CONTINUING TO CARRY THE TORCH

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Mission Overview

Expedition 8: Continuing to Carry the Torch

The next crew to live and work aboard the International Space Station is scheduled to launch on Oct. 18, 2003, aboard a Russian Soyuz spacecraft from the Baikonur Cosmodrome in Kazakhstan to replace the American astronaut and the Russian cosmonaut who have been living and working on the ISS since April.

Cosmonaut Alexander Kaleri (left) and Astronaut Michael Foale pose for their official Expedition 8 crew portrait.

American Commander and NASA ISS Science Officer Michael Foale (Ph.D.), 46, and Russian Flight Engineer and Soyuz Commander Alexander Kaleri, 47, will launch on the Soyuz TMA-3 spacecraft for a two-day flight to dock to the Pirs Docking Compartment of the ISS.

European Space Agency (ESA) Soyuz crewmember Pedro Duque fields a question during the Expedition 8 pre-flight press conference at Johnson Space Center.

Foale and Kaleri will be joined aboard the Soyuz by European Space Agency astronaut Pedro Duque of Spain, 40, who will spend eight days aboard the ISS performing scientific experiments under a commercial contract between ESA and the Russian Aviation and Space Agency (Rosaviakosmos). Duque will return to Earth on Oct. 28 with Expedition 7 Commander Yuri Malenchenko and NASA ISS Science Officer Ed Lu, who have been aboard the Station since April. They will land in Kazakhstan in the Soyuz TMA-2 capsule.

Once on board, Foale and Kaleri will conduct more than a week of handover activities with Malenchenko and Lu, familiarizing themselves with Station systems and procedures. They will also receive proficiency training on the Canadarm2 robotic arm from Lu and will engage in safety briefings with the Expedition 7 crew as well as payload and scientific equipment training.

The Expedition 7 crewmembers, Yuri I. Malenchenko (left), mission commander, and astronaut Edward T. Lu, NASA ISS science officer and flight engineer, pose for a crew photo in the Destiny laboratory on the International Space Station.

Foale and Kaleri will assume formal control of the station at the time of hatch closure before the Expedition 7 crew and Duque undock the Soyuz TMA-2 craft from the nadir port of the Zarya Control Module. With Malenchenko at the controls of TMA-2, he and Lu and will land in the steppes of north central Kazakhstan to wrap up six months in orbit. Duque's mission will span 10 days.

After landing, Malenchenko and Lu will be flown from Kazakhstan to the Gagarin Cosmonaut Training Center in Star City, Russia, for about two weeks of initial physical rehabilitation. Duque will spend a much shorter time acclimating himself to Earth's gravity due to the brevity of his flight.

Foale and Kaleri are expected to spend almost 200 days aboard the ISS. After the Columbia accident on Feb. 1, 2003, the ISS Program and the international partners determined that the station would be occupied by only two crewmembers until the resumption of Shuttle flights because of limitations on consumables.

Foale, a veteran astronaut, is making his sixth trip into space, including more than four months aboard the Russian space station Mir in 1997. His other flights aboard the Space Shuttle include STS-45, STS-56, STS-63, STS-84 which brought him to the Mir, and STS-103. In all, Foale has totaled more than 178 days in space and three spacewalks, including one during his tenure on Mir.

Kaleri, a veteran cosmonaut, is making his fourth flight into space, having accumulated 416 days in orbit on his three missions to Mir. Kaleri is also a veteran of four spacewalks.

Duque is making his second trip into space, having flown aboard the Space Shuttle Discovery in 1998 on the STS-95 mission.

American and Russian planners are planning for a spacewalk out of the Pirs Docking Compartment airlock during Expedition 8 with Foale and Kaleri wearing Russian Orlan spacesuits. The spacewalk would be designed to swap out experiments on the Zvezda Service Module that measure the microgravity environment in low-Earth orbit and to begin preparing equipment on Zvezda for next year's planned maiden flight of ESA's "Jules Verne" Automated Transfer Vehicle (ATV) cargo ship. The unpiloted ATV, like the Russian Progress craft, will deliver equipment and supplies to the ISS.

Once the Expedition 7 crew has departed, the Expedition 8 crew will settle down to work.

Station operations and station maintenance will take up a considerable share of the time of the two-person crew. But science will continue, as will science-focused education activities and Earth observations.

The Expedition 8 crewmembers and training staff assemble for a group photo in the Space Vehicle Mockup Facility at the Johnson Space Center. Astronaut C. Michael Foale, mission commander and NASA ISS science officer, and cosmonaut Alexander Y. Kaleri, flight engineer, are visible center front. Kaleri represents Rosaviakosmos.

Experiments make use of the microgravity environment in the Destiny Laboratory and the orientation of the station to conduct investigations in a variety of disciplines. Those fields include life sciences, physics and chemistry, and their applications in materials and manufacturing processes. The Station also is used for studies of the Earth – its environment, climate, geology, oceanography and more. Indeed, Earth observations are expected to occupy a relatively large share of this crew's time for scientific activity. The crew is scheduled to devote nearly 300 hours to U.S., Russian, and other partner research during its stay on orbit.

The science team at the Payload Operations Center at the Marshall Space Flight Center in Huntsville, Ala., will operate some experiments without crew input and other experiments are designed to function autonomously. Together, operation of individual experiments is expected to total several thousand hours, adding to the more than 100,000 hours of experiment operation time already accumulated aboard the station.

In addition, some Expedition 7 science activities will be continued. Many of the Expedition 8 Russian science experiments were delivered on the ISS Progress 12 resupply vehicle, which docked to the International Space Station Aug. 31.

Among Expedition 8's functions will be to provide motivation and inspiration for today's youth, the next generation of explorers. These young people will add to human knowledge using information space station science will provide, taking us further and further into yet uncharted scientific waters.

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During more than six months aloft, Foale and Kaleri will monitor the arrival of three Russian Progress resupply cargo ships like the one pictured above, filled with food, fuel, water, new research experiments and supplies. They will also upgrade the software in the on-board Station computers and conduct more than four dozen U.S. and Russian experiments.

ISS Progress 13 is scheduled to reach the ISS in late November or early December, ISS Progress 14 is earmarked to fly to the ISS at the end of January and ISS Progress 15 is slated for launch in late March, about a month before the launch of the next piloted Soyuz vehicle to the Station. All three Progress craft will dock to the aft port of Zvezda.

Also on the crew's agenda is work with the station's robotic arm, Canadarm2. Robotics work will focus on observations of the station's exterior, maintaining operator proficiency, and completing the schedule of on-orbit checkout requirements that were developed to fully characterize the performance of the robotic system.

Expedition 8 Crew

Commander and NASA ISS Science Officer: Michael Foale

Astronaut Michael Foale will command the Expedition 8 crew of the International Space Station. Foale is a veteran of long-duration spaceflight aboard the Russian space station Mir as Flight Engineer 2. He also flew as a Mission Specialist on STS-45, STS-56, STS-63, STS-84 and STS-103.

On May 17, 1997, Foale flew on STS-84 to join the Mir 23 crew to conduct science experiments. Foale helped re-establish Mir after a Progress resupply vehicle collided into the station's Spektr module causing a depressurization. Foale conducted a spacewalk with cosmonaut Anatoly Solovyev to inspect the exterior of Mir. After spending 145 days in space, Foale left the Mir 24 crew and returned to Earth aboard STS-86 Oct. 6, 1997.

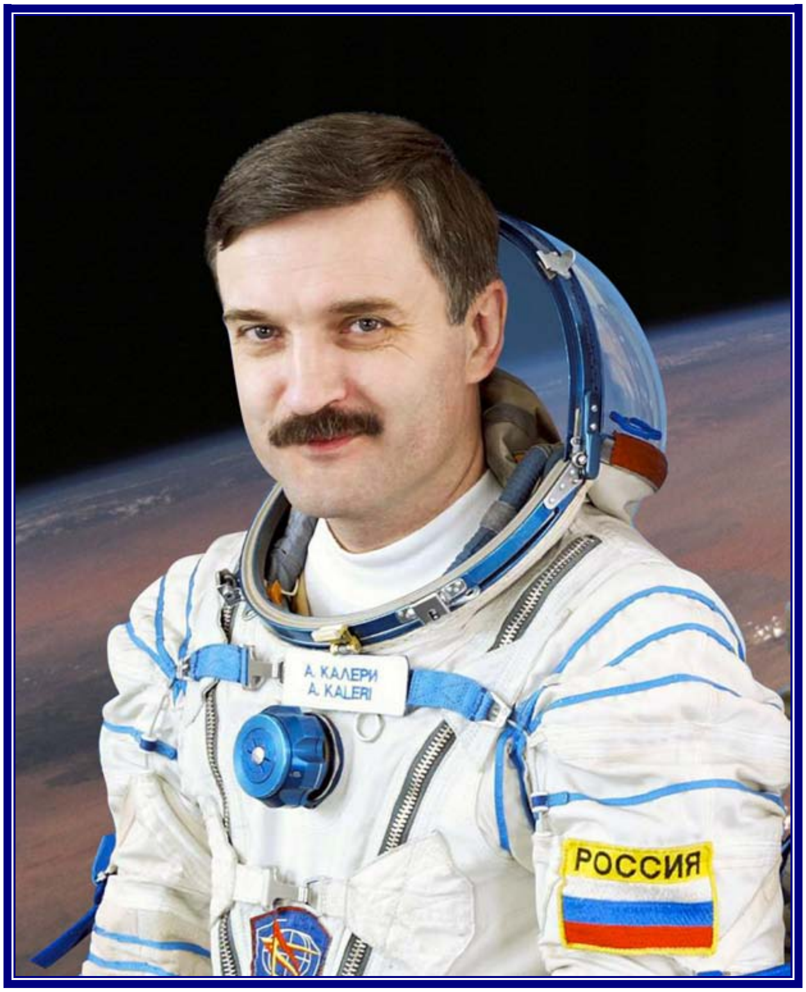
Foale was born Jan. 6, 1957, in Louth, England, but considers Cambridge, England, to be his hometown. He graduated from Kings School, Canterbury, in 1975 and received a bachelor of arts degree in physics from the University of Cambridge, Queens' College with first-class honors in 1978. He completed his doctorate in laboratory astrophysics at Cambridge University in 1982.

Pursuing a career in the U.S. space program, Foale moved to Houston to work at McDonnell Douglas Aircraft Corporation. In June 1983, Foale joined NASA Johnson Space Center in the payload operations area of the Mission Operations Directorate. NASA selected him as an astronaut candidate in June 1987.

Foale's STS-45 mission in 1992 was the first of the ATLAS (Atmospheric Laboratory for Applications and Science) series of missions to study the atmosphere and solar interactions. STS-56, in 1993, carried ATLAS-2 and the SPARTAN (Shuttle Pointed Autonomous Research Tool for Astronomy) retrievable satellite that made observations of the solar corona. During STS-63, in 1995, Foale conducted a spacewalk with crewmate Bernard Harris to evaluate extremely cold conditions on his spacesuit and explore mass handling of the 2,800-pound SPARTAN satellite. Foale's latest spaceflight aboard STS-103 in 1999 was a maintenance mission to the Hubble Space Telescope during which Foale and crewmate Claude Nicollier conducted a spacewalk to replace the telescope's main computer and Fine Guidance Sensor.

Foale has logged over 178 days in space and more than 18 hours of spacewalk time.

Soyuz Commander and ISS Flight Engineer: Alexander Kaleri



Cosmonaut Alexander Kaleri will serve as the Soyuz commander and Space Station flight engineer for Expedition 8. He is a veteran of long-duration spaceflight as a resident aboard the Russian space station Mir.

Kaleri served as the flight engineer for missions Mir 11, Mir 22 and Mir 28 during which he participated in international joint flights with German and French cosmonauts as well as American astronauts.

Kaleri was born May 13, 1956, in Yurmala, Latvia. He graduated from Moscow Institute of Mechanical Physics and began work at the Energia Rocket and Space Corporation (RSC) in 1979. He participated in design and technical documentation and full-scale tests of the Mir space station. He was selected as a cosmonaut candidate by Energia RSC in

April 1984 and completed basic training at the Gagarin Cosmonaut Training Center in 1986. In 1987 he was qualified for flight assignment as a test pilot.

Assigned as a backup flight engineer for Mir 3 and Mir 9, Kaleri trained for long-duration spaceflight missions to Mir from 1987 until 1992 when he was then named to the primary crew of Mir 11 as a flight engineer. The Mir 11 mission lasted 145 days from March 17 to Aug. 10, 1992.

Kaleri again flew to Mir for 197 days as the flight engineer for Mir 22 from Aug. 17, 1996 to March 2, 1997. The Mir 22 mission consisted of joint flights with NASA astronauts Shannon Lucid, John Blaha and Jerry Linenger as part of the Shuttle-Mir Program.

Kaleri's last mission to Mir as a flight engineer for Mir 28 lasted 74 days from April 4 to June 16, 2000.

He has logged a total of 416 days in space and has conducted four spacewalks.

European Space Agency Astronaut Pedro Duque

European Space Agency (ESA) Astronaut Pedro Duque of Spain will fly to the International Space Station (ISS) aboard ISS Soyuz 7. He will spend eight days aboard the ISS performing scientific experiments under a commercial contract between ESA and the Russian Aviation and Space Agency (Rosaviakosmos). Duque will return to Earth on Oct. 28 with Expedition 7 Commander Yuri Malenchenko and NASA ISS Science Officer Ed Lu.

Duque was a mission specialist on STS-95 aboard the Space Shuttle Discovery in 1998. The nine-day mission was dedicated to research in weightlessness and the study of the Sun. Duque was responsible, among others, for the five ESA scientific facilities on board and for the extensive computer system and configurations used on the Shuttle.

Duque was born on March 14, 1963, in Madrid, Spain. He graduated with a degree in aeronautical engineering from the Escuela Técnica Superior de Ingenieros Aeronáuticos, Universidad Politécnica, Madrid in 1986.

Duque joined GMV (Grupo Mecánica del Vuelo) in 1986 and moved to ESA's European Space Operations Center in Darmstadt, Germany, to give support to the Precise Orbit Determination Group. Until 1992, he worked on the development of models for orbit determination, algorithms and implementation of orbit computation software. He was also part of the Flight Control Team for ESA's ERS-1 satellite and EURECA, the European Retrievable Carrier.

Duque was selected to join the ESA astronaut corps based at the European Astronaut Centre (EAC) in Cologne, Germany, in May 1992. He completed the Introductory and Basic Training Programs at EAC and a four-week training program at the Russian Cosmonaut Training Center in Star City, Russia.

In August 1993, Duque returned to the Russian Cosmonaut Training Center in Star City to train for the joint ESA-Russian Euromir 94 mission. During Euromir 94, which took place from Oct. 3 to Nov. 4 in 1994, he was the prime Crew Interface Coordinator (CIC) in the Russian Mission Control Center in Moscow. He served as coordinator between the crew on board Mir and the European scientists.

In May 1995, NASA selected Duque as an alternate payload specialist for the Space Shuttle Life and Microgravity Spacelab mission (STS-78) flown in June-July 1996. During this 17-day mission, Duque was one of the two CICs, acting as the interface between researchers on the ground and the crew on board the shuttle Columbia for all experiment-related issues. ESA had five major facilities on the flight and was responsible for more than half of the experiments performed.

In August 1996, Duque entered the Mission Specialist Class at the NASA Johnson Space Center in Houston. This training led to his certification as mission specialist in April 1998, qualifying him for assignments on board the Space Shuttle.

In 1999, Duque was assigned to ESA/ESTEC, Noordwijk, The Netherlands, providing support to the Module Projects Division within the Directorate of Manned Spaceflight and Microgravity. In April 2001, Duque was assigned to the first ISS advanced training class to prepare for one of the first European long-term flights aboard the ISS.

Mission Objectives

Increment 8 Flight Summary identifies planning data for all flights scheduled to visit the ISS during this increment.

The mission duration column lists the planned mission duration of each flight. Duration calculations are based on the calendar day difference between events.

The docked duration column lists the planned docked duration for each flight.

All planning docking altitudes presented in this document represent average altitudes unless stated otherwise.

All launch dates contained in the table are shown in the time standard of the launch vehicle organization. Space Shuttle Program dates correspond to the Kennedy Space Center (KSC) time zone. Russian dates correspond to the Moscow local time zone.

Increment 8 Flight Summary

ISS Flight Name	**Launch Vehicle Flight Name**	**Launch Vehicle Crew Size [4]**	**Planned Launch Date**	**Mission Duration (Days)**	**Shuttle Docking Altitude (km/nmi)**	**Planned Docking Date**	**Docked Duration (Days)**	**Planned Undocking Date**
6S (c)	Soyuz-TMA	2+0 [3]	[1]	185	-	[1]	183	28 Oct 03
12P	Progress-M	Unmanned	[1]	82 **<TBR 3-3>**	-	[1]	80 **<TBR 3-3>**	19 Nov 03 **<TBR 3-3>**
7S (c)	Soyuz-TMA	2+1	18 Oct 03	194	-	20 Oct 03	192	29 Apr 04
13P	Progress-M1	Unmanned	20 Nov 03 **<TBR 3-3>**	70 **<TBR 3-3>**		22 Nov 03 **<TBR 3-3>**	68 **<TBR 3-3>**	29 Jan 04 **<TBR 3-3>**
14P	Progress-M	Unmanned	30 Jan 04 **<TBR 3-3>**	54 **<TBR 3-3>**	-	01 Feb 04 **<TBR 3-3>**	52 **<TBR 3-3>**	24 Mar 04 **<TBR 3-3>**
15P	Progress-M	Unmanned	25 Mar 04 **<TBR 3-3>**	[2]	-	27 Mar 04 **<TBR 3-3>**	[2]	[2]
8S (c) **<TBR 3-1>**	Soyuz-TMA	2+1	19 Apr 04	[2]	-	21 Apr 04	[2]	[2]

NOTES:
(c) Crew Rotation flight
[1] The planned launch and docking dates of this flight are specified by SSP 54007.
[2] The planned undocking date, as well as the mission and docked duration of this flight are specified by SSP 54009 **<TBD 1-1>**.
[3] Flight 6S descent crew size is 2+1.
[4] Soyuz ascent crew size is denoted in the “Launch Vehicle Crew Size” column in Table 3.2-1, using the following convention: x+y, where x=number of Expedition crewmembers, and y=number of Soyuz passengers. Soyuz descent crew size will be identified with a table note when it differs from crew size.

Increment 8 Summary

Increment Start	Flight 7S Launch (18 Oct 03)	
Increment End **<TBR 3-1>**	Undocking of Flight 7S (29 Apr 04)	
Increment Duration (days) **<TBR 3-1>**	194	
Crew Plan	CDR (NASA - C. Michael Foale) FE (Rosaviakosmos - Alexander Kaleri)	
Crew Days	In Space: 194	On the ISS: 192
Flight 7S Assembly/System Objectives	• Rotate ISS 7 crew with ISS 8 crew • Undock 6 Soyuz	
Flight 7S Utilization Objectives	• NASA: Journals, Interactions • Russian: МВИ-7 Biotest, МБИ-11 Gematologia, ВИО-10 Intercellular Interactions, БТХ-32 MSC • ESA: Visiting Crew Science Objectives (Including PromISS 2 and Nanoslab)	
Stage 7S (6S undock - 13P dock) Assembly/System Objectives	• Load and undock 12 Progress-M • Perform software load updates • Perform MSS OCRs	
Stage 7S (6S undock - 13P dock) Utilization Objectives	NASA: Code M - Crew Earth Observations, EarthKAM, MISSE, SPHERES, ESTER, EPO; Human Life Science - Interactions, Journals, Advanced U.S., Epstein-Barr, FOOT; Renal Stone; Physical Science Research - MAMS, SAMS, PCG-STES, BCSS-FDI, CFE, PFMI; Foam Study, FMVM, BCAT 3, DAFT; Space Product Development - GAP Yeast; Fundamental Space-ADSEP CEMSS, ADSEP SPEGIS Russian: Commercial – 3 Experiments, Geophysical – 3 Experiments, Biomedical – 16 Experiments, Study of Earth Natural Resources and Ecological Monitoring – 1 Experiment, Biotechnology – 7 Experiments, Technical Studies – 11 Experiments, Study of Cosmic Rays – 1 Experiment, Space Energy Systems – 1 Experiment	

Increment 8 Summary (continued)

Stage 13P (13P dock – 14P dock) Assembly/System Objectives	• Dock 13 Progress-M1 and perform cargo transfer • Load and undock 13 Progress-M1 • Perform MSS OCRs
Stage 13P (13P dock – 14P dock) Utilization Objectives	NASA: Code M – Crew Earth Observations, EarthKAM, MISSE, SPHERES, ESTER, EPO; Human Life Science – Interactions, Journals, Advanced U.S., Epstein-Barr, FOOT; Renal Stone; Physical Science Research – MAMS, SAMS, PCG-STES, BCSS-FDI, CFE, PFMI; Foam Study, FMVM, BCAT-3, DAFT; Space Product Development – GAP Yeast; Fundamental Space-ADSEP CEMSS, ADSEP SPEGIS Russian: Commercial – 3 Experiments, Geophysical – 3 Experiments, Biomedical – 16 Experiments, Study of Earth Natural Resources and Ecological Monitoring – 1 Experiment, Biotechnology – 7 Experiments, Technical Studies – 11 Experiments, Study of Cosmic Rays – 1 Experiment, Space Energy Systems – 1 Experiment
Stage 14P (14P dock – 15P dock) Assembly/System Objectives	• Dock 14 Progress-M and perform cargo transfer • Load and undock 14 Progress-M • Perform MSS OCRs
Stage 14P (14P dock - 15P dock) Utilization Objectives	NASA: Code M - Crew Earth Observations, EarthKAM, MISSE, SPHERES, ESTER, EPO; Human Life Science - Interactions, Journals, Advanced U.S., Epstein-Barr, FOOT; Renal Stone; Physical Science Research - MAMS, SAMS, PCG-STES, BCSS-FDI, CFE, PFMI; Foam Study, FMVM, BCAT-3, DAFT Space Product Development - GAP Yeast; Fundamental Space-ADSEP CEMSS, ADSEP SPEGIS Russian: Russian EVA #9 (MPAC/SEEDs, Matryeshka, CKK, Kromka, ATV LRR Relocation, Platan-M) Commercial - 3 Experiments, Geophysical - 3 Experiments, Biomedical - 16 Experiments, Study of Earth Natural Resources and Ecological Monitoring - 1 Experiment, Biotechnology - 7 Experiments, Technical Studies - 11 Experiments, Study of Cosmic Rays - 1 Experiment, Space Energy Systems - 1 Experiment

Increment 8 Summary (concluded)

Stage 15P (15P dock - 8S dock) Assembly/System Objectives	• Dock 15 Progress-M and perform cargo transfer • ISS Crew prepare to return on 7 Soyuz • ISS Crew prepare for Flight ULF1[1] • ISS crew prepare for 8 Soyuz docking • Perform MSS OCRs
Stage 15P (15P dock - 8S dock) Utilization Objectives	NASA: Code M - Crew Earth Observations, EarthKAM, MISSE, SPHERES, ESTER, EPO; Human Life Science - Interactions, Journals, Advanced U.S., Epstein-Barr, FOOT; Renal Stone; Physical Science Research - MAMS, SAMS, PCG-STES, BCSS-FDI, CFE, PFMI; Foam Study, FMVM, BCAT-3, DAFT; Space Product Development - GAP Yeast; Fundamental Space-ADSEP CEMSS, ADSEP SPEGIS
Stage 15P (15P dock - 8S dock) Utilization Objectives (continued)	Russian: Commercial - 3 Experiments, Geophysical - 3 Experiments, Biomedical - 16 Experiments, Study of Earth Natural Resources and Ecological Monitoring - 1 Experiment, Biotechnology - 7 Experiments, Technical Studies - 11 Experiments, Study of Cosmic Rays - 1 Experiment, Space Energy Systems - 1 Experiment

NOTE:

[1] This task will be executed, if Shuttle flight ULF1 is scheduled prior to 8 Soyuz launch. If ULF1 is scheduled prior to the launch of 15 Progress-M, these tasks will be moved to the appropriate stage **<TBR 3-1>**.

ESA Mission

Spanish Soyuz Mission
"Cervantes"

Spanish European Space Agency (ESA) astronaut Pedro Duque will fly on the Spanish Soyuz mission "Cervantes" to the International Space Station on Oct. 18. His 10-day flight will include eight days on the ISS.

The Spanish Ministry of Science and Technology, through the Centre for Development of Industrial Technology (CDTI), has financed a commercial contract agreement between ESA and Rosaviakosmos to fly Duque.

European Space Agency Soyuz crewmember Pedro Duque participates in the Human Research Facility Ultrasound proficiency training in the International Space Station Destiny laboratory mockup/trainer at the Johnson Space Center.

Duque will carry out a full scientific program, spending some 40 hours of his eight-day stint on the ISS on experimental activity. Most of the experiments are sponsored by the Spanish government although there are also a number of reflights of experiments from the Belgian Odissea mission to the ISS in October 2002.

Duque will also participate in a number of educational and promotional activities with the aim of bringing the European human space program and research performed in space to a wider public, and young people in particular.

From a European perspective, the “Cervantes” mission is important because it increases ESA’s astronaut experience before the launch of Columbus, Europe’s own laboratory, to the Space Station. Duque has worked previously on the development of Columbus. He reviewed its design in terms of operability and maintainability and checked on ergonomic aspects of its structure. The ongoing development of Columbus and its research facilities will benefit from the "hands-on" experience Duque will get during his stay on the ISS.

Duque’s flight is the result of longstanding cooperation between Europe and Russia. It is one outcome of a framework agreement signed between ESA and Rosaviakosmos in May 2001, paving the way for European astronauts to fly to the ISS on Russian Soyuz vehicles between 2001 and 2006.

The cooperation between ESA and Rosaviakosmos allows for European astronauts to take up positions normally occupied by Russian cosmonauts, performing technical functions during the Soyuz flights to and from the Space Station.

The cooperation is motivated by ESA’s desire to develop operational expertise for Europe’s astronauts and perform research before the intensive use of the ISS by Europe for scientific research, technology experiments and application purposes becomes possible after the launch of the Columbus laboratory.

Under the agreement so far, three ESA astronauts have participated in Soyuz missions – Claudie Haigneré (France), Roberto Vittori (Italy) and Frank de Winne (Belgium). Two other European astronauts, Umberto Guidoni (Italy) and Philippe Perrin (France), have participated in missions with the Space Shuttle to the ISS through bilateral agreements with NASA. These missions are an important bridge between the end of Spacelab and the start of Columbus through the international agreements for Space Station operations.

A sign of Europe and ESA's growing experience in ISS operations with Rosaviakosmos is reflected in that, for the first time on a Soyuz mission, a European, André Kuipers, a Dutch ESA astronaut scheduled to fly on the spring 2004 Soyuz mission, is backup to Duque.

The “Cervantes“ mission was originally planned for April 2003, but in the aftermath of the Columbia accident, ESA was asked by the partners in the Space Station program to delay to this flight opportunity and make a crew exchange possible. ESA agreed to give up its seat and to postpone the flight of Duque to October 2003.

The experimental program, which will be executed by Duque, encompasses a series of experiments in the fields of life and physical sciences, Earth observation, education and technology. Most of them will be performed in the Russian segment of the Station. Some experiments are also planned in NASA’s Destiny laboratory.

As in the previous European Soyuz mission Odissea, the Microgravity Science Glovebox, developed by ESA and located in the Destiny laboratory, will be used for European physical science experiments.

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 already docked to 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 located 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's couch/seat, which are 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 existing Soyuz spacecraft as part of crew handover activities.

The module has a periscope, which allows the crew to see 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). About 50 kilograms (110 pounds) of payload can be returned to Earth in this module -- up to 150 kilograms (331 pounds) if only two crewmembers are aboard. 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, which has 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. 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.

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 laterally around the second stage central core. The boosters are identical and cylindrical-conic in shape with the oxygen tank located 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 booster 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 differs from those of the boosters by the presence of four vernier thrusters, which are necessary for three-axis flight control of the launcher 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 compelte, the third stage engine is ignited. Separation of the two stages 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, and cutoff occurs when the calculated velocity increment is reached, 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 located 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 horizontally on a railcar. Transfer to the launch zone occurs two days before launch, during which 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 after launch 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

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

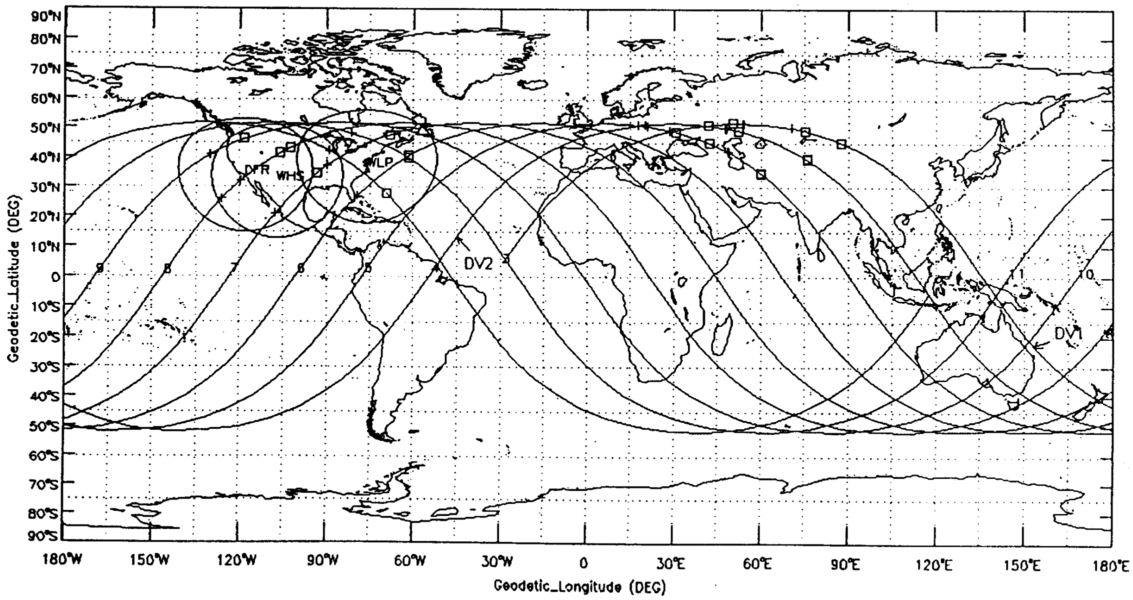
FLIGHT DAY 1 OVERVIEW	
Orbit 1	**Post insertion: Deployment of solar panels, antennas and docking probe**
	- Crew monitors all deployments
	- Crew reports on pressurization of OMS/RCS and ECLSS systems and crew health. Entry thermal sensors are manually deactivated
	- Ground provides initial orbital 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
	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.
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
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



Expedition 7/ESA Soyuz TMA-2 Landing

For the second time, an American astronaut will return to Earth from orbit in a Russian Soyuz capsule. With Russian Soyuz Commander Yuri Malenchenko at the controls, NASA ISS Science Officer Ed Lu, Malenchenko and European Space Agency Soyuz astronaut Pedro Duque of Spain will touch down in the steppes of north central Kazakhstan in the Soyuz TMA-2 craft currently docked at the International Space Station's Zarya Control Module to complete their mission. Malenchenko and Lu will be wrapping up six months in orbit, while Duque will return after a brief 10-day flight under a commercial contract between ESA and the Russian Aviation and Space Agency (Rosaviakosmos).

The grounding of the Space Shuttle fleet following the Columbia accident on Feb.1, 2003, necessitated the landing of the Expedition 7 crew in a Soyuz capsule, as did the Expedition 6 crew back in May. The Soyuz always provides an assured crew return capability for residents aboard the ISS.

On May 4, as Expedition 6 Commander Ken Bowersox, Soyuz Commander Nikolai Budarin and NASA ISS Science Officer Don Pettit re-entered the atmosphere in their Soyuz TMA-1 vehicle, the craft's Landing Control System experienced a glitch in a gyroscopic system which targets the Soyuz capsule to its intended landing site. This resulted in a "ballistic" landing, which left the Soyuz about 250 miles short of its planned landing target. All other Soyuz systems functioned normally during entry and the crew landed safely.

Although the Soyuz TMA-2 may be susceptible to a similar problem, Malenchenko has trained in procedures designed to override the gyroscopic system should it occur again. And, the departing crew has been equipped with a satellite phone and Global Positioning System locator hardware for instant communications with recovery teams in the unlikely event they land off-course.

Russian engineers say the Soyuz TMA-3 capsule that will carry Expedition 8 Commander Michael Foale, Flight Engineer and Soyuz Commander Alexander Kaleri and Duque into orbit on Oct. 18 has been outfitted with an electronic safeguard that will prevent the problem from happening again.

About three hours before undocking, Malenchenko, Lu and Duque will bid farewell to Foale and Kaleri. The departing crew will climb into the Soyuz vehicle, closing the hatch between Soyuz and Zarya.

After activating Soyuz systems and getting approval from Russian flight controllers at the Russian Mission Control Center outside Moscow, Malenchenko will send commands to open hooks and latches between Soyuz and Zarya which held the craft together since the Soyuz' arrival on April 28.

Malenchenko will fire the Soyuz thrusters to back away from Zarya, and six minutes after undocking with the Soyuz about 20 meters away from the ISS, he will conduct a separation maneuver, firing the Soyuz jets for about 15 seconds to begin to depart the vicinity of the ISS.

A little less than 2½ hours later, at a distance of about 19 kilometers from the ISS, Soyuz computers will initiate a deorbit burn braking maneuver of about 4½ minutes in duration to slow the spacecraft and enable it to drop out of orbit to begin its re-entry to Earth.

Less than a half hour 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 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 in almost six months at the point called Entry Interface, when the module is about 400,000 feet above the Earth, about 3 minutes after module separation.

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.

At this point, 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. Initially, the Descent Module will hang underneath the main parachute at a 30 degree angle with respect to the horizon for aerodynamic stability, but the bottommost harness will be severed a few minutes before landing, allowing the Descent Module to hang vertically through touchdown. The deployment of the main parachute slows down the Descent Module to a velocity of about 7 meters per second.

Within minutes, 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.

With the jettisoning of the capsule's heat shield, the Soyuz altimeter is exposed to the surface of the Earth. Using a reflector system, 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 Malenchenko 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, enabling the Soyuz to land to complete its mission, settling down at a velocity of about 1.5 meters per second.

A recovery team, including two U.S. flight surgeons and astronaut support personnel, 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 begin the removal of the crew.

Within minutes of landing, 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, one-by-one. 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.

Within two hours after landing, the crew will be assisted to the helicopters for a flight back to Astana, the capital of Kazakhstan, where local officials will welcome them. The crew will then board a Russian military transport plane to be flown back to the Gagarin Cosmonaut Training Center in Star City, Russia, where their families will meet them. In all, it will take at least eight hours between landing and return to Star City.

Assisted by a team of flight surgeons, the crew will undergo around two weeks of medical tests and physical rehabilitation before Malenchenko and Lu return to the U.S. for additional debriefings and follow-up exams. Duque's acclimation to Earth's gravity will take a much shorter period of time due to the brevity of his flight.

Key Times for Expedition 8/ISS Soyuz 7 Events

Expedition 8 / ESA Soyuz Crewmember Launch on ISS Soyuz 7:

Oct. 18 at 537 GMT, 12:37 a.m. CT, 9:37 a.m. Moscow time, 11:37 a.m. Baikonur time.

Expedition 8 / ESA Soyuz Crewmember Docking to ISS:

Oct. 20 at 711 GMT, 2:11 a.m. CT, 11:11 a.m. Moscow time.

Expedition 8 / ESA Soyuz Crewmember Hatch Opening to ISS:

Oct. 20 at 3:45 p.m. CT, 845 GMT, 12:45 p.m. Moscow time.

Expedition 7 / ESA Soyuz Crewmember Hatch Closing:

Oct. 27 at 2:10 p.m. CT, 2010 GMT on Oct. 27, 11:10 p.m. Moscow time on Oct. 27, 2:10 a.m. Astana Time on Oct. 28.

Expedition 7 / ESA Soyuz Crewmember Undocking from ISS:

Oct. 27 at 5:20 p.m. CT, 2320 GMT on Oct. 27, 2:20 a.m. Moscow time on Oct. 28,

5:20 a.m. Astana time on Oct. 28.

Expedition 7 / ESA Soyuz Crewmember Deorbit Burn:

Oct. 27 at 7:40 p.m. CT, approximately 140 GMT on Oct. 28, 4:40 a.m. Moscow time on Oct. 28, 7:40 a.m. Astana time on Oct. 28.

Expedition 7 / ESA Soyuz Crewmember Landing:

Oct. 27 at 8:36 p.m. CT, 236 GMT on Oct. 28, 5:36 a.m. Moscow time on Oct. 28,

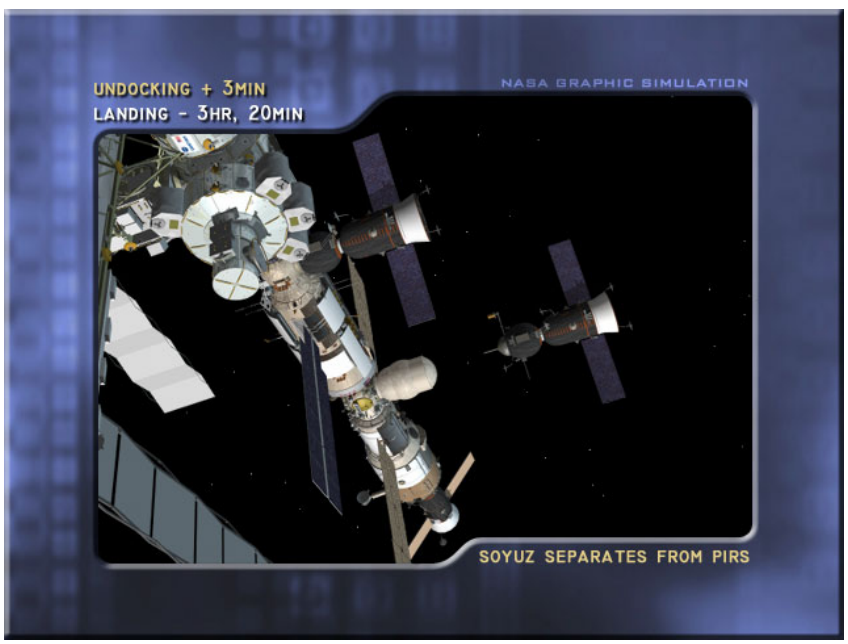
8:36 a.m. Astana time on Oct. 28.

Entry Timeline for Soyuz

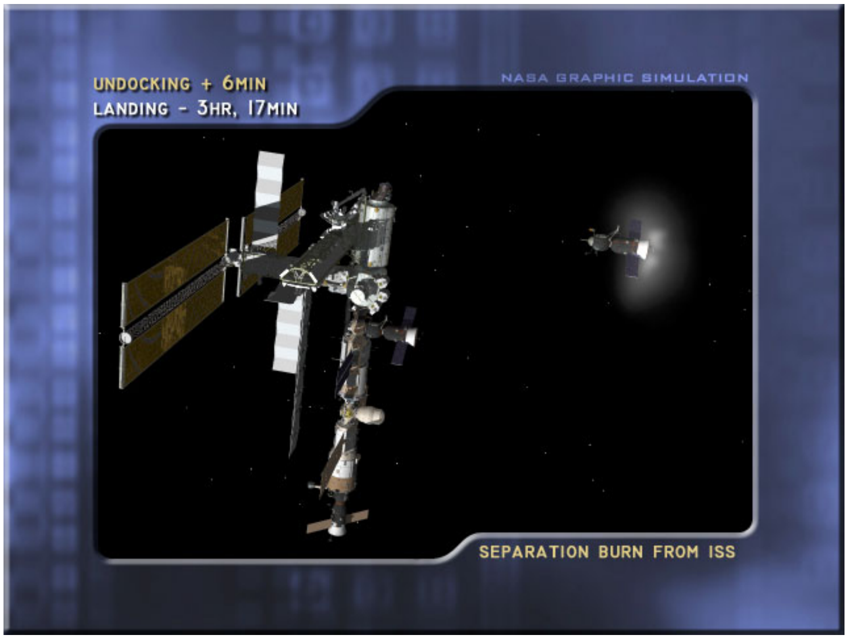
<u>Times are approximate. All times are keyed to elapsed time from undocking.</u>

Separation Command to Begin to Open Hooks and Latches:
Undocking + 0 minutes
Landing –3 hours
23 minutes

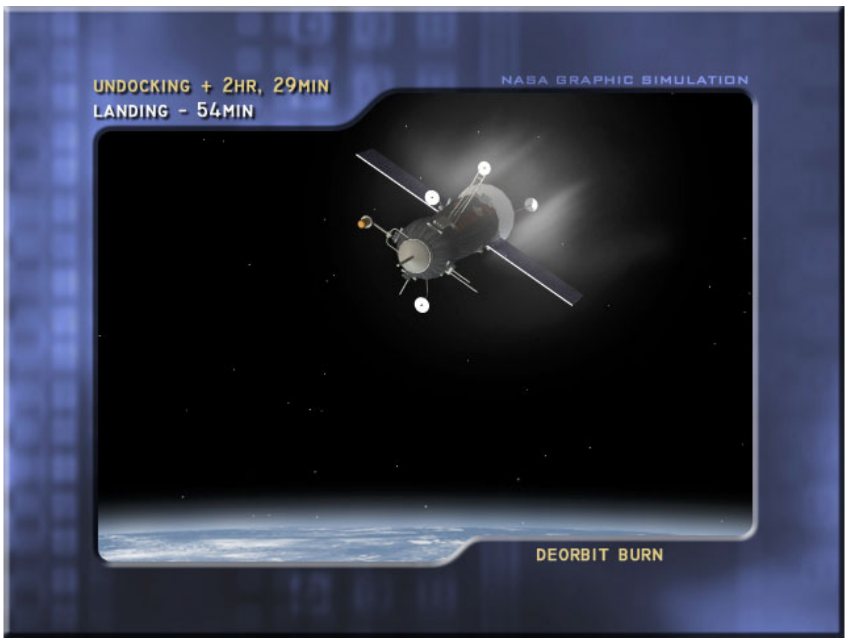
Hooks Opened / Physical Separation of Soyuz from Pirs at .1 meter/sec:
Undocking + 3 minutes
Landing – 3 hours
20 minutes



Separation Burn from ISS (15 second burn of the Soyuz engines, .57 meters/sec; Soyuz distance from the ISS is ~20 meters):
Undocking + 6 minutes
Landing – 3 hours
17 minutes



Deorbit Burn (4:21 in duration; Soyuz distance from the ISS is ~19 kilometers):
Undocking + 2 hours, 29 minutes
Landing – 54 minutes

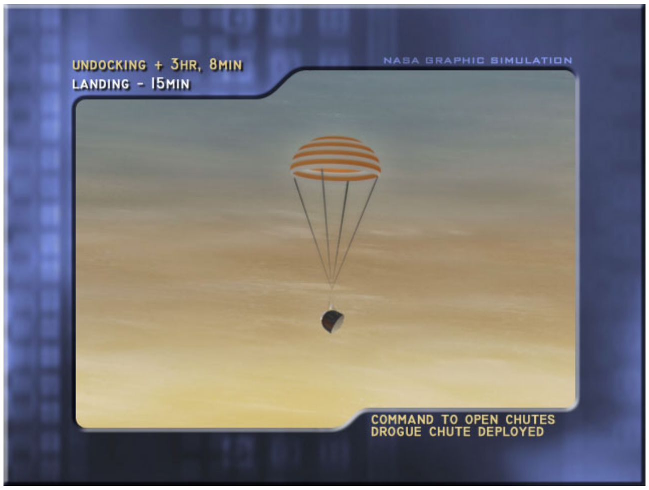


Separation of Modules (28 minutes after Deorbit Burn):
Undocking + 2 hours, 57 minutes
Landing – 26 minutes

Entry Interface (400,000 feet in altitude; 3 minutes after Module Separation; 31 minutes after Deorbit Burn):
Undocking + 3 hours
Landing – 23 minutes

Command to Open Chutes (8 minutes after Entry Interface; 39 minutes after Deorbit Burn):

Undocking + 3 hours, 8 minutes
Landing – 15 minutes

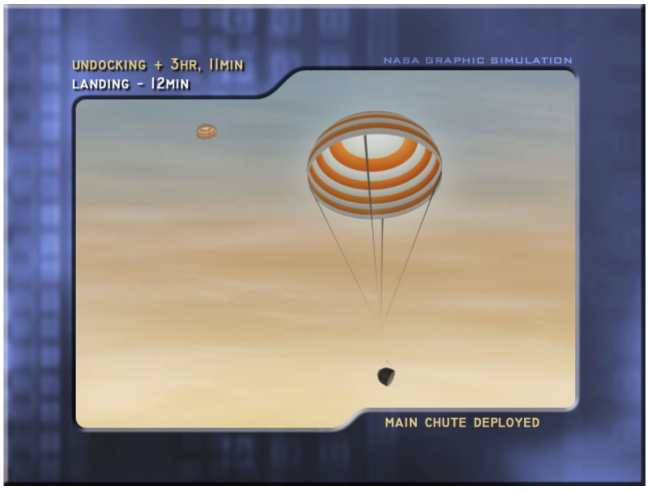


Two pilot parachutes are first deployed, the second of which extracts the drogue chute.

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…

Undocking + 3 hours, 11 minutes
Landing – 12 minutes



Soft Landing Engine Firing (6 engines fire to slow the Soyuz descent rate to 1.5 meters/second just .8 meter above the ground)

Landing – 2 seconds

Landing (54 minutes after Deorbit Burn):
Undocking + 3 hours, 23 minutes.

Science Overview

Expedition 8, the eighth science research mission on the International Space Station, is scheduled to begin in October 2003, when the Station's eighth crew arrives at the Station aboard a Russian Soyuz spacecraft. It is designated ISS Soyuz 7 for the seventh Soyuz to visit the Space Station. A crew of two will replace Expedition 7 crewmembers, Ed Lu and Yuri Malenchenko, who are scheduled to return home in October on another Soyuz spacecraft (ISS Soyuz 6), currently docked at the Station. During Expedition 8, three Russian Progress cargo flights, called ISS Progress 13, ISS Progress 14 and ISS Progress 15 for the 13th, 14th and 15th Progress vehicles, are scheduled to dock with the Station. The Progress re-supply ships will transport supplies to the Station and also may carry scientific equipment.

Most of the research complement for Expedition 8 will be carried out with scientific research facilities and samples already on board the Space Station. Additional experiments are being evaluated and prepared to take advantage of the limited cargo space on the Soyuz or Progress vehicles. The research agenda for the expedition remains flexible. A few perishable samples, such as urine samples and crystals, may be returned to Earth on the Soyuz, but most equipment and samples can remain on board the Station with minimal or no detrimental effects.

Astronaut C. Michael Foale (center), Expedition 8 mission commander and NASA ISS science officer, and cosmonaut Alexander Y. Kaleri (right), flight engineer, listen to instructor for Advanced Diagnostic Ultrasound in Microgravity (ADUM) Ashot Sargsyan, MD, during a mission training session in the Space Vehicle Mockup Facility at Johnson Space Center.

Expedition 8 crewmembers are Commander Michael Foale, who will also serve as Space Station Science Officer, and Alexander Kaleri, who will serve as Commander of the Soyuz and Space Station Flight Engineer. They will continue maintaining the Space Station and work with science teams on the ground to operate experiments and collect data.

European Space Agency astronaut Pedro Duque will fly with the Expedition 8 crew to the Station to conduct research for a 10-day period, and then return to Earth with the Expedition 7 crew.

The Expedition 8 crew is scheduled to devote more than 300 hours to research, while continuing to maintain the orbiting research complex. Station science also will be conducted by the ever-present additional "crewmembers" – the team of controllers and scientists on the ground who will continue to plan, monitor and operate experiments from control centers around the United States.

A new cadre of controllers for Expedition 8 will replace their Expedition 7 colleagues in the International Space Station's Payload Operations Center at NASA's Marshall Space Flight Center in Huntsville, Ala. Controllers work in three shifts around the clock, seven days a week in NASA’s Payload Operations Center -- the world's primary science command post for the Space Station. Its mission is to link earthbound researchers around the world with their experiments and the crew aboard the Space Station.

Experiments Using On-board Resources

Many experiments from earlier Expeditions remain aboard the Space Station and will continue to benefit from the long-term research platform provided by the orbiting laboratory. These experiments include:

Crew Earth Observations (CEO) take advantage of the crew in space to observe and photograph natural and man-made changes on Earth.

Earth Knowledge Acquired by Middle School Students (EarthKAM), an education experiment, allows students to program a digital camera aboard the Station to take pictures of a variety of geographical targets for study in the classroom.

Exploration Research (ESTER), an Earth observation experiment, records images revealing surface changes on Earth, with particular emphasis on short-lived events, such as hurricanes, plankton blooms and volcanic eruptions. This experiment uses on-board hand-held cameras and the Station’s high-quality optical window. Digital images are sent to scientists on the ground.

Crew Interactions will identify and characterize interpersonal and cultural factors that may affect crew and ground support personnel performance during Space Station missions. This experiment has been conducted on several other Space Station expeditions and was performed during five joint NASA/Russian Mir Space Station missions. Crewmembers answer a questionnaire and send data back to Earth using the Station's Human Research Facility.

Pore Formation and Mobility Investigation (PFMI), an experiment performed in the Microgravity Science Glovebox, will melt samples of transparent modeling material to study how bubbles can be trapped in metal or crystal samples during space processing. Eliminating these bubbles could contribute to the development of stronger materials. Several samples were processed inside the glovebox during Expedition 5 and Expedition 7. These samples can be processed several times, allowing investigators to study different phenomena.

Materials International Space Station Experiment (MISSE) is a suitcase-sized experiment attached to the outside of the Space Station. It exposes hundreds of potential space construction materials to the environment. The samples will be returned to Earth for study during a later expedition. Investigators will use the resulting data to design stronger, more durable spacecraft.

Protein Crystal Growth Single-locker Thermal Enclosure System (PCG-STES) will continue to process crystals that began growing during Expedition 6. This experiment was also flown on Expeditions 2, 4 and 5. The facility provides a temperature-controlled environment for growing high-quality protein crystals of selected proteins in microgravity for later analyses on the ground to determine the proteins' molecular structure. Research may contribute to advances in medicine, agriculture and other fields.

Space Acceleration Measurement System (SAMS) and **Microgravity Acceleration Measurement System (MAMS)** sensors measure vibrations caused by crew, equipment and other sources that could disturb microgravity experiments.

Pre- and Post-flight Human Physiology

Many continuing experiments will use pre- and post-flight measurements of Expedition 8 crewmembers to study changes in the body caused by exposure to the microgravity environment.

Promoting Sensorimotor Response to Generalizability: A Countermeasure to Mitigate Locomotor Dysfunction After Long-duration Spaceflight (Mobility) studies changes in posture and gait after long-duration spaceflight.

Space Flight-Induced Reactivation of Latent Epstein-Barr Virus (Epstein-Barr) performs tests to study changes in human immune function.

Foot/Ground Reaction Forces During Space Flight (FOOT), an experiment to characterize the load on the lower body and muscle activity in crewmembers while working on the Station.

Subregional Bone uses tests to study changes in bone density caused by long-duration spaceflight.

Biopsy allows researchers to take biopsies of their calf muscles before and after their stay on board the International Space Station. This will allow scientists to begin developing an in-space countermeasure exercise program aimed at keeping muscles at their peak performance during long missions in space.

Experiments Requiring Transport by Soyuz or Progress Vehicles

Expedition 8 may include these experiments:

Cell Biotechnology Operations Support Systems (CBOSS) is used to grow three-dimensional tissue that retains the form and function of natural living tissue, a capability that could hold insights in studying human diseases, including various types of cancer, diabetes, heart disease and AIDS. These types of cellular experiments were conducted during Expeditions 3 and 4. A critical step in performing these cell experiments involves mixing fluids. To improve future experiments, a fluid-mixing test will be conducted using the CBOSS fluid samples transported to the Station.

Education Payload Operations (EPO) includes three educational activities that will focus on demonstrating science, mathematics, technology, engineering or geography principles. Items such as tomato seeds and a blues harp will be used in demonstrations.

Experiments Requiring Upmass

Group Activation Packs – YEAST will evaluate the role of individual genes in the response of yeast to spaceflight conditions. The results of this research could help clarify how mammalian cells grow under microgravity conditions and determine if genes are altered

Viscous Liquid Foam-Bulk Metallic Glass (Foam–BMG) will study the structure of viscous or thick liquid foam produced by processing bulk metallic glasses – a new family of glasses discovered by NASA-funded researchers in the 1990s. Investigators will compare samples produced on the Space Station to samples on the ground and will determine if microgravity made it easier to control the processing of the materials.

Fluid Merging Viscosity Measurement (FMVM) will study the viscosity or thickness of fluids – a property of fluids that causes them to resist flowing because of the internal friction created as the molecules move against each other. Understanding the viscosity of molten materials is important for everything from designing laboratory experiments to industrial production of materials.

Binary Colloidal Alloy Test – 3 (BCAT – 3) will study the long-term behavior of colloids in a microgravity environment, where the effects of sedimentation and convection are removed. Crewmembers will even out the samples, photograph the growth and formations of the colloids, and downlink the images for analysis.

Synchronized Position Hold, Engage, Reorient, Experimental Satellites (SPHERES) will allow scientists to study maturing technologies in the flights of self-directed or autonomous satellites, as well as their rendezvous.

Renal Stone collects urine samples from the crew and tests a possible countermeasure for preventing kidney stone formation. This experiment can continue only if resupply hardware can be launched.

The Capillary Flow Experiment (CFE) will provide fundamental insight that can be applied by designers of low-gravity fluids systems. Experiments will produce conclusive data about how fluids move by capillary flow in long, complex geometries.

Destiny Laboratory Facilities

Several research facilities are in place aboard the Station to support Expedition 8 science investigations.

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

The **Microgravity Science Glovebox** is the other major dedicated science facility inside Destiny. It has a large front window and built-in gloves to provide a sealed environment for conducting science and technology experiments. The Glovebox is particularly suited for handling hazardous materials when a crew is present. The facility's hardware is working and is available for Expedition 8 operations.

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 a variety of utilities such as power, data, cooling, fluids and gasses. The racks support payloads in a several 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 8 experiments and payload operations, click on

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

European Space Agency Spanish Experiments for Pedro Duque

Experimental Program in Life Science

Discipline	Name	Description	Principal Investigator
Biology	AGEING	Study of the increased activity of fruit flies in weightlessness	R. Marco (E)
	GENE	Effects of space environment on gene expression of embryos of fruit flies	
	ROOT	Effects of space environment on the nuclear structure and function of Arabidopses Thalina root cells	F. J. Medina (E)
Microbiology	MESSAGE	Effects of weightlessness on bacterial gene expression with special attention to genes involved in the response to stress, in motility (flagella) and in genetic rearrangements	M. Mergeay (B)
	WINOGRAD	Study of growth of winogradski columns in weightlessness	R. Dhir, D. Smillie, T. Banergee (GB)
Human Physiology	NEUROCOG	Analysis of human spatial perception and the effect of gravity on it and the spatial memory	G. Cheron (B)
	CARDIOCOG	Study of the effects of weightlessness on the cardiovascular system, the respiratory system and the physiological reactions	A. Aubert (B) M. Paiva (B)
	SYMPATHO	Study of adrenal activity in the sympathetic nervous system in humans	N. Christensen (DK)
	BMI	Study of cardiovascular assessment in weightlessness	C. Gharib (F)
	RHYTHM	Evaluation of the change in cardiovascular control and adaptation mechanisms in humans	A. Aubert (B)
	Carbon Dioxide Survey	Investigation of Carbon Dioxide concentration onboard ISS	F. de Jong (ESA)

Experimental Program in Physical Science and Earth Observation

Discipline	Name	Description	Principal Investigator
Physical Science	NANOSLAB	Analysis of the formation of a zeolite structure from two separate materials, e.g. ammonium hydroxide and aluminum silicate	J. Martens (B)
	PROMISS	Monitoring of protein crystal growth	I. Zegers (B)
Earth Observation	LSO	Study of optical radiation in the ionosphere of the Earth related to thunder activity and seismic processes	E. Blanc (F)

Experimental Program in Education

Discipline	Name	Description	Principal Investigator
Educational	ARISS	Use of the ISS radio amateur station to communicate with students on the ground	G. Bertels (B) E. Grifoni (ESA)
	APIS	Investigation of the effect of weightlessness on the behavior of a rotation rigid body around its center	Instituto Universitario Ignacio da Riva, Universidad Politécnica de Madrid (E)
	CHONDRO	Student experiment investigating the effect of weightlessness on chondrocyte cells	Technical University of Zurich (CH)
	THEBAS	Student experiment investigating the effect of weightlessness on basic principles of mechanics	Instituto Universitario Ignacio da Riva, Universidad Politécnica de Madrid (E)
	VIDEO-2	Video shooting of simple physical phenomena	M. Paiva (B)

Experimental Program in Technology

Discipline	Name	Description	Coordinator
Technology	Crew restraint	Testing of new crew restraint technologies	P. Mitschdoerfer (ESA)
	3D Camera	Use of the 3D camera in Soyuz and ISS	D. Isakeit (ESA)

Experimental Program in on the Ground

Discipline	Name	Description	Principal Investigator
Ground investigations	CHROMOSOMES	Chromosomal aberrations in blood lymphocytes of astronauts	G. Obe (G)
	AORTA	Physiological parameters that predict orthostatic intolerance after spaceflight	J. M. Karamaker (NL)

Short Description of Experiments

Experimental Program in Life Science

AGEING

The AGEING experiment aims to study the increased activity of fruit flies in weightlessness. This follows on from previous research, which linked accelerated ageing of the species to increased activity under weightless conditions. This is a phenomenon found to be more noticeable in the younger male fruit flies.

Three different strains of fruit fly will be studied: a long-living strain, a short-living strain and a strain that shows an increased response to gravity on Earth. All flies will be recently hatched except for one two-week-old population of one strain to confirm the increased activity exhibited by the younger species members.

Ground-controlled experiments on Earth, with a similar population of flies, will complement the experiment executed in space.

GENE

The GENE experiment studies the effect that the space environment has on the gene expression of fruit fly embryos. Gene expression is the processing of DNA information to yield biological active molecules, such as proteins.

Fruit flies are chosen for the experiment, as we understand more about the genetics of the fruit fly than any other higher organism. Also, they are small, require little storage space or maintenance, and can be grown in numbers large enough to support meaningful statistical analysis.

Because the entire DNA sequence of the fruit fly is now known and it is also easy to perform genetic interventions in this species, an almost limitless ability to control the biology of a multicellular organism is available.

The post-flight analysis of the data collected will be looking for increases, decreases and non-changes of gene expression levels when compared to similar ground experiments. If the results obtained in space are significantly different to those collected during earth-based experimentation, a method will be used to map the molecular structure of the proteins.

ROOT

The ROOT experiment aims to study the effects of the space environment on the structure and function of root cells of plants. The particular type of plant used for this experimentation is a member of the mustard family. This is a model organism in plant biology, the first plant with a completely sequenced genome or genetic map. The specific cells studied are those responsible for new cell production.

On return to Earth the roots will be processed for microscopic observation, determining changes in structure and physiology by comparison against similar samples obtained from ground-based experiments, which take place at the same time as the experiments in space.

MESSAGE

The scientific research program MESSAGE stands for Microbial Experiments in the Space Station About Gene Expression. The main objective of this program is to study the effects of space conditions such as weightlessness and cosmic radiation on metabolic processes in bacteria.

The MESSAGE experiments will analyze many different aspects of bacterial activity using many different microbial and molecular methods. The effects of space conditions on bacteria will be studied on four domains, i.e., the bacterial cell physiology, the bacterial motility, the genetic stability and rearrangements in bacteria, and the gene expression with special attention to genes involved in the response to stress. This will lead to a unique view on the physiological and metabolic response of a whole organism to such a specific growth condition as space.

The results will be used to improve projects covering microorganism detection devices and microbial life support systems.

The MESSAGE experiment is an improved re-flight of an ESA experiment performed by the Belgian astronaut Franck De Winne on board of the International Space Station (ISS) during the Odissea mission in November 2002. The MESSAGE experiment proposed here is essential for reproducibility and statistic analysis of the scientific results obtained in the original experiment.

Winograd

The Winograd experiment will be used to grow Winogradski columns in a weightless environment.

A Winogradski column is a colony of different types of bacteria wherein the waste products of one bacterium serve as the nutrients of the other. They are systems that are found in ordinary pond or lake water and need no other input than light for photosynthesis.

This experiment was launched to the ISS on the Progress mission 12P in August 2003 and thereafter started. It will be returned to Earth on Pedro Duque's return flight. On return these samples will be analyzed to determine where certain bacteria were located during flight and hence determine the effect of weightlessness on the formation of Winogradski columns.

The experiment should clarify if the bacteria in the water will organize themselves in a similar pattern as they would do on Earth.

NEUROCOG

The NEUROCOG experiment aims at expanding our knowledge in the field of neuroscience in weightlessness. The experiment is divided into two parts.

The first part of this experiment investigates human spatial perception and the role that the sensory information of sight, balance, motion and position play in this.

The second part measures the precision of the perceptual processes of the brain and tests the effect of gravity on spatial perception and spatial memory.

The post-flight analysis will include a comparison of results obtained with similar ground experiments.

CARDIOCOG

The CARDIOCOG experiment is studying the consequences of weightlessness on the cardiovascular system, the respiratory system, as well as stress and cognitive and physiological reactions of an astronaut during a space mission. During short duration flights the body adapts itself to the consequences of weightlessness. An example: on Earth the blood has to be pumped 'uphill' against gravity. But in weightlessness there is no “up“ or “down“. When an astronaut returns to Earth his brain is left short of blood until his body has adapted itself completely to gravity.

With a better understanding of how these adaptations work, researchers could provide astronauts with countermeasures that help to smooth the transition from weightlessness to gravity.

SYMPATHO

This experiment will study the adrenal activity of the sympathetic nervous system in weightlessness. The sympathetic system is that part of the nervous system that accelerates the heart rate, constricts blood vessels, and raises blood pressure.

The experiment will test the hypothesis that after initially low adrenal activity in the first 24 hours in space, the adrenal activity increases due to a fall in the volume of blood in the cardiovascular system.

Blood samples of the crew will be taken before flight and analyzed. Shortly after arriving in space and just before the end of the mission further samples will be taken and stored in a freezer for return to Earth, at which point more samples will be taken and post-flight analyses will begin.

This experiment is related to the BMI and RHYTHM experiments.

Blood Pressure Measurement Instrument (BMI)

The BMI experiment aims to investigate the modifications in blood pressure rhythms under weightless conditions over a period of 24 hours, using a computer-controlled blood pressure recorder specially developed for round-the-clock monitoring. Astronauts will be used as test subjects.

In order to gain tangible results from the experiment, blood pressure readings are taken pre-flight (40 days and 30 days before launch), in-flight (beginning and end of flight) and post-flight (four days and 10 days after return).

During post-flight analysis, the results will also be compared to the data obtained during the Italian Marco Polo mission, which took place in 2002 and where the test subject was the ESA astronaut Roberto Vittori.

Rhythm

The aim of the experiment is to evaluate the change in cardiovascular control and adaptation mechanisms in space through analysis of variations in heart rate, blood pressure and respiration.

The hypothesis underlying this study is that cardiovascular control and adaptation mechanisms undergo significant but reversible changes due to long-term spaceflights. These changes will also influence post-flight cardiovascular function.

These hypotheses will be confirmed or rejected by comparing Electrocardiogram, blood pressure variability and respiration data pre-, in flight and post-flight.

Carbon Dioxide Survey

Constant monitoring of environmental factors such as CO_2 is of critical importance in the enclosed setting of the ISS. The purpose of this operational activity is to monitor the level of CO_2 in the ISS sleeping quarters during times of potential CO_2 accumulation, i.e. sleep.

This comes from the fact that ISS crewmembers have experienced headaches after sleep. This could be due to a build up of CO_2.

Experimental Program in Physical Science and Earth Observation

NANOSLAB

The aim of this experiment is to analyze the process of formation of a zeolite structure from two separate materials. The materials used in this experiment are an ammonium hydroxide and an aluminum silicate.

Zeolites are microporous crystalline solids with well-defined structures or pores in them. Many occur naturally as minerals, and are extensively mined in many parts of the world. Others are synthetic, and are made commercially for specific uses, or produced by research scientists trying to understand more about their chemistry.

PROMISS

PROMISS aims to investigate the growth processes of proteins in weightless conditions. The experiment will use special techniques, which produce efficient protein growth in weightlessness.

The major objective of the present experiment is to see how the growth conditions influence the quality of the crystals by analyzing them using advanced imaging methods (digital holography).

Lightning and Spright Observation (LSO)

Sprites are a meteorological phenomenon discovered in 1989, which have the appearance of a luminous glow above lightning storms between 50-90 km above the Earth's surface. Sprites have a duration of only a few milliseconds and are caused as a result of powerful lightning strikes, which affect the electrical field in the ionosphere (part of the upper atmosphere).

The aim of this experiment is to observe sprites during storms, determine the energy emitted by them (and elves, which are similar phenomenon to sprites), and compare this to nightly emissions of lightning. It is also planned to compile statistical data to determine the frequency of sprites and their origin.

Experimental Program in Education

ARISS

The objectives of this operation are to provide a live radio link from the ISS to selected Spanish primary schools where students will ask ESA astronaut Pedro Duque questions and to develop and maintain the amateur radio activity on the ISS using the onboard ARISS radio equipment.

APIS

This experiment focuses on the behavior of a rigid body rotating around its center of mass. The rigid body used in the experiment will simulate a rotating spacecraft.

The objective is to prepare a video for educational purposes to demonstrate the dynamics of solid body rotation. This aims to show the different types of motion, which may occur depending on the distribution of mass of the body. Such factors can have the effect of changing the axis of rotation of a spacecraft.

Chondro

The objective of the Chondro space experiment is to find more stable bone cartilage structures by dissolving cartilage tissue from pig bones into its basic components and then regrowing these components into new cartilage. Another purpose of this experiment is to test the student-developed experiment hardware.

THEBAS

The experiment aims to illustrate with relatively simple hardware the principles of dynamics, ranging from the classical rational mechanics of solid bodies to the continuous media mechanics. Also, experimental video material will be prepared for educational purposes.

The behavior of transparent closed containers (having the same size and total mass) filled with solid bodies (spheres) of different radii will be analyzed. The mass of the content of each container is the same in all the considered cases.

Video-2

The objective of the experiment is to demonstrate basic physical phenomena, e.g., Newton's Three Laws of Motion, by filming some basic physics experiments in weightlessness.

The videos will be used for educational purposes, fitting the basic physics curriculum of the target age group of 12- to 18-year-olds.

Experimental Program in Technology

Crew Restraint

The experiment is aimed at testing new crew restraint equipment, which uses an astronaut's knees to hold them in position during operational activities. Almost all current restraint devices use the feet to restrain the body and it is generally perceived that this unnaturally overloads the smaller muscle groups of the feet. Restraining the crewmember at the knee level lowers the forces needed since the knees are closer to the center of gravity of the astronaut and larger muscle groups are relied upon to a greater extent.

3D Camera

The purpose of this activity is to test and evaluate a 3D still photo camera under weightless conditions in the ISS operational environment. This will provide illustrative aids for future technical mission aspects and astronaut training.

3D pictures will further help improve ISS simulators such as the virtual reality simulator at ESTEC in Noordwijk, The Netherlands, and help to better satisfy the public interest in the International Space Station.

Activities with the 3D camera will lead ESA further with future ISS development of 3D video images and also help to forge cooperation with ISS partners undertaking 3D research.

Experimental Program on the Ground

Chromosomes

The aim is to study chromosome damage in space caused by ionizing radiation, which comes from the Sun or cosmic rays. Ionizing radiation is strong enough to change the atomic structure of cells. This experiment will be looking at the effect of ionizing radiation at a genetic level.

This experiment will use astronauts as test subjects but will not actually fly to the ISS. Scientifically the research consists in analyzing and comparing blood samples drawn from the astronauts pre-flight and post-flight. This experiment is linked to the GENE experiment.

AORTA

This ground experiment is a repeat of the experiment performed on the Odissea mission of ESA astronaut Frank De Winne in 2002. The experiment ties in with the RHYTHM experiment, as the objective is to predict orthostatic intolerance (the inability to stand upright) of astronauts who have spent a long period in a weightless environment.

The predictions will be based on the measurements of physical parameters such as blood pressure, elctrocardiograms, and brain blood flow (by ultrasound). The astronauts are tested pre-flight and post-flight in a ground-based lab using a computerized tilting table.

These parameters will act as predictors for the outcome of the test, where astronauts are asked to stand relaxed, leaning against a wall for a maximum of 10 minutes. Orthostatic intolerance is defined as the inability to stand for 10 minutes.

The Payload Operations Center

The Payload Operations Center (POC) at NASA's Marshall Space Flight Center in Huntsville, Ala., is the world's primary science command post for the International Space Station.

The Payload Operations team is responsible for managing all science research experiments aboard the station. The center also is home for coordination of the mission-planning work of a variety of international sources, all 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 round-the-clock reports from science outposts around the planet to systems controllers and science experts staffing numerous consoles beneath the glow of wall-sized video screens. Other computers stream information to and from the space station itself, linking the orbiting research facility with the science command post on Earth.

The International Space Station will accommodate dozens of experiments in fields as diverse as medicine, human life sciences, biotechnology, agriculture, manufacturing, Earth observation, and more.

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 worldwide -- makes the job of coordinating space station research a critical one.

The POC 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 carried to orbit in the early '80s by the space shuttle for more than a dozen missions -- was the prototype for Marshall's space station science operations.

The POC is the focal point for incorporating research and experiment requirements from all international partners into an integrated space station payload mission plan.

Four international partner control centers -- in the United States, Japan, Russia and one representing the 11 participating countries of Europe -- prepare independent science plans for the POC. Each partner's plan is based on submissions from its participating universities, science institutes and commercial companies.

The U.S. partner control center incorporates submissions from Italy, Brazil and Canada until those nations develop partner centers of their own. The U.S. center's plan also includes payloads commissioned by NASA from the four Telescience Support Centers in the United States. Each support center is responsible for integrating specific disciplines of study with commercial payload operations. They are:

- Marshall Space Flight Center**,** managing microgravity (materials sciences, biotechnology research, microgravity research, space product development)
- Ames Research Center in Moffett Field, Calif., managing gravitational biology and ecology (research on plants and animals)
- John 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 all the partners into a Science Payload Operations master plan, delivered to the Space Station Control Center at Johnson Space 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 execution of science experiments and operations in orbit.

Once payload schedules are finalized, the POC oversees delivery of experiments to the space station. These will be constantly in cycle: new payloads will be delivered by the space shuttle, or aboard launch vehicles provided by international partners; completed experiments and samples will be returned to Earth via the shuttle. This dynamic environment provides the true excitement and challenge of science operations aboard the space station.

Housed in a two-story complex at Marshall, the POC is staffed around the clock by three shifts of 13 to 19 systems controllers -- essentially the same number of controllers that staffed the operations center for Spacelab more than a decade earlier.

During space station operations, however, center personnel will routinely manage three to four times the number of experiments as were conducted aboard Spacelab, and also will be responsible for station-wide payload safety, planning, execution and troubleshooting.

The POC's main flight control team, or the "cadre," is headed by the payload operations director, who approves all science plans in coordination with Mission Control at Johnson, the station crew and various outside research facilities.

The payload communications manager, the voice of the POC, coordinates and delivers messages and project data to the station. The systems configuration manager monitors station life support systems. The operations controller oversees station science operations resources such as tools and supplies. The photo and TV operations manager is responsible for station video systems and links to the POC.

The timeline maintenance manager 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, temperature control and the proper working conditions of station experiments.

Additional systems and support controllers routinely monitor payload data systems, provide research and science expertise during experiments, and evaluate and modify timelines and safety procedures as payload schedules are revised.

The international partner control centers include Mission Control Center, Moscow; the Columbus Orbital Facility Control Center, Oberpfaffenhoffen, Germany; Tsukuba Space Center, Tsukuba, Japan; and the Space Station Control Center at Johnson Space Center. NASA's primary Space Station Control Center, Johnson, is also home to the U.S. partner control center, which prepares the science plan on behalf of the United States, Brazil, Canada and Italy.

For updates to this fact sheet, visit the Marshall News Center at:

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

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

Russian Increment 8 Research and Experiments

Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
Commercial	КНТ-1	GTS	Electronics unit; Antenna assembly with attachment mechanism	Global time system test development	Unattended
Commercial	КНТ-2	MPAC&SEED	Equipment for catching microparticles and for exposing MPAC&SEED materials Special returnable cassette Transfer rack with interface	Study of meteoroid and man-made environment and of the outer space factor effects on exposed materials	EVA
Commercial	КНТ-20	GCF-NASDA	Kit GCF-02	Cristaligeishen protein	
Geophysical	ГФИ-1	Relaksatsiya	"Fialka-MB-Kosmos"; Spectrozonal ultraviolet system	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	"Rubinar" telescope *Nominal hardware:* Kodak 760 camera; Nikon D1 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
Geophysical	ГФИ-10	Molniya-SM	ВФС-3М videophotometric system Hardware LSO	Study of the electrodynamic interaction between the Earth atmosphere, ionosphere, and magnetosphere associated with thunderstorm or seismic activity using a video photometric system	
Biomedical	МБИ-1	Sprut-MBI	Sprut-K kit *Nominal Hardware:* Tsentr power supply; Central Post Computer laptop	Study of human bodily fluids during long-duration space flight	
Biomedical	МБИ-2	Diurez	Urine receptacle kit; KB-03 container; *Nominal Hardware:* Kriogem-03/1 freezer; Plazma-03 kit; Hematocrit kit;	Study of fluid-electrolyte metabolism and hormonal regulation of blood volume in microgravity	During ISS-8, ISS-9 crews rotation
Biomedical	МБИ-3	Parodont	Saliva-A Parodont kit; Parodont test tube kit;	Study of the effects of space flight on human parodontium tissue	
Biomedical	МБИ-4	Farma	Saliva-F kit	Study of specific pharmacological effects under long-duration space flight conditions	

Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
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	The activity will be performed if time is available Will need help from US crewmember
Biomedical	МБИ-7	Biotest	*Nominal Hardware:* Gamma-1M equipment; Hematocrit kit	Biochemical mechanisms of metabolic adaptation to space flight environment	During ISS-7, ISS-8 crews rotation During ISS-8, ISS-9 crews rotation
Biomedical	МБИ-8	Profilaktika	Laktat kit; TEEM-100M gas analyzer; Accusport device; *Nominal Hardware:* Reflotron-4 kit; TVIS treadmill; ВБ-3 cycle ergometer; Set of bungee cords; Computer; 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-9	Pulse	Pulse set, Pulse kit; *Nominal Hardware:* Computer	Study of the autonomic regulation of the human cardiorespiratory system in weightlessness	
Biomedical	МБИ-11	Gematologia	Erythrocyte kit *Nominal hardware:* Kriogem-03/1 freezer Plazma-03 kit Hematocrit kit	New data obtaining of the outer space factor effects on human blood system in order to extend its diagnostic and prognostic capabilities, studying the mechanism of appearance of changes in hematological values (space anemia, lymphocytosis)	During ISS-8, ISS-9 crews rotation
Biomedical	МБИ-15	Pilot	Right Control Handle Left Control Handle Synchronizer Unit (БС) ULTRABIY-2000 Unit *Nominal hardware:* Laptop №3	Researching for individual features of state psychophysiological regulation and crewmembers professional activities during long space flights.	US astronaut
Biomedical	БИО-2	Biorisk	Biorisk-KM set (4 units) Biorisk-MSV conteiners (6 units) Biorisk-MSN set	Study of space flight impact on microorganisms-substrates systems state related to space technique ecological safety and planetary quarantine problem	
Biomedical	БИО-5	Rasteniya-2	Lada greenhouse; Water container; *Nominal Hardware:* Sony DVCam; Computer	Study of the space flight effect on the growth and development of higher plants	
Biomedical	БИО-10	Mezhkletochnoe vzaimodeistvie (Intercellular interaction)	Fibroblast-1 kit Aquarius hardware (+37°C during 24 hours) Glovebox КВ-03 container	Study of microgravity influence on cells surface behavior and intercellular interaction	During ISS-7, ISS-8 crews rotation

Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
Biomedical	РБО-1	Prognoz	*Nominal Hardware for the radiation monitoring system:* P-16 dosimeter; ДБ-8 dosimeters (4 each)	Development of a method for real-time prediction of dose loads on the crews of manned spacecraft	Unattended
Biomedical	РБО-2	Bradoz	Bradoz kit	YersiniaBioradiation dosimetry in space flight	
Biomedical	РБО-3	Matryeshka-R		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 ISS	
	РБО-3-1 (1 stage)		Passive detectors unit Phantom set		
	РБО-3-3В (3 stage)		Matryeshka equipment (monoblock)		EVA
Study of Earth natural resources and ecological monitoring	ДЗЗ-2	Diatomea	Nikon F5 camera; DSR-PD1P video camera; Dictophone; Laptop No. 3; Diatomea kit;	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-2	Mimetik-K		Anti-idiotypic antibodies as adjuvant-active glycoproteid mimetic	
Biotechnology	БТХ-3	KAF	Luch-2 biocrystallizer	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		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	
Biotechnology	БТХ-11	Biodegradatsiya	Biodegradatsiya-ГО1 kit; Bioproby kit	Assessment of the initial stages of biodegradation and biodeterioration of the surfaces of structural materials	
Biotechnology	БТХ-12	Bioekologiya	Bioekologiya kit; (Kits # 1, 2, 3, and 4)	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-32	MSC (Mesenchymal stem cells)	Embrion kit with accessories Aquarius hardware (+37oC during 4 hours)	Study of behavior of mesenchymal stem cells from bone marrow under space flight conditions	During ISS-7, ISS-8 crews rotation

Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
Technical Studies	TEX-3	Akustika-M (Phase 1)	Akustika-M kit	Acoustic studies of the conditions of ISS crew voice and audio communications	
Technical Studies	TEX-5 (SDTO 16002-R)	Meteoroid	Nominal micrometeoroid monitoring system: MMK-2 electronics unit; Stationary electrostatic sensors КД1, КД2, КД3, and КД4; Removable electrostatic sensor КДС	Recording of meteoroid and man-made particles on the ISS RS Service Module exterior surface	Unattended
Technical Studies	TEX-8	Toksichnost	Biotox 10K	Development of a system for express monitoring of water toxicity in space flight	
Technical Studies	TEX-13 (SDTO 12001-R)	Tenzor	*Nominal Hardware:* ISS RS motion control and navigation system (СУДН) sensors; Star tracker; SM TV systems	Determination of ISS dynamic characteristics	Unattended
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)	Study of the relationship between the onboard systems operating modes and ISS flight conditions	Unattended
Technical Studies	TEX-16 (SDTO 12003-R)	Privyazka	*Nominal Hardware:* ISS RS СУДН SM-8M sensors and magnetometer	High-precision orientation of science instruments in space with consideration given to ISS hull deformation	Unattended
Technical Studies	TEX-17 (SDTO 16001-R)	Iskazhenie	*Nominal Hardware:* ISS RS СУДН SM-8M sensors and magnetometer	Determination and analysis of magnetic disturbance on the ISS	Unattended
Technical Studies	TEX-20	Plazmennyi Kristall	Plazmennyi kristall equipment Telescience flight equipment	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

Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
Technical Studies	TEX-25	Skorpion	Skorpion equipment	Development, testing, and verification of a multi-functional instrument to monitor the science experiment conditions inside ISS pressurized compartments	
Study of cosmic rays	ИКЛ-1В	Platan	Platan-M equipment	Search for low-energy heavy nuclei of solar and galactic origin	EVA
Space energy systems	ПКЭ-1В	Kromka	Tray with materials to be exposed	Study of the dynamics of contamination from liquid-fuel thruster jets during burns, and verification of the efficacy of devices designed to protect the ISS exterior surfaces from contamination	Unattended
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	Isokinetic 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
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.

Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
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.
Pre/Post Flight		Thermographia	Thermograph «IRTIS-200»	Human peripheral thermoregulation during re-adaptation after long duration space flight.	Pre-flight: 2 times (BDC); Post-flight: daily for the first 3 days, then each 1-2 days until the end of rehabilitation period. 30 min for one session.
Pre/Post Flight		Khemo-luminomer	Khemoluminomer «ХЛ-003»	Space flight factors impact on free-radical oxidation level, as well as changes in human organism during re-adaptation to Earth conditions.	Pre-flight: 2 times; Post-flight: blood samples are taken on 1(2), 5(7) days; 15-20 min for one session.

Experiments

Effect of Prolonged Spaceflight on Human Skeletal Muscle (Biopsy)

Missions: Expeditions 5-9, preflight and postflight

Principal Investigator: Dr. Robert H. Fitts, Marquette University, Milwaukee, Wis.

Co-investigators: Dr. Scott Trappe and Dr. David Costill, Ball State University, Muncie, Ind., and Dr. Danny Riley, Medical College of Wisconsin, Milwaukee

Project Manager: David Baumann, NASA Johnson Space Center, Houston

Overview

As engineers develop technologies that will carry humans to Mars, scientists search for ways to make sure space travelers will arrive on the Red Planet healthy and ready to explore – and return to Earth healthy, too. One of the human systems most affected by extended stays in space is the neuromuscular system. Past space missions have shown weightlessness can cause deterioration of muscle fiber, nerves and physical strength.

Research Objective

To determine the time course and extent of functional and structural change in limb skeletal muscle with prolonged spaceflight, establish the cellular mechanisms of the observed functional alterations, and calculate the new steady state that would likely be reached in calf muscle structure and function following a trip to Mars and back.

Flight History/Background

A series of human physiology experiments during the Space Shuttle STS-78 Life and Microgravity Spacelab mission in June 1996 focused on the effects of weightlessness on skeletal muscles. Astronauts provided biopsies before and after flight, and exercised in space using a Torque Velocity Dynamometer to measure changes in muscle forces in the arms and legs. This mission provided the first set of data for use in determining how long it takes for change in skeletal muscle structure and function to occur. Expeditions 5-9 build on that 17-day mission. Results are needed from the longer stays in space, which the International Space Station can provide, before longer crewed missions exploring deeper into space can take place.

Benefits

Crew safety is NASA's top priority when planning human space exploration. The results of this research will be used to calculate specific changes that will happen to muscles on a flight to Mars and back, so effective countermeasures can be developed, ensuring the arrival – and return – of a healthy crew

For more about Expedition 8 science experiments please visit the Web at:

www.scipoc.msfc.nasa.gov

www.spaceflight.nasa.gov

Experiments

Cellular Biotechnology Operations Support System-Fluid Dynamics Investigation (CBOSS-FDI)

Project Manager: John Love, Cellular Biotechnology Program, Biological Systems Office, NASA Johnson Space Center, Houston

Principal Investigators: Joshua Zimmerberg, National Institutes of Health, Bethesda, MD
J. Milburn Jessup, Georgetown University, Washington, DC

Overview

The near-weightless (microgravity) environment of orbital spaceflight affords unprecedented opportunities in biomedical research and biotechnology. Adherent mammalian cells cultured on Earth, under the persistent influence of unit gravity characteristic of terrestrial ecosystems, typically proliferate into a two-dimensional monolayer array. In contrast, previous Space Shuttle and *Mir* experiments demonstrated that adherent mammalian cells, cultured *in vitro* in space, grow into three-dimensional tissue assemblies that are similar to their natural counterparts in some of their molecular, structural, and functional characteristics.

For more than a decade the goal of the NASA Cellular Biotechnology Program at Johnson Space Center has been to develop and utilize microgravity technology to support the scientific community's research in cell biology and tissue engineering. Previous Cellular Biotechnology investigations included the longest duration continuous cell culture in space (*Mir* NASA 3) and mapping of the genetic signatures of cells in microgravity (STS-90, STS-106). In addition, the program developed the NASA rotating bioreactor, which is employed for ground-based propagation of cells in a suspended state with minimal stress.

The Cellular Biotechnology Operations Support System (CBOSS) is a stationary bioreactor system developed by the Cellular Biotechnology Program for the cultivation of cells aboard the International Space Station (ISS). The CBOSS payload complement consists of the following hardware elements. Cell cultures are incubated in the Biotechnology Specimen Temperature Controller (BSTC), which contains an isothermal chamber with carbon dioxide concentration control. The Gas Supply Module (GSM) provides pressurized gases to the incubator unit, while the Biotechnology Refrigerator (BTR) serves for cold storage of labile experiment components. The Biotechnology Cell Science Stowage (BCSS) is comprised of caddies containing experiment supplies and cryodewars for the transport of cryopreserved cells for on-orbit inoculation and the return of frozen biospecimen samples. Cellular Biotechnology Program experiments conducted in the ISS with this system during Expeditions 3, 4, and 5 involved human kidney cells, human colon cancer cells, rat adrenal gland tumor cells, ovarian cancer cells, mouse blood cancer cells, human immune system tissue, and human liver cells, representing principal investigators from various institutions and industry.

Typically CBOSS is used to provide a controlled environment for the cultivation of cells into functional three-dimensional tissues. A critical step in performing these experiments involves complete mixing of cells and fluids during various tissue culture procedures. The CBOSS - Fluid Dynamics Investigation (FDI) is comprised of a series of experiments aimed at optimizing CBOSS operations while contributing to the characterization of the CBOSS stationary bioreactor vessel (the Tissue Culture Module or TCM) in terms of fluid dynamics in microgravity. These experiments will also validate the most efficient fluid mixing techniques on orbit, which are essential to conduct cellular research in that environment. In addition, some experiments may examine microgravity biotechnology processes with applications to future cell science research in space.

Background/Flight History

The first cellular biotechnology experiments flew aboard the Space Shuttle in the mid-1990s, such as in the STS-70 and STS-85 missions. Long-duration cellular biotechnology experiments were conducted in the Biotechnology System facility on the Russian space station *Mir* from 1996 through 1998. Cellular biotechnology experiments were also performed onboard the International Space Station during Expeditions 3, 4, and 5.

In the future, the Biotechnology Facility (BTF) is expected to maximize utilization of the ISS microgravity environment by enhancing cellular biotechnology research capabilities and increasing scientific output. Because of its continuous operation, BTF research will generate a critical threshold of data that the cell science community may use to advance research in human tissue engineering and gravitational biology, which could have significant impact in science and medicine.

Benefits

Bioreactor cell culture in microgravity permits *in vitro* cultivation of cells into tissue constructs of size and quality not possible on Earth. Such a capability provides unprecedented opportunities for research in human diseases, including various types of cancer, diabetes, heart disease, and AIDS. This approach to tissue engineering and modeling has potential applications in areas such as tissue transplantation, drug testing, the pathogenesis of infectious microorganisms, and the production of biopharmacological therapeutic agents, and may yield insight into the fundamental effects of gravity on biological systems.

More information on NASA biotechnology research and other Expedition 8 experiments is available at:

http://microgravity.msfc.nasa.gov

http://scipoc.msfc.nasa.gov

Experiments

Chromosomal Aberrations in Blood Lymphocytes of Astronauts

Principal Investigator: Günter Obe, Ph.D., University of Essen, Germany

Research Objectives

Cosmic radiation is a major risk factor in human spaceflight. This study will assess the mutagenic impact of ionizing radiations in crewmembers by analyzing chromosomal aberrations in blood lymphocytes, from pre- and post-flight blood samples.

Previous investigations studying chromosomal aberrations were conducted using conventional block stained Giemsa preparations. A disadvantage of this method is that only unstable aberrations, which are of less biological significance, can be detected.

In the past few years, new methods of chromosome recognition were developed, such as fluorescence *in situ* hybridization (FISH), multi-color FISH (mFISH), and multi-color banding FISH (mBAND), which enable researchers to mark all chromosome pairs and allow detection of almost all aberration types in the genome, including stable and unstable ones. These new methods will provide new information about the effects of space radiation on humans.

Flight Operations Summary

The investigation requires 10-15 ml of venous blood to be collected preflight and postflight from each participating crewmember. Preflight, the blood draw is scheduled together with the L-10 physical; the postflight blood draw is performed within a week of landing.

Flight History/Background

Dr. Obe and his investigator team had conducted chromosomal aberration studies on 18 astronauts and cosmonauts flown on board the Space Shuttle and the Mir Space Station between 1993 and 1997.

The study will include blood samples from 20 astronauts: 10 short-duration Shuttle crewmembers, and 10 long-duration Expedition crewmembers, living on board the International Space Station. The investigation is part of the experiment compliment of ISS Increment 6 through 10, and part of the experiment complement for the STS-115, STS-116 and STS-117 Shuttle flights.

Benefits

The expected results will provide a better knowledge of the genetic risk of astronauts in space and in consequence can help to optimize radiation shielding. The data will allow calculation of aberration frequencies expected during deep-space missions.

Experiments

Crew Earth Observations (CEO)

Principal Investigator: Kamlesh Lulla, NASA Johnson Space Center, Houston

Payload Developer: Sue Runco, NASA Johnson Space Center, Houston

Overview

By allowing photographs to be taken from space, the Crew Earth Observations (CEO) experiment provides people on Earth with image data needed to better understand our planet. The photographs—taken by crewmembers using handheld cameras—record observable Earth surface changes over a period of time, as well as more fleeting events such as storms, floods, fires and volcanic eruptions.

Orbiting 220 miles or more above the Earth, the International Space Station offers an ideal vantage point for crewmembers to continue observational efforts that began in the early 1960s when space crews first photographed the Earth. This experiment on the Space Station began during Expedition 1, STS-97 (ISS Assembly Flight 4A), and is planned to continue throughout the life of the space station.

History/Background

This experiment has flown on every crewed NASA space mission beginning with Gemini in 1961. Since that time, astronauts have photographed the Earth, observing the world's geography and documenting events such as hurricanes and other natural phenomena. As a precursor to this ISS experiment, crews conducted Earth observations on long-duration NASA-Mir missions and gained experience that is useful on board the ISS.

Over the years, space crews also have documented human impacts on Earth—city growth, agricultural expansion and reservoir construction. The CEO experiment aboard the ISS will build on that knowledge.

Benefits

Today, images of the world from 10, 20 or 30 years ago provide valuable insight into Earth processes and the effects of human developments. Photographic images taken by space crews serve as both primary data on the state of the Earth and as secondary data to be combined with images from other satellites in orbit. Worldwide more than three million users log on to the Astronaut Earth Photography database each year. Through their photography of the Earth, Space Station crewmembers will build on the time series of imagery started 35 years ago—ensuring this record of Earth remains unbroken. These images also have tremendous educational value. Educators use the image database to help make future generations of children "Earth-smart."

For more information visit:

http://eol.jsc.nasa.gov/

Experiments

Earth Knowledge Acquired by Middle School Students

Experiment Location on ISS: The U.S. Laboratory Window

Principal Investigator: Dr. Sally Ride, University of California, San Diego

Project Manager: Brion J. Au, NASA Johnson Space Center, Houston

Overview

EarthKAM (Earth Knowledge Acquired by Middle school students) is a NASA education payload that enables students to photograph and examine Earth from a space crew's perspective.

Using the Internet, working through the EarthKAM Mission Operations Center located at the University of California at San Diego (UCSD), middle school students direct a camera mounted in the Window Observational Research Facility (WORF) located in the station's *Destiny* science module to capture high-resolution digital images of features around the globe. Students use these images to enhance their study of geography, geology, botany, history, earth science, and to identify changes occurring on the Earth's surface, *all from the unique vantage point of space*. Utilizing the high-speed digital communications capabilities of the ISS, the images are downlinked in near real-time and posted on the EarthKAM web site for the public and participating classrooms around the world to view.

Experiment Operations

Funded by NASA, EarthKAM is operated by the University of California, San Diego, and NASA field centers. It is an educational payload that allows middle school students to conduct research from the International Space Station as it orbits 220 miles above the Earth. Using the tools of modern technology – computers, the Internet and a digital camera mounted at the Space Station's laboratory window – EarthKAM students are able to take stunning, high-quality digital photographs of our planet.

The EarthKAM camera is periodically set-up in the International Space Station, typically for a 4-day data gathering session. Beginning with the Expedition 2 crew, in May 2001, the payload is scheduled for operations that coincide with the traditional school year. When the ISS crew mounts the camera at the window, the payload requires no further crew interaction for nominal operations.

EarthKAM photographs are taken by remote operation from the ground. When the middle school students target the images of terrestrial features they choose to acquire, they submit the image request to the Mission Operation Center at UCSD. Image requests are collected and compiled into a "Camera Control File" for each ISS orbit that the payload is operational. This camera control file is then uplinked to a Station Support Computer aboard the Space Station that controls when the digital camera captures the image. The Station Support Computer activates the camera at the specified times and immediately transfers these images to a file server, storing them until they are downlinked to Earth. With all system performing nominally, the entire cycle takes about five hours.

EarthKAM is monitored from console positions in the Tele-Science Support Center (Mission Control) at Johnson Space Center in Houston. As with all payloads, the EarthKAM operations on board the Space Station are coordinated through the Payload Operations Integration Center (POIC) at NASA's Marshall Space Flight Center in Huntsville, Ala. EarthKAM is a long-term payload that will operate on the Space Station for several Increments.

Flight History/Background

In 1994, Dr. Sally Ride, a physics professor and former NASA astronaut, started what is now EarthKAM with the goal of integrating education with the space program. EarthKAM has flown on five Shuttle flights. Its first flight was aboard Space Shuttle Atlantis in 1996, with three participating schools taking a total of 325 photographs. Since 1996, EarthKAM students have taken over thirteen thousand images of the Earth.

EarthKAM invites schools from all around the world to take advantage of this educational opportunity. Previous participants include schools from the United States, Japan, Germany, France and Mexico.

Benefits

EarthKAM brings education out of textbooks and into real life. By integrating Earth images with inquiry-based learning, EarthKAM offers students and educators the opportunity to participate in a space mission while developing teamwork, communication and problem-solving skills.

Long after the photographs are taken, students and educators continue to reap the benefits of EarthKAM. Educators are able to use the images alongside suggested curriculum plans for studies in physics, computers, geography, math, earth science, botany, biology, art, history, cultural studies and more.

More information on EarthKAM and the International Space Station can be found at:

www.earthkam.ucsd.edu

www.spaceflight.nasa.gov

Experiments

Educational Payload Operations (EPO)

Overview

Education Payload Operations (EPO) is an education payload designed to support the NASA Mission to inspire the next generation of explorers. Generally, these activities will focus on demonstrating science, mathematics, technology, engineering or geography principles. Video recording of the demonstrations and/or still photographic documentation of a crewmember operating EPO hardware while on-orbit will achieve EPO goals and objectives. Overall goal for every expedition is to facilitate education opportunities that use the unique environment of human space flight.

The Expedition 8 crew will use two educational payloads, EPO-8 and EPO-9.

EP0-8

Through an agreement with NASA Headquarters, five museums and science centers from around the country provided the hardware and procedures for EPO-8. These organizations form the Museum Aerospace Education Alliance (MAEA). Members of the group are the Bishop Museum, Honolulu; St. Louis Science Center, St. Louis; Denver Museum of Nature and Science, Denver; Maryland Science Center, Baltimore, Md.; Center of Science and Industry (COSI), Columbus and Toledo, Ohio.

The overall objectives of the payload are to help students discover how familiar objects may perform differently in the microgravity environment onboard the ISS. Students will also learn ways that humans must adapt to use these familiar objects in space.

Payload

During Increment 8, eight payload items will be used in educational demonstrations. The hardware consists of the following: tools block, balsa airplane, Starfire glider, hand helicopter, blues harp, crazy maze, bits and pieces puzzle, and chicken shake. Two crewmembers are needed to perform and videotape educational demonstrations using these items.

In addition, crewmembers are expected to use a Wright Flyer Model in activities related to the Centennial of Flight. The Wright Flyer, part of EPO-8, was launched in April with other EPO-8 hardware, on Soyuz 6. Formal payload operations with the Wright Flyer Model took place during Increment 7.

Tools Block

Crewmembers will use the wooden tool block to demonstrate how adaptations must be made to use simple tools in space. The tool block contains a nail, a screw, and a nut and bolt. A screwdriver, a wrench, and a hammer, all part of the ISS toolkit, will be used in this demonstration. Using the tools, crewmembers will show how they must restrain themselves to perform simple tasks.

Flight Activities

A balsa airplane, Starfire glider, and hand helicopter will be used by the crew to demonstrate and discuss principles of flight, including thrust, lift, and drag. Students will have the opportunity to experiment with similar items at the museums and science centers. They will be asked to predict how the airplane, glider, and helicopter will perform in microgravity. Students will be asked to compare the way these items perform on Earth to the way they perform in microgravity.

Blues Harp

The blues harp, or harmonica, will be used in discussions and demonstrations about sound. Students will be asked to predict whether the blues harp performs differently in microgravity. Crewmembers will discuss whether adaptations must be made to use the blues harp in space.

Chicken Shake

The chicken shake, an egg shaped object filled with beads, is similar to a maraca. The crew will use the chicken shake in discussions and demonstrations about sound. Students will be asked to predict whether the chicken shake performs differently in microgravity.

Puzzles

Two dexterity puzzles, the Crazy Maze and the Bits and Pieces puzzle, will be part of demonstrations that show how crewmembers must adapt to use familiar objects in space. Students will have the opportunity to play with the puzzles. They will apply their knowledge about microgravity to predict whether the puzzles will be easier or harder to solve in space.

Wright Flyer Model

Sixth grade students at Orono Middle School, Orono, Maine, constructed the scale model of the Wright Flyer. As part of Centennial of Flight activities in 2003, NASA plans to provide educators and students around the country with plans to construct similar scale model Wright Flyers.

Outcomes

At MAEA locations, students and educators will participate in lessons and activities related to payload operations. Video of on orbit demonstrations will be distributed to member organizations for use in lessons and also for future use in museum exhibits. Students at these locations will also have the opportunity to participate in live in-flight education programs during which the crew will demonstrate and answer questions about the payload. Video and information will also be distributed to NASA's education programs for use in educational resources, multimedia products and web sites.

EP0-9

The Canadian Space Agency (CSA) sponsors EPO-9, in partnership with H.J. Heinz Canada, CRESTech (Centre for Research in Environment, Space, and Technology), and the University of Guelph. The project is affiliated with Stokes Seeds, Canada, and the Canadian Space Resource Centre.

The seeds are part of Tomatosphere II. Following their return from the ISS, the seeds will be distributed to over 5,000 classrooms across Canada for use in growth experiments. The project is aligned with Canada's national science curriculum. Students will measure the germination rates of the seeds, the growth patterns, and the vigor of the growth.

Payload

The payload consists of four packets containing approximately 1.5 million tomato seeds. The seeds are all Heinz 9478 F1, which received no special handling or treatment prior to flight.

Crewmembers will photograph the seed packets on orbit.

Outcomes

Canadian students in grades 3 – 10 will use the seeds in growth experiments. All seed activities will be found at the Tomatosphere website. CDs will also be distributed to the schools. Activities include: an introduction to space; seed germination; the scientific method and its application; exploring different media for plant growth; space travel and essentials for human in space; photosynthesis and light; solar energy; energy and space; and energy and greenhouses. All of the activities include links to the national science curriculum, modifications for students with special needs, suggestions for assessment, and a glossary of terms.

Experiments

Spaceflight-Induced Reactivation of Latent Epstein-Barr Virus (Epstein-Barr)

Principal Investigator: Dr. Alan D.T. Barrett, University of Texas Medical Branch, Galveston, Texas

Overview

As space mission duration increases, the potential development of infectious illness in crewmembers during flight also increases. This is especially true with latent viruses, and infections caused by these viruses are not mitigated by a quarantine period. An example of a latent infection is Epstein-Barr virus (EBV), of which about 90 percent of the adult population is infected. Stress and other acute/chronic events reactivate this virus from latency, which results in increased virus replication. This investigation will assess the immune system function using blood and urine samples collected before and after spaceflight.

Flight Operations Summary

Blood and 24-hour urine samples will be collected from crewmembers both pre-flight and post-flight. Data collections will occur on or around L-180, L-60, L-10 and L-3 for pre-flight and R+0, R+3, R+14 and R+180 for post-flight. The L-180, L-60 and L-10 data collections pre-flight and the R+0, R+3, R+180 data collections post-flight will be coordinated to data share with MedOps if possible.

Flight History/Background

Flown as a Detailed Supplementary Objective on STS-108.

Benefits

This research will provide new insights into the mechanisms of EBV reactivation during spaceflight. In addition, this research may provide important information that may lead to a better understanding of latent herpesvirus reactivation in humans living on Earth. Potential applications of this research also include the development of rapid and sensitive diagnostic methods for identifying station crewmembers who may be at increased risk of illness.

Researchers must understand how the body's immune system adjusts to long stays in microgravity, both for continuing Space Station missions and for any future long-duration missions within our own solar system.

For more information on any Expedition 8 science experiment, visit the Web at:

www.scipoc.msfc.nasa.gov

http://spaceflight.nasa.gov/station/science/index.html

Experiments

Earth Science Toward Exploration Research (ESTER)

Principal Investigator: Susan Runco, NASA-Johnson Space Center, Houston
Co-Principal Investigator: Greg Byrne: Ph.D., NASA-Johnson Space Center, Houston

Overview

Earth Science Toward Exploration Research (ESTER) consists of two parts. First, it captures images of the Earth using a digital camera mounted in the U.S. Lab window and is commanded from the ground. Second, it is a continuation of crewmember handheld photography of weekly uplinked selected sites to record observable Earth surface changes and image ephemeral events such as hurricanes volcanic eruptions and plankton blooms.

Orbiting 220 miles or more above the Earth, the International Space Station offers an ideal vantage point for crewmembers to continue observational efforts that began in the early 1960s when space crews first photographed the Earth. Every Expedition crew will conduct this experiment. The imagery collected will be added into a database of human observations of Earth from space that spans more than 30 years.

Flight History/Background

This experiment has flown on every crewed NASA space mission beginning with Gemini in 1961. Since that time, astronauts have photographed the Earth, observing the world's geography and documenting events such as hurricanes and other natural phenomena. Over the years, space crews also have documented human impacts on Earth -- city growth, agricultural expansion and reservoir construction. The ESTER experiment aboard the ISS will build on that knowledge.

Benefits

Today, images of the world from 10, 20 or 30 years ago provide valuable insight into Earth processes and the effects of human developments. Photographic images taken by space crews serve as both primary data on the state of the Earth and as secondary data to be combined with images from other satellites in orbit. Worldwide more than 14 million users log on to the Astronaut Earth Photography database each month. Through their photography of the Earth, space station crewmembers will build on the time series of imagery started 35 years ago -- ensuring this record of Earth remains unbroken.

For more information visit:

http://earth.jsc.nasa.gov/sseop/efs/

http://eol.jsc.nasa.gov/

Experiments

Fluid Merging Viscosity Measurement (FMVM)

Mission: To be delivered on International Space Station Progress 13; experiment to be conducted during International Space Station Expedition 8 and/or Expedition 9

Experiment Location: Maintenance Work Area in Destiny Laboratory Module

Investigators: Dr. Edwin Ethridge, NASA Marshall Space Flight Center, Huntsville, Ala., Dr. Basil Antar, University of Tennessee Space Institute, Tullahoma, Tenn., and Dr. William Kaukler, University of Alabama in Huntsville, Ala.

Project Manager: Jim Kennedy, NASA Marshall Space Flight Center, Huntsville, Ala.

Overview

For this experiment, scientists are mainly interested in studying viscosity – a property of fluids that causes them to resist flowing because of the internal friction created as the molecules move against each other. Viscosity can be thought of as "thickness" of the fluid. For example, honey is more viscous than water. Water molecules would flow through a small tube quicker than honey because its molecules are less viscous; the more viscous honey would move through the same tube at a slower rate.

Understanding the viscosity of molten materials is important for everything from designing laboratory experiments to industrial production of materials. It is one of the key parameters that materials scientists must measure to create accurate models predicting the best methods for materials production. Understanding and controlling viscosity can even enable researchers to make new materials or improve existing ones.

Scientists can measure the viscosity of low viscosity liquids such as molten metal in low-gravity, by measuring vibrations of liquid drops. This method cannot be used with viscous liquids. The FMVM experiment will verify a new method for measuring the viscosity of viscous liquids by measuring the time it takes for two spheres to coalescence into a single spherical drop.

Studying extremely viscous materials in space, such as glass, can also provide data that is difficult to obtain on Earth. When glass is processed on Earth, the molten glass crystallizes if it touches any part of the container wall, and the viscosity cannot be measured once the liquid crystallizes. This is particularly true for exotic glasses created by undercooling – cooling the glass below the temperature at which it would normally form a solid.

To obtain accurate data for precise models, it is best to measure viscosity in liquid that is free-floating and uncontained. The International Space Station's microgravity environment is an excellent test bed for this procedure because drops float freely in low gravity.

This experiment will also provide data useful for understanding the sintering of materials in low-gravity. Sintering is a method for forming powders into solid shapes. This data can be used for materials that may be fabricated and manufactured in space.

Experiment Operations

Much of the hardware used for this investigation is already available on the International Space Station. The experiment will be conducted inside the Space Station Maintenance Work Area -- a portable workbench with a tabletop that measures 36 inches by 25 inches. When not in use, it is folded and stored inside a drawer.

The Maintenance Work Area can be used throughout the Station. An astronaut unfolds and clamps it to a slotted mechanism similar to seat tracks found in cars or airplanes. The tracks are located on the sides of most of the floor-to-ceiling racks inside the Station. Gloveports on the sides and ends of the workbench's plastic cover and a front flap that unzips allow crew members to conduct the experiment but still contain the liquid.

For each test, crew members will release two drops from a syringe onto strings and record digital images of the drops as they coalesce to form one drop. One way to measure viscosity is to measure how long it takes two spheres of liquid to merge into a single spherical drop. On contact a neck will from between the two drops. This neck will increase in diameter until the two drops become one single sphere.

On Earth, gravity distorts liquid spheres and drops are too heavy to be supported by strings. Drop distortion should not occur in the Space Station's microgravity environment, and the drops can be held on strings. Without gravity's influence, the drops' movement and coalescence should be controlled by surface tension and viscosity.

To verify this technique as an accurate method for measuring viscosity, the experiment will use fluids with known viscosities: honey, corn syrup, glycerin and silicone oil. Several runs will be conducted – some with equal diameter drops and others with different size drops. The initial diameters of the drops will be measured.

The experiment will be videotaped with a digital color camera so investigators can watch the drops combine and measure the rate of shape change. They will observe how the "neck" --the place were the drops connect – is formed and how the neck grows to form the final, single drop.

Investigators may monitor the video from the Telescience Center – a work area at the Marshall Center where scientists monitor and communicate with experiments on the Space Station.

Experiments were conducted on NASA's KC-135 – an aircraft that flies in a roller coaster-like parabolic flight patterns and exposes experiments to a few seconds of low gravity. The experiment on the Space Station can be conducted over much longer periods in microgravity, allowing investigators to measure the viscosity of larger drops and more viscous fluids.

Benefits

The data will provide insight to the behavior of glasses – materials that may be used to fabricate parts or equipment for long-term space missions. The viscosity measurements can be used in models that predict the viscosity of materials processed by a variety of methods. This will improve future materials processing experiments carried out in space and on Earth.

More information on this experiment and other Space Station experiments is available at:

http://spaceresearch.nasa.gov/

www.scipoc.msfc.nasa.gov

www.spaceflight.nasa.gov

http://www.microgravity.nasa.gov

Experiments

Viscous Liquid Foam- Bulk Metallic Glass (Foam)

Mission: To be delivered on International Space Station Progress 14; experiment to be conducted during Expedition 8 and/or Expedition 9

Experiment Location: Maintenance Work Area in Destiny Laboratory Module

Investigator: Dr. William (Bill) Johnson, and Chris Veazey, both of California Institute of Technology, Pasadena, Calif., and Dr. William Kaukler, NASA Marshall Space Flight Center, Huntsville, Ala.

Project Manager: Jim Kennedy, NASA Marshall Space Flight Center, Huntsville, Ala.

Overview

In the 1980s, scientists discovered a new family of glasses: bulk metallic glasses. NASA-funded researcher Dr. Bill Johnson and his team at the California Institute of Technology (Caltech) in Pasadena, Calif., built on this original discovery and combined five elements to make an alloy that could be stiffer and thus have more applications. Their research included experiments on the ground and during two Space Shuttle flights in the 1990s. Precise conditions for forming bulk metallic glasses -- including many elusive properties -- were identified during these flight missions.

What makes bulk metallic glass different from other metals and glasses? Conventional metallic materials have a crystalline structure consisting of single crystal grains of varying sizes that fit together to form the metal's microstructure. To create these metal alloys, materials are heated so that they combine. As they are cooled, crystals form and arrange themselves together to make the structure of the solid metal.

On the other hand, to form bulk metallic glasses, the alloy is undercooled – cooled below the temperature at which it would normally form a solid. At around 650 degrees Fahrenheit, the liquid cools rapidly and solidifies from a molten form to create the solid. Unlike normal metals, it changes into the solid without forming crystals. This solid, non-crystalline structure makes bulk metallic glasses much stronger than their metal counterparts – by factors of 2 or 3 – and tougher than ceramics.

This experiment continues the Caltech team's pioneering work on these novel materials and uses them to examine foaming, viscosity and bubble formation.

Viscosity – the "stiffness" of fluids – is determined by complex interactions between atoms that make up a material. It is very hard to model and calculate the viscosity of complex materials. Viscosity is a critical parameter for creating foams – materials that may flow through a tube, but also are thick enough to be shaped and molded.

Understanding viscosity and foaming will help scientists understand industrially important materials such as paints, emulsions, polymer melts and even foams used to produce pharmaceutical, food and cosmetic products.

Experiment Operations

Much of the hardware used for this investigation is already available on the International Space Station. To heat samples, astronauts will use a battery-operated soldering iron that is part of their on-orbit tool kit.

The experiment will be conducted inside the Space Station Maintenance Work Area -- a portable workbench with a tabletop that measures 36 inches by 25 inches. When not in use, it is folded and stored inside a drawer.

The Maintenance Work Area can be used throughout the Station. An astronaut unfolds it and clamps it to a slotted mechanism similar to seat tracks found in cars or airplanes. The tracks are located on the sides of most of the floor-to-ceiling racks inside the Station. Gloveports on the sides and ends of the workbench's plastic cover and a front flap that unzips allow crew members to use the soldering iron or other tools at the same time.

Johnson's team will prepare three small, 0.5-gram samples of bulk metallic glass on Earth. The samples will be injected with a gas so that when they are heated, they will foam. The samples will be contained in copper ampoules, containers that are evacuated and sealed by welding. The ampoules are 2.5 centimeters long by 0.6 centimeters in diameter.

The ampoules will fit into brass sleeves that slide over the soldering iron. Astronauts will use the tip of the soldering iron to heat the ampoule and the enclosed samples. The three samples will be heated for 30 minutes, 15 minutes and 7.5 minutes, respectively. The samples will foam, increasing in volume as they are heated. When cooled, they will retain this foam shape because the viscosity will increase during cooling until it is a solid.

For this experiment, scientists are mainly interested in studying viscosity – a property of fluids that causes them to resist flowing because of the internal friction created as the atoms move against each other. Structurally bulk metallic glasses are liquids with very high viscosity, and investigators have designed these samples and the processing technique to form stiff foams having thick cell walls. This is the first microgravity study of foaming in a liquid alloy that is undercooled.

Investigators have designed the processing technique to take advantage of the stability, or longevity, offered by the high viscosity when heated above the glass transition temperature. Foaming a conventional metal alloy is limited by its very low viscosity above the melting temperature. By analogy, bulk metallic glass foam captures bubbles like honey while conventional alloy foam captures bubbles like froth above soapy water. This makes bulk metallic glasses ideal for studying foaming and bubble behavior.

In microgravity, bubbles don't rise, liquid doesn't sink, and surface tension dominates. The advantage of microgravity is significant for metal foam, where the density difference between gas and liquid is very large.

Producing a bulk metallic glass foam in space that is strong enough to retain its structure on return to Earth will allow for a comprehensive study to be made of the parameters which affect bubble size, wall thickness and other foam characteristics. Investigators will compare the morphology of bulk metallic foam made in space to that made in Earth gravity to determine differences in wall thickness, bubble size distribution and shape effects.

Benefits

Bulk metallic glasses are a relatively new material with enormous potential. Solid foams are the best materials to make large, stiff structures due to their high strength to weight ratio. Foaming also considerably reduces the thermal conductivity of the metal alloy. Even bulk metallic glasses have significant thermal conductivity that engineers wish to reduce.

The more investigators characterize how and why these materials form, the more they can develop specific formulas for use in various applications – from sports equipment to military hardware to spacecraft. Better measurements of viscosity and a better understanding of foaming will help investigators improve a variety of materials used for everything from medical to industrial processing.

More information on this experiment and other Space Station experiments is available at:

http://spaceresearch.nasa.gov/
www.scipoc.msfc.nasa.gov
www.spaceflight.nasa.gov
http://www.microgravity.nasa.gov

Experiments

Foot/Ground Reaction Forces During Spaceflight (FOOT)

Principal Investigator: Peter R. Cavanagh, Ph.D., Chairman, Department of Biomedical Engineering, Lerner Research Institute, The Cleveland Clinic Foundation, Cleveland, Ohio

Overview

Without appropriate countermeasures, astronauts traveling in space can lose as much bone mineral in the lower extremity in one month as a typical post-menopausal woman looses in an entire year. Muscle strength can also be lost rapidly during spaceflight. Such decrements as a result of prolonged exposure to microgravity have important implications for performance and safety during space missions and thus the identification of mechanisms and countermeasures for such changes are a high priority for NASA.

It is widely believed that changes in bone and muscle are directly related to the decrease in mechanical loading. This hypothesis is supported by the fact that little or no bone mineral is usually lost from the upper extremity – which may be even more frequently used in orbit than it is on the ground. The objective of the experiment called FOOT is to quantify and explore the relationship between loading of the human body and changes in the musculoskeletal system during spaceflight.

The principal investigator on the experiment, Peter R. Cavanagh, Ph.D., has previously been involved with the design of the Human Research Facility in the Space Station and in the evaluation of the treadmill vibration isolation system (TVIS) that is used for exercise on the International Space Station (ISS).

Experiment Operations

FOOT will accomplish its objectives through direct measurement of forces on the feet, joint angles and muscle activity in astronauts during typical entire days of daily life both on Earth and on the ISS. In addition, bone mineral density, muscle strength, and muscle volume will be measured before and after the mission.

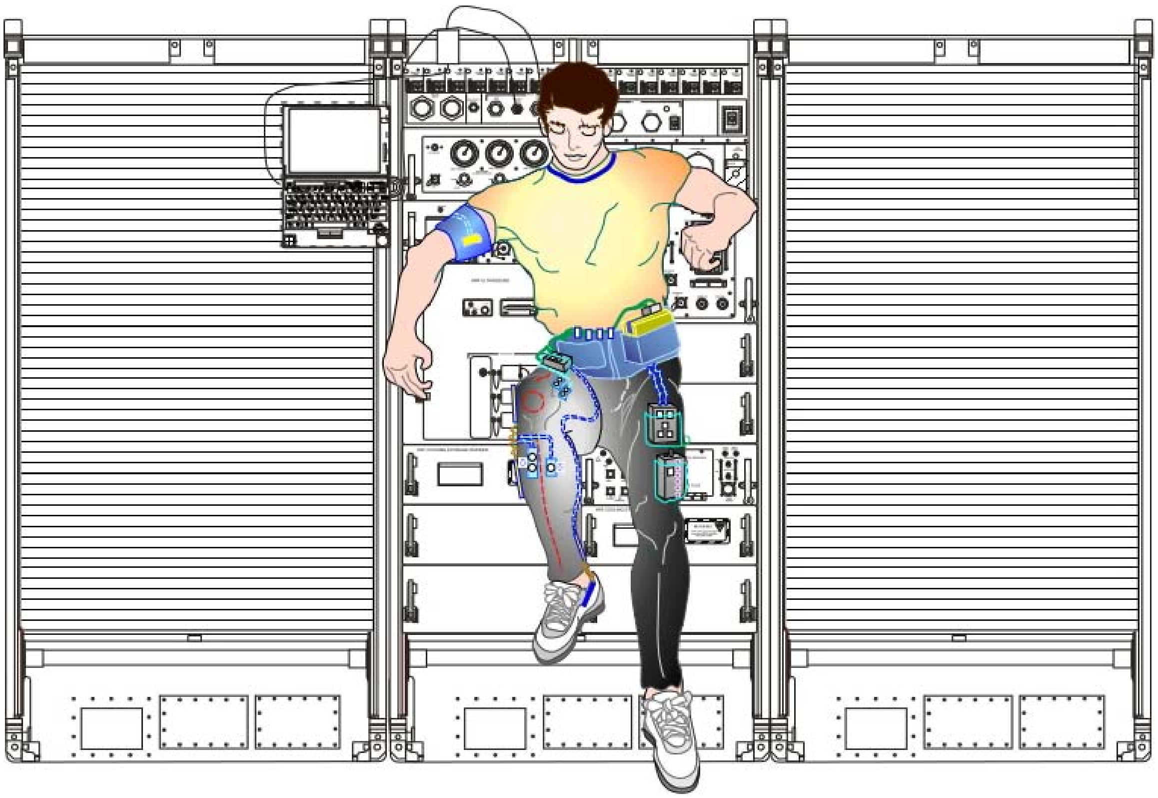
The heart of the FOOT experiment is an instrumented suit called the Lower Extremity Monitoring Suit (LEMS) (see sketch below). This customized garment is a pair of Lycra cycling tights incorporating 20 carefully placed sensors and the associated wiring, control units, and amplifiers. LEMS will enable the electrical activity of muscles, the angular motions of the hip, knee, and ankle joints, and the force under both feet to be measured continuously. Information from the sensors can be recorded for up to 14 hours on a small wearable computer. Measurements will also be made on the arm muscles. The crewmembers will put the suit on in the morning before they start their workday and, after calibration, they will go about their regular daily activities. Throughout the day, the sensors will capture data that will allow researchers to characterize differences between use of the arms and legs on Earth and in space.

Before launch and after landing, DXA scans, MRIs, and Cybex testing will be used to measure the changes in bone mineral density, muscle volume, and muscle strength respectively. Researchers will relate these changes to the measurements made from the LEMS.

The first subject to perform the experiment on the International Space Station was Ken Bowersox, commander of Expedition 6. For Expedition 8, Commander Mike Foale will wear the instrumented pants for a number of days. The instrumentation will measure where how his muscles are moving, how the nerves that are triggering his muscles are firing, and indeed, the actual resulting position of his leg.

Benefits

FOOT has the potential to shed significant new light on the reasons for bone and muscle loss during spaceflight and on the design of exercise countermeasures. The data should allow the “dose” of mechanical load to be chosen based on the measurements performed in the study. Ideally, exercise countermeasures should replace the critical mechanical input that is present on Earth but missing in space. The ISS environment offers an ideal setting in which the experimental hypothesis can be examined. In addition, the theories that are to be explored in this project have significance for understanding, preventing, and treating osteoporosis on Earth, which is a major public health problem.



Artist's impression of the Lower Extremity Monitoring Suit (LEMS)

Experiments

Group Activation Packs (GAP) Yeast Experiment

Mission: Experiment to International Space Station on ISS Progress 13; experiment conducted during Expedition 8

Experiment Location: Destiny Laboratory Module

Principal Investigators: Timothy G. Hammond, M.B., B.S., Tulane University Medical Center, New Orleans

NASA Research Partnership Center Director: Dr. Louis Stodieck, BioServe Space Technologies, University of Colorado, Boulder

NASA Research Partnership Market Manager: Brian Mitchell, NASA Marshall Space Flight Center, and Huntsville, Ala.

Overview

The objective of NASA's biotechnology cell science research aboard the International Space Station is to provide a controlled environment for the cultivation of cells into healthy, three-dimensional tissues that retain the form and function of natural, living tissue.

As normal human cells grow and replicate, they form complex "colonies" of fibers, proteins and other structures that make up living tissue. Studying this mechanism outside the human body is difficult, however, because cells do not easily associate to form these cellular colonies outside living organisms.

Most cultivated cells form flat, thin specimens that offer only limited insight into the way cells work together. Scientists were excited, therefore, to discover that cells grown in microgravity -- the low-gravity environment inside spacecraft orbiting the Earth -- much more closely resemble those found in human bodies.

The genes of every living organism determine the organism's physical traits and how each cell operates. For example, kidney cells receive instructions from genes that tell the cells how to form and how to operate together to remove wastes from the body. Scientists want to understand how the cells receive instructions from genes and express specific genetic traits – gene expression patterns.

Understanding gene expression patterns and how they are altered when cells are grown in the low-gravity, or microgravity inside the Space Station, will help scientists learn how cells respond to gravity. This information could be used eventually to improve the method for culturing cells here on Earth. Improved cell culturing techniques could help scientists improve pharmaceutical testing and drug development processes, produce new biological products, and potentially produce tissues that can be implanted inside humans to replace diseased tissues or organs.

The challenge in studying human cells or cells from other mammals is that the genome – the entire group of genes that make up each living creature and determine its traits – is large and complex. This makes it difficult to study how gravity or microgravity affects individual genes that control specific cells.

For this experiment, scientists will study yeast cells, which are eukaryotic cells – cells that contain a distinct nucleus bound by a cell membrane. Mammalian cells have a similar eukaryotic structure. However, yeast cells are far simpler and have a well-characterized, much smaller genome. This will make it easier for scientists to study how microgravity is altering the cells' makeup and potential their function.

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

Experiment Operations

The yeast cells will be cultured inside Group Activation Packs – a cell growth and storage system developed by BioServe Space Technologies located at the University of Colorado in Boulder. BioServe is one of 15 NASA Research Partnership Centers managed by NASA's Space Product Development Program at NASA's Marshall Space Flight Center in Huntsville, Ala.

BioServe has developed numerous facilities designed to conduct biotechnology experiments in space and has flown research on more than 23 missions including three missions aboard the International Space Station.

Two Group Activation Packs will be flown. Each contains eight Fluid Processing Apparatuses that hold the yeast cultures, growth medium and fixative, a chemical used to preserve the cells for post-flight examination.

To activate the experiment, the Space Station crew will insert a crank into the top of the GAP. This causes the yeast cells to mix with the liquid growth medium. The cells will grow in the cultures for three days. Then the crank will be turned again, releasing the fixative.

The preserved cells will be placed in a special stowage container. They will be returned to Earth where scientists will compare them to similar yeast cells grown inside a ground control unit. By comparing the genes of the Earth-produced cells with the cells grown in space, scientists can determine how microgravity altered the genetic makeup of the cells.

Benefits

This experiment is one of a series of investigations that is being flown as part of NASA's cellular biotechnology research program conducted by NASA researchers in academia, government and industry. The potential benefits and applications include:

- Increased understanding of basic cell biology, as well as the effects of gravity on terrestrial cell biology;
- Potential production of living, functional replacement tissue for research and medical applications;
- Identification of new technologies that will advance science on Earth; and
- Potentially impact the determination of health remedies and countermeasures for future long-term spaceflight.

More information on this experiment and other Space Station experiments is available at:

http://spd.nasa.gov

http://www.colorado.edu/engineering/BioServe/

http://spaceresearch.nasa.gov/

www.scipoc.msfc.nasa.gov

www.spaceflight.nasa.gov

Experiments

Hand Posture Analyzer (HPA)

Principal Investigator: Dr. Valfredo Zolesi, Kayser Italia, Livorno, Italy
Co-Investigators: Prof. Francesco Lacquaniti - IRCCS - S. Lucia - Roma
Dr. Federico Posteraro - Hospital Versilia - Camaiore - Lucca
Dr. Paolo Pastacaldi - Hospital S. Chiara - Pisa
Project Manager: Dr. Aleandro Norfini - Kayser Italia - Livorno
Program Manager: F. Bracciaferri - ASI - Roma

Overview

The research objective of the ASI Facility Hand Posture Analyzer (HPA) is to investigate the performance degradation of the human upper limb muscle-skeletal apparatus and its morphological-functional modifications during long-term exposition to weightlessness and to study the role of gravity in the planning-execution hierarchy of reaching, grasping, manipulating and transporting objects.

The HPA Facility consists of an Hand Grip (HGD) and a Pinch Force Dynamometer (PFD), an instrumented Posture Acquisition Glove (PAG) with 15 degrees of freedom allowing the measurement of the bending angles on individual phalanxes, coupled to a Wrist Electronic Box (WEB) housing an inertial tracking system in order to acquire tri-axial acceleration and rotation of the forearm.

Fig. 1 HPA devices

Flight Operations Summary

The crew will set up the HPA specific hardware and will be guided by the HPA software running on the International Space Station laptop to perform the following experimental protocols:

- **CHIRO**: **C**rew **H**ealth **I**nvestigation on **R**educed **O**perability

  (P.I: V. Zolesi – Kayser Italia-Livorno; Co.I.: P. Pastacaldi-Hospital S. Chiara-Pisa;)

  Measurement of Hand Grip and Pinch Isometric force with visual and proprioceptive feedback.

  After application of the Maximum Voluntary Contraction, the astronaut is guided by the software to maintain a certain level of force (25, 50 and 75% of MVC) for 24 seconds; during the first 8 seconds he gets a visual feedback from the Laptop, then he operates for other 8 seconds only with proprioceptive feedback and again for the last 8 seconds with visual feedback. Each level is repeated three times during the session.

  The following parameters are recorded and computed:

  MVC, time history of the force, force RMS, frequency contents, fatigue index, statistical data.

- **MAIS**: **M**anipulation **A**ctivities **I**n **S**pace

  (P.I.: F. Posteraro-Hospital Versilia - Camaiore; Co.I.: S. Micera- Scuola Superiore S. Anna-Pisa; V. Zolesi, Kayser Italia-Livorno)

  Grasping and reaching of target objects of different sizes.

  Three small cylinders of different size are placed in front of the astronaut, standing with the hand at the sternum as rest position, and wearing the instrumented glove and the wrist electronics box; he is guided by the software instructions to reach the first cylinder (without grasping it) and to go back to the rest position, and then to repeat the movement grasping and taking the object to the sternum. The protocol is repeated in sequence 3 times for each cylinder. The following parameters are recorded and computed:

  Time history of angles of phalanxes (15), triaxial acceleration and angular velocities of the wrist.

- **IMAGINE**: **I**magery of object **M**otion **A**ffected by **G**ravity **I**n **N**ull-gravity **E**xperiments

  (P.I.: F. Lacquaniti-IRCCS S. Lucia - Roma; Co.I: M. Zago, E. Daprati, V. Maffei – IRCCS – S. Lucia -Roma; Co-I: Zolesi –Kayser Italia-Livorno)

  Launch and grasping of a virtual ball with different gravity and force.

  The astronaut is standing with his upper limb in rest position along the body, palm toward the leg; while wearing the instrumented glove and the wrist electronics box he is then prompted by the software to imagine to launch an imaginary tennis ball against the ceiling and to catch it after bouncing, thinking to be (as it is in effect) at zero-g condition. This has to be done 4 times each impressing to the virtual ball a low, a medium, and a high initial velocity, for a total of 12 launches. The entire sequence has then to be repeated thinking to be at normal gravity. The following parameters are recorded and computed:

  Time history of angles of phalanxes (15), tri-axial acceleration and angular velocities of the wrist.

History/Background

This is the very first facility conceived by the Italian Space Agency (ASI) for the utilization on ISS.

A precursor flight of the CHIRO experiment was executed in April 2002 during the taxi flight Soyuz TM34, with the ESA astronaut R. Vittori, collecting data in the Russian segment of the ISS during seven mission days.

Benefits

The ISS is a unique platform to perform experiments of human physiology in space. In particular, the research conducted on Upper Limb will gain more importance in the next future for the following reasons:

- The upper limb is the normal locomotion medium for the crewmembers in weightlessness.

- The hand is an organ subjected to significant stress and fatigue, particularly during EVA.

- The performance degradation of the muscle-skeleton apparatus, the disturbances on the motor control and the adaptation to the new environment, are revealed and objectively measured on the hand, with protocols repeated during the permanence aboard, then they are compared with the Baseline Data Collection taken on ground before and after the flight.

- For the purpose of determining the effectiveness and usefulness of the introduction of appropriate countermeasures in order to reduce the bone and muscle mass loss, it is essential to perform local measurement on the upper limb.

- The motor control programs learned on ground are deeply altered by the reduced gravity on ISS, not only due to the changed characteristic of the bio-mechanical apparatus, but also by the different environment as subjectively perceived by the astronaut. It is therefore of uppermost importance to verify the speed of learning of the new processes.

The results of the experiments can be transferred on ground to subjects with local trauma or with Central Nervous System diseases, in order to study the correct protocols for their rehabilitation.

Fig. 2 PAG and WEB

Fig. 3 HGD

Experiments

Crewmember and Crew-Ground Interactions During ISS Missions (Interactions)

Principal Investigator: Dr. Nick Kanas, Professor of Psychiatry, University of California and Veterans Hospital, San Francisco

Overview

Spaceflight places humans in an environment unlike any found on Earth. The nearly complete absence of gravity is perhaps the most prominent obstacle that astronauts face. It requires a significant modification of living and working habits by the astronauts. Not only do they have to learn to adapt to the way they perform routine operations, such as eating, moving and operating equipment, but they must also learn to adjust to the internal changes that their bodies experience and to the psychosocial stressors that result from working under isolated and confined conditions.

The Interactions experiment seeks to identify and characterize important interpersonal and cultural factors that may impact the performance of the crew and ground support personnel during International Space Station missions. The study will examine — as it did in similar experiments on the Russian space station Mir— issues involving tension, cohesion and leadership roles in the crew in orbit and in the ground support crews. The study will have both the crewmembers and ground control personnel complete a standard questionnaire. Crewmembers and mission control personnel from several of the first eight increments will serve as subjects for this study.

History/Background

NASA performed similar “interaction” studies during the Shuttle/Mir Program in the late 1990s. That experiment examined the crewmembers’ and mission control personnel’s perception of tension, cohesion, leadership and the crew-ground relationship.

Benefits

Because interpersonal relationships can affect crewmembers in the complicated day-to-day activities they must complete, studies such as this are important to crew health and safety on future long-duration space missions. Findings from this study will allow researchers to develop actions and methods to reduce negative changes in behavior and reverse gradual decreases in mood and interpersonal interactions during the ISS missions—and even longer missions, such as an expedition to Mars.

Experiments

In Space Soldering Investigation (ISSI)

Mission: Uses materials presently on-board the Space Station; experiment conducted during Space Station Expedition 7 and/or Expedition 8

Experiment Location: Maintenance Work Area in Destiny Laboratory Module

Principal Investigators: Dr. Richard Grugel, NASA Marshall Space Flight Center, Huntsville, Ala., Dr. Fay Hua, Intel Corporation, Santa Clara, Calif., and Dr. A.V. Anilkumar, Vanderbilt University, Nashville, Tenn.

NASA Project Manager: Lucinda Murphy NASA Marshall Space Flight Center, Huntsville, Ala.

Overview

Many of the methods used to build and repair equipment on Earth must now be adapted for space. International Space Station crews have tools for making small repairs, but little research has been conducted on the best ways to manufacture and repair equipment in space.

In the low-gravity environment inside the orbiting Space Station, surface tension has a greater influence on materials and fluids than on Earth. Fluids that would splatter and spill to the ground on Earth form drops held together by surface tension. Left uncontained, these drops float through the air in space.

Convection and surface tension are two forces that influence how a fluid moves or flows. Both forces play a role in fabrication and repair techniques -- such as soldering and welding. Soldering involves melting a metal or metal alloy, usually lead or tin. The molten material is applied and flows between surfaces or joints of materials that are being held together. When it cools and solidifies, the solder joins the materials together. However, on-orbit, gravity is balanced by the equal but opposite centrifugal force or orbital rotation, thus eliminating convection and leaving surface tension to be the dominant force influencing flow.

On Earth possible gas bubbles inside solder are lighter, and convection causes them to rise to the surface and separate from the molten fluid. In space, another method must be used to remove the bubbles from the soldering metal. If too many bubbles become trapped, the solder is weakened and the joined parts could separate.

The goal of this study is to investigate solder flows and the quality and strength of solder connections formed in the absence of convection. Hopefully this will lead to a better understanding of fabrication and repair methods for use in space.

Experiment Operations

The investigation will use hardware already available on the Space Station. For small on-orbit repairs, the astronaut tool kit includes a battery-operated soldering iron that heats up to 315.6 degrees Celsius (600 degrees Fahrenheit.) The soldering iron has special safety features, such as a holder that protects the user from burns.

The experiment will be conducted inside the International Space Station Maintenance Work Area -- a portable workbench with a tabletop that measures 36 by 25 inches. When not in use, it is folded and stored inside a drawer.

The Maintenance Work Area can be used most anywhere throughout the Station. An astronaut unfolds it and clamps it to a slotted mechanism similar to seat tracks found in cars or airplanes. The tracks are located on the sides of most of the floor-to-ceiling racks inside the Station.

To contain debris during cutting, drilling, filing, or soldering, a clear, plastic cover can be placed around the workbench. Gloveports on the sides and ends of the workbench's plastic cover and a front flap that unzips allow both crew members to use the soldering iron or other tools at the same time. The Station's vacuum can be attached to capture and dispose of particles or liquids that are 6 microns in diameter or larger. One challenging aspect of soldering in space is that any smoke created during the heating will not easily disperse, possibly leaving the operator unable to see the work piece. In the Maintenance Work Area, this problem will be avoided by using the vacuum.

The crew will perform several tests connecting metal alloy wires of various configurations together with solder. These test pieces, or coupons, are designed to evaluate the effectiveness of different geometries typical of the kinds of operations that might be required in future.

Investigator on Earth will monitor the experiment from the Telescience Center at NASA's Marshall Center. By viewing video, they will be able to observe the soldering operation as the crew works on samples.

The samples will be returned to Earth for examination. Tests will include a microscopic evaluation of the structures of the solder joints, and how they compare with those done in the laboratory on Earth. The tensile strength will be measured in specially designed coupons.

Benefits

The International Space Station must be maintained for its lifetime of a decade or longer. This orbiting home and workplace never returns to the ground, so all repairs must be made in space.

Conducting repairs in space is challenging. Tools and loose materials must be tethered or restrained so that they don't float away. Crewmembers must anchor themselves so they have a steady hand when making repairs. Particles of debris created during drilling, filing, and other operations must be collected and disposed of so they do not contaminate the crew's living environment.

Besides the soldering iron, other tools used for repairs inside the Space Station include ratchets, sockets, screw drivers, wrenches, pliers, hacksaws, chisels, files, hammers and even a sewing kit. Special tool kits allow astronauts to repair electronics, fiber optics, and fluid lines.

The more Space Station crews work with tools in space, the easier future repairs will be. Experiments like this one provide a systematic method for studying how to improve tools and repair procedures. This information can be used to design future tools and develop the best procedures for repairing equipment in the unique environment inside an orbiting spacecraft.

More information on this experiment and other Space Station experiments is available at:

http://spaceresearch.nasa.gov/

www.scipoc.msfc.nasa.gov

www.spaceflight.nasa.gov

http://www.microgravity.nasa.gov

Experiments

Acceleration Measurements Aboard the International Space Station

Acceleration Measurement Discipline Program Manager: David Francisco, NASA Glenn Research Center, Cleveland, Ohio

Acceleration Measurement Discipline Scientist: Richard DeLombard, NASA Glenn Research Center

Overview

Providing a quiescent microgravity, or low-gravity, environment for fundamental scientific research is one of the major goals of the International Space Station Program. However, tiny disturbances aboard the Space Station mimic the effects of gravity, and scientists need to understand, track and measure these potential disruptions. Two accelerometer systems developed by the Glenn Research Center will be used aboard the station. Operation of these systems began with Expedition 2 and will continue throughout the life of the station.

The Space Acceleration Measurement System II (SAMS-II) will measure accelerations caused by vehicle, crew and equipment disturbances. To complement the SAMS-II measurements, the Microgravity Acceleration Measurement System (MAMS) will record accelerations caused by the aerodynamic drag created as the station moves through space. It also will measure accelerations created as the vehicle rotates and vents water. These small, quasi-steady accelerations occur in the frequency range below 1 Hertz.

Using data from both accelerometer systems, the Principal Investigator Microgravity Services project at the Glenn Research Center will help investigators characterize accelerations that influence their station experiments. The acceleration data will be available to researchers during the mission via the World Wide Web. It will be updated nominally every two minutes as new data is transmitted from the station to Glenn’s Telescience Support Center. A catalog of acceleration sources also will be maintained.

Space Acceleration Measurement System II (SAMS-II)

Project Manager: Richard DeLombard, NASA Glenn Research Center, Cleveland, Ohio

The Space Acceleration Measurement System II (SAMS-II) began operations on ISS Mission 6A. It measures vibrations that affect nearby experiments. SAMS-II uses small remote triaxial sensor systems that are placed directly next to experiments throughout the laboratory module. In EXPRESS (Expedite the Processing of Experiments to the Space Station) Racks 1 and 4, it will remain on board the station permanently.

As the sensors measure accelerations electronically, they transmit the measurements to the interim control unit located in an EXPRESS rack drawer. SAMS-II is designed to record accelerations for the lifetime of the Space Station. As larger, facility-size experiments fill entire Space Station racks in the future, the interim control unit will be replaced with a more sophisticated computer control unit. It will allow on-board data analysis and direct dissemination of data to the investigators' telescience centers located at university laboratories and other locations around the world. Special sensors are being designed to support future experiments that will be mounted on the exterior of the Space Station.

Microgravity Acceleration Measurement System (MAMS)

Project Manager: Richard DeLombard, NASA Glenn Research Center, Cleveland, Ohio

The Microgravity Acceleration Measurement System (MAMS) measures accelerations that affect the entire Space Station, including experiments inside the laboratory. It fits in a double middeck locker, in the U.S. Laboratory Destiny in EXPRESS Rack No.1. It was preinstalled in the rack, which was placed in the laboratory during Expedition 2, ISS Flight 6A. It will remain on board the station permanently.

The MAMS accelerometer sensor is a spare flight sensor from the Orbital Acceleration Research Experiment program that characterizes similar accelerations aboard the Space Shuttle. Unlike SAMS-II, MAMS measures more subtle accelerations that only affect certain types of experiments, such as crystal growth. Therefore MAMS will not have to be on all the time. During early expeditions, MAMS will require a minimum operational period of 48 or 96 hours to characterize the performance of the sensors and collect baseline data. During later increments, MAMS can be activated for time periods sufficient to satisfy payload or Space Station requirements for acceleration data.

MAMS is commanded on and off from the Telescience Support Center at Glenn. MAMS is activated when the crew switches on the power switch for the EXPRESS Rack No. 1, and the MAMS computer is powered up from the ground control center. When MAMS is powered on, data is sent to Glenn Research Center's Telescience Support Center where it is processed and displayed on the Principal Investigator Microgravity Services Space Station Web site to be viewed by investigators.

History/Background

The Space Acceleration Measurement System (SAMS) – on which SAMS-II is based -- first flew in June 1991 and has flown on nearly every major microgravity science mission. SAMS was used for four years aboard the Russian space station Mir where it collected data to support science experiments.

Experiments

Materials on International Space Station Experiment (MISSE)

Overview

The Materials on International Space Station Experiment (MISSE) Project is a NASA/Langley Research Center-managed cooperative endeavor to fly materials and other types of space exposure experiments on the Space Station. The objective is to develop early, low-cost, non-intrusive opportunities to conduct critical space exposure tests of space materials and components planned for use on future spacecraft.

The Boeing Co., the Air Force Research Laboratory and Lewis Research Center are participants with Langley in the project.

History/Background

Flown to the Space Station in 2001, the MISSE experiments were the first externally mounted experiments conducted on the ISS. The experiments are in four Passive Experiment Containers (PECs) that were initially developed and used for an experiment on Mir in 1996 during the Shuttle-Mir Program. The PECs were transported to Mir on STS-76. After an 18-month exposure in space, they were retrieved on STS-86.

PECs are suitcase-like containers for transporting experiments via the Space Shuttle to and from an orbiting spacecraft. Once on orbit and clamped to the host spacecraft, the PECs are opened and serve as racks to expose experiments to the space environment.

The first two MISSE PECs were transported to the ISS on STS-105 (ISS Assembly Flight 7A.1) in August 2001. Samples deployed on 7A.1 will be retrieved and replaced with new samples on STS-114 (ULF-1).

Examples of tests to be performed in MISSE include: new generations of solar cells with longer expected lifetimes to power communications satellites; advanced optical components planned for future Earth observational satellites; new, longer-lasting coatings that better control heat absorption and emissions and thereby the temperature of satellites; new concepts for lightweight shields to protect crews from energetic cosmic rays found in interplanetary space; and the effects of micrometeoroid impacts on materials planned for use in the development of ultra-light membrane structures for solar sails, large inflatable mirrors and lenses.

Benefits

New affordable materials will enable the development of advanced reusable launch systems and advanced spacecraft systems.

Experiments

Promoting Sensorimotor Response Generalizability: A Countermeasure to Mitigate Locomotor Dysfunction After Long-duration Spaceflight (MOBILITY)

Principal Investigator: Dr. Jacob Bloomberg, Johnson Space Center, Houston

Overview

Astronauts returning from spaceflight can experience difficulty walking, as the brain must readapt to programming body movements in a gravity environment. The MOBILITY experiment will use tests taken before and after a long-duration spaceflight to determine whether a specific training regimen using the station's treadmill can help astronauts recover more quickly when they return to Earth. Specifically, do astronauts who use this unique treadmill workout in space readjust more quickly when once again exposed to the effects of gravity?

Two tests, the Treadmill Locomotion Test and the Functional Mobility Test, will be performed by each participating crewmember both before and after their mission (pre- and post-flight). The pre-flight data will be collected on or around six months, four months and 60 days before launch. Post-flight data will be collected on the day of landing and on post-landing days 1, 2, 4, 8, 12, 24 and 48.

Benefits

How quickly an astronaut's body readjusts to gravity after a long-duration spaceflight is very important, both for Space Station missions and for any future long-duration missions within our own solar system.

Researchers are continuing to search for the best exercise program that will keep astronauts fit while in space and ensure a quick return to their pre-flight physical conditions once they re-encounter the effects of Earth's gravity.

For more information on any Expedition 8 science experiment, visit the Web at:

www.scipoc.msfc.nasa.gov

http://spaceflight.nasa.gov/station/science/index.html

Experiments

Protein Crystal Growth (PCG) Single-locker Thermal Enclosure System (STES) Housing the Protein Crystallization Apparatus for Microgravity (PCAM)

Missions: The STES on orbit went up on 11A (STS-113) and will return on ULF1 (STS-114).
Experiment Location on ISS: U.S. Lab EXPRESS Rack No. 4
Project Manager: Clark Darty, NASA's Marshall Space Flight Center, Huntsville, Ala.

Overview

Structural biological experiments conducted in the Single-locker Thermal Enclosure System (STES) may provide a basis for understanding the function and structure of macromolecules. The scope of biological macromolecules includes proteins, polysaccharides and other carbohydrates, lipids and nucleic acids of biological origin, or those expressed in plant, animal, fungal or bacteria systems.

The fundamental goal for growing biological macromolecular crystals is to determine their three dimensional structure in order to understand the biological processes in which they are involved. Scientists select macromolecules, crystallize them, and analyze the atomic details -- often by using X-ray crystallography. By sending an intense X-ray beam through a crystal, scientists try to determine the three-dimensional atomic structure of the macromolecule. Understanding these structures may impact the studies of medicine, agriculture, the environment and other biosciences. Every chemical reaction essential to life depends on the function of these compounds.

Microgravity – the near weightlessness condition created inside a spacecraft as it orbits the Earth – offers an environment which sometimes allows the growth of macromolecular structures – crystals – that show greater detail when exposed to X-ray diffraction (the pattern showing the structure of crystals when exposed to X-ray beams) than those crystals grown on Earth.

The International Space Station provides for longer-duration experiments in a more research-friendly, acceleration-free (no change in the rate of speed, or velocity, of the spacecraft that could affect the experiments), dedicated laboratory, than provided by the Space Shuttle. Mission ULF-1 is a continuation of similar structural biology experiments to characterize the use of the Space Station for this type of research.

Flight History/Background

Mission	Year
STS-62	1994
STS-63	1995
STS-67	1995
STS-73	1995
STS-83	1997
STS-94	1997
STS-85	1997
STS-95	1998
STS-101	2000
STS-100 delivery to ISS; returned on STS-104	2001
STS-108 delivery to ISS; returned STS-110	2001, 2002
STS-111 delivery to ISS; returned STS-112	2002
STS-112 delivery to ISS; returned STS-113	2002

Benefits

With science being performed on the International Space Station, scientists are no longer restricted to relatively short-duration flights to conduct structural biology experiments. This research will enable the more accurate mapping of the 3-dimensional structure of macromolecules. Once the structure of a particular macromolecule is known, it may become much easier to determine how these compounds function. Every chemical reaction essential to life depends on the function of these compounds.

Additional Information/Photos

Additional information on structural biology crystal growth in microgravity is available at:

http://crystal.nasa.gov
http://crystal.nasa.gov/technical/pcam.html
http://www.microgravity.nasa.gov/
http://www.scipoc.msfc.nasa.gov
http://www.spaceflight.nasa.gov
http://spaceresearch.nasa.gov/
http://mix.msfc.nasa.gov/ABSTRACTS/MSFC-9807368.html

Experiments

Pore Formation and Mobility Investigation (PFMI)

Mission: Begun on Expedition 5, ISS Flight UF2, STS-111 Space Shuttle Flight; samples will be returned on 12A.1 (STS-116).

Payload Location: Microgravity Science Glovebox inside U.S. Destiny Laboratory Module

Principal Investigator: Dr. Richard Grugel, NASA Marshall Space Flight Center, Huntsville, Ala.

Project Scientist: Dr. Martin Volz, NASA Marshall Space Flight Center

Project Manager: Linda B. Jeter, NASA Marshall Space Flight Center

Project Engineer: Paul Luz, NASA Marshall Space Flight Center

Payload Developer: NASA Marshall Space Flight Center

Overview

On Earth when scientists melt metals, bubbles that form in the molten material can rise to the surface, pop and disappear. In microgravity, in the near-weightless environment created as the International Space Station orbits the Earth, the lighter bubbles do not rise and disappear. Prior space experiments have shown that bubbles often become trapped in the final metal or crystal sample. In the solid, these bubbles, or porosity, are defects that diminish both the material's strength and usefulness.

The Pore Formation and Mobility Investigation will melt samples of a transparent modeling material, succinonitrile and succinonitrile water mixtures. Investigators will be able to observe how bubbles form in the samples and study their movements and interactions.

Benefits

This investigation gives scientists an opportunity to observe bubble dynamics in a sample being processed in a way similar to industrial methods. The intent of the experiment is to gain insights that will improve solidification processing in a microgravity environment. The generated data also may promote better understanding of processes on Earth.

For more information on this experiment, the Microgravity Science Glovebox and other Space Station investigations visit:

www.scipoc.msfc.nasa.gov

www.spaceflight.nasa.gov

http://www.microgravity.nasa.gov

http://www.spaceresearch.nasa.gov

Experiments

Renal Stone Risk During Spaceflight: Assessment and Countermeasure Validation

Principal Investigator: Dr. Peggy A. Whitson, Johnson Space Center, Houston

Overview

Exposure to microgravity results in a number of physiological changes in the human body, including alterations in kidney function, fluid redistribution, bone loss and muscle atrophy. Previous data have shown that human exposure to microgravity increases the risk of kidney stone development during and immediately after spaceflight. Expeditions 3-6 and 8-12 will test the efficacy of potassium citrate, a proven Earth-based therapy to minimize calcium-containing kidney stone development, in decreasing the chance of kidney stone formation during long-duration spaceflights. This study also will assess the kidney stone-forming potential in humans based on mission duration, and determine how long after spaceflight the increased risk exists.

Beginning three days before launch and continuing through 14 days after landing, each crewmember will either ingest two potassium citrate pills or two placebos daily with the last meal of the day. Urine will be collected for later study over several 24-hour periods before, during and after flight. Food, fluid, exercise and medications also will be monitored before and during the urine collection period to assess any environmental influences other than microgravity.

Benefits

The formation of kidney stones could have severe health consequences for ISS crewmembers and negatively impact the success of a mission. This study will provide a better understanding of the risk factors associated with kidney stone development both during and after a spaceflight, as well as test the effectiveness of potassium citrate as a countermeasure to reduce this risk. Understanding how the disease may form in otherwise healthy crewmembers under varying environmental conditions also may provide insight into kidney stone-forming diseases on Earth.

For more information on Expedition 8 science experiments, visit the Web at:

scipoc.msfc.nasa.gov

http://spaceflight.nasa.gov/station/science/index.html

Experiments

Sub-regional Assessment of Bone Loss in the Axial Skeleton in Long-term Spaceflight (Sub-regional Bone)

Principal Investigator: Dr. Thomas F. Lang, U. of California, San Francisco
Project Manager: David K. Baumann, NASA Johnson Space Center

Overview

As demonstrated by Skylab and Russian space station Mir missions, bone loss is an established medical risk factor for long-duration space missions. There is little information about the extent to which lost bone is recovered after spaceflight. This experiment is designed to measure bone loss and recovery experienced by crewmembers on the ISS.

Expeditions 2 thru 8 are scheduled to participate in this study.

Experiment Operations

Bone loss in the spine and hip will be determined by comparing pre-flight and post-flight measurements of crewmembers' spine and hipbones using Quantitative Computed Tomography -- a three-dimensional technique that examines the inner and outer portions of a bone separately. It can determine if the loss was localized in a small sub-region of the bone or over a larger area.

Bone recovery will be assessed by comparing tomography data taken before and after flight and one year later. Results will be compared with ultrasound measurements and dual x-ray absorptiometry (DXA) taken at the same time points. The measurements will include DXA of the spine, hip and heel, and ultrasound of the heel. To determine how the bone loss in space compares to the range of bone density in a normal adult population, crewmember bone measurements in the spine and hip will be compared to measurements of 120 healthy people of different genders and races between ages 35 and 45.

Benefits

This study will provide the first detailed information on the distribution of spaceflight-related bone loss between the trabecular and cortical compartments of the axial skeleton, as well as the extent to which lost bone is recovered in the year following return. The study will provide information that could be used in determining the frequency of crewmember assignments to long-duration missions, and for studying their health in older age. It also may be of use in the design of exercise or pharmacological countermeasures to prevent bone loss. Finally, comparison of bone mineral density in the hip and spine in the control population will help to improve understanding of the prevalence of osteoporosis between different race and gender subgroups.

Experiments

Synchronized Position, Hold, Engage, Reorient Experiment in Space Beacon-to-Beacon Test (SPHERES BBT)

Principal Investigator: David Miller, Ph.D., Harvard University, Cambridge, Mass.

Overview

The Synchronized Position, Hold, Engage, Reorient Experiment in Space (SPHERES) experiment will be used to develop the software needed to control multiple spacecraft flying close together and to test formation flying in microgravity. The experiment will serve as an International Space Station-based test bed for the development and testing of formation flying and other multi-spacecraft control algorithms.

SPHERES consists of three self-contained, bowling ball-sized "satellites" or free-flyers, which perform the various algorithms. Each satellite is self-contained with power (AA batteries), propulsion (CO_2 gas), computers and navigation equipment. As the satellites fly through the Station, they will communicate with each other and an ISS laptop via a low-power, 900 MHz wireless link.

Flight History/Background

The MIT Space Systems Laboratory is developing the SPHERES formation flight testbed to provide the Air Force and NASA with a long-term, replenishable, and upgradeable testbed for the validation of high-risk metrology, control and autonomy technologies. The technologies are critical to the operation of distributed satellite and docking missions such as TechSat21, Starlight, Terrestrial Planet Finder, and Orbital Express.

This experiment is being flown for the first time. Expeditions 8 and 9 are scheduled to work with this experiment.

Benefits

Developing autonomous formation flight and docking control algorithms is an important step in making many future space missions possible. The ability to autonomously coordinate and synchronize multiple spacecraft in tightly controlled spatial configurations enables a variety of new and innovative mission operations concepts.

For more information on SPHERES visit:

http://ssl.mit.edu/spheres/

http://ssl.mit.edu/spheres/library.html

Media Assistance

NASA Television Transmission

NASA Television is available through the AMC-9 satellite system which is located on Transponder 9C, at 85 degrees west longitude, frequency 3880.0 MHz, audio 6.8 MHz.

The schedule for television transmissions from the orbiter and for mission briefings will be available during the mission at Kennedy Space Center, Fla.; Marshall Space Flight Center, Huntsville, Ala.; Dryden Flight Research Center, Edwards, Calif.; Johnson Space Center, Houston, Texas; and NASA Headquarters, Washington, DC. The television schedule will be updated to reflect changes dictated by mission operations.

Status Reports

Status reports on countdown and mission progress, on-orbit activities and landing operations will be produced by the appropriate NASA news center.

Briefings

A mission press briefing schedule will be issued before launch. During the mission, status briefings by a flight director or mission operations representative and when appropriate, representatives from the payload team, will occur at least once each day. The updated NASA television schedule will indicate when mission briefings are planned.

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

Shuttle Pre-Launch Status Reports

http://www-pao.ksc.nasa.gov/kscpao/status/stsstat/current.htm

Information on other current NASA activities is available through the Today@NASA page:

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

The NASA TV schedule is available from the NTV Home Page:

http://spaceflight.nasa.gov/realdata/nasatv/schedule.html

Resources for educators can be found at the following address:

http://education.nasa.gov

Access by CompuServe

Users with CompuServe accounts can access NASA press releases by typing "GO NASA" (no quotes) and making a selection from the categories offered.

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