National Aeronautics and Space Administration

INTERNATIONAL SPACE STATION ■ EXPEDITION 16

Expanding International Research

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Mission Overview

Expedition 16: Expanding for International Science

Attired in Russian Sokol launch and entry suits, NASA astronaut Peggy A. Whitson (right), Expedition 16 commander; cosmonaut Yuri I. Malenchenko, Soyuz commander and flight engineer representing Russia's Federal Space Agency; and Malaysian spaceflight participant Sheikh Muszaphar Shukor take a break from training in Star City, Russia to pose for a portrait. Whitson, Malenchenko and Shukor are scheduled to launch to the International Space Station in a Soyuz spacecraft in October. Photo credit: Gagarin Cosmonaut Training Center.

On Oct. 10, an American astronaut, a Russian cosmonaut and a Malaysian spaceflight participant will be launched aboard the Soyuz TMA-11 spacecraft to the International Space Station from the Baikonur Cosmodrome in Kazakhstan. The crew will replace two other Russians, who have been in space for six months. The arrival of the Expedition 16 crew marks the beginning of the most complex phase of station assembly since humans first occupied the outpost seven years ago.

Making her second flight into space, NASA astronaut Peggy Whitson, 47, will become the first female commander of the station. She was a flight engineer and the first NASA science officer during the Expedition 5 mission to the complex in 2002. Joining Whitson is veteran Russian cosmonaut Yuri Malenchenko (Muh-LEHN'chen-ko), a Russian Air Force colonel, 45, who will serve as flight engineer and Soyuz commander for launch, landing and on-orbit operations. This is Malenchenko's fourth flight and third trip to the station, having commanded the Expedition 7 mission after the shuttle Columbia accident in 2003.

Whitson and Malenchenko will be joined for launch by Dr. Sheikh Muzaphar Shukor (SHAYK' Moo-ZAH'-far SHOO'-kor), 35, a Malaysian spaceflight participant. He is an orthopedic surgeon in Kuala Lumpur and the first Malaysian to fly in space under a commercial agreement with the Russian Federal Space Agency. Shukor will spend nine days on the station, returning to Earth in the Soyuz TMA-10 spacecraft on October 21 with Expedition 15 Commander Fyodor Yurchikhin (Fee-OH'-dohr YOOR'-chee-kin), 48, and Oleg Kotov (AH'-leg KOH'-toff) 41, who will be the Soyuz commander for entry and landing. They have been aboard the station since April 9.

For launch, Whitson will be in the left seat of the Soyuz as board engineer while Malenchenko occupies the center seat as Soyuz commander. His call sign for launch, docking and landing in April 2008 will be "Agat," a Russian word for stone. Shukor will be in the right seat of the Soyuz.

Two days after launch, the Soyuz TMA-11 craft will dock to the station's Zarya module. Once hatches are opened, Whitson and Malenchenko will join Flight Engineer Clayton Anderson, 48, who was launched on the shuttle Atlantis in June. Anderson will be replaced by Flight Engineer Dan Tani (TAW'-knee), 46, during shuttle Discovery's STS-120 mission. Discovery will deliver and install the Node 2 module, known as Harmony, and will carry Anderson back to Earth.

Astronaut Peggy A. Whitson (background), Expedition 16 commander, and cosmonaut Yuri I. Malenchenko, flight engineer representing Russia's Federal Space Agency, participate in a training session at the Gagarin Cosmonaut Training Center, Star City, Russia. Whitson and Malenchenko are attired in training versions of Russian Sokol launch and entry suits. Photo credit: Gagarin Cosmonaut Training Center.

Astronauts Peggy Whitson, Expedition 16 commander; and Dan Tani, Expedition 15/16 flight engineer, use the virtual reality lab at the Johnson Space Center to train for their duties aboard the International Space Station. This type of computer interface, paired with virtual reality training hardware and software, helps to prepare the entire team for dealing with space station elements.

Discovery's crew also will relocate the first set of station solar arrays on the Port 6 (P6) truss on the left side of the station from its current location atop the Z1 truss to the far end of the port side of the station's truss structure. The arrays, which were retracted during two shuttle flights last December and in June, will be redeployed to add more power capability for the remainder of the station modules and experiments yet to be launched.

Whitson and Malenchenko will see two other partial crew rotations during their six months in space. Tani will be replaced by European Space Agency (ESA) astronaut Leopold Eyharts (A'-yarts), a French Air Force colonel, 50, in December on the STS-122 mission that delivers the European Columbus science laboratory to the station. Eyharts, in turn, will be replaced in February 2008 by NASA astronaut Garrett Reisman (REEZ'-mun), 39, who will be launched on the STS-123 mission that brings the first Japanese "Kibo" element to the station, the Experiment Logistics Module-Pressurized Section.

This crew portrait shows the variety of crewmembers who will occupy the International Space Station during Expedition 16. Astronaut Peggy Whitson (front row, right), station commander; and Russia's Federal Space Agency cosmonaut Yuri Malenchenko (front row, left), flight engineer and Soyuz commander, will join NASA astronaut Clay Anderson (back row, left), flight engineer, in October after launching from the Baikonur Cosmodrome in Kazakhstan on the Soyuz TMA-11 spacecraft. Anderson will be replaced in October by astronaut Dan Tani (back row, second from left), flight engineer, who will yield his place in December to Leopold Eyharts of the European Space Agency (back row, third from left). Eyharts will be replaced in February 2008 by astronaut Garrett Reisman (back row, far right), flight engineer.

Once on board, Whitson and Malenchenko will conduct more than a week of handover activities with Yurchikhin, Kotov and Anderson, familiarizing themselves with station systems and procedures. They also will receive proficiency training on the Canadarm2 robotic arm from the resident crew and engage in safety briefings as well as payload and scientific equipment training.

The change of command ceremony during the docked operations between crews will mark the formal handover of the station to Whitson and Malenchenko, just days before the Expedition 15 crew members and Shukor depart the station.

After landing, Yurchikhin, Kotov and Shukor will be flown from Kazakhstan to the

Gagarin Cosmonaut Training Center in Star City, for approximately two weeks of initial physical rehabilitation. Due to the brevity of his fight, Shukor will spend significantly less time acclimating himself to Earth's gravity than Yurchikhin and Kotov.

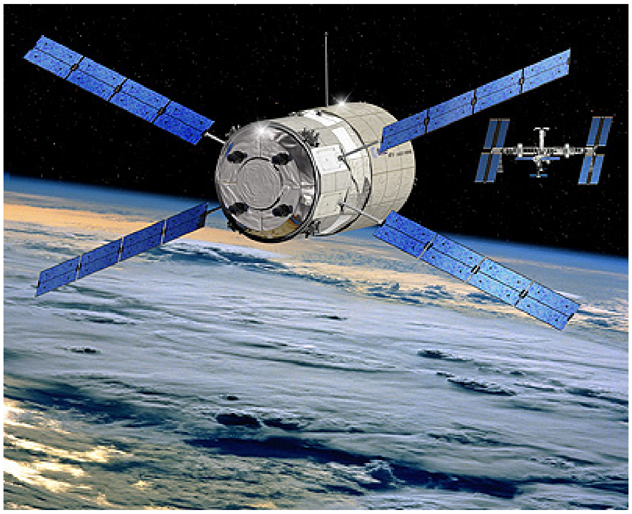
The Expedition 16 crew will work with experiments across a wide variety of fields, including human life sciences, physical sciences and Earth observation, as well as education and technology demonstrations. Many experiments are designed to gather information about the effects of long-duration spaceflight on the human body, which will help with planning future exploration missions to the moon and Mars. The science team at the Payload Operations Integration Center at NASA's Marshall Space Flight Center in Huntsville, Ala., will operate some experiments without crew input and other experiments are designed to function autonomously.

In addition to an unprecedented trio of shuttle missions that will deliver the Harmony and Columbus modules and the initial Japanese element, the station crew is expected to greet the arrival of two Russian Progress resupply cargo ships filled with food, fuel, water and supplies that will augment the delivery of supplies on visiting shuttles. The ISS Progress 27 cargo craft is targeted to reach the station on Christmas Day, and ISS Progress 28 is slated to arrive in February.

In addition, Whitson, Malenchenko and Eyharts are set to preside over the maiden rendezvous and docking of the unpiloted European Space Agency's Automated Transfer Vehicle (ATV) cargo craft, named Jules Verne, currently targeted for launch early next year on a European Ariane 5 rocket from the Arianespace launch site in Kourou, French Guiana.

The 14-ton ATV is capable of delivering up to eight tons of cargo to the station, roughly four times the amount that is brought to orbit on the Russian Progress vehicles. The Jules Verne will automatically dock to the aft port of the Zvezda Service Module a little more than two weeks after launch following an extensive on-orbit checkout of its systems, and will remain at the station until early April.

Whitson will conduct a station "stage" spacewalk during the docked phase of STS-120. Whitson conducted one spacewalk during Expedition 5, and Malenchenko conducted two spacewalks in 1994 during a mission on the Mir Space Station and a third spacewalk during the STS-106 shuttle mission in 2000.



Artist's rendition of the Automated Transfer Vehicle approaching the International Space Station.

Astronaut Peggy A. Whitson, Expedition 16 commander, dons a training version of the Extravehicular Mobility Unit (EMU) space suit prior to being submerged in the waters of the Neutral Buoyancy Laboratory (NBL) near the Johnson Space Center. Suit technicians assisted Whitson.

During their spacewalk, Whitson and Malenchenko will stow cables and avionics for the forward docking port on the Destiny Laboratory, known as the Pressurized Mating Adapter-2 (PMA-2). This will be done in preparation for its detachment and relocation to the forward end of the newly delivered Harmony module in early November. Harmony and its PMA-2 will then be moved from the port side of Unity to the forward end of Destiny to complete an intricate series of robotics activities in the early days of the Expedition 16 mission.

Whitson will join Tani for two additional spacewalks in November to hook up electrical and cooling loop connections to the newly located Harmony/PMA-2 so it can serve as the new docking port for Atlantis on the STS-122 mission and beyond. Tani conducted one previous spacewalk on the STS-108 mission to the station in 2001.

No Russian-based spacewalks are currently scheduled during Expedition 16.

After six months on the station, Whitson and Malenchenko will board the Soyuz TMA-11 and depart the station, leaving it in the hands of Expedition 17 Commander Sergei Volkov and flight engineers Oleg Kononenko and Reisman.

Expedition 16 Crew

Peggy Whitson

With more than 184 days of long-duration spaceflight experience behind her, Peggy Whitson is well prepared to lead as the first female commander of the International Space Station. Whitson served as a flight engineer on Expedition 5 in 2002. During her six-month stay aboard the station, Whitson installed the Mobile Base System and two truss segments using the station's robotic arm. She also performed a spacewalk to install micrometeoroid shielding on the Zvezda Service Module and activated the Microgravity Sciences Glovebox. She was named the first NASA science officer during her stay, and conducted 21 investigations in human life sciences and microgravity sciences, as well as commercial payloads.

Whitson received a Bachelor of Science degree in biology/chemistry from Iowa Wesleyan College in 1981, and a doctorate in biochemistry from Rice University in 1985. From 1989 to 1993, Whitson worked as a research biochemist in the Biomedical Operations and Research Branch at NASA. For the next several years, she held a number of senior positions within NASA until her selection as an astronaut in 1996.

Yuri Malenchenko

This will be the fourth flight for cosmonaut Yuri Malenchenko. His first mission was a 126-day spaceflight in 1994 as part of the Mir-16 mission. He then went on to train for shuttle missions, and served on the crew of STS-106 preparing the International Space Station for the arrival of the first permanent crew.

His next mission, as commander of Expedition 7, paired him back up with one of his shuttle crewmates, Ed Lu. The two worked and lived on the orbiting complex for more than 185 days in 2003. Since then, Malenchenko has continued his long-duration training, including training as a backup for Expedition 14.

He will serve as commander of the Soyuz spacecraft as well as flight engineer during his stay on the station.

Clayton Anderson

Clayton Anderson will be in the final stretch of his first spaceflight mission when he joins the Expedition 16 crew as a flight engineer. Anderson arrived to the station in June as part of the STS-117 crew. He then joined Expedition 15 as a flight engineer. He has completed three spacewalks and supported the visit of the STS-118 space shuttle crew in August.

Anderson is scheduled to return to Earth later this fall as part of the STS-120 crew.

Anderson is a graduate of Hastings College in Nebraska and Iowa State University. He joined NASA in 1983 in the Mission Planning and Analysis Division, then transitioned to the Mission Operations Directorate where he progressed to chief of the Flight Design Branch. He was selected to join NASA's astronaut corps in 1998.

Daniel Tani

Replacing Anderson will be astronaut Daniel Tani, a veteran of one prior space shuttle flight. Tani will serve as flight engineer for the Expedition 16 crew, after arriving on space shuttle Discovery on the STS-120 mission. Once his Soyuz seatliner is transferred from the shuttle to the station, he will officially become a station crew member and will remain onboard with Whitson and Malenchenko. He is scheduled to come back on STS-122, targeted for launch in December.

A Massachusetts Institute of Technology graduate, Tani joined NASA in 1996. He served in numerous roles, including the EVA (Extravehicular Activity) Branch and as a crew support astronaut for Expedition 4. Tani flew on STS-108 in 2001 and has logged more 11 days in space, including a spacewalk to wrap thermal blankets around ISS Solar Array Gimbals. He also trained and qualified as the backup flight engineer for Expedition 11.

Leopold Eyharts

This will be the second spaceflight for Leopold Eyharts, a French astronaut from the Center National d'Etudes Spatiales. He was selected by CNES in 1990, and was selected as an astronaut by the European Space Agency 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, the European Space Agency assigned Eyharts to train at NASA's Johnson Space Center. He is scheduled to arrive to the orbiting laboratory on the STS-122 mission and return via STS-123, targeted for February 2008.

Garrett Reisman

This will be the first spaceflight mission for Garrett Reisman, who was selected by NASA in 1998. Reisman is from New Jersey and holds a bachelor's degree in economics as well as a bachelor's, master's and doctorate in mechanical engineering. He has worked in the aerospace industry since his graduation. Once he joined NASA and fulfilled his initial astronaut training, he supported various technical assignments such as the Astronaut Office Robotics Branch, Advanced Vehicles Branch and a mission on NEEMO V, living on the bottom of the sea in the Aquarius habitat for two weeks.

Reisman is scheduled to arrive to the orbiting complex on shuttle mission STS-123 and return on shuttle mission STS-119.

Sheikh Muszaphar Shukor

Joining Whitson and Malenchenko for the journey to the space station will be Dr. Sheikh Muszaphar Shukor. He began the process for cosmonaut selection in Malaysia in 1995, and more than 10 years later was assigned to travel to the Gagarin Cosmonaut Training Center for spaceflight training. Shukor arrived in Moscow in September 2006 and began training in October 2006.

Shukor holds a Master of Science degree in orthopedic surgery from the Kebangsaan University, Malaysia. He will perform a number of Malaysian science and outreach experiments as part of his stay on the station. He is scheduled to return via the Soyuz with Expedition 15 Commander Fyodor Yurchikhin and Flight Engineer Oleg Kotov.

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Mission Milestones

(Dates are subject to change)

2007:

Oct. 10	Expedition 16 launch from the Baikonur Cosmodrome, Kazakhstan on Soyuz TMA-11 with Malaysian spaceflight participant
Oct. 12	Expedition 16 docks to the International Space Station’s Zarya Module on Soyuz TMA-11 with Malaysian spaceflight participant
Oct. 19	Change of command ceremony with departing Expedition 15 crew
Oct. 21	Undocking and landing of Expedition 15 crew from Zvezda Service Module and landing in Kazakhstan on Soyuz TMA-10 with Malaysian spaceflight participant
Oct. 23	Launch of Discovery on the STS-120/10A mission
Oct. 25	Docking of Discovery to ISS Pressurized Mating Adapter-2 (PMA-2); Anderson and Tani swap places as Expedition 16 crew members
Oct. 26	Installation of Harmony Node 2 to port side of Unity Node 1
Nov. 1	U.S. stage EVA 9 by Whitson and Malenchenko (occurs during STS-120 docked operations)
Nov. 3	Undocking of Discovery from ISS PMA-2
Nov. 5	Relocation of PMA-2 from forward end of Destiny to Harmony Node 2
Nov. 7	Relocation of Harmony Node 2/PMA-2 from port side of Unity Node 1 to forward end of Destiny Laboratory
Nov. 13	U.S. Stage EVA 10 by Whitson and Tani to hook up connections between Harmony Node 2 and Destiny
Nov. 17	U.S. Stage EVA 11 by Whitson and Tani to hook up connections between Harmony Node 2 and Destiny
Nov. 20	Harmony Node 2 ingress and outfitting
Dec. 6	Launch of Atlantis on the STS-122/1E mission

Dec. 8	Docking of Atlantis to ISS PMA-2
Dec. 9	Installation of Columbus Module to starboard docking port of Harmony Node 2; Tani and Eyharts swap places as Expedition 16 crew members
Dec. 15	Undocking of Atlantis from PMA-2
Dec. 22	Undocking of ISS Progress 26 from Pirs docking compartment
Dec. 23	Launch of ISS Progress 27 from Baikonur Cosmodrome, Kazakhstan
Dec. 25	Docking of ISS Progress 27 to Pirs docking compartment

2008:

NET Jan. 31	Launch of the “Jules Verne” Automated Transfer Vehicle (ATV) on an Ariane 5 rocket from Kourou, French Guiana
Feb. 6	ISS Progress 27 undocking from Pirs docking compartment
Feb. 7	Launch of ISS Progress 28 from Baikonur Cosmodrome, Kazakhstan
Feb. 9	Docking of ISS Progress 28 to Pirs docking compartment
Feb. 10	ATV Demo Day 1
Feb. 12	ATV Demo Day 2
Feb. 14	Launch of Endeavour on the STS-123/1J-A mission
Feb. 16	Docking of Endeavour to PMA-2; Eyharts and Reisman swap places as Expedition 16 crew members
Feb. 17	Installation of the Japanese Experiment Logistics Module-Pressurized Section (ELM-PS) to zenith port of Harmony Node 2
Feb. 27	Undocking of Endeavour from PMA-2
March 3	Docking of ATV to aft port of Zvezda Service Module
April 4	Undocking of ATV from aft port of Zvezda Service Module
April 7	Undocking of ISS Progress 28 from Pirs docking compartment
April 8	Expedition 17 launch from the Baikonur Cosmodrome, Kazakhstan on Soyuz TMA-12 with spaceflight participant

April 10	Expedition 17 docks to the International Space Station’s Pirs docking compartment on Soyuz TMA-12 with spaceflight participant
April 19	Undocking of Expedition 16 crew from Zarya Module and landing in Kazakhstan on Soyuz TMA-11 with spaceflight participant

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Expedition 16 Spacewalks

Cosmonaut Yuri I. Malenchenko, Expedition 16 flight engineer representing Russia's Federal Space Agency, dons a training version of the Extravehicular Mobility Unit (EMU) space suit prior to being submerged in the waters of the Neutral Buoyancy Laboratory (NBL) near the Johnson Space Center. Suit technicians assisted Malenchenko.

During three planned U.S. spacewalks, Expedition 16 crew members will prepare the station for the activation of the newly delivered Harmony node, a utility hub providing air, electrical power, water and other systems essential to support life on the station. During future missions, the station’s European and Japanese segments will be mated to the station at the Harmony node. The Expedition 16 spacewalks will prepare for the robotic relocations of PMA-2 and Harmony.

The first of the three spacewalks — also known as extravehicular activities or EVAs — of the Expedition 16 crew will be performed on the eleventh day of the STS-120 space shuttle mission. While it is the first for the Expedition 16 mission, it will be the fifth spacewalk of the STS-120 mission and will occur while Discovery is docked to the station. This 6.5-hour spacewalk initiates preparations for the detachment and relocation of PMA-2 from the forward docking port of the Destiny Laboratory to the forward end of the Harmony.

Harmony's installation and activation is a two-step process. Discovery will dock to PMA-2 and then the STS-120 crew will attach Harmony to a temporary position on the port side of Unity before its final installation to the station. After Discovery leaves, the Expedition 16 crew will use Candarm2 to move PMA-2 to the forward port on Harmony. Then, the crew will use the arm to move and install Harmony to its permanent location at the end of Destiny, completing a series of robotics activities.

Also during the spacewalk, Whitson and Malenchenko will:

- stow cables from the recently installed shuttle-to-station power transfer system
- stow avionics for the PMA-2
- remove the cover from Harmony's Common Berthing Mechanism
- reconfigure the power and jumper cables that connect Unity to the starboard truss and those that connect the PMA-1 to the Zarya

For the first spacewalk, Expedition 16 Commander Peggy Whitson will wear the spacesuit with red stripes. Flight Engineer Yuri Malenchenko will wear the all-white spacesuit.

Astronaut Peggy A. Whitson, Expedition 16 commander, dons an EMU space suit prior a simulation at the NBL.

For the two additional spacewalks, designated EVA 10 and EVA 11, Whitson will be joined by newly arrived Expedition 16 Flight Engineer Dan Tani.

The primary goal of these two spacewalks is to hook up electrical and cooling loop connections to the newly mated and relocated Harmony/PMA-2. This will allow PMA-2 to serve as the docking port for future missions, including the upcoming STS-122 mission. Planned tasks for the two spacewalks include:

- release, vent, and stow S0 truss port/starboard ammonia shunt jumpers
- deploy Harmony port and starboard fluid umbilical trays
- connect and install S0/Harmony rigid avionics pigtails, ammonia (NH_3) umbilicals, the 12 port and starboard fluid umbilical tray Spool Positioning Devices (SPDs) and internal utilities;
- connect Harmony/PMA-2 umbilicals
- release petal cover launch restraints on the Harmony starboard Common Berthing Mechanism (CBM)
- install Lab/Harmony gap spanner
- reconnect the radiator beam P1 fluid line secondary heaters
- install fluid tray thermal blanket

During these spacewalks, Tani will wear the all-white spacesuit.

No Russian-based spacewalks are currently scheduled during Expedition 16.

Astronaut Daniel M. Tani, Expedition 16 flight engineer, dons an EMU before a training dive at the NBL. European Space Agency (ESA) astronaut Paolo Nespoli (left), STS-120 mission specialist, assists Tani who is scheduled to join Expedition 16 after launching to the International Space Station on STS-120.

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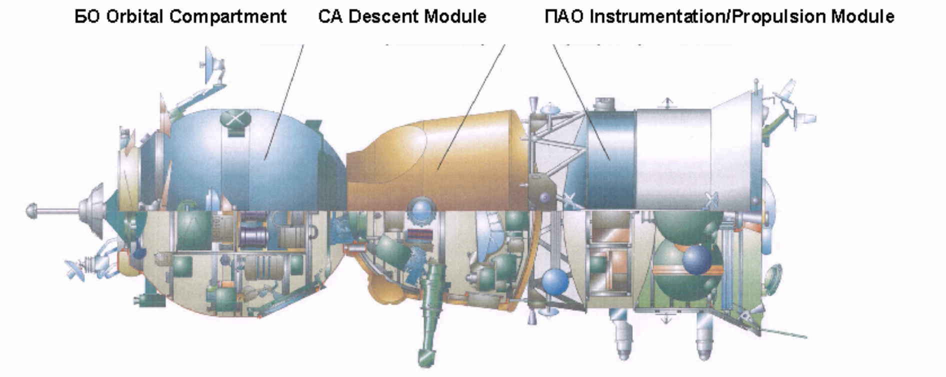
Russian Soyuz TMA



The Soyuz TMA spacecraft is designed to serve as the International Space Station's crew return vehicle, acting as a lifeboat in the unlikely event an emergency would require the crew to leave the station. A new Soyuz capsule is normally delivered to the station by a Soyuz crew every six months, replacing an older Soyuz capsule at the ISS.

The Soyuz spacecraft is launched to the space station from the Baikonur Cosmodrome in Kazakhstan aboard a Soyuz rocket. It consists of an orbital module, a descent module and an instrumentation/propulsion module.

Orbital Module

This portion of the Soyuz spacecraft is used by the crew while on orbit during free-flight. It has a volume of 6.5 cubic meters (230 cubic feet), with a docking mechanism, hatch and rendezvous antennas located at the front end. The docking mechanism is used to dock with the space station and the hatch allows entry into the station. The rendezvous antennas are used by the automated docking system — a radar-based system — to maneuver towards the station for docking. There is also a window in the module.

The opposite end of the orbital module connects to the descent module via a pressurized hatch. Before returning to Earth, the orbital module separates from the descent module — after the deorbit maneuver — and burns up upon re-entry into the atmosphere.

Descent Module

The descent module is where the cosmonauts and astronauts sit for launch, re-entry and landing. All the necessary controls and displays of the Soyuz are here. The module also contains life support supplies and batteries used during descent, as well as the primary and backup parachutes and landing rockets. It also contains custom-fitted seat liners for each crewmember, individually molded to fit each person's body — this ensures a tight, comfortable fit when the module lands on the Earth. When crewmembers are brought to the station aboard the space shuttle, their seat liners are brought with them and transferred to the Soyuz spacecraft as part of crew handover activities.

The module has a periscope, which allows the crew to view the docking target on the station or the Earth below. The eight hydrogen peroxide thrusters located on the module are used to control the spacecraft's orientation, or attitude, during the descent until parachute deployment. It also has a guidance, navigation and control system to maneuver the vehicle during the descent phase of the mission.

This module weighs 2,900 kilograms (6,393 pounds), with a habitable volume of 4 cubic meters (141 cubic feet). Approximately 50 kilograms (110 pounds) of payload can be returned to Earth in this module and up to 150 kilograms (331 pounds) if only two crewmembers are present. The Descent Module is the only portion of the Soyuz that survives the return to Earth.

Instrumentation/Propulsion Module

This module contains three compartments: intermediate, instrumentation and propulsion.

The intermediate compartment is where the module connects to the descent module. It also contains oxygen storage tanks and the attitude control thrusters, as well as electronics, communications and control equipment. The primary guidance, navigation, control and computer systems of the Soyuz are in the instrumentation compartment, which is a sealed container filled with circulating nitrogen gas to cool the avionics equipment. The propulsion compartment contains the primary thermal control system and the Soyuz radiator, with a cooling area of 8 square meters (86 square feet). The propulsion system, batteries, solar arrays, radiator and structural connection to the Soyuz launch rocket are located in this compartment.

The propulsion compartment contains the system that is used to perform any maneuvers while in orbit, including rendezvous and docking with the space station and the deorbit burns necessary to return to Earth. The propellants are nitrogen tetroxide and unsymmetric-dimethylhydrazine. The main propulsion system and the smaller reaction control system, used for attitude changes while in space, share the same propellant tanks.

The two Soyuz solar arrays are attached to either side of the rear section of the instrumentation/propulsion module and are linked to rechargeable batteries. Like the orbital module, the intermediate section of the instrumentation/propulsion module separates from the descent module after the final deorbit maneuver and burns up in atmosphere upon re-entry.

TMA Improvements and Testing

The Soyuz TMA spacecraft is a replacement for the Soyuz TM, which was used from 1986 to 2002 to take astronauts and cosmonauts to Mir and then to the International Space Station.

The TMA increases safety, especially in descent and landing. It has smaller and more efficient computers and improved displays. In addition, the Soyuz TMA accommodates individuals as large as 1.9 meters (6 feet, 3 inches tall) and 95 kilograms (209 pounds), compared to 1.8 meters (6 feet) and 85 kilograms (187 pounds) in the earlier TM. Minimum crewmember size for the TMA is 1.5 meters (4 feet, 11 inches) and 50 kilograms (110 pounds), compared to 1.6 meters (5 feet, 4 inches) and 56 kilograms (123 pounds) for the TM.

Two new engines reduce landing speed and forces felt by crewmembers by 15 to 30 percent and a new entry control system and three-axis accelerometer increase landing accuracy. Instrumentation improvements include a color “glass cockpit,” which is easier to use and gives the crew more information, with hand controllers that can be secured under an instrument panel. All the new components in the Soyuz TMA can spend up to one year in space.

New components and the entire TMA were rigorously tested on the ground, in hangar-drop tests, in airdrop tests and in space before the spacecraft was declared flight-ready. For example, the accelerometer and associated software, as well as modified boosters (incorporated to cope with the TMA's additional mass), were tested on flights of Progress unpiloted supply spacecraft, while the new cooling system was tested on two Soyuz TM flights.

Descent module structural modifications, seats and seat shock absorbers were tested in hangar drop tests. Landing system modifications, including associated software upgrades, were tested in a series of airdrop tests. Additionally, extensive tests of systems and components were conducted on the ground.

Soyuz Launcher

Throughout history, more than 1,500 launches have been made with Soyuz launchers to orbit satellites for telecommunications, Earth observation, weather, and scientific missions, as well as for human flights.

A Soyuz launches from the Baikonur Cosmodrome, Kazakhstan.

The basic Soyuz vehicle is considered a three-stage launcher in Russian terms and is composed of:

- A lower portion consisting of four boosters (first stage) and a central core (second stage).
- An upper portion, consisting of the third stage, payload adapter and payload fairing.
- Liquid oxygen and kerosene are used as propellants in all three Soyuz stages.

First Stage Boosters

The first stage's four boosters are assembled around the second stage central core. The boosters are identical and cylindrical-conic in shape with the oxygen tank in the cone-shaped portion and the kerosene tank in the cylindrical portion.

An NPO Energomash RD 107 engine with four main chambers and two gimbaled vernier thrusters is used in each booster. The vernier thrusters provide three-axis flight control.

Ignition of the first stage boosters and the second stage central core occur simultaneously on the ground. When the boosters have completed their powered flight during ascent, they are separated and the core second stage continues to function.

First stage separation occurs when the pre-defined velocity is reached, which is about 118 seconds after liftoff.

Second Stage

An NPO Energomash RD 108 engine powers the Soyuz second stage. This engine has four vernier thrusters, necessary for three-axis flight control after the first stage boosters have separated.

An equipment bay located atop the second stage operates during the entire flight of the first and second stages.

Third Stage

The third stage is linked to the Soyuz second stage by a latticework structure. When the second stage's powered flight is complete, the third stage engine is ignited. Separation occurs by the direct ignition forces of the third stage engine.

A single-turbopump RD 0110 engine from KB KhA powers the Soyuz third stage.

The third stage engine is fired for about 240 seconds. Cutoff occurs at a calculated velocity. After cutoff and separation, the third stage performs an avoidance maneuver by opening an outgassing valve in the liquid oxygen tank.

Launcher Telemetry Tracking & Flight Safety Systems

Soyuz launcher tracking and telemetry is provided through systems in the second and third stages. These two stages have their own radar transponders for ground tracking. Individual telemetry transmitters are in each stage. Launcher health status is downlinked to ground stations along the flight path. Telemetry and tracking data are transmitted to the mission control center, where the incoming data flow is recorded. Partial real-time data processing and plotting is performed for flight following and initial performance assessment. All flight data is analyzed and documented within a few hours after launch.

Baikonur Cosmodrome Launch Operations

Soyuz missions use the Baikonur Cosmodrome's proven infrastructure, and launches are performed by trained personnel with extensive operational experience.

Baikonur Cosmodrome is in the Republic of Kazakhstan in Central Asia between 45 degrees and 46 degrees north latitude and 63 degrees east longitude. Two launch pads are dedicated to Soyuz missions.

Final Launch Preparations

The assembled launch vehicle is moved to the launch pad on a railcar. Transfer to the launch zone occurs two days before launch. The vehicle is erected and a launch rehearsal is performed that includes activation of all electrical and mechanical equipment.

On launch day, the vehicle is loaded with propellant and the final countdown sequence is started at three hours before the liftoff time.

Rendezvous to Docking

A Soyuz spacecraft generally takes two days to reach the space station. The rendezvous and docking are both automated, though once the spacecraft is within 150 meters (492 feet) of the station, the Russian Mission Control Center just outside Moscow monitors the approach and docking. The Soyuz crew has the capability to manually intervene or execute these operations.

Soyuz Booster Rocket Characteristics

First Stage Data - Blocks B, V, G, D	
Engine	RD-107
Propellants	LOX/Kerosene
Thrust (tons)	102
Burn time (sec)	122
Specific impulse	314
Length (meters)	19.8
Diameter (meters)	2.68
Dry mass (tons)	3.45
Propellant mass (tons)	39.63
Second Stage Data, Block A	
Engine	RD-108
Propellants	LOX/Kerosene
Thrust (tons)	96
Burn time (sec)	314
Specific impulse	315
Length (meters)	28.75
Diameter (meters)	2.95
Dry mass (tons)	6.51
Propellant mass (tons)	95.7
Third Stage Data, Block I	
Engine	RD-461
Propellants	LOX/Kerosene
Thrust (tons)	30
Burn time (sec)	240
Specific impulse	330
Length (meters)	8.1
Diameter (meters)	2.66
Dry mass (tons)	2.4
Propellant mass (tons)	21.3
PAYLOAD MASS (tons)	6.8
SHROUD MASS (tons)	4.5
LAUNCH MASS (tons)	309.53
TOTAL LENGTH (meters)	49.3

Prelaunch Countdown Timeline

T- 34 Hours	Booster is prepared for fuel loading
T- 6:00:00	Batteries are installed in booster
T- 5:30:00	State commission gives go to take launch vehicle
T- 5:15:00	Crew arrives at site 254
T- 5:00:00	Tanking begins
T- 4:20:00	Spacesuit donning
T- 4:00:00	Booster is loaded with liquid oxygen
T- 3:40:00	Crew meets delegations
T- 3:10:00	Reports to the State commission
T- 3:05:00	Transfer to the launch pad
T- 3:00:00	Vehicle 1st and 2nd stage oxidizer fueling complete
T- 2:35:00	Crew arrives at launch vehicle
T- 2:30:00	Crew ingress through orbital module side hatch
T- 2:00:00	Crew in re-entry vehicle
T- 1:45:00	Re-entry vehicle hardware tested; suits are ventilated
T- 1:30:00	Launch command monitoring and supply unit prepared
	Orbital compartment hatch tested for sealing
T- 1:00:00	Launch vehicle control system prepared for use; gyro instruments activated
T - :45:00	Launch pad service structure halves are lowered
T- :40:00	Re-entry vehicle hardware testing complete; leak checks performed on suits
T- :30:00	Emergency escape system armed; launch command supply unit activated
T- :25:00	Service towers withdrawn
T- :15:00	Suit leak tests complete; crew engages personal escape hardware auto mode
T- :10:00	Launch gyro instruments uncaged; crew activates on-board recorders
T- 7:00	All prelaunch operations are complete
T- 6:15	Key to launch command given at the launch site
	Automatic program of final launch operations is activated
T- 6:00	All launch complex and vehicle systems ready for launch
T- 5:00	Onboard systems switched to onboard control
	Ground measurement system activated by RUN 1 command
	Commander's controls activated
	Crew switches to suit air by closing helmets
	Launch key inserted in launch bunker
T- 3:15	Combustion chambers of side and central engine pods purged with nitrogen

Prelaunch Countdown Timeline (concluded)

T- 2:30	Booster propellant tank pressurization starts
	Onboard measurement system activated by RUN 2 command
	Prelaunch pressurization of all tanks with nitrogen begins
T- 2:15	Oxidizer and fuel drain and safety valves of launch vehicle are closed
	Ground filling of oxidizer and nitrogen to the launch vehicle is terminated
T- 1:00	Vehicle on internal power
	Automatic sequencer on
	First umbilical tower separates from booster
T- :40	Ground power supply umbilical to third stage is disconnected
T- :20	Launch command given at the launch position
	Central and side pod engines are turned on
T- :15	Second umbilical tower separates from booster
T- :10	Engine turbopumps at flight speed
T- :05	First stage engines at maximum thrust
T- :00	Fueling tower separates
	Lift off

Ascent/Insertion Timeline

T- :00	Lift off
T+ 1:10	Booster velocity is 1,640 ft/sec
T+ 1:58	Stage 1 (strap-on boosters) separation
T+ 2:00	Booster velocity is 4,921 ft/sec
T+ 2:40	Escape tower and launch shroud jettison
T+ 4:58	Core booster separates at 105.65 statute miles
	Third stage ignites
T+ 7:30	Velocity is 19,685 ft/sec
T+ 9:00	Third stage cut-off
	Soyuz separates
	Antennas and solar panels deploy
	Flight control switches to Mission Control, Korolev

Orbital Insertion to Docking Timeline

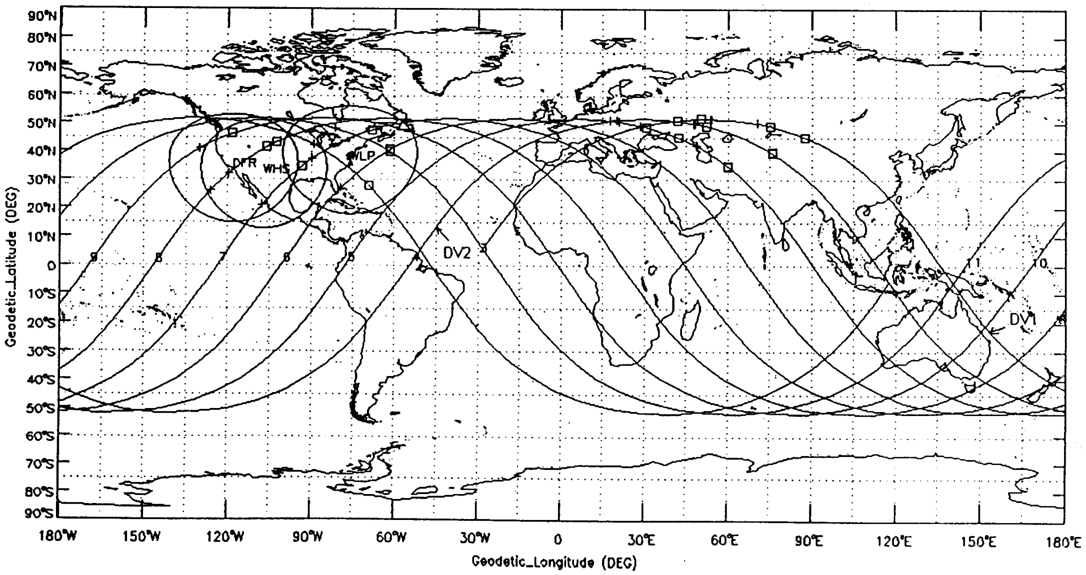
FLIGHT DAY 1 OVERVIEW	
Orbit 1	**Post insertion: Deployment of solar panels, antennas and docking probe**
	- Crew monitors all deployments
	- Crew reports on pressurization of OMS/RCS and ECLSS systems and crew health. Entry thermal sensors are manually deactivated
	- Ground provides initial orbital insertion data from tracking
Orbit 2	**Systems Checkout: IR Att Sensors, Kurs, Angular Accels, "Display" TV Downlink System, OMS engine control system, Manual Attitude Control Test**
	- Crew monitors all systems tests and confirms onboard indications
	- Crew performs manual RHC stick inputs for attitude control test
	- Ingress into HM, activate HM CO2 scrubber and doff Sokols
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
	Manual maneuver to +Y to Sun and initiate a 2 deg/sec yaw rotation. MCS is deactivated after rate is established.
Orbit 3	**Terminate +Y solar rotation, reactivate MCS and establish LVLH attitude reference (auto maneuver sequence)**
	- Crew monitors LVLH attitude reference build up
	- Burn data command upload for DV1 and DV2 (attitude, TIG Delta V's)
	- Form 14 preburn emergency deorbit pad read up
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
	Auto maneuver to DV1 burn attitude (TIG - 8 minutes) while LOS
	- Crew monitor only, no manual action nominally required
	DV1 phasing burn while LOS
	- Crew monitor only, no manual action nominally required
Orbit 4	**Auto maneuver to DV2 burn attitude (TIG - 8 minutes) while LOS**
	- Crew monitor only, no manual action nominally required
	DV2 phasing burn while LOS
	- Crew monitor only, no manual action nominally required

FLIGHT DAY 1 OVERVIEW (CONTINUED)	
Orbit 4 (continued)	**Crew report on burn performance upon AOS**
	- HM and DM pressure checks read down
	- Post burn Form 23 (AOS/LOS pad), Form 14 and “Globe” corrections voiced up
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
	Manual maneuver to +Y to Sun and initiate a 2 deg/sec yaw rotation. MCS is deactivated after rate is established.
	External boresight TV camera ops check (while LOS)
	Meal
Orbit 5	**Last pass on Russian tracking range for Flight Day 1**
	Report on TV camera test and crew health
	Sokol suit clean up
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 6-12	**Crew Sleep, off of Russian tracking range**
	- Emergency VHF2 comm available through NASA VHF Network
FLIGHT DAY 2 OVERVIEW	
Orbit 13	**Post sleep activity, report on HM/DM Pressures**
	Form 14 revisions voiced up
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 14	**Configuration of RHC-2/THC-2 work station in the HM**
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 15	**THC-2 (HM) manual control test**
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 16	**Lunch**
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 17 (1)	**Terminate +Y solar rotation, reactivate MCS and establish LVLH attitude reference (auto maneuver sequence)**
	RHC-2 (HM) Test
	- Burn data uplink (TIG, attitude, delta V)
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
	Auto maneuver to burn attitude (TIG - 8 min) while LOS
	Rendezvous burn while LOS
	Manual maneuver to +Y to Sun and initiate a 2 deg/sec yaw rotation. MCS is deactivated after rate is established.

FLIGHT DAY 2 OVERVIEW (CONTINUED)	
Orbit 18 (2)	**Post burn and manual maneuver to +Y Sun report when AOS**
	- HM/DM pressures read down
	- Post burn Form 23, Form 14 and Form 2 (Globe correction) voiced up
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 19 (3)	**CO2 scrubber cartridge change out**
	Free time
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 20 (4)	**Free time**
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 21 (5)	**Last pass on Russian tracking range for Flight Day 2**
	Free time
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 22 (6) - 27 (11)	**Crew sleep, off of Russian tracking range**
	- Emergency VHF2 comm available through NASA VHF Network
FLIGHT DAY 3 OVERVIEW	
Orbit 28 (12)	**Post sleep activity**
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 29 (13)	**Free time, report on HM/DM pressures**
	- Read up of predicted post burn Form 23 and Form 14
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
Orbit 30 (14)	**Free time, read up of Form 2 “Globe Correction,” lunch**
	- Uplink of auto rendezvous command timeline
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radar and radio transponder tracking
FLIGHT DAY 3 AUTO RENDEZVOUS SEQUENCE	
Orbit 31 (15)	**Don Sokol spacesuits, ingress DM, close DM/HM hatch**
	- Active and passive vehicle state vector uplinks
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radio transponder tracking

FLIGHT DAY 3 AUTO RENDEZVOUS SEQUENCE (CONCLUDED)	
Orbit 32 (16)	**Terminate +Y solar rotation, reactivate MCS and establish LVLH attitude reference (auto maneuver sequence)**
	Begin auto rendezvous sequence
	- Crew monitoring of LVLH reference build and auto rendezvous timeline execution
	- A/G, R/T and Recorded TLM and Display TV downlink
	- Radio transponder tracking
FLIGHT DAY 3 FINAL APPROACH AND DOCKING	
Orbit 33 (1)	**Auto Rendezvous sequence continues, flyaround and station keeping**
	- Crew monitor
	- Comm relays via SM through Altair established
	- Form 23 and Form 14 updates
	- Fly around and station keeping initiated near end of orbit
	- A/G (gnd stations and Altair), R/T TLM (gnd stations), Display TV downlink (gnd stations and Altair)
	- Radio transponder tracking
Orbit 34 (2)	**Final Approach and docking**
	- Capture to “docking sequence complete” 20 minutes, typically
	- Monitor docking interface pressure seal
	- Transfer to HM, doff Sokol suits
	- A/G (gnd stations and Altair), R/T TLM (gnd stations), Display TV downlink (gnd stations and Altair)
	- Radio transponder tracking
FLIGHT DAY 3 STATION INGRESS	
Orbit 35 (3)	**Station/Soyuz pressure equalization**
	- Report all pressures
	- Open transfer hatch, ingress station
	- A/G, R/T and playback telemetry
	- Radio transponder tracking

Typical Soyuz Ground Track



Key Times for Expedition 16/15 International Space Station Events

Expedition 16/SFP Launch:

8:22:37 a.m. CT on Oct. 10

13:22:37 GMT on Oct. 10

17:22:37 p.m. Moscow time on Oct. 10

19:22:37 p.m. Baikonur time on Oct. 10

Expedition 16/SFP Docking to the ISS:

9:52:30 a.m. CT on Oct. 12

14:52:30 GMT on Oct. 12

18:52:30 p.m. Moscow time on Oct. 12

Expedition 16/SFP Hatch Opening to the ISS:

11:20 a.m. CT on Oct. 12

16:20 GMT on Oct. 12, 20:20 p.m.

Moscow time on Oct. 12

Expedition 15/SFP Hatch Closure to the ISS:

11:05 p.m. CT on Oct. 20

4:05 GMT on Oct. 21

8:05 a.m. Moscow time on Oct. 21

10:05 a.m. Kazakhstan time on Oct. 21

Expedition 15/SFP Undocking from the ISS:

2:13 a.m. CT on Oct. 21

7:13 GMT on Oct. 21

11:13 a.m. Moscow time on Oct. 21

13:13 p.m. Kazakhstan time on Oct. 21

Expedition 15/SFP Deorbit Burn:

4:45:45 a.m. CT on Oct. 21

9:45:45 GMT on Oct. 21

13:45:45 p.m. Moscow time on Oct. 21

15:45:45 p.m. Kazakhstan time on Oct. 21

Expedition 15/SFP Landing:

5:35:57 a.m. CT on Oct. 21

10:35:57 GMT on Oct. 21

14:35:57 p.m. Moscow time on Oct. 21

16:35:57 p.m. Kazakhstan time on Oct. 21 (1 hour, 52 minutes before sunset)

Expedition 15/Soyuz TMA-10 Landing

Following a nine-day handover with the newly arrived Expedition 16 crew, Expedition 15 Commander Fyodor Yurchikhin, Flight Engineer Oleg Kotov and Malaysian Spaceflight Participant Sheikh Muszaphar Shukor will board their Soyuz TMA-10 capsule for undocking and a one-hour descent back to Earth. Yurchikhin and Kotov will complete a six-month mission in orbit, while Shukor will return after an 11-day flight.

About three hours before undocking, Yurchikhin, Kotov and Shukor will bid farewell to the new Expedition 16 crew, Commander Peggy Whitson and Russian Flight Engineer Yuri Malenchenko, along with Flight Engineer Clay Anderson, who arrived at the station in June on the shuttle Atlantis. The departing crew will climb into the Soyuz vehicle, closing the hatch between Soyuz and the Zvezda Service Module. Yurchikhin will be seated in the Soyuz' left seat for entry and landing as on-board engineer. Kotov will be in the center seat as Soyuz commander as he was for the April launch, and Shukor will occupy the right seat.

After activating Soyuz systems and getting approval from Russian flight controllers at the Russian Mission Control Center outside Moscow, Kotov will send commands to open hooks and latches between Soyuz and Zvezda. The Soyuz was relocated in September from its original docking port on the Zarya module.

Kotov will fire the Soyuz thrusters to back away from Zvezda. Six minutes after undocking, with the Soyuz about 20 meters away from the station, Kotov will conduct a separation maneuver, firing the Soyuz jets for about 15 seconds to begin to depart the vicinity of the complex.

About 2.5 hours after undocking, at a distance of about 19 kilometers from the station, Soyuz computers will initiate a de-orbit burn braking maneuver. The 4.5-minute maneuver to slow the spacecraft will enable it to drop out of orbit and begin its reentry to Earth.

About 30 minutes later, just above the first traces of the Earth's atmosphere, computers will command the separation of the three modules of the Soyuz vehicle. With the crew strapped in to the Descent Module, the forward Orbital Module containing the docking mechanism and rendezvous antennas and the rear Instrumentation and Propulsion Module, which houses the engines and avionics, will pyrotechnically separate and burn up in the atmosphere.

The Soyuz TMA-10 spacecraft moves away from the International Space Station shortly after undocking. Image credit: NASA TV.

The Descent Module's computers will orient the capsule with its ablative heat shield pointing forward to repel the buildup of heat as it plunges into the atmosphere. The crew will feel the first effects of gravity about three minutes after module separation at the point called entry interface, when the module is about 400,000 feet above the Earth.

About 8 minutes later at an altitude of about 10 kilometers, traveling at about 220 meters per second, the Soyuz' computers will begin a commanded sequence for the deployment of the capsule's parachutes. First, two "pilot" parachutes will be deployed, extracting a larger drogue parachute, which stretches out over an area of 24 square meters. Within 16 seconds, the Soyuz's descent will slow to about 80 meters per second.

The initiation of the parachute deployment will create a gentle spin for the Soyuz as it dangles underneath the drogue chute, assisting in the capsule's stability in the final minutes prior to touchdown.

The drogue chute is jettisoned, allowing the main parachute to be deployed. Connected to the Descent Module by two harnesses, the main parachute covers an area of about 1000 meters. The deployment of the main parachute slows down the Descent Module to a velocity of about 7 meters per second. Initially, the Descent Module will hang underneath the main parachute at a 30 degree angle with respect to the horizon for aerodynamic stability. The bottommost harness will be severed a few minutes before landing, allowing the Descent Module to hang vertically through touchdown.

At an altitude of a little more than 5 kilometers, the crew will monitor the jettison of the Descent Module's heat shield, which is followed by the termination of the aerodynamic spin cycle and the dumping of any residual propellant from the Soyuz. Computers also will arm the module's seat shock absorbers in preparation for landing.

When the capsule's heat shield is jettisoned the Soyuz altimeter is exposed to the surface of the Earth. Signals are bounced to the ground from the Soyuz and reflected back, providing the capsule's computers updated information on altitude and rate of descent.

At an altitude of about 12 meters, cockpit displays will tell Kotov to prepare for the soft landing engine firing. Just one meter above the surface, and just seconds before touchdown, the six solid propellant engines are fired in a final braking maneuver. This enables the Soyuz to settle down to a velocity of about 1.5 meters per second and land to complete its mission.

A Russian recovery team and several NASA observers, including three engineers from the Orion Crew Exploration Vehicle Program, will be in the landing area in a convoy of Russian military helicopters awaiting the Soyuz landing. Once the capsule touches down, the helicopters will land nearby to meet the crew.

A portable medical tent will be set up near the capsule in which the crew can change out of its launch and entry suits. Russian technicians will open the module's hatch and begin to remove the crew members. They will be seated in special reclining chairs near the capsule for initial medical tests and to provide an opportunity to begin readapting to Earth’s gravity.

About two hours after landing, the crew will be assisted to the helicopters for a flight back to a staging site in Kazakhstan, where local officials will welcome them. The crew will then board a Russian military transport plane and flown back to the Chkalovsky Airfield adjacent to the Gagarin Cosmonaut Training Center in Star City, Russia, where their families will meet them. In all, it will take around eight hours between landing and the return to Star City.

Assisted by a team of flight surgeons, Yurchikhin and Kotov will undergo several weeks of medical tests and physical rehabilitation. Shukor’s acclimation to Earth’s gravity will be much shorter due to the brevity of his flight.

Soyuz Entry Timeline

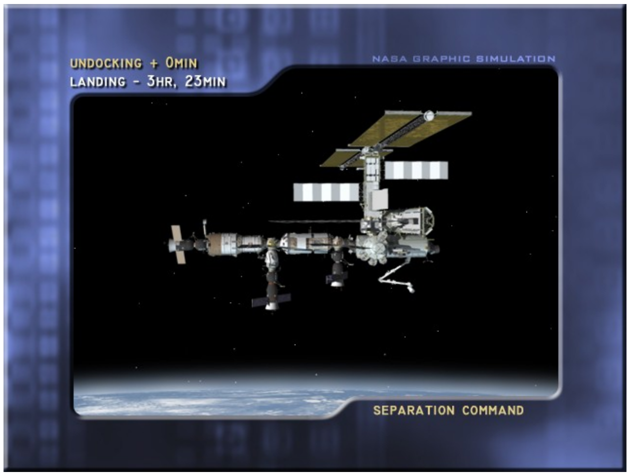
Separation Command to Begin to Open Hooks and Latches; Undocking Command + 0 mins.

2:10 a.m. CT on Oct. 21

7:10 GMT on Oct. 21

11:10 a.m. Moscow time on Oct. 21

13:10 p.m. Kazakhstan time on Oct. 21



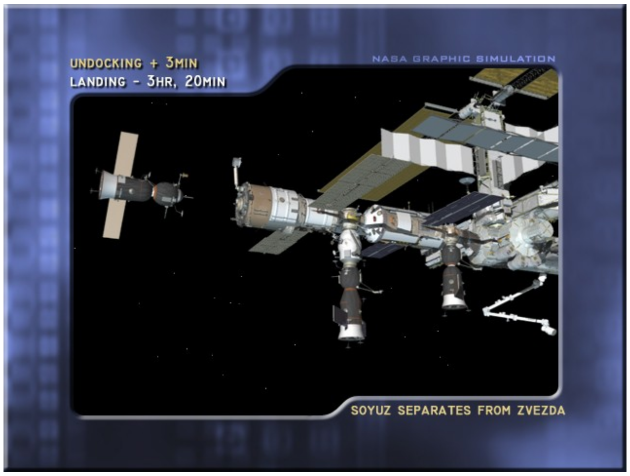
Hooks Opened/Physical Separation of Soyuz from Zarya Module nadir port at .12 meter/sec.; Undocking Command + 3 mins.

2:13 a.m. CT on Oct. 21

7:13 GMT on Oct. 21

11:13 a.m. Moscow time on Oct. 21

13:13 p.m. Kazakhstan time on Oct. 21



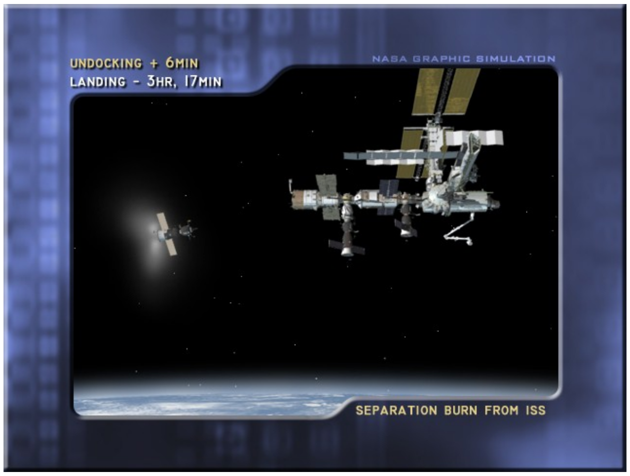
Separation Burn from ISS (15 second burn of the Soyuz engines, 0.65 meters/sec; Soyuz distance from the ISS is ~20 meters)

2:16 a.m. CT on Oct. 21

7:16 GMT on Oct. 21

11:16 a.m. Moscow time on Oct. 21

13:16 p.m. Kazakhstan time on Oct. 21



Deorbit Burn (appx 4:35 in duration, 115.2 m/sec; Soyuz distance from the ISS is ~12 kilometers; Undocking Command appx + ~2 hours, 30 mins.)

4:45:45 a.m. CT on Oct. 21

9:45:45 GMT on Oct. 21

13:45:45 p.m. Moscow time on Oct. 21

15:45:45 p.m. Kazakhstan time on Oct. 21

Separation of Modules (~23 mins. after Deorbit Burn; Undocking Command + ~2 hours, 57 mins.)

5:10 a.m. CT on Oct. 21

10:10 GMT on Oct. 21

14:10 p.m. Moscow time on Oct. 21

16:10 p.m. Kazakhstan time on Oct. 21

Entry Interface (400,000 feet in altitude; 3 mins. after Module Separation; 31 mins. after Deorbit Burn; Undocking Command + ~3 hours)

5:12:44 a.m. CT on Oct. 21

10:12:44 GMT on Oct. 21

14:12:44 p.m. Moscow time on Oct. 21

16:12:44 p.m. Kazakhstan time on Oct. 21

Command to Open Chutes (8 mins. after Entry Interface; 39 mins. after Deorbit Burn; Undocking Command + ~3 hours, 8 mins.)

5:20:57 a.m. CT on Oct. 21

10:20:57 GMT on Oct. 21

14:20:57 p.m. Moscow time on Oct. 21

16:20:57 p.m. Kazakhstan time on Oct. 21

Two pilot parachutes are first deployed, the second of which extracts the drogue chute. The drogue chute is then released, measuring 24 square meters, slowing the Soyuz down from a descent rate of 230 meters/second to 80 meters/second.

The main parachute is then released, covering an area of 1,000 meters; it slows the Soyuz to a descent rate of 7.2 meters/second; its harnesses first allow the Soyuz to descend at an angle of 30 degrees to expel heat, then shifts the Soyuz to a straight vertical descent.

Soft Landing Engine Firing (six engines fire to slow the Soyuz descent rate to 1.5 meters/second just 0.8 meter above the ground)

Landing - appx. 2 seconds

Landing (~50 mins. after Deorbit Burn; Undocking Command + ~3 hours, 24 mins.)

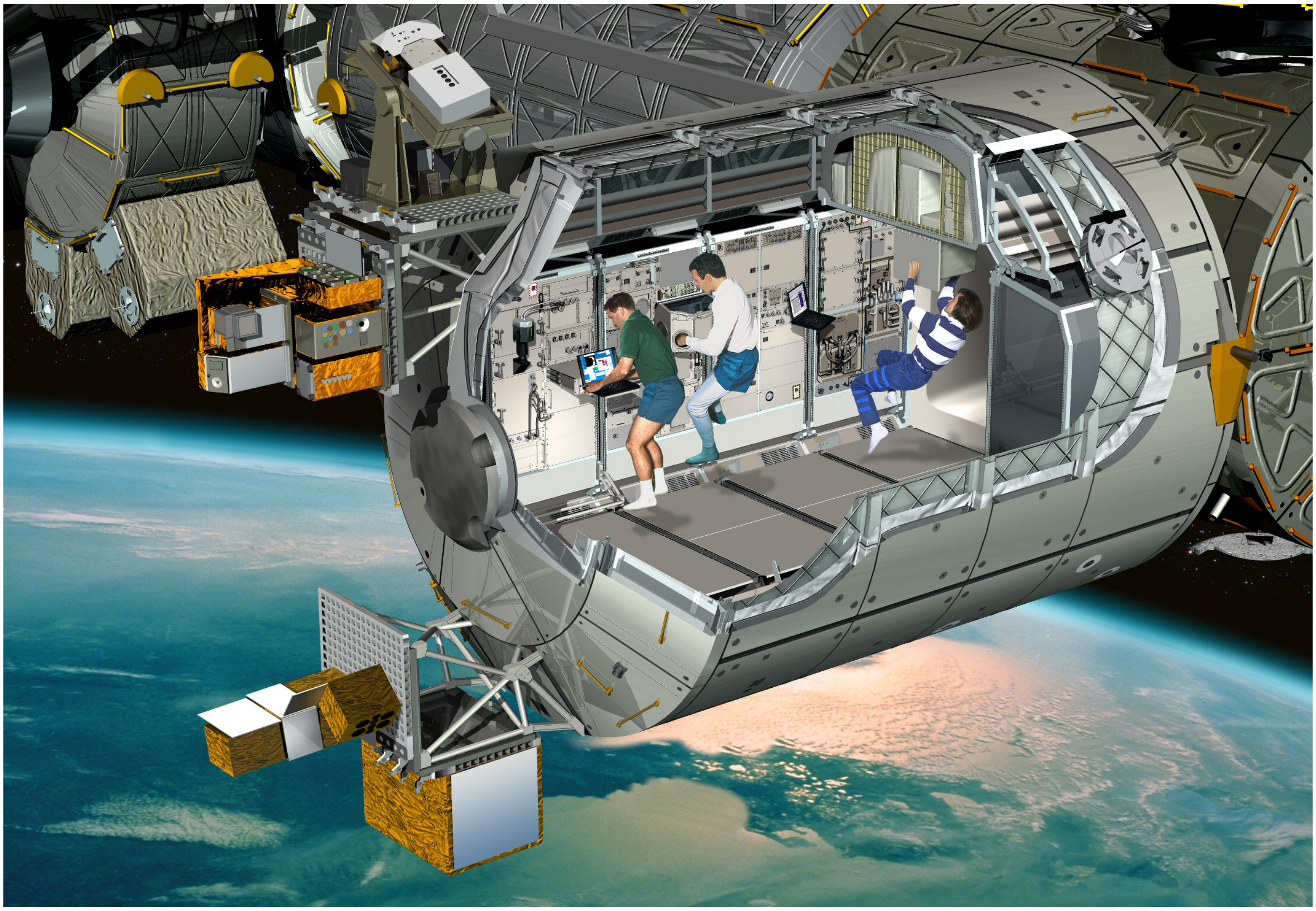
5:35:57:11 a.m. CT on Oct. 21

10:35:57:11 GMT on Oct. 21

14:35:57:11 p.m. Moscow time on Oct. 21

16:35:57:11 p.m. Kazakhstan time on Oct. 21 (1:52 before sunset at the landing site)

Columbus European Laboratory Module



Artist's impression of Columbus laboratory (cutaway view) attached to the International Space Station. (Image: ESA/Ducros)

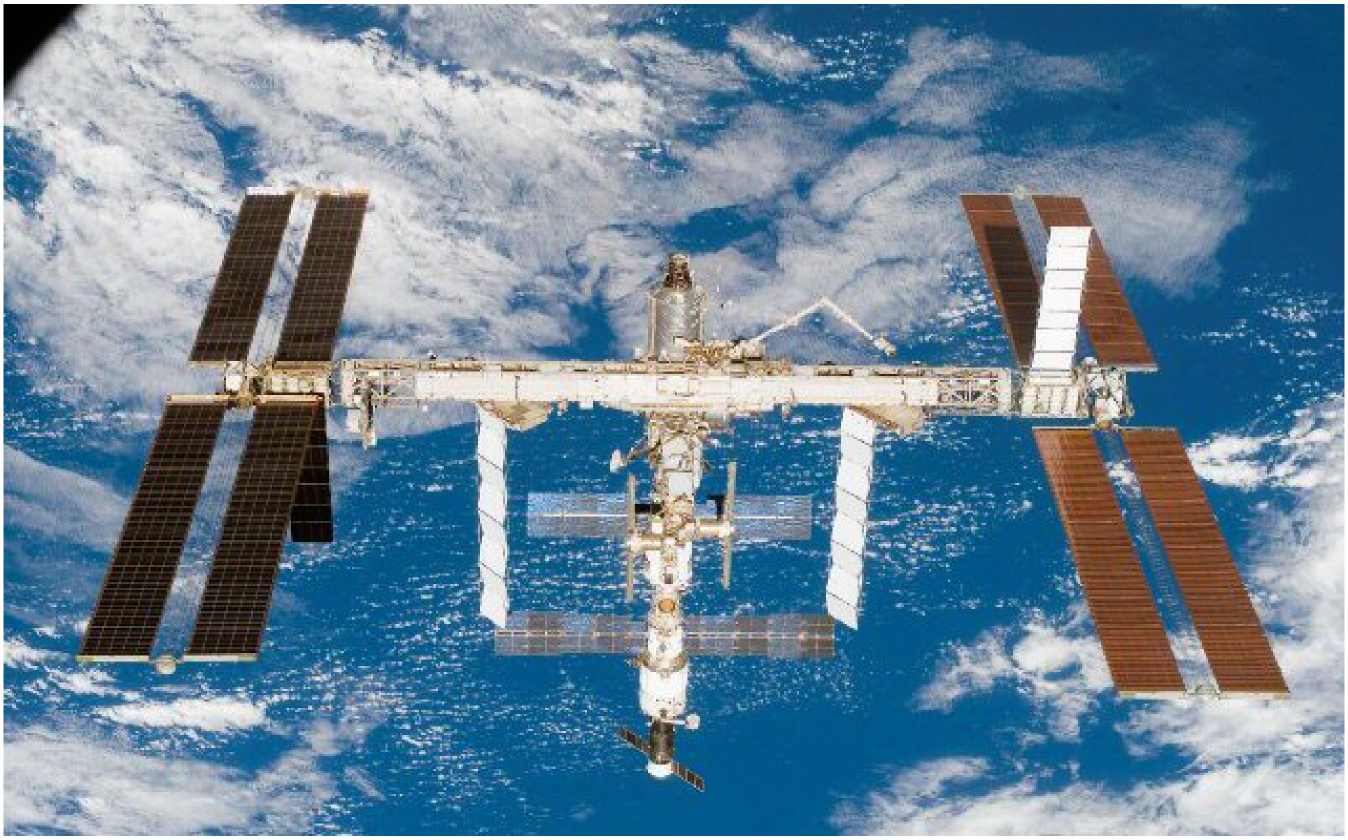
The Columbus laboratory is the cornerstone of the European Space Agency's (ESA's) contribution to the International Space Station (ISS) and is the first European laboratory dedicated to long-term research in space. Named after the famous explorer from Genoa, the Columbus laboratory will give an enormous boost to current European experiment facilities in weightlessness and to the research capabilities of the ISS. The Columbus laboratory is targeted for launch on space shuttle Atlantis on the STS-122 mission in December 2007.

Columbus will support sophisticated research in weightlessness, having internal and external accommodation for numerous experiments in life sciences, fluid physics and other scientific disciplines. The laboratory marks a significant enhancement in European space experimentation and hardware development building on the achievements of the European-developed Spacelab in the 1980s and 1990s.

The 7 meter long Columbus laboratory consists of a pressurized cylindrical hull 4.5 meters in diameter, closed with welded end cones. To reduce costs and maintain high reliability, the laboratory is similar to 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 an aluminum alloy together with a layer of Kevlar and Nextel for protection against space debris.

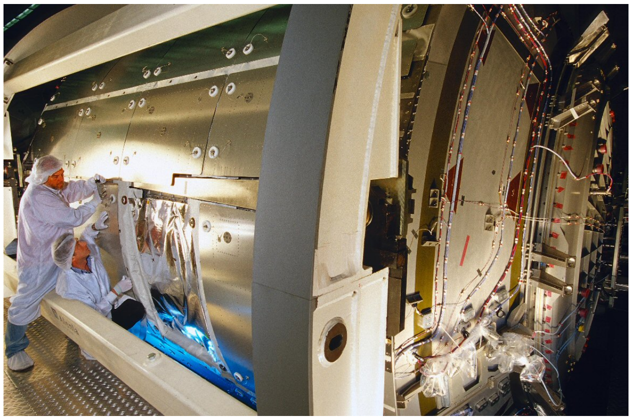
The Columbus laboratory has a mass of 10.3 tons and an internal volume of 75 cubic meters, which can accommodate 16 racks arranged around the circumference of the cylindrical section. These racks, arranged in four sets of four racks, have standard dimensions with standard interfaces, used in all non-Russian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



The International Space Station photographed from Space Shuttle Endeavour after undocking during the STS-118 mission on Aug. 19 2007. (Image: NASA)

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. (Image: NASA)

International Standard Payload Rack into which experiment facilities, subsystems or storage racks can be fitted. (Image: EADS Astrium)



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

Ten of the 16 racks 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. 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.

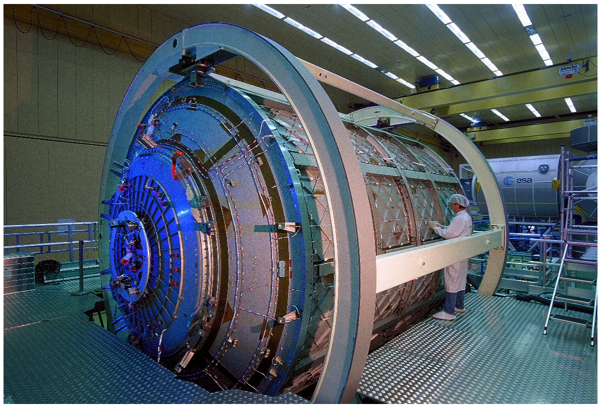
Although it is the station's smallest laboratory module, the Columbus laboratory offers the same payload volume, power, and data retrieval as the station's other laboratories. A significant benefit of this cost-saving design is that Columbus will be launched outfitted with 2500 kilograms of experiment facilities and additional hardware. This includes the ESA-developed experiment facilities:

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

- 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

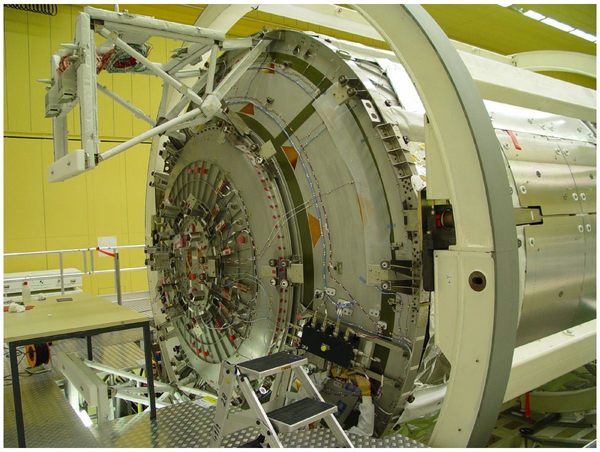
- European Drawer Rack, which provides a flexible experiment carrier for a large variety of scientific disciplines. These multi-user facilities will have a high degree of autonomy in order to maximize the use of astronauts' time in orbit.



Columbus laboratory in Integration hall of EADS in Bremen. Primary structure exposed. June 2002. (Image: EADS Astrium)

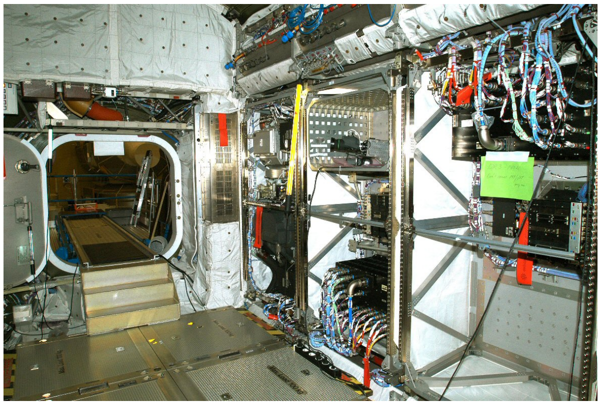
Biolab Experiment facility during payload integration. May 2004. (Image: ESA)

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 laboratory is attached to the space station: 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.



Columbus laboratory with External Payload Facility attached. August 2004. (Image: EADS Astrium)

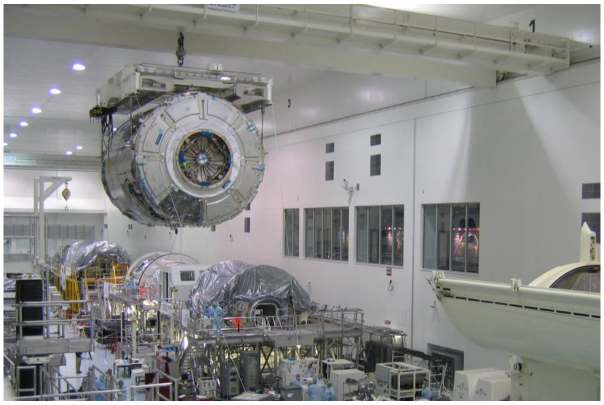
These will be followed by the Atomic Clock Ensemble in Space (ACES), which will test a new generation of microgravity cold-atom clocks in space and the Atmosphere Space Interactions Monitor (ASIM), which will study the coupling of thunderstorms processes to the upper atmosphere, ionosphere and radiation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



Columbus subsystem racks during testing.

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

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 and quality is monitored by Columbus subsystems.



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. Node 2 is scheduled to be attached to the ISS in October 2007 during the STS-120 mission. (Image: NASA)

The crew can also control the temperature (16-30º C) 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 that occurs at some station attitudes.

Once it is attached to the station, the Columbus Control Centre (Col-CC) in Oberpfaffenhofen in Germany on the premises of 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 station's data transfer system, directly to the Columbus Control Center.

Col-CC will coordinate European experiment (payload) operations. Data will be distributed from Col-CC to the 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 International Space Station, 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 Centre in Oberpfaffenhofen in Germany. (Image: ESA)

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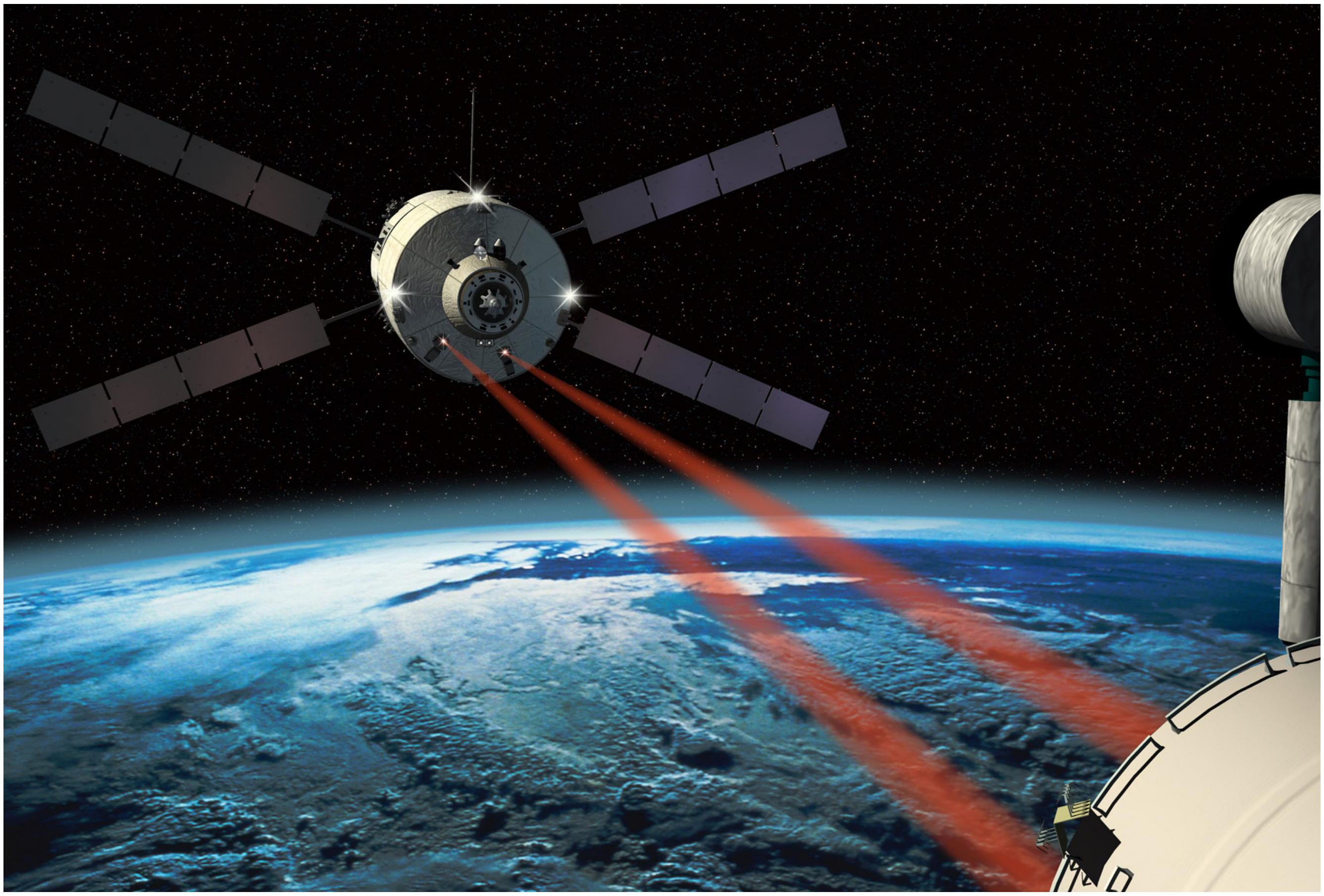
ESA’s Automated Transfer Vehicle (ATV)



Artist’s impression of the European Automated Transfer Vehicle docking with the International Space Station (Image: ESA/D. Ducros)

The International Space Station (ISS) depends on regular deliveries of experimental equipment and spare parts as well as food, air and water for its permanent crew. Beginning in 2008, the Automated Transfer Vehicle, developed by the European Space Agency and European industry, will become a key ISS unmanned supply ship.

Each ATV will deliver around 7.7 tons of cargo to the International Space Station 400 kilometers above the Earth about every 18 months. It will be launched into orbit by an Ariane 5 launcher from Kourou, ESA’s launch site in French Guiana. An on-board high precision navigation system will guide the ATV on a rendezvous trajectory toward the space station, where it will automatically dock with the station’s Russian service module, Zvezda. Each ATV will remain there as a pressurized and integral part of the station for up to six months until its final mission: a one-way trip into the Earth’s atmosphere to dispose of up to 6.3 tons of waste and material that is no longer used on the station.

New Generation Spaceship

The ATV, which is equipped with its own propulsion and navigation systems, is a multi-functional spaceship. It is a fully automatic unmanned vehicle able to dock with the ISS in a manner consistent with human spacecraft safety requirements. To succeed in docking safely with the station, the 20-ton ATV must be a highly sophisticated, new generation spacecraft.

The exterior is a cylinder, 10.3 meters long and 4.5 meters in diameter, about the size of a London double-decker bus. The ATV's structure is covered with an eggshell-colored insulating foil layer on top of meteorite protection panels. The metallic blue solar arrays extend in an X shape from the main body of the spacecraft. Inside, the ATV consists of two modules: the Avionics/Propulsion module, called the ATV service module and the Integrated Cargo Carrier, which docks with the ISS.

Astronauts on board station will be able to access the contents of the ATV while it is docked with the station. The 48 cubic meter-pressurized section of the Integrated Cargo Carrier can accommodate eight standard racks loaded with modular storage cargo elements. The Integrated Cargo Carrier also holds several tanks, containing up to 840 kilograms of drinking water, 860 kilograms of propellant for the station's propulsion system and 100 kilograms of air (oxygen and nitrogen).

The 'nose' of the Integrated Cargo Carrier contains the Russian made docking equipment and rendezvous sensors. The ATV pressurized cargo section is based on the Italian-built Multi-Purpose Logistics Module (MPLM), which is already used to transport equipment to and from the station.

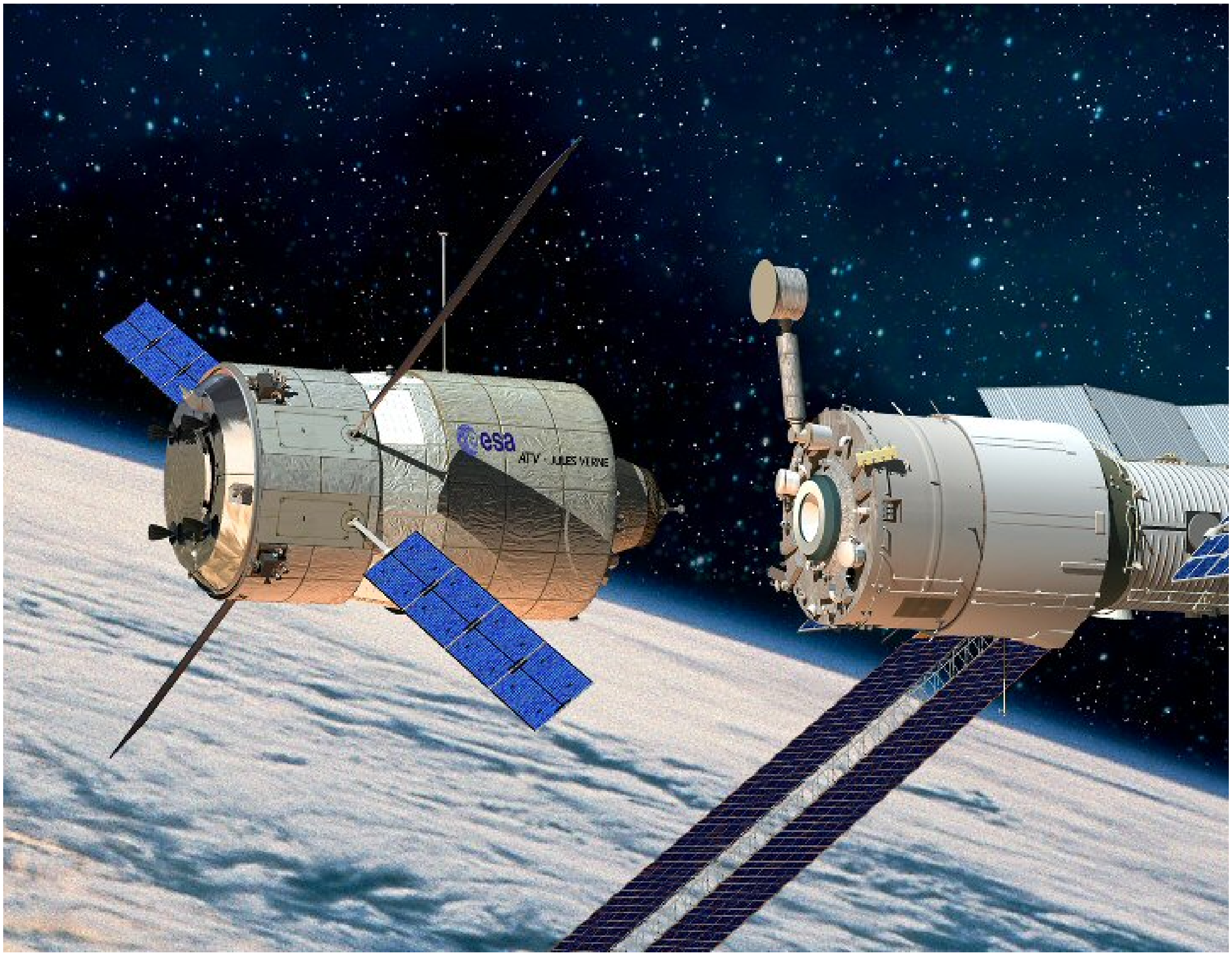
The ATV's service module navigates with four main engines and 28 smaller engines for attitude control. After docking, the ATV can perform station attitude control, debris avoidance maneuvers and reboost the station's orbit to overcome the effects of atmospheric drag. In order to perform this reboost the ATV may use up to 4.7 tons of propellant. In raising the station altitude, the ATV mission in space will resemble the combination of a tugboat pushing a large river barge.

ATV during acoustic test campaign (Image: ESA/S.Corvaja)

Mission Scenario

A typical ATV mission will begin when the craft is launched into a 260-kilometer orbit atop an Ariane 5 from the French Guiana equatorial launch site. The 20.7 ton ATV is well protected under the fairing at the top of the Ariane 5 during the three minutes of high pressure aerodynamic ascent. At the end of ascent, the ATV separates from the Ariane launcher 1 hour and 10 minutes after the liftoff and activates its navigation systems. Thrusters are fired to boost the ATV into the transfer orbit to the station. 100 minutes after lift-off, the ATV becomes a fully automatic spaceship navigating toward the space station. The ATV flight will be controlled from the ATV Control Center located in Toulouse, France.

The ATV enclosed in Ariane's protective fairing during launch phase (Image: ESA/D.Ducros)



The Automated Transfer Vehicle during docking with the ISS (Image: ESA/D.Ducros)

After raising its circular orbit to a 400 kilometer altitude over the first 10 days, the ATV will come in sight of the ISS and will start relative navigation from about 30 kilometers behind and 5 kilometers (3.1 miles) below the station. The cargo ship's computers begin final approach maneuvers over the next two orbits, closing in on the ISS with a relative velocity similar to a walking pace while the absolute speed remains close to 28,000 kilometers per hour (17,360 mph). ATV's inaugural mission, with 'Jules Verne', will require additional days in orbit to perform demonstration maneuvers before docking.

The actual docking will be fully automatic. If there are any last-minute issues, the ATV's computers, the ATV Control Center or the station's crew can trigger a pre-programmed anti-collision maneuver, which is fully independent of the main navigation system. This back-up system adds an additional level of safety.

The Automated Transfer Vehicle will enable ESA to transport payloads to the International Space Station (Image: ESA/D.Ducros)

With the ATV securely docked, the station's crew can enter the cargo section and remove the payload: maintenance supplies, science hardware, and parcels of fresh food, mail and family tapes or CD-ROMs. Meanwhile, the ATV's fluid tanks will be connected automatically (propellant) or manually (water and air) to transfer their contents to the station.

The station crew will manually release the air supply carried by the ATV directly into the ISS's cabin atmosphere. For up to six months, the ATV, mostly in dormant mode, will remain attached to the ISS with the hatch remaining open. The crew will steadily fill the cargo section with the station's waste and material that is no longer used or needed. At intervals of 10 to 45 days, the ATV's thrusters will be used to boost the station's altitude.

Once its re-supply mission is accomplished, the ATV, filled with up to 6.3 tons of waste and other material, will be closed by the crew and automatically separated. Its thrusters will use their remaining fuel to de-orbit the spacecraft, not at the shallow angle used for the relatively gentle re-entry of manned vehicles, but on a steep flight path to perform a controlled destructive re-entry high above the Pacific Ocean over a predefined uninhabited South Pacific area.

From its first operational flight in 2008, the ATV will play a vital role in station servicing. The project involves dozens of companies from ten European countries operating under a prime contract held by EADS Astrium and CNES for the ATV Control Center.

The ATV will be used to raise the altitude of the ISS (Image: ESA/D.Ducros)

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International Space Station: Expedition 16 Science Overview

Plans for Expedition 16 include the operation of 38 U.S.-managed experiments in human research, exploration technology testing, life sciences, physical sciences and education. Twenty-six experiments also are planned for operation by the international partners — the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA).

During Expedition 16, the scientific work of more than a hundred scientists will be supported through U.S.-managed experiments. The team of controllers and scientists on the ground will continue to plan, monitor and remotely operate experiments from control centers across the United States.

A team of controllers for Expedition 16 will staff the Payload Operations Center — the science command post for the space station — at NASA's Marshall Space Flight Center in Huntsville, Ala. Controllers work in three shifts around the clock, seven days a week in the Payload Operations Center, which links researchers around the world with their experiments and the station crew.

The Payload Operations Center also coordinates the payload activities of NASA's international partners. The partners are responsible for the planning and operations of their space agencies' modules. NASA's Payload Operations Center is chartered to synchronize the payload activities among the partners and optimize the use of valuable on-orbit resources.

Experiments Related to Spacecraft Systems

Many experiments are designed to help develop technologies, designs and materials for future spacecraft and exploration missions. These include:

Coarsening in Solid Liquid Mixtures-2 (CSLM-2) will investigate the interaction of small and large particles in a mixture that can influence the strength of materials ranging from turbine blades to dental fillings and iron copper.

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

Microgravity Acceleration Measurement System (MAMS) and Space Acceleration Measurement System – II (SAMS-II) measure vibration and quasi-steady accelerations that result from vehicle control burns, docking and undocking activities. The two different equipment packages measure vibrations at different frequencies.

These measurements help investigators characterize the vibrations and accelerations that may influence space station experiments.

Smoke and Aerosol Measurement Experiment (SAME) will measure the smoke properties, or particle size distribution, of typical particles from smoke generated from spacecraft fires. Results will identify ways to improve smoke detectors on future spacecraft.

Human Life Science Investigations

Physical measurements of Expedition 16 crew members will be used to study changes in the body caused by living in microgravity. Continuing and new experiments include:

Cardiovascular and Cerebrovascular Control on Return from ISS (CCISS) studies the effects of long-duration spaceflight on crew members' heart functions and blood vessels that supply the brain. Learning more about the cardiovascular and cerebrovascular systems could lead to specific countermeasures that might better protect future space travelers.

ELaboratore Immagini Televisive – Space 2 (ELITE-S2) will investigate the connection between brain, visualization and motion in the absence of gravity. By recording and analyzing the three-dimensional motion of astronauts, this study will help engineers apply ergonomics into future spacecraft designs and determine the effects of weightlessness on breathing mechanisms for long-duration missions. This experiment is a cooperative effort with the Italian Space Agency, ASI.

Spaceflight-Induced Reactivation of Latent Epstein-Barr Virus (Epstein-Barr) performs tests to study changes in the human immune function. Using blood and urine samples collected from crew members before and after spaceflight, the study will provide insight for possible countermeasures to prevent the potential development of infectious illness in crew members during flight.

Hand Posture Analyzer (HPA) examines the way hand and arm muscles are used differently during grasping and reaching tasks in microgravity. Measurements are compared to those taken before and after flight to improve understanding of the effects of long-duration missions on muscle fatigue.

Behavioral Issues Associated with Isolation and Confinement: Review and Analysis of Astronaut Journals (Journals) is studying the effect of isolation by using surveys and journals kept by the crew. By quantifying the importance of different behavioral issues in crew members, the study will help NASA design equipment and procedures to allow astronauts to best cope with isolation and long-duration spaceflight.

Nutritional Status Assessment (Nutrition) is NASA's most comprehensive in-flight study to-date of human physiologic changes during long-duration spaceflight. Its measurements will include 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 beyond. This experiment also will help researchers understand the impact of countermeasures — exercise and pharmaceuticals — on nutritional status and nutrient requirements for astronauts.

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

Sleep-Wake Actigraphy and Light Exposure During Spaceflight-Long (Sleep-Long) examines the effects of spaceflight and ambient light exposure on the sleep-wake cycles of the crew members during long-duration stays on the space station.

Stability of Pharmacotherapeutic and Nutritional Compounds (Stability) studies 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.

Other Biological Experiments

Plant growth experiments give insight into the effects of the space environment on living organisms. These experiments include:

The Reverse Genetic Approach to Exploring Genes Responsible for Cell Wall Dynamics in Supporting Tissues of Arabidopsis Under Microgravity Conditions and Role of Microtubule-Membrane-Cell Wall Continuum in Gravity Resistance in Plants (CWRW) will explore the molecular mechanism by which the cell wall construction in *Arabidopsis thaliana* — a small plant of the mustard family — is regulated by gravity. The results of this investigation will support future plans to cultivate plants on long-duration missions to the moon and beyond.

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

The Optimization of Root Zone Substrates (ORZS) for Reduced Gravity Experiments Program was developed to provide direct measurements and models for plant rooting instructions that will be used in future advanced life support plant growth experiments. The goal is to develop and enhance hardware and procedures to allow optimal plant growth in microgravity.

Education and Earth Observation

NASA powers inspiration that encourages future generations to explore, learn and build a better future. Many experiments on board the space station continue to teach the next generation of explorers about living and working in space. These experiments include:

Crew Earth Observations (CEO) takes advantage of the crew in space to observe and photograph natural and human-made changes on Earth. The photographs record the Earth's surface changes over time, along with more fleeting events such as storms, floods, fires and volcanic eruptions. Together, they provide researchers on Earth with vital, continuous images to better understand the planet.

Crew Earth Observations - International Polar Year (CEO-IPY) is an international collaboration of scientists for the observation and exploration of Earth's Polar Regions from 2007 to 2009. Space station crew members photograph polar phenomena including auroras and mesospheric clouds in response to daily correspondence from the scientists on the ground.

Commercial Generic Bioprocessing Apparatus Science Insert – 02 (CSI-02) is an educational payload designed to interest middle school students in science, technology, engineering and math by participating in near real-time research conducted on board the station. Students will observe four experiments through data and imagery downlinked and distributed directly into the classroom via the Internet. The first experiment will examine seed germination and plant development in microgravity. It will be followed by an experiment to examine yeast cells adaptation to the space environment; another will examine plant cell cultures; and the final experiment — a silicate garden — will examine crystal growth formation using silicates — compounds containing silicon, oxygen and one or more metals.

Earth Knowledge Acquired by Middle School Students (EarthKAM), an education experiment, allows middle school students to program a digital camera on board the station to photograph a variety of geographical targets for study in the classroom. Photos are made available on the Web for viewing and study by participating schools around the world. Educators use the images for projects involving Earth science, geography, physics and technology.

Japan Aerospace Exploration Agency - Education Payload Observation (JAXA-EPO) aims to excite students' interest in microgravity research and enhance their knowledge of science and technology. Activities will include educational events with astronauts on orbit, space and ground experiments conducted by students and creation of an educational video library. JAXA-EPO is designed to support the mission to inspire the next generation of explorers.

Space Shuttle Experiments

Many other experiments are scheduled to be performed during upcoming space shuttle missions that are part of Expedition 16. These experiments include:

Maui Analysis of Upper Atmospheric Injections (MAUI) observes 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 collect 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) measures the ability of the drug midodrine, as a countermeasure, to reduce the incidence or severity of orthostatic hypotension — dizziness caused by the blood-pressure decrease that many astronauts experience when returning to Earth's gravity.

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

Perceptual Motor Deficits in Space (PMDIS) investigates why shuttle astronauts experience difficulty with hand-eye coordination while on orbit. This experiment will measure the decline of astronauts' hand-eye coordination during space shuttle missions. These measurements will be used to distinguish between three possible explanations: the brain not adapting to the near weightlessness of space; the difficulty of performing fine movements when floating in space; and stress due to factors such as space sickness and sleep deprivation. This experiment is a cooperative effort with the Canadian Space Agency, CSA.

Bioavailablity and Performance Effects of Promethazine During Spaceflight (PMZ) examines 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.

Ram Burn Observations (RAMBO) is an experiment in which the Department of Defense uses a satellite to observe space shuttle orbital maneuvering system engine burns. The study's purpose is to improve plume models, which predict the direction of the plume, or rising column of exhaust, as the shuttle maneuvers on orbit. Understanding this flow direction could be significant to the safe arrival and departure of spacecraft on current and future exploration missions.

Rigidizable Inflatable Get-Away-Special Experiment (RIGEX) is a self-sufficient computer and sensor system that operates in the space shuttle cargo bay. It is designed to test and collect data on inflated and rigid structures in space. The rigidized structures used for this investigation are three inflatable tubes, which will be heated and cooled to form structurally stiff tubes.

Sleep-Wake Actigraphy and Light Exposure During Spaceflight - Short (Sleep-Short) examines the effects of spaceflight on the sleep-wake cycles of the astronauts during space 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.

Reserve Payloads

Several additional experiments are ready for operation, but designated as "reserve" and will be performed if crew time becomes available. They include:

Analyzing Interferometer for Ambient Air (ANITA) will monitor 32 potentially gaseous contaminants, including formaldehyde, ammonia and carbon monoxide, in the atmosphere on board the station. The experiment will test the accuracy and reliability of this technology as a potential next-generation atmosphere trace-gas monitoring system for the station.

BCAT-3 (Binary Colloidal Alloy Test – 3) consists of two investigations which will study the long-term behavior of colloids — a system of fine particles suspended in a fluid — in a microgravity environment, where the effects of sedimentation and convection are removed. Crew members will mix the samples, photograph the growth and formations of the colloids and downlink the images for analysis. Results may lead to improvements in supercritical fluids used in rocket propellants and biotechnology applications and advancements in fiber-optics technology.

BCAT-4 (Binary Colloidal Alloy Test – 4) is a follow-on experiment to BCAT-3. BCAT-4 will study 10 colloidal samples. Several of these samples will determine phase separation rates and add needed points to the phase diagram of a model critical fluid system initially studied in BCAT-3. Crew members photograph samples of polymer and colloidal particles — tiny nanoscale spheres suspended in liquid — that model liquid/gas phase changes. Results will help scientists develop fundamental physics concepts previously cloaked by the effects of gravity.

Capillary Flow Experiment (CFE) is a suite of fluid physics experiments that investigate how fluids behave in space. Capillary flow is the key process used to move fluids in a microgravity environment. Results will improve current computer models that are used by designers of low gravity fluid systems, and may improve fluid transfer systems on future spacecraft.

Education Payload Operations (EPO) includes curriculum-based educational activities demonstrating basic principles of science, mathematics, technology, engineering and geography. These activities are videotaped and then used in classroom lectures. EPO is designed to support the NASA mission to inspire the next generation of explorers.

Investigating the Structure of Paramagnetic Aggregates from Colloidal Emulsions - 2 (InSPACE – 2) will obtain data on magnetorheological fluids — fluids that change properties in response to magnetic fields — that can be used to improve or develop new brake systems and robotics.

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. The study will validate a flight-compatible immune monitoring strategy by collecting and analyzing blood, urine and saliva samples from crew members before, during and after spaceflight to monitor changes in the immune system.

Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES) are bowling-ball sized spherical satellites. They will be used inside the space station to test a set of well-defined instructions for spacecraft performing autonomous rendezvous and docking maneuvers. Three free-flying spheres will fly within the cabin of the station, performing flight formations. Each satellite is self-contained with power, propulsion, computers and navigation equipment. The results are important for satellite servicing, vehicle assembly and formation flying spacecraft configurations.

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

Destiny Laboratory Facilities

The Destiny Laboratory is equipped with state-of-the-art research facilities to support Expedition 16 science investigations:

The **Human Research Facility-1** is designed to house and support life sciences experiments. It includes equipment for lung function tests, ultrasound to image the heart and many other types of computers and medical equipment.

Human Research Facility-2 provides an on-orbit laboratory that enables human life science researchers to study and evaluate the physiological, behavioral and chemical changes in astronauts induced by spaceflight.

European Modular Cultivation System (EMCS) is a large incubator that provides control over the atmosphere, lighting and humidity of growth chambers used to study plant growth. The facility was developed by the European Space Agency.

Minus Eighty-Degree Laboratory Freezer for ISS (MELFI) provides refrigerated storage and fast-freezing of biological and life science samples. It can hold up to 300 liters of samples ranging in temperature from -80°C, -26°C, or 4°C throughout a mission.

The **Microgravity Science Glovebox (MSG)** provides a safe environment for research with liquids, combustion and hazardous materials on board the International Space Station. Without the MSG, many types of hands-on investigations would be impossible or severely limited on the station.

The Destiny lab also is outfitted with five **EXPRESS Racks**. EXPRESS, or Expedite the Processing of Experiments to the Space Station, racks are standard payload racks designed to provide experiments with utilities such as power, data, cooling, fluids and gasses. The racks support payloads in disciplines including biology, chemistry, physics, ecology and medicines. The racks stay in orbit, while experiments are changed as needed. EXPRESS Racks 2 and 3 are equipped with the **Active Rack Isolation System (ARIS)** for countering minute vibrations from crew movement or operating equipment that could disturb delicate experiments.

On the Internet

For fact sheets, imagery and more on Expedition 16 experiments and payload operations, click on:

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

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The Payload Operations Center

A team of controllers for Expedition 16 will staff the Payload Operations Center at NASA's Marshall Space Flight Center in Huntsville, Ala.

The Payload Operations Center (POC) at Marshall Space Flight Center in Huntsville, Ala., is NASA's primary science command post for the International Space Station. Space station scientific research plays a vital role in implementing the Vision for Space Exploration, NASA's roadmap for returning to the moon and exploring our solar system.

The International Space Station will accommodate dozens of experiments in fields as diverse as medicine, human life sciences, biotechnology, agriculture, manufacturing and Earth observation. Managing these science assets — as well as the time and space required to accommodate experiments and programs from a host of private, commercial, industry and government agencies nationwide — makes the job of coordinating space station research critical.

The Payload Operations Center continues the role Marshall has played in management and operation of NASA's on-orbit science research. In the 1970s, Marshall managed the science program for Skylab, the first American space station. Spacelab — the international science laboratory that the space shuttle carried to orbit in the 1980s and 1990s for more than a dozen missions — was the prototype for Marshall's space station science operations.

Today, the POC team is responsible for managing all U.S. science research experiments aboard the station. The center also is home for coordination of the mission-planning work, all U.S. science payload deliveries and retrieval, and payload training and payload safety programs for the station crew and all ground personnel.

State-of-the-art computers and communications equipment deliver around-the-clock reports from science outposts around the United States to systems controllers and science experts. Other computers stream information to and from the space station itself, linking the orbiting research facility with the science command post on Earth.

Once launch schedules are finalized, the POC oversees delivery of experiments to the space station. Experiments are in cycle constantly as the shuttle or launch vehicles, provided by our international partners, deliver new payloads and the shuttle returns completed experiments and samples to Earth.

The POC is the science command post for the space station, which links researchers around the world with their experiments and the station crew.

The POC works with support centers around the country to develop an integrated U.S. payload mission plan. Each support center is responsible for integrating specific disciplines with commercial payload operations:

- Marshall Space Flight Center**,** managing microgravity (materials sciences, microgravity research experiments, space partnership development program research)
- Glenn Research Center in Cleveland, managing microgravity (fluids and combustion research)
- Johnson Space Center in Houston, managing human life sciences (physiological and behavioral studies, crew health and performance)

The POC combines inputs from these centers into a U.S. payload operations master plan, which is delivered to Johnson's Space Station Control Center to be integrated into a weekly work schedule. All necessary resources are then allocated, available time and rack space are determined and key personnel are assigned to oversee the science experiments and operations in orbit.

Housed in a two-story complex at Marshall, three shifts of systems controllers staff the POC around the clock. During space station operations, center personnel routinely manage three to four times the number of experiments as were conducted aboard Spacelab.

The payload operations director leads the POC's main flight control team, known as the "cadre." The payload operations director approves all science plans in coordination with Mission Control at Johnson, the station crew and the payload support centers. The payload communications manager, the voice of the POC, coordinates and manages real-time voice responses between the station crew conducting payload operations and the researchers whose science the crew is conducting. The operations controller oversees station science operations resources such as tools and supplies and assures support systems and procedures are ready to support planned activities. The photo and television operations manager and data management coordinator are responsible for station video systems and high-rate data links to the POC.

The timeline coordination officer maintains the daily calendar of station work assignments based on the plan generated at Johnson Space Center, as well as daily status reports from the station crew. The payload rack officer monitors rack integrity, power and temperature control, and the proper working conditions of station experiments.

Additional support controllers routinely coordinate anomaly resolution and procedure changes and maintain configuration management of on-board stowed payload hardware.

For more information, visit the Marshall News Center at:

http://www.msfc.nasa.gov/news

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ISS 16 Russian Research Objectives

RUSSIAN RESEARCH OBJECTIVES					
Category	**Experiment Code**	**Experiment Name**	**Hardware Description**	**Research Objective**	**Unique Payload Constraints**
Commercial	КНТ-20	GCF-JAXA	GCF-02 kit	Protein crystallization	
Commercial	КНТ-32	JAXA 3DPC	3DPCU equipment	Obtaining 3-D photon crystals by means of colloid nano-particles self-organization and ordering in electrolytic solution with the further fixation in elastic gel mould	
Commercial	GTS	GTS-2	Electronics unit-2; Antenna assembly with attachment mechanism	Global time system test development	Unattended
Technology &Material Science	ТХН-7	SVS (CBC)	“CBC” researching camera CamCorder DSR PD-150P as part of Videocomplex DVCAM-150 *Nominal hardware:* “Klest” (“Crossbill”) TV-system Picture monitor (ВКУ)	Self-propagating high-temperature fusion in space	
Technology &Material Science	ТХН-9	Kristallizator (Crystallizer)	“Crystallizer” complex	Biological macromolecules crystallization and obtaining bio-crystal films under microgravity conditions	
Geophysical	ГФИ-1	Relaksatsiya	“Fialka-MB-Kosmos” - Spectrozonal ultraviolet system High sensitive images recorder	Study of chemiluminescent chemical reactions and atmospheric light phenomena that occur during high-velocity interaction between the exhaust products from spacecraft propulsion systems and the Earth atmosphere at orbital altitudes and during the entry of space vehicles into the Earth upper atmosphere	Using OCA
Geophysical	ГФИ-8	Uragan	*Nominal hardware:* Kodak 760 camera; Nikon D1X LIV video system	Experimental verification of the ground and space-based system for predicting natural and man-made disasters, mitigating the damage caused, and facilitating recovery	Using OCA
Biomedical	МБИ-5	Kardio-ODNT	*Nominal Hardware:* “Gamma-1M” equipment; “Chibis” countermeasures vacuum suit	Comprehensive study of the cardiac activity and blood circulation primary parameter dynamics	Will need help from U.S. crew member

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Biomedical	МБИ-8	Profilaktika	TEEM-100M gas analyzer; Accusport device; *Nominal Hardware:* “Reflotron-4” kit; TVIS treadmill; ВБ-3 cycle ergometer; Set of bungee cords; Laptop RSE-Med; “Tsentr” equipment power supply	Study of the action mechanism and efficacy of various countermeasures aimed at preventing locomotor system disorders in weightlessness	Time required for the experiment should be counted toward physical exercise time
Biomedical	МБИ-12	Sonokard	“Sonokard” set “Sonokard” “Sonokard- Data” kit Laptop RSE-Med	Integrated study of physiological functions during sleep period throughout a long space flight	
Biomedical	МБИ-15	Pilot	Right Control Handle Left Control Handle Synchronizer Unit (БС) ULTRABUOY-2000 Unit *Nominal hardware:* Laptop RSE-Med	Researching for individual features of state psychophysiological regulation and crewmembers professional activities during long space flights	
Biomedical	МБИ-18	Dykhanie	“Dykhanie-1” set *Nominal hardware:* Laptop RSE-Med	Study of respiration regulation and biomechanics under space flight conditions	
Biomedical	МБИ-21	Pneumocard	“Pneumocard” set “Pneumocard-KPM” kit “Pneumocard-Data” kit	Study of space flight factors impacts on vegetative regulation of blood circulation, respiration and contractile heart function during long space flights	
Biomedical	МБИ-22	BIMS (Onboard Information Medical System)	Kit TBK-1 Kit TBK-1. Accessories Kit TBK-1. Data *Nominal Hardware:* Laptop RSE-Med	Study of flight medical information support using onboard information medical system	During Expedition 15 & 16 crews rotation
Biomedical	БИО-2	Biorisk	“Biorisk-KM” set “Biorisk-MSV” containers “Biorisk-MSN” kit	Study of spaceflight impact on microorganisms-substrates systems state related to space technique ecological safety and planetary quarantine problem	
Biomedical	БИО-4	Aquarium	“Rasteniya (Plants)” kit (with “Aquarium” packs - 2 items)	Study of stability of model closed ecological system and its parts under microgravity conditions, both as microsystem components and as perspective biological systems of space crews life support	Crew members involvement is taken into account in Rasteniya experiment

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Biomedical	БИО-5	Rasteniya	“Lada” greenhouse *Nominal Hardware:* Water container; Sony DVCam; Computer	Study of the spaceflight effect on the growth and development of higher plants	
Biomedical	БИО-8	Plazmida	Hybridizers Recomb-K Kit with tubes “Kubik Amber” freezer	Investigation of microgravity effect on the rate of transfer and mobilization of bacteria plasmids	During Expedition 15 & 16 crews rotation
Biomedical	РБО-1	Prognoz	*Nominal Hardware for the radiation monitoring system:* P-16 dosimeter; ДБ-8 dosimeters “Pille-ISS” dosimeter “Lyulin-ISS” complex	Development of a method for real-time prediction of dose loads on the crews of manned spacecraft	Unattended
Biomedical	РБО-3	Matryeshka-R	Passive detectors unit “Phantom” set “MOSFET-dosimeter” scientific equipment “Bubble-dosimeter” hardware “Lyulin-5” hardware	Study of radiation environment dynamics along the ISS RS flight path and in ISS compartments, and dose accumulation in antroph-amorphous phantom, located inside and outside station	
Study of Earth natural resources and ecological monitoring	ДЗЗ-2	Diatomea	“Diatomea” kit *Nominal hardware:* Nikon F5 camera; DSR-PD1P video camera; Dictaphone; Laptop	Study of the stability of the geographic position and form of the boundaries of the World Ocean biologically active water areas observed by space station crews	
Biotechnology	БТХ-1	Glykoproteid	“Luch-2” biocrystallizer “Kriogem-03M” freezer	Obtaining and study of E1-E2 surface glycoprotein of α-virus	
Biotechnology	БТХ-2	Mimetik-K		Anti-idiotypic antibodies as adjuvant-active glycoproteid mimetic	
Biotechnology	БТХ-3	KAF		Crystallization of Caf1M protein and its complex with C-end peptide as a basis for formation of new generation of antimicrobial medicines and vaccine ingredients effective against yersiniosis	
Biotechnology	БТХ-4	Vaktsina-K (Vaccine)		Structural analysis of proteins-candidates for vaccine effective against AIDS	
Biotechnology	БТХ-20	Interleukin-K		Obtaining of high-quality 1α, 1β interleukins crystals and interleukin receptor antagonist – 1	

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Biotechnology	БТХ-5	Laktolen	“Bioekologiya” kit	Effect produced by spaceflight factors on Laktolen producing strain	
Biotechnology	БТХ-6	ARIL		Effect produced by SFFs on expression of strains producing interleukins 1α, 1β, “ARIL”	
Biotechnology	БТХ-7	OChB		Effect produced by SFFs on strain producing superoxidodismutase (SOD)	
Biotechnology	БТХ-8	Biotrack	“Bioekologiya” kit	Study of space radiation heavy charged particles fluxes influence on genetic properties of bioactive substances cells-producers	
Biotechnology	БТХ-10	Kon’yugatsiya (Conjugation)	“Rekomb-K” hardware “Kubik Amber”“ freezer *Nominal Hardware:* “Kriogem-03” freezer	Working through the process of genetic material transmission using bacteria conjugation method	During Expedition 15 & 16 crews rotation
Biotechnology	БТХ-11	Biodegradatsiya	“Bioproby” kit	Assessment of the initial stages of biodegradation and biodeterioration of the surfaces of structural materials	
Biotechnology	БТХ-12	Bioekologiya (Bioecology)	“Bioekologiya” kit	Generation of high-efficiency strains of microorganisms to produce petroleum biodegradation compounds, organophosphorus substances, vegetation protection agents, and exopolysaccharides to be used in the petroleum industry	
Biotechnology	БТХ-14	Bioemulsiya (Bioemulsion)	Changeable bioreactor Thermostat with drive control unit with stand and power supply cable in cover “Kubik Amber”“ freezer	Study and improvement of closed-type autonomous reactor for obtaining biomass of microorganisms and bioactive substance without additional ingredients input and metabolism products removal	During Expedition 15 & 16 crews rotation
Biotechnology	БТХ-27	Astrovaktsina	“Bioekologiya” kit	Cultivation in zero-gravity conditions E.Coli–producer of Caf1 protein	
Biotechnology	БТХ-29	Zhenshen-2	“Bioekologiya” kit	Study of a possibility to increase biological activity of ginseng	

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Biotechnology	БТХ-31	Antigen	“Bioekologiya” kit	Comparative researching heterologous expression of acute viral hepatitis HbsAg in S.cerevisiae yeast under microgravity and Earth conditions and determining synthesis optimization methods	
Technical Studies	TEX-14 (SDTO 12002-R)	Vektor-T	*Nominal Hardware:* ISS RS СУДН sensors; ISS RS orbit radio tracking [PKO] system; Satellite navigation; equipment [ACH] system GPS/GLONASS satellite systems	Study of a high-precision system for ISS motion prediction	Unattended
Technical Studies	TEX-15 (SDTO 13002-R)	Izgib	*Nominal Hardware:* ISS RS onboard measurement system (СБИ) accelerometers; ISS RS motion control and navigation system GIVUS (ГИВУС СУДН) Nominal temperature-sensing device for measures inside “Progress” vehicle modules “Dakon” hardware	Study of the relationship between the onboard systems operating modes and ISS flight conditions	
Technical Studies	TEX-20	Plazmennyi Kristall (Plasma Crystal)	“PC-3 Plus” experimental unit “PC-3 Plus” telescience *Nominal hardware* “Klest” (“Crossbill”) TV-system БСПН – Payload Server Block	Study of the plasma-dust crystals and fluids under microgravity	
Technical Studies	TEX-22 (SDTO 13001-R)	Identifikatsiya	*Nominal Hardware:* ISS RS СБИ accelerometers	Identification of disturbance sources when the microgravity conditions on the ISS are disrupted	Unattended
Technical Studies	TEX-44	Sreda-ISS (Environment)	*Nominal Hardware:* Movement Control System sensors; orientation sensors; magnetometers; Russian and foreign accelerometers	Studying ISS characteristics as researching environment	Unattended

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Category	**Experiment Code**	**Experiment Name**	**Hardware Description**	**Research Objective**	**Unique Payload Constraints**
Complex Analysis. Effectiveness Estimation	КПТ-2	Bar	Remote – indicating IR thermometer “Kelvin-Video” Pyroendoscope “Piren-V” Thermohygrometer “Iva-6A” Hot-wire anemometer-thermometer TTM-2 Ultrasound analyzer AU-01 Leak indicator UT2-03	Selection and testing of detection methods and means for depressurization of the International Space Station modules.	
Complex Analysis. Effectiveness Estimation	КПТ-3	Econ	“Econ” kit Nominal Hardware: Nikon D1X digital camera, Laptop RSK1	Experimental researching of ISS RS resources estimating for ecological investigation of areas	
Complex Analysis. Effectiveness Estimation	КПТ-6	Plazma-MKS (Plasma-ISS)	“Fialka-MB-Kosmos” - Spectrozonal ultraviolet system	Study of plasma environment on ISS external surface by optical radiation characteristics	
Complex Analysis. Effectiveness Estimation	КПТ-14	Ten’-Mayak (Shadow – Beacon)	Complex of amateur packet radio communication set with 145/430 MHz frequency range: - receiver-transmitter; - 4 antenna-feeder devices; - 2 power supply units; - controlling computer	Working-out of the method for radio probing of board-ground space for supporting preparation of “Ten’” (“Shadow”) plasma experiment on ISS RS	
Study of cosmic rays	ИКЛ-2В	BTN-Neutron	Detection Block Electronic Equipment Block Mechanical interface	Study of fast and thermal neutrons fluxes	
Education	ОБР-2	MATI-75	Poroplast pouch with original samples Photographic/Video Camera	Demonstration effect of shape recovery of blanks made from cellular polymeric materials	
Pre/Post-flight		Motor control	Electromiograph, control unit, tensometric pedal, miotometer «Miotonus», «GAZE» equipment	Study of hypo-gravitational ataxia syndrome;	Pre-flight data collection is on L-60 and L-30 days; Post-flight: on 1, 3, 7, 11 days Total time for all 4 tests is 2.5 hours
Pre/Post-flight		MION		Impact of microgravity on muscular characteristics.	Pre-flight biopsy (60 min) on L-60, and L-30 days; Post-flight: 3-5 days
Pre/Post-flight		Izokinez	Isocinetic ergometer «LIDO», electromiograph, reflotron-4, cardiac reader, scarifier	Microgravity impact on voluntary muscular contraction; human motor system re-adaptation to gravitation.	Pre-flight: L-30; Post-flight: 3-5, 7-9, 14-16, and 70 days. 1.5 hours for one session

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Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
Pre/Post-flight		Tendometria	Universal electrostimulator (ЭСУ-1); bio-potential amplifier (УБП-1-02); tensometric amplifier; oscilloscope with memory; oscillograph	Microgravity impact on induced muscular contraction; long duration space flight impact on muscular and peripheral nervous apparatus	Pre-flight: L-30; Post-flight: 3, 11, 21, 70 days; 1.5 hours for one session
Pre/Post-flight		Ravnovesie	“Ravnovesie” (“Equilibrium”) equipment	Sensory and motor mechanisms in vertical pose control after long duration exposure to microgravity	Pre-flight: L-60, L-30 days; Post-flight: 3, 7, 11 days, and if necessary on 42 or 70 days; Sessions: pre-flight data collection 2x45 min, post-flight: 3x45 min
Pre/Post-flight		Sensory adaptation	IBM PC, Pentium 11 with 32-bit s/w for Windows API Microsoft.	Countermeasures and correction of adaptation to space syndrome and of motion sickness	Pre-flight: L-30, L-10; Post-flight: 1, 4, and 8 days, then up to 14 days if necessary; 45 min for one session.
Pre/Post-flight		Lokomotsii	Bi-lateral video filming, tensometry, miography, pose metric equipment.	Kinematic and dynamic locomotion characteristics prior and after space flight	Pre-flight: L-20-30 days; Post-flight: 1, 5, and 20 days; 45 min for one session.
Pre/Post-flight		Peregruzki	Medical monitoring nominal equipment: Alfa-06, Mir 3A7 used during descent phase.	G-forces on Soyuz and recommendations for anti-g-force countermeasures development	In-flight: 60 min; instructions and questionnaire familiarization: 15 min; Post-flight: cosmonauts checkup – 5 min; debrief and questionnaire – 30 min for each cosmonauts.
Pre/Post-flight		Polymorphism	No hardware is used in-flight	Genotype parameters related to human individual tolerance to space flight conditions.	Pre-flight: blood samples, questionnaire, anthropometrical and anthroposcopic measurements – on early stages if possible; blood samples could be taken during preflight medical checkups on L - 60, L - 30 days. 30 min for one session.

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European Experiment Program

During the Expedition 16 mission, there will be a full European experiment program in different scientific areas with many utilizing the internal and external experiment facilities of the Columbus laboratory. Columbus is scheduled to arrive on the STS-122 space shuttle flight targeted for December 2007. Some experiments will be undertaken by members of the Expedition 16 crew, including ESA astronaut Léopold Eyharts, Russian cosmonaut Yuri Malenchenko and NASA astronaut Garrett Reisman who is scheduled to arrive on shuttle flight STS-123 in February 2008 and take over the duties of Eyharts. Other experiments will be carried out by ESA astronaut Hans Schlegel, who will be a mission specialist on the STS-122 flight, and by a Malaysian spaceflight participant who will launch with the Expedition 16 crew.

Internal Experiments

Biology

Biolab: WAICO

This is the first experiment to be carried out in the Biolab facility within the European Columbus Laboratory. WAICO, which is the short name for Waving and Coiling of Aridopsis Roots, concerns the spiralling motion (circumnutation) of plant roots in weightlessness. By observing Aridopsis roots growth in space, one can predict that without the interference of gravity they would grow in spirals. Root samples from Aridopsis seedlings grown from seed for 10-15 days in space will be analysed post-flight to identify the role of the cell wall structure in the different tissues for this kind of growth imbalance.

Science Team: G. Scherer (DE)

EMCS: Multigen-1

The main goal of the Multigen experiment, which will take place in the European Modular Cultivation System (EMCS) will be to test how plants will behave at different developmental levels under weightless conditions. During this first part of the experiment, the plant (Arabidopsis thaliana) will be observed from seed to seed where the growth, development and production of flowers and new seeds are the ultimate goals. The first part of this experiment also will record circumnutations in the shoots, i.e., spiralling growth.

Science Team: T. -H. Iversen (NO), A. -I. Kittang (NO); B.G.B. Solheim (NO); A. Johnsson (NO); H. Svare (NO), F. Migliaccio (IT)

Kubik Incubator Experiments

Three biology experiments will be carried out using two European incubators called Kubik, one of which is already on the station, the other of which will be uploaded to the station during the Soyuz flight in October 2007. As well as providing a thermally–controlled environment, each incubator has a centrifuge, which provides the ability to run 1g control experiments while on orbit.

At-Space – The aim of the proposal is to identify genes which are activated, or in some way regulated, by gravity. This knowledge can have an impact on practical agricultural issues such as architecture of root and shoot systems, as well as realizing the potential for regulating plant growth in space.

Science Team: K. Palme (DE), M. Bennet (UK), H. Hammerle (DE), D. Volkmann (DE)

Biokin-4 – The goal is to determine the growth profile of the bacteria Xanthobacter autotrophicus in a bioreactor to be used in a biological air filter for the purification of contaminated air during human spaceflight missions. This is a follow up to experiments on previous Euromir and STS-107 missions.

Science Team: J. Krooneman (NL), J. van der Waarde (NL), D. M. Klaus (US)

Pkinase – The experiment is a study on the enzyme PKC (Protein Kinase C), which is involved in many cellular processes. The aim of the experiment is to determine the effect that station's weightless environment has on: activation of PKC isoforms and their spatial distribution; control of white blood cell (monocyte) differentiation, and initiation of programmed cell death (apoptosis) and cell cycle arrest. The experiment also will test whether enhancers can be used to restore PKC isoforms disturbed by weightlessness.

Science Team: M. Hughes-Fulford (US), A. Cogoli (CH)

Fluid Science

Fluid Science Laboratory: Geoflow

Geoflow is the first experiment to take place within the Fluid Science Laboratory inside the European Columbus Laboratory. The experiment will investigate the flow of an incompressible viscous fluid (silicon oil) held between two concentric spheres rotating about a common axis. A temperature gradient and voltage difference are maintained from the inside to the outside sphere. This geometrical configuration can be seen as a representation of a planet, with the electric field simulating its gravitational field. This research is of importance in such areas as flow in the atmosphere, the oceans, and in the liquid nucleus of planets on a global scale.

Science Team: Ch. Egbers (DE), P. Chossat (FR), F. Feudel (DE), Ph. Beltrame (DE), I. Mutabazi (FR), L. Tuckerman (FR), R. Hollerbach (UK)

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.

Science Team: C. Johannes (DE), M. Horstmann (DE)

EDOS

Early Detection of Osteoporosis in Space (EDOS) is a study into the mechanisms underlying the reduction in bone mass, which occurs in astronauts in weightlessness. The 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.

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

ETD

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. 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 level of atrophy 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

This experiment covers the effects of weight-lessness 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 analyse 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)

Sample

This experiment will investigate what kind of microbial species are to be found on board of the International Space Station and how these adapt to conditions of spaceflight. The participant will take samples in certain areas of the station and from his own body. The samples will be obtained by rubbing swab sticks over surfaces, which are susceptible to having bacteria including switches, keyboards and personal hygiene equipment.

Science Team: H. Harmsen (NL), G. Welling, (NL), J. Krooneman (NL), L. van den Bergh (NL)

Spin

This experiment is a comparison between pre-flight 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

ALTCRISS

ALTCRISS (Alteino Long Term monitoring of Cosmic Rays on the International Space Station) is an ESA experiment to study the effect of shielding on cosmic rays in two different and complementary ways. The detector of the Alteino device will monitor differences in the flow of cosmic rays with regard to the position and orientation of the Alteino device, with the focus being on radiation monitoring in the Pirs module in the station's Russian segment.

Science Team: M. Casolino (IT), F. Cucinotta (US), M. Durante (IT), C. Fuglesang (SE), C. Lobascio (IT), L. Narici (IT), P. Picozza (IT), L. Sihver (SE), R. Scrimaglio (IT), P. Spillantini (IT)

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 doing spacewalks.

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

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

Matroshka 2B

The ESA Matroshka facility has been an ongoing experiment on the ISS since February 2004 with the aim of studying radiation levels experienced by astronauts. It consists of a human shape (head and torso), called the Phantom, equipped with several active and passive radiation dosimeters. For the Matroshka 2B experiment, new passive radiation sensors uploaded during the Soyuz flight in October 2007 will be installed inside the Phantom. The active radiation dosimeters will be activated in December. The Matroshka facility will be installed inside the station to take 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

External Experiments

EuTEF

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 housing on the station's external surface:

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-millimeter sized particles and has 3 sensors facing in different directions. The scientific results from several DEBIE instruments onboard different spacecraft will be compiled into a single database for 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)

EXPOSE-E

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

LIFE – This experiment will test the limits of survival of Lichens, Fungi and symbionts under simulated space conditions.

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), W. Nicholson (US), J. Pillinger (UK), E. Rabbow (DE), P. Rettberg (DE), J. Sprey (UK), 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 (DE), L. Sydney (FR), S. Hoffmann (DK), P. Ducrot (FR), F. Corbineau (FR), C. Wood (UK)

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

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 ISS 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 understand 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 which 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. The FIPEX micro-sensor system 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 Materials Exposure and Degradation Experiment (MEDET) aims to evaluate the effects of open space on materials currently being considered for utilization on spacecraft in low earth orbit. It also will verify the validity of data from the space simulation currently used for materials evaluation and 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 important as uncontrollable discharge events can adversely affecting the functioning of spacecraft electronic systems.

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

R3D

The Radiation Risks Radiometer-Dosimeter (R3D) is an environmental monitor which records the irradiance of solar light in four different wavelength ranges (UV-A, UV-B, UV-C and photosynthetic active light) as well as the dose and flux of heavy cosmic particles.

Science Team: D-P Häder (DE), M. Schuster (DE), T. Dachev (BU)

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)

SOLAR

The SOLAR 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 3 instruments complementing each other, which are:

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. By an auto-calibration capability, it is expected to gain long term spectral data with a high absolute resolution. In its center, it contains 4 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 SPECc-tral irradiance measurements) is to measure the solar spectum irradiance from 180 nm to 3,000 nm. The aims of this investigation are the study of solar variability at short and long term and the achievement of absolute measurements (2% in UV and 1% 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.

Science Team: C. Frohlich (CH)

The Digital NASA Television

NASA Television can be seen in the continental United States on AMC-6, at 72 degrees west longitude, Transponder 17C, 4040 MHz, vertical polarization, FEC 3/4, Data Rate 36.860 MHz, Symbol 26.665 Ms, Transmission DVB. If you live in Alaska or Hawaii, NASA TV can now be seen on AMC-7, at 137 degrees west longitude, Transponder 18C, at 4060 MHz, vertical polarization, FEC 3/4, Data Rate 36.860 MHz, Symbol 26.665 Ms, Transmission DVB.

Digital NASA TV system provides higher quality images and better use of satellite bandwidth, meaning multiple channels from multiple NASA program sources at the same time.

Digital NASA TV has four digital channels:

1. NASA Public Service ("Free to Air"), featuring documentaries, archival programming, and coverage of NASA missions and events.
2. NASA Education Services ("Free to Air/Addressable"), dedicated to providing educational programming to schools, educational institutions and museums.
3. NASA Media Services ("Addressable"), for broadcast news organizations.
4. NASA Mission Operations (Internal Only).

Note: Digital NASA TV channels may not always have programming on every channel simultaneously.

Internet Information

Information is available through several sources on the Internet. The primary source for mission information is the NASA Human Space Flight Web, part of the World Wide Web. This site contains information on the crew and its mission and will be updated regularly with status reports, photos and video clips throughout the flight. The NASA Shuttle Web's address is:

http://spaceflight.nasa.gov

General information on NASA and its programs is available through the NASA Home Page and the NASA Public Affairs Home Page:

http://www.nasa.gov

or

http://www.nasa.gov/newsinfo/index.html

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