiance from 180 to 3,000 nautical miles. The aims of this investigation are the study of solar variability at short and long term and the achievement of absolute measurements (2 percent in UV and 1 percent above). The SOLSPEC instrument is fully refurbished and improved with respect to the experience gained in the previous missions (Spacelab-1, Atlas-1, Atlas-2, Atlas-3, Eureca).

Science Team:
M.G. Thuillier (FR)

SOVIM

The Solar Variability and Irradiance Monitor (SOVIM) is a re-flight of the SOVA experiment on-board Eureca-1. The investigation will observe and study the irradiance of the sun, with high precision and high stability. The total irradiance will be observed with active cavity radiometers and the spectral irradiance measurement will be carried out by one type of sun-photometer.

SOVIM is interested in the basic solar variability in itself or in using this variability to study other physical phenomena, as e.g., solar oscillations. The basic reasons for irradiance changes are crucially important for the understanding of solar and stellar evolution.

Science Team:
C. Frohlich (CH)

The SOLAR facility with the three different instruments highlighted. A is SOLSPEC, B is SOL-ACES and C is SOVIM.

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.

Transoceanic Abort Landing

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

In a TAL abort, the vehicle continues on a ballistic trajectory across the Atlantic Ocean to land at a predetermined runway. Landing occurs about 45 minutes after launch. The landing site is selected near the normal ascent ground track of the orbiter to make the most efficient use of space shuttle main engine propellant. The landing site also must have the necessary runway length, weather conditions and U.S. State Department approval. The three landing sites that have been identified for a launch are Zaragoza, Spain; Moron, Spain; and Istres, France.

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

Abort to Orbit

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

Abort Once Around

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

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

Contingency Aborts

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

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

Abort Decisions

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

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

Mission Control Houston is prime for calling these aborts because it has a more precise knowledge of the orbiter's position than the crew can obtain from on-board systems. Before main engine cutoff, Mission Control makes periodic calls to the crew to tell them which abort mode is (or is not) available. If ground communications are lost, the flight crew has on-board methods, such as cue cards, dedicated displays and display information, to determine the abort region. Which abort mode is selected depends on the cause and timing of the failure causing the abort and which mode is safest or improves mission success. If the problem is a space shuttle main engine failure, the flight crew and Mission Control Center select the best option available at the time a main engine fails.

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

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

SHUTTLE ABORT HISTORY

RSLS Abort History

(STS-41 D) June 26, 1984

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

(STS-51 F) July 12, 1985

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

(STS-55) March 22, 1993

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

(STS-51) Aug. 12, 1993

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

(STS-68) Aug. 18, 1994

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

Abort to Orbit History

(STS-51 F) July 29, 1985

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

SPACE SHUTTLE MAIN ENGINES

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

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

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

The engines operate for about 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 post-flight inspection of recovered hardware.

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

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

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

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

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

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

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

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

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

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

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

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

The SRB nose caps and nozzle extensions are not recovered.

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

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

Hold-Down Posts

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

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

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

SRB Ignition

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

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

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

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

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

At T minus zero, the two SRBs are ignited under command of the four on-board computers; separation of the four explosive bolts on each SRB is initiated (each bolt is 28 inches long and 3.5 inches in diameter); the two T-0 umbilicals (one on each side of the spacecraft) are retracted; the on-board master timing unit, event timer and mission event timers are started; the three SSMEs are at 100 percent; and the ground launch sequence is terminated.

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

Electrical Power Distribution

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

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

Hydraulic Power Units

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

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

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

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

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

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

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

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

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

Thrust Vector Control

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

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

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

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

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

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

SRB Rate Gyro Assemblies

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

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

SRB Separation

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

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

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

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

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

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

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

SPACE SHUTTLE SUPER LIGHT WEIGHT TANK (SLWT)

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

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

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

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

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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

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

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

CID	Circuit Interrupt Device
CIOB	Cargo Integration and Operations Branch
CLA	Camera and Light Assembly
CLPA	Camera Light and Pan/Tilt Assembly
CMG	Control Moment Gyroscope
CMG-TA	Control Moment Gyroscope-Thruster Assist
CO_2	Carbon Dioxide
COAS	Crew Optical Alignment Sight
COR	Communication Outage Recorder
COTS	Commercial-Off-The-Shelf
CP	Cold Plate
CPCG-H	Commercial Protein Crystal Growth-High
CR	Change Request
CRES	Corrosion Resistant Steel
CRIM	Commercial Refrigerator Incubator Module
CRIM-M	Commercial Refrigerator Incubator Module-Modified
CRPCM	Canadian Remote Power Controller Module
CSA	Computer Systems Architecture
CSA-CP	Compound Specific Analyzer-Combustion Products
CSCI	Computer Software Configuration Item
CSM	Cargo Systems Manual
CSS	Crew Support Station
CTB	Cargo Transfer Bag
CVIU	Common Video Interface Unit
CVT	Current Value Table
CVV	Carbon Dioxide Vent Valve
CWC	Contingency Water Collection
DAA	Docked Air-to-Air
DAG1	Docked A/G 1
DAIU	Docked Audio Interface Unit
DAP	Digital Autopilot
DC	Docking Compartment
dc	direct current
DCP	Display and Control Panel
DCSU	Direct Current Switching Unit
DDCU	DC-to-DC Converter Unit
DDCU-CP	DC-to-DC Converter Unit-Cold Plate
DDCU-E	External DDCU
DDCU-HP	DC-to-DC Converter Unit-Heat Pipe
DDCU-I	Internal DDCU
DFL	Data Format Load

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

ETVCG	External Television Cameras Group
EUE	Experiment Unique Equipment
EuTEF	European Technology Exposure Facility
EV	Extravehicular
EV-CPDS	Extravehicular-Charged Particle Directional Spectrometer
EVA	Extravehicular Activity
EVR	Extravehicular Robotics
EVSU	External Video Switching Unit
EXPRESS	EXpedite the PRocessing of Experiments to the Space Station
EXT	Experimental Terminal
EWIS	External Wireless Instrumentation System
FAWG	Flight Assignment Working Group
FC	Firmware Controller
FCC	Flat Controller Circuit
FCT	Flight Control Team
FCV	Flow Control Valve
FD	Flight Day
FDA	Fault Detection Annunciation
FDIR	Failure, Detection, Isolation and Recovery
FDS	Fire Detection and Suppression
FET	Field Effect Transistor
FGB	Functional Cargo Block
FHRC	Flex Hose Rotary Coupler
FI	Fault Isolator
FPU	Fluid Pumping Unit
FQDC	Fluid Quick Disconnect Coupling
FRD	Flight Requirements Document
FRGF	Flight Releasable Grapple Fixture
FSE	Flight Support Equipment
FSS	Fluid System Servicer
FWCI	Firmware Configuration Item
GAS	Get Away Special
GC	Growth Cell
GCA	Growth Cell Assembly
GFE	Government-Furnished Equipment
GFI	Ground Fault Interrupter
GJOP	Generic Joint Operations Panel
GLONASS	GLObal Navigational Satellite System
GN&C	Guidance, Navigation and Control
GNC	Guidance Navigation Computer
GPC	General Purpose Computer

GPRV	Gas Pressure regulating Valve
GPS	Global Positioning System
GUI	Graphical User Interface
H_2	Hydrogen
HAB	Habitat Module
HC	Hand Controller
HCA	Hollow Cathode Assembly
HCOR	High-Rate Communication Outage Recorder
HDR	High Data Rate
HDRL	High Date Rate Link
HEPA	High Efficiency Particulate Air
HGA	High Gain Antenna
HHL	Handheld Lidar
HP	Heat Pipe
HPGT	High Pressure Gas Tank
HRF	Human Research Facility
HRF-PUF-DK	Human Research Facility Puff Data Kit
HRF-Res	Human Research Facility Resupply
HRFM	High Rate Frame Multiplexer
HRM	High Rate Modem
HRS	Hand Reaction Switch
I/F	Interface
I/O	Input/Output
IAC	Internal Audio Controller
IAS	Internal Audio Subsystem
IATCS	Internal Active Thermal Control System
ICC	Integrated Cargo Carrier
ICOM	Intercom
IDA	Integrated Diode Assembly
IDRD	Increment Definition Requirements Document
IEA	Integrated Equipment Assembly
IFHX	Interface Heat Exchanger
IFI	Item for Investigation
IFM	In-flight Maintenance
IMCA	Integrated Motor Control Assembly
IMCS	Integrated Mission Control System
IMU	Impedance Matching Unit
IMV	Intermodule Ventilation
INCO	Instrumentation and Communication Officer
INSTM	Insrtumentation
INT	Internal

INTSYS	Internal Systems
IOC	Input/Output Controller
IOCU	Input/Output Controller Unit
IP	International Partner
IRU	In-Flight Refill Unit
ISA	Internal Sampling Adapter
ISIS	International Space Station Interface Standard
ISL	Integrated Station LAN
ISO	Inventory and Stowage Officer
ISPR	International Standard Payload Rack
ISS	International Space Station
ISSPO	International Space Station Program Office
ISSSH	International Space Station Systems Handbook
IT	Integrated Truss
ITCS	Internal Thermal Control System
ITS	Integrated Truss Segment
IUA	Interface Umbilical Assembly
IV	Intravehicular
IVA	Intravehicular Activity
IVSU	Internal Video Switch Unit
IWIS	Internal Wireless Instrumentation System
JAXA	Japan Aerospace Exploration Agency
JEM	Japanese Experiment Module
JEU	Joint Electronic Unit
KSC	Kennedy Space Center
kW	Kilowatt
LA	Launch Aft
Lab	Laboratory
LAN	Local Area Network
LB	Local Bus
LB-RWS	RWS Local Bus
LCA	Lab Cradle Assembly
LCC	Launch Commit Criteria
LCD	Liquid Crystal Display
LDI	Local Data Interface
LDR	Low Data Rate
LDU	Linear Drive Unit
LED	Light-Emitting Diode
LEE	Latching End Effector
LEU	LEE Electronic Unit

LFDP	Load Fault Detection Protection
LGA	Low Gain Antenna
LLA	Low Level Analog
LMC	Lightweight Multipurpose Carrier
LON	Launch On Need
LT	Low Temperature
LTA	Launch to Activation
LTL	Low Temperature Loop
LTU	Load Transfer Unit
LVLH	Local Vertical Local Horizontal
MA	Mechanical Assembly
MAM	Manual Augmented Role
MBA	Motorized Bolt Assembly
MBE	Metal Bellows Expander
MBM	Manual Berthing Mechanism
MBS	Mobile Remote Service Base System
MBSU	Main Bus Switching Unit
MC	Midcourse Correction
MCA	Major Constituent Analyzer
MCAS	MBS Common Attach System
MCC	Mission Control Center
MCC-H	Mission Control Center-Houston
MCC-M	Mission Control Center-Moscow
MCDS	Multifunction CRT Display System
MCS	Motion Control System
MCU	MBS Computer Unit
MDA	Motor Drive Assembly
MDL	Middeck Locker
MDM	Multiplexer/Demultiplexer
MED OPS	Medical Operations
MEPS	Microencapsulation Electrostatic Processing System
MEPSI	Micro-Electromechanical System-based Pico Satellite Inspector
MER	Mission Evaluation Room
MET	Mission Elapsed Time
METOX	Metal Oxide
MFCV	Manual Flow Control Valve
MHS	MCU Host Software
MIL-STD	Military Standard
MILA	Mode Indicating Light Assembly
MIP	Mission Integration Plan
MISSE	Materials International Space Station Experiment

MLI	Multi-Layer Insulation
MM/OD	Micrometeoroid/Orbital Debris
MMT	Mission Management Team
MOD	Mission Operations Directorate
MPEV	Manual Pressure Equalization Valve
MPLM	Multipurpose Logistics Module
MPM	Manipulator Positioning Mechanism
MRL	Manipulator Retention Latch
MRS	Mobile Remote Servicer
MRSBS	Mobile Remote Servicer Base System
MSD	Mass Storage Device
MSFC	Marshall Space Flight Center
MSG	Microgravity Science Glovebox
MSS	Mobile Servicing System
MT	Mobile Transporter
MTCL	Mobile Transporter Capture Latch
MTL	Moderate Temperature Loop
MTS	Module-to-Truss Segment
MTSAS	Module-to-Truss Segment Attachment System
MTWsN	Move to Worksite Number

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

O_2	Oxygen
OCA	Orbital Communications Adapter
OCAD	Operational Control Agreement Document
OCJM	Operator-Commanded Joint Position Mode
OCPM	Operator-Commanded POR Mode
OCS	Operations and Control Software
ODIN	Orbital Design Integration System

ODS	Orbiter Docking System
OI	Operational Increment
OIU	Orbiter Interface Unit
OIV	Oxygen Isolation Valve
OMI	On-Orbit Maintainable Item
OMS	Orbital Maneuvering System
OPCGA	Observable Protein Crystal Growth Apparatus
OPP	OSVS Patch Panel
Ops	Operations
OPS LAN	Operations Local Area Network
ORBT	Optimized RBar Targeting Technique
ORCA	Oxygen Recharge Compressor Assembly
ORU	Orbital Replacement Unit
OSE	Orbiter Support Equipment
OSO	Operations Support Officer
OSVS	Orbiter Space Vision System
OTD	ORU Transfer Device
OV	Orbiter Vehicle
P&S	Pointing and Support
P-Code	Precision Code
P/L	Payload
P/TV	Photo/Television
P3/P4	Port 3/Port 4
PAS	Payload Attach System
PBA	Portable Breathing Apparatus
PC	Personal Computer
PCA	Pressure Control Assembly
PCAM	Protein Crystallization Apparatus for Microgravity
PCBM	Passive Common Berthing Mechanism
PCC	Power Converter Controller
PCG-STES	Protein Crystal Growth-Single Thermal Enclosure System
PCMCIA	Personal Computer Memory Card International Adapter
PCP	Pressure Control Panel
PCR	Portable Computer Receptacle
PCS	Portable Computer System
PCT	Post-Contact Thrusting
PCU	Plasma Connector Unit
PCVP	Pump and Control Valve Package
PDGF	Power and Data Grapple Fixture
PDI	Payload Data Interface
PDIP	Payload Data Interface Panel

PDRS	Payload Deployment and Retrieval System
PDTA	Power Data Transfer Assembly
PDU	Power Drive Unit
PEHG	Payload Ethernet Hub Gateway
PF	Payload Forward
PFCS	Pump Flow Control Subassembly
PFE	Portable Fire Extinguisher
PFMC	Pump/Fan Motor Controller
PFR	Portable Foot Restraint
PGBA-S	Plant Generic Bioprocessing Apparatus-Stowage
PGSC	Portable General Support Computer
PGT	Pistol Grip Tool
PHALCON	Power, Heating, Articulation, Lighting, and Control Officer
PJPAM	Pre-stored Joint Position Autosequence Mode
PLB	Payload Bay
PM	Pump Module
PMA	Pressurized Mating Adapter
PMCU	Power Management Control Unit
PMDIS	Perceptual Motor Deficits In Space
PMP	Payload Mounting Panel
POA	Payload/ORU Accommodation
POC	Portable Onboard Computer
POR	Point of Reference
POST	Power ON Self-Test
PP	Planning Period
PPA	Pump Package Assembly
PPAM	Pre-stored POR Autosequence Mode
ppO_2	partial pressure of oxygen
PPRV	Positive Pressure Relief Valve
PPT	Precipitate
PRD	Payload Retention Device
PRLA	Payload Retention Latch Assembly
Prox-Ops	Proximity Operations
psi	Pounds per square inch
PSN	Power Source Node
PSP	Payload Signal Processor
PTB	Payload Training Buffer
PTCS	Passive Thermal Control System
PTR	Port Thermal Radiator
PTU	Pan/Tilt Unit
PV	Photovoltaic
PVCA	Photovoltaic Controller Application

PVCE	Photovoltaic Controller Element
PVCU	Photovoltaic Controller Unit
PVM	Photovoltaic Module
PVR	Photovoltaic Radiator
PVRGF	Photovoltaic Radiator Grapple Fixture
PVTCS	Photovoltaic Thermal Control System
PWP	Portable Work Platform
PWR	Portable Water Reservoir
PYR	Pitch Yaw Roll
QD	Quick Disconnect
R/F	Refrigerator/Freezer
R&R	Removal and Replacement
RACU	Russian-to-American Converter Unit
RAIU	Russian Audio Interface Unit
RAM	Random Access Memory
RAMV	Rheostat Air Mix Valve
RB	Radiator Beam
RBB	Right Blanket Box
RBI	Remote Bus Isolator
RBVM	Radiator Beam Valve
RCC	Reinforced Carbon-Carbon
RCS	Reaction Control System
RDA	Retainer Door Assembly
RF	Radio Frequency
RFCA	Rack Flow Control Assembly
RFG	Radio Frequency Group
RGA	Rate Gyro Assemblies
RHC	Rotational Hand Controller
RHX	Regenerative Heat Exchanger
RIC	Rack Interface Controller
RJMC	Rotary Joint Motor Controller
RMS	Remote Manipulator System
ROBO	Robotics Operations Support Officer
ROS	Russian Orbital Segment
RP	Receiver/Processor
RPC	Remote Power Controller
RPCM	Remote Power Controller Module
RPDA	Remote Power Distribution Assembly
RPM	Rbar Pitch Maneuver
RPOP	Rendezvous and Proximity Operations Program
RS	Russian Segment

RSC	RMS Sideview Camera
RSP	Resupply Stowage Platform
RSR	Resupply Stowage Rack
RSTS	Rack Standalone Temperature Sensor
RSU	Roller Suspension Unit
	Remote Sensing Unit
RT	Remote Terminal
RT-Box	Reaction Time Box
RTAS	Rocketdyne Truss Attachment System
RTD	Resistive Thermal Device
RTL	Ready to Latch
RWS	Robotic Workstation

S	Starboard
S&M	Structures and Mechanisms
S3/S4	Starboard 3/Starboard 4
SA	Solar Array
SABB	Solar Array Blanket Box
SAGE	Space Arabidoposis Genomics Experiment
SARJ	Solar Alpha Rotary Joint
SARJ_C	SARJ Controller
SARJ_M	SARJ Manager
SASA	S-band Antenna Support Assembly
SAW	Solar Array Wing
SCA	Switchgear Controller Assembly
SCI	Signal Conditioning Interface
SCU	Service and Cooling Umbilical
SD	Smoke Detector
SDO	Solenoid Driver Output
SDS	Sample Delivery System
SEM	Shunt Electronics Module
SEPS	Secondary Electrical Power Subsystem
SFCA	System Flow Control Assembly
SFU	Squib Firing Unit
SGANT	Space-to-Ground Antenna
SHOSS	Spacehab Oceaneering Space System
SHOT	Space Hardware Optimization Technology
SIGI	Space Integrated Global Positioning System/Inertial Navigation System
SJRM	Single Joint Rate Mode
SLDP	Spacelab Data Processing
SLP	Spacelab Logistics Pallet
SM	Service Module

SMCC	Shuttle Mission Control Center
SMDP	Service Module Debris Panel
SOC	State of Charge
SOLAR	Sun Monitoring on the External Payload Facility of Columbus
SOV	Shutoff Valve
SPCE	Servicing Performance and Checkout Equipment
SPD	Spool Positioning Device
SPDA	Secondary Power Distribution Assembly
SPDM	Special Purpose Dexterous Manipulator
SPG	Single-Point Ground
SRMS	Shuttle Remote Manipulator System
SSAS	Segment-to-Segment Attach System
SSBA	Space Station Buffer Amplifier
SSC	Station Support Computer
SSMDM	Space Station Multiplexer/Demultiplexer
SSOR	Space-to-Space Orbiter Ratio
SSP	Standard Switch Panel
SSPTS	Station-to-Shuttle Power Transfer System
SSRMS	Space Station Remote Manipulator System
SSSH	Space Shuttle Systems Handbook
SSSR	Space-to-Space Station Radio
SSU	Sequential Shunt Unit
STCR	Starboard Thermal Control Radiator
STES	Single Thermal Enclosure System
STR	Starboard Thermal Radiator
SVS	Space Vision System
TA	Thruster Assist
TAA	Triaxial Accelerometer Assembly
TAH	Tray Actuation Handle
TBA	Trundle Bearing Assembly
TC	Terminal Computer
TCCS	Trace Contaminant Control Subassembly
TCCV	Temperature Control and Check Valve
TCS	Trajectory Control Sensor
TD	Translation Drive
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TEA	Torque Equilibrium Attitude
TFR	Translation Foot Restraint
THC	Temperature and Humidity Control
THOR	Thermal Operations and Resources Officer

TI	Terminal Phase Initiation
TORF	Twice Orbital Rate Flyaround
TORU	Teleoperator Control Mode
TORVA	Twice Orbital Rate +Rbar to +Vbar Approach
TPL	Transfer Priority List
TRAC	Test of Reaction and Adaption Capabilities
TRC	Transmitter Receiver Controller
TRRJ	Thermal Radiator Rotary Joint
TSP	Twisted Shielded Pair
TTCR	Trailing Thermal Control Radiator
TUS	Trailing Umbilical System
TVIS	Treadmill Vibration Isolation System
TWMV	Three-Way Mixing Valve
UB	User Bus
UCCAS	Unpressurized Cargo Carrier Attach System
UDG	User Data Generation
UF	Utilization Flight
UHF	Ultrahigh Frequency
UIA	Umbilical Interface Assembly
ULCAS	Unpressurized Logistics Carrier Attach System
UIP	Utility Interface Panel
ULF	Utilization Logistics Flight
UMA	Umbilical Mechanism Assembly
UOP	Utility Outlet Panel
USA	United Space Alliance
USL	U.S. Laboratory
USOS	United States On-Orbit Segment
UTA	Utility Transfer Assembly
VAJ	Vacuum Access Jumper
VBSP	Video Baseband Signal Processor
VCP	Video Camera Port
VCSA	Video Camera Support Assembly
VDS	Video Distribution System
VDU	Video Distribution Unit
VES	Vacuum Exhaust System
VGS	Video Graphics Software
VRCV	Vent/Relief Control Valve
VRIV	Vent/Relief Isolation Valve
VRS	VES Resource System
VRV	Vent/Relief Valve

VSC	Video Signal Converter
VSSA	Video Stanchion Support Assembly
W/S	Worksite
WETA	WVS External Transceiver Assembly
WHS	Workstation Host Software
WIF	Worksite Interface
WRM	Water Recovery Management
WS	Water Separator
WVA	Water Vent Assembly
XPOP	X-axis Pointing Out of Plane
ZCG-SS	Zeolite Crystal Growth—Sample Stowage
ZSR	Zero-g Stowage Rack

MEDIA ASSISTANCE

NASA TELEVISION TRANSMISSION

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

http://www.nasa.gov/ntv

NASA TV's digital conversion will require members of the broadcast media to upgrade with an 'addressable' Integrated Receiver De-coder, or IRD, to participate in live news events and interviews, media briefings and receive NASA's Video File news feeds on a dedicated Media Services channel. NASA mission coverage will air on a digital NASA Public Services ("Free to Air") channel, for which only a basic IRD will be needed.

Television Schedule

A schedule of key 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:

http://www.nasa.gov/shuttle

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

Briefings

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

More Internet Information

Information on the International Space Station is available at:

http://www.nasa.gov/station

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

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

Information on other current NASA activities is available at:

http://www.nasa.gov

Resources for educators can be found at the following address:

http://education.nasa.gov

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