EXPEDITION 9:
THE JOURNEY CONTINUES

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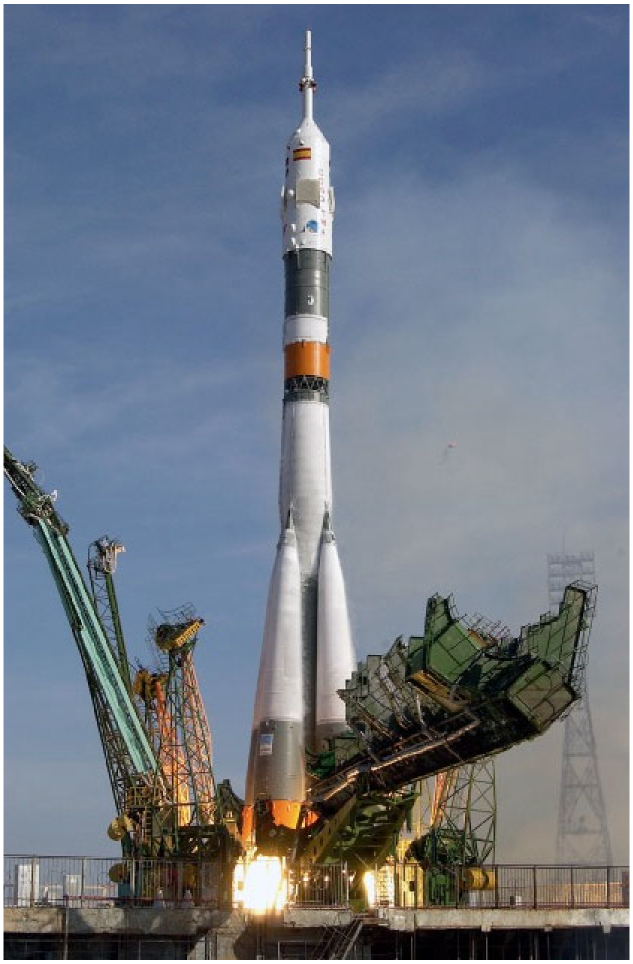
Overview

Expedition 9: The Journey Continues

The next crew to live and work aboard the International Space Station is scheduled to launch at 10:19 p.m. CT April 18 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 Station since October.

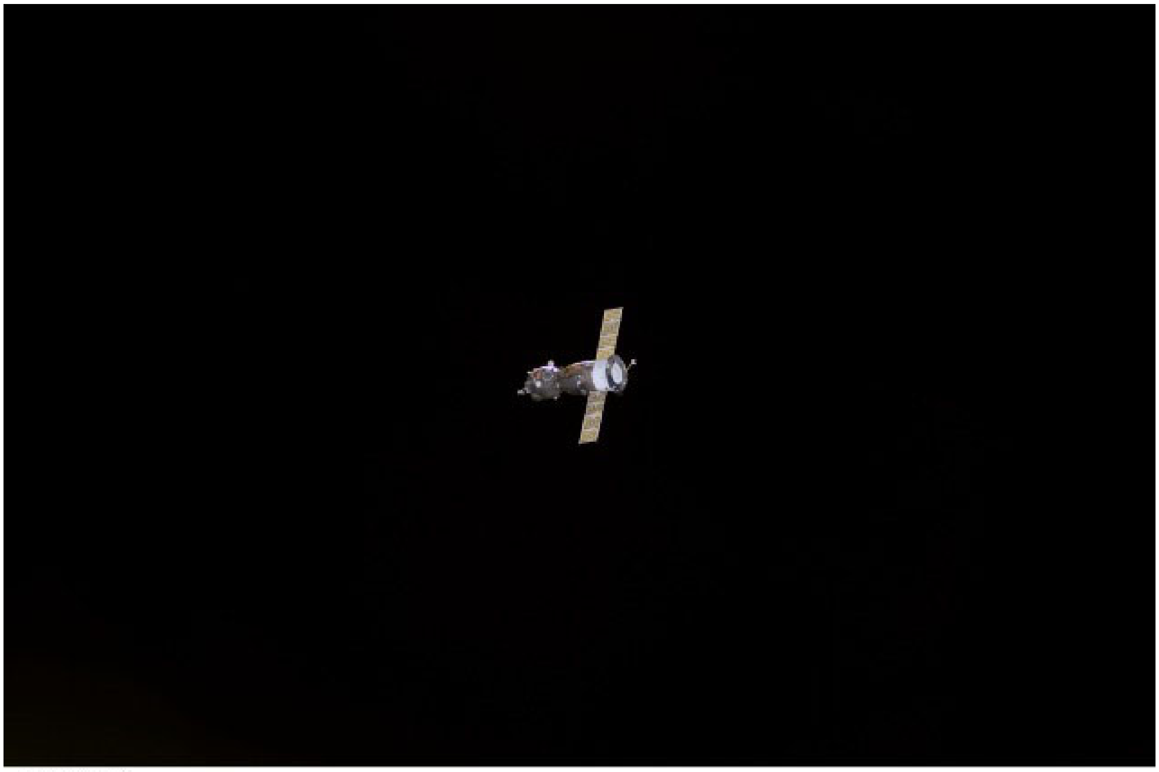


Russian Commander Gennady Padalka (Guh-NAH'-dee Puh-DAHL'-kah) (Col., Russian Air Force), 45, and Flight Engineer and NASA ISS Science Officer Edward "Mike" Fincke (Fink), 37, an Air Force lieutenant colonel, will launch on the ISS Soyuz 8 spacecraft for a two-day flight to dock to the nadir port of the Zarya Control Module on the ISS. Docking is scheduled for midnight CT April 21. Hatch opening is scheduled for 1:25 a.m. CT April 21.

The Expedition 9 crewmembers and European Space Agency (ESA) Soyuz crewmember Andre Kuipers (right) of the Netherlands, wearing Russian Sokol suits, take a break from training to pose for a portrait at the Gagarin Cosmonaut Training Center, Star City, Russia. From the left are astronaut Edward M. (Mike) Fincke, NASA ISS science officer and flight engineer, and cosmonaut Gennady I. Padalka, commander representing the Federal Space Agency.

Padalka and Fincke will be joined aboard the Soyuz by European Space Agency astronaut Andre Kuipers (KOY'-pers) of the Netherlands, 45, who will spend nine days aboard the ISS performing scientific experiments under a commercial contract between ESA and the Federal Space Agency (of Russia). Kuipers will return to Earth on April 30 with Expedition 8 Commander and NASA Science Officer Michael Foale (Fohl) and Flight Engineer Alexander Kaleri (Kuh-LAIR'-ee), who have been aboard the Station since October. They will land in Kazakhstan in the ISS Soyuz 7 capsule, which is docked to the Pirs Docking Compartment.

Once on board, Padalka and Fincke will conduct more than a week of handover activities with Foale and Kaleri familiarizing themselves with Station systems and procedures. They will also receive proficiency training on the Canadarm2 robotic arm from Foale and will engage in safety briefings with the off-going Expedition 8 crew as well as payload and scientific equipment training.



Backdropped by the blackness of space, the Soyuz spacecraft departs from the International Space Station.

Padalka and Fincke will assume formal control of the Station at the time of hatch closure (scheduled for 12:34 p.m. CT April 29) before the Expedition 8 crew and Kuipers undock the Soyuz 7 craft from Pirs. Undocking is scheduled for 3:46 p.m. CT April 29. With Kaleri at the controls of Soyuz, he, Foale and Kuipers will land in the steppes of north Kazakhstan to wrap up more than six months in orbit. Kuipers' mission will span 11 days. Landing is scheduled for 7:09 p.m. CT April 29.

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

Padalka (right) and Fincke (left) are expected to spend more than 180 days aboard the ISS. Padalka, a veteran cosmonaut, is making his second flight into space, having accumulated 198 days in orbit on a previous mission on the Mir Space Station from August 1998 to February 1999. Padalka is also a veteran of two spacewalks.

Fincke is making his first flight into space after spending several years in training in Russia while helping to develop Station crew procedures.

Kuipers is also making his first flight into space.

American and Russian planners are developing plans for two spacewalks Padalka and Fincke would conduct during their mission to continue the external outfitting of the Zvezda Service Module and to install cameras, communications gear and navigational aids to Zvezda for next year's arrival of the European Space Agency's unpiloted Automated Transfer Vehicle, a cargo ship similar to the Russian Progress vehicle.

Padalka and Fincke will wear Russian Orlan spacesuits to conduct the spacewalks out of the Pirs Docking Compartment airlock.

Once the Expedition 8 crew has departed, the Expedition 9 crew will settle down to work.

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

Astronaut Edward Michael (Mike) Fincke, Expedition 9 NASA ISS science officer and flight engineer, participates in an EXPRESS Physics Colloids in Space (EXPPCS) payload training session in the International Space Station Destiny laboratory mockup/trainer in the Space Vehicle Mockup Facility at the Johnson Space Center.

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 is also used to study 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. U.S., Russian and Partner experiments and hardware on board the ISS could use 300 hours of crew time, which will be prioritized and scheduled as time permits surrounding the spacewalks, Progress dockings, medical operations and system maintenance activities.

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. In addition, some Expedition 8 science activities will be continued. Many of the Expedition 9 Russian science experiments were delivered on the ISS Progress 13 resupply vehicle, which docked to the International Space Station in late January.

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An unpiloted Progress supply vehicle approaches the International Space Station.

During more than six months aloft, Padalka and Fincke will monitor the arrival of two Russian Progress resupply cargo ships filled with food, fuel, water and supplies. They will also upgrade the software in the on-board Station computers. Progress 14 is scheduled to reach the ISS in late May, and Progress 15 is earmarked to fly to the ISS at the end of July. The Progress craft will link up 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 9 Crew

Soyuz and ISS Commander: Gennady Padalka

Cosmonaut Gennady Padalka will serve as the Soyuz and Space Station commander for Expedition 9. He is a veteran of long-duration spaceflight as a resident aboard the Russian space station Mir.

Padalka logged 198 days in space while serving as commander of the Mir 26 mission, the third to last crew to live aboard Mir. During his mission Padalka conducted two spacewalks with crewmate Sergei Avdeyev. His first spacewalk, to repair cabling inside the depressurized Spektr module for solar array articulation, lasted 30 minutes. The second lasted 5 hours, 54 minutes and involved installing tools on the exterior of Mir and deploying a small science satellite.

Padalka was born in Krasnodar, Russia. He graduated from Eisk Military Aviation College in 1979 and then served as a pilot and a senior pilot in the Russian Air Force. In 1989 he was selected as a cosmonaut candidate and began training at the Gagarin Cosmonaut Training Center.

He was classified as a test cosmonaut in 1991 and trained as the commander for the backup crew to the Mir 25 mission that flew in 1997. Next, he trained as the prime crew for the Mir 26 mission, which flew Aug. 13, 1998, to Feb. 28, 1999.

Padalka trained as a backup crewmember for ISS Expedition 4 and was first assigned to the ISS Expedition 9 prime crew in March 2002. After the Columbia accident, Station crew size was reduced from three to two, and expedition crew assignments were adjusted accordingly. In early February 2004, in an effort to keep crews together that had trained for years, Padalka was reassigned to Expedition 9 with Michael Fincke.

ISS Flight Engineer and NASA Space Station Science Officer: Michael Fincke

Astronaut Mike Fincke will serve as flight engineer and NASA Space Station science officer on the Expedition 9 crew. Fincke, a U.S. Air Force lieutenant colonel, will be making his first spaceflight. He has trained as a backup Station crewmember for two previous missions, Expeditions 4 and 6.

Fincke was born March 14, 1967, in Pittsburgh, but considers Emsworth, Pa., his hometown. He graduated from Sewickley Academy, Sewickley, Pa., in 1985 and then attended the Massachusetts Institute of Technology on an Air Force ROTC scholarship. He graduated in 1989 with a bachelor of science in aeronautics and astronautics and another bachelor of science in Earth, atmospheric and planetary sciences.

After graduation, Fincke participated in a summer exchange program with the Moscow Aviation Institute in the former Soviet Union, where he studied cosmonautics. Next he attended Stanford University and received a master of science in aeronautics and astronautics in 1990.

Fincke entered the U.S. Air Force in 1990 and was assigned to the Air Force Space and Missiles Systems Center, Los Angeles Air Force Base, Calif. There he served as a space systems engineer and a space test engineer. In 1994, upon completion of the U.S. Air Force Test Pilot School, Edwards Air Force Base, Calif., Fincke joined the 39th Flight Test Squadron, Eglin Air Force Base, Fla., where he served as a flight test engineer working on a variety of flight test programs, flying the F-16 and F-15 aircraft. In January 1996, he reported to the Gifu Test Center, Gifu Air Base, Japan, where he was the U.S. flight test liaison to the Japanese/United States XF-2 fighter program.

In 1996 Fincke was selected as an astronaut candidate at NASA. After two years of introductory training at Johnson Space Center he was assigned to technical duties in the Astronaut Office Station Operations Branch. His duties included acting as an ISS capcom, or spacecraft communicator, and participating in the Crew Test Support Team in Russia as the ISS crew procedures team lead.

Beginning in 1999, Fincke trained as a backup crewmember for Expedition 4 and then 6. He received a second master of science in physical sciences (planetary geology) from the University of Houston-Clear Lake in 2001. He was first assigned to the Expedition 9 prime crew in March 2002. After the Columbia accident, Station crew size was reduced from three to two, and Expedition crew assignments were readjusted accordingly. In early February 2004, in an effort to keep crews together that had trained for years, Fincke was reassigned to Expedition 9 with Gennady Padalka.

European Space Agency Astronaut and Flight Engineer: André Kuipers

European Space Agency astronaut André Kuipers was born on Oct. 5, 1958, in Amsterdam, Netherlands. He graduated from Van der Waals Lyceum (now Amstel Lyceum), Amsterdam, in 1977. He received a medical doctorate from the University of Amsterdam in 1987.

Since 1991, Kuipers has been involved in the preparation, coordination, baseline data collection and ground control of physiological experiments developed by the European Space Agency for space missions. In particular, he was a project scientist for Anthrorack, a human physiology facility that flew on the D-2 Spacelab mission in 1993, and for two payloads, for lung and bone physiology, that flew on board the Mir space station during the six-month Euromir 95 mission.

In July 1999, Kuipers joined the European Astronaut Corps of the European Space Agency, whose home base is at the European Astronaut Center (EAC) in Cologne, Germany.

In 2002, Kuipers completed ESA's basic training program, performed at the EAC and at the Yuri A. Gagarin Cosmonaut Training Centre in Star City near Moscow. Basic training includes lessons in science and technology, as well as the systems on board the International Space Station, winter and water survival training and extravehicular activity, or spacewalk, training.

As crew interface coordinator during the recent Belgian Soyuz flight "Odissea," which included Belgian ESA astronaut Frank De Winne, Kuipers supported ESA's ground team in the Russian Control Center. He will fulfill this role during the Spanish Soyuz mission as well.

In December 2002, Kuipers was assigned as a flight engineer for a Soyuz flight to the International Space Station. Kuipers will fly to the ISS in the framework of the Dutch Soyuz mission DELTA. DELTA stands for Dutch Expedition for Life Science, Technology and Atmospheric Research. He had trained as backup of Pedro Duque for the Soyuz 7S mission to the International Space Station.

Mission Objectives

Flight 8S Tasks (In Descending Prioritized Order)

These tasks, listed in order of International Space Station Program priority, are to be executed during this flight. The order of execution for these tasks in the nominal plan may vary, depending on timeline efficiencies.

1. Dock Flight ISS Soyuz 8 to the nadir port of Zarya.
2. Rotate Expedition 8 crew with Expedition 9 crew, transfer mandatory crew rotation cargo, and perform mandatory tasks consisting of the safety briefing for all crewmembers.
3. Transfer visiting crew’s FE-1 cargo including Sokol suit, and transfer and install Individual Equipment Liner Kit (IELK) in Soyuz 7.
4. Perform minimum crew handover of 12 hours per crewmember.
5. Transfer critical items.
6. Undock Soyuz 7 from Docking Compartment (DC)-1 nadir port.
7. Perform daily oxygen monitoring.
8. Perform weekly carbon dioxide monitoring.
9. Return critical equipment and environmental samples on the Soyuz 7 transport.
10. Perform U.S./Russian payload operations on the ISS.
11. Conduct visiting crew operations.

The following activities are Soyuz 8 visiting crew activities (not listed in priority order) and support from ISS crewmembers will be on a non-interference basis:

A. Conduct photo/video imagery.
B. Conduct utilization activities.
C. Conduct public affairs activities and commemorative activities.

D. Conduct transfer activities.

1) Soyuz unloading
2) Equipment return

E. Conduct communications.

1) Russian Mission Control Center (Soyuz and ISS)
2) Sessions using the Sputnik-Service Module (SM) ham radio

F. Conduct Soyuz systems maintenance.

G. Conduct Soyuz handover.

H. Conduct crew life support activities onboard the ISS.

12. Install local signal commutator and Read Only Memory (ROM) into Soyuz 8.

13. Remove local signal commutator and ROM from Soyuz 7.

14. Perform an additional four hours per crewmember of ISS crew handover (16 hours per crewmember total).

15. Perform Internal Thermal Control System Sampling.

16. Perform photo/video imagery on the Russian Segment.

17. Transfer remaining items.

18. Install Radiation Area Monitors (RAMs).

19. Perform PAO events and commemorative activities.

Flight 7 Soyuz Undock To 14 Progress-M Dock (Stage 8S) Requirements

The following are requirements from Soyuz 7 undock through Flight 14 Progress-M dock.

Tasks (in descending prioritized order):

These tasks, listed in order of ISS Program priority, are to be executed during this stage. The order of execution for these tasks in the nominal plan may vary, depending on timeline efficiencies.

1. Perform U.S./Russian maintenance activities for those systems with no redundancy.

2. Complete 13 Progress-M1 loading of trash and undock from Service Module aft port.

3. Perform high priority U.S./Russian medical operations (average of eight crew hours/week).

4. Perform daily oxygen monitoring.

5. Perform weekly carbon dioxide monitoring.

6. Remove local signal commutator and ROM from 13 Progress-M1 before undock.

7. Perform high priority On-Board Training (average of two and quarter crew hours/week).

8. Perform high priority U.S./Russian payload operations (average of 9 hours per week).

    A. Mandatory daily maintenance for powered payloads.

    B. Daily scheduled payload operations and data capture.

9. Perform high priority Public Affairs Office activities (average of one and quarter crew hours/week).

10. Perform U.S. /Russian maintenance activities for those systems with redundancy.

11. Perform medium priority U.S./Russian payloads operations.

12. Perform low priority U.S./Russian medical operations (average of one crew hour/week).

13. Perform low priority On-Board Training. (average of 0.75 of crew hours/week).

14. Perform low priority Public Affairs Office activities (average of 1.75 crew hours/week).

15. Perform software transition of EXT R3 to EXT R4.

16. Perform software transition of SO R1 to SO R2.

17. Perform remaining maintenance.

18. Perform remaining U.S./Russian payload operations.

19. Perform remaining Mobile Servicing System (MSS) Start-of-Life On-orbit Checkout Requirements (OCRs).

20. Reboost ISS with Progress as required.

Flight 14 Progress-M Dock To Flight 15 Progress-M Dock (Stage 14P) Requirements

These requirements are applicable from Flight 14 Progress-M dock through Flight 15 Progress-M dock.

Tasks (In Descending Prioritized Order):

These tasks, listed in order of ISS Program priority, are to be executed during this stage. The order of execution for these tasks in the nominal plan may vary, depending on timeline efficiencies.

1. Perform U.S./Russian maintenance activities for those systems with no redundancy.

   A. Treadmill with Vibration Isolation and Stabilization roller bearing maintenance.

2. Dock 14 Progress-M to Service Module aft port and perform cargo/propellant/water transfer.

3. Complete 14 Progress-M loading of trash and undock from Service Module aft port.

4. Perform high priority U.S./Russian medical operations (average of eight crew hours/week).

5. Perform daily oxygen monitoring.

6. Perform weekly carbon dioxide monitoring.

7. Perform Expedition Crew Station Support Computer (SSC) software loads.

8. Perform Russian Extravehicular Activity No. 10. EVA tasks include:

   A. Installation of protection components on the circular handrail brackets of the Pirs Docking Compartment (DC)-1 EVA hatch

   B. Install flexible handrails on the DC-1

   C. Photograph and remove tray #2, install and photograph tray #3 with the exposed samples for the Kromka experiment

D. Photograph and remove the removable cassette container on the SM, install and photograph the new removable cassette container in the old one's place (if time is available)

E. Remove the Platan-M detection unit (if time is available)

F. Automated Transfer Vehicle-related operations:

1) Install backup TV camera
2) Removal of laser retro reflectors Nos. 1, 2, 4, 5, and 6 from the SM assemble compartment
3) Install external videometer targets (three modified laser retro reflectors) and an internal videometer target
4) Install the transport and installation device for the space-to-space radio link and perform routing of cables for their connection using cable fasteners.

9. Perform U.S. tool preparations to support Russian EVAs.

10. Perform high priority On-Board Training (OBT) (average of 2.25 crew hours/week).

11. Perform high priority U.S./Russian payload operations (average of nine hours per week).

    A. Mandatory daily maintenance for powered payloads.
    B. Daily scheduled payload operations and data capture.

12. Perform high priority PAO activities (average of 1.25 crew hours/week).

13. Install local signal commutator and ROM into 14 Progress-M.

14. Remove local signal commutator and ROM from 14 Progress-M.

15. Perform U.S./Russian maintenance activities for those systems with redundancy.

16. Perform EMU E9 sizing hardware inventory.

17. Perform medium priority U.S./Russian payloads operations.

18. Perform low priority U.S./Russian medical operations (average of 1 crew hour/week).

19. Perform low priority On-Board Training (OBT) (average of 0.75 crew hours/week).

20. Perform low priority PAO activities (average of 1.75 crew hours/week).

21. Perform software transition of ePCS 5A to ePCS R2.

22. Perform RS resupply activities including the following:

    A. Install IMU sensors in SM and FGB

    B. Install vibration isolators on the fans.

    C. Perform software transition of SM 7.01 to SM 7.02

    D. Perform the following IVA tasks to augment SM for the ATV proximity operations.

        (1) Test installation of navigation receiver module (НПМ) of the standalone satellite navigation equipment (ACH-M), with mating of connectors to the network and Laptop.

23. Perform Internal Wireless Instrumentation System Accelerometer removal from Service Module and relocate sensor to lab.

24. Perform remaining maintenance.

25. Perform remaining U.S./Russian payload operations.

26. Perform remaining Mobile Servicing System (MSS) Start-of-Life On-orbit Checkout Requirements (OCRs).

27. Reboost ISS with Progress as required.

FLIGHT 15 PROGRESS-M DOCK TO FLIGHT SOYUZ 9 DOCK (STAGE 15P) REQUIREMENTS

This section identifies requirements applicable from Flight 15 Progress-M dock through Flight Soyuz 9 docking.

TASKS (IN DESCENDING PRIORITIZED ORDER)

These tasks, listed in order of ISS Program priority, are to be executed during this stage. The order of execution for these tasks in the nominal plan may vary, depending on timeline efficiencies.

1. Perform U.S./Russian maintenance activities for those systems with no redundancy.

2. Dock 15 Progress-M to SM aft port and perform cargo/propellant/water transfer.

3. Perform high priority U.S./Russian medical operations (average of eight crew hours/week).

4. Install local signal commutator and ROM into 15 Progress-M.

5. Perform ISS handover preparation.

6. Perform training and preparation for Soyuz 9 arrival.

7. Perform Russian EVA No. 11 (not listed in priority order):

    A. Installation of protection components on the circular handrail brackets of the DC-1 EVA hatch 2 (if time permits)
    B. Replace the replaceable panel of the Zarya coolant flow control valve
    C. Install four fairleads on the Zarya handrails
    D. Install pressure and particulate contamination monitoring unit
    E. ATV-related operations:
        (1) Install the transport and installation device for the air-to-air radio link, with routing of cables for their connection using cable fasteners (if time permits).
    F. Perform panoramic imagery, from the "face" and rear side of panel 3 of the MPAC and SEED hardware (if time permits)

8. Perform high priority On-Board Training. (average of two and quarter crew hours/week)

9. Perform high priority U.S./Russian payload operations (average of nine hours per week).

    A. Mandatory daily maintenance for powered payloads.
    B. Daily scheduled payload operations and data capture.

10. Perform high priority Public Affair Office activities (average of one and quarter crew hours/week).

11. Perform midterm full checkout of the Extravehicular Mobility Unit (1) hardware.

12. Perform Station Development Test Objective, Russian Vehicle Docking/Undocking Loads, for 9-Soyuz docking to DC-1.

13. Perform U.S./Russian maintenance activities for those systems with redundancy.

14. Perform resupply activities including the following:

    A. Install the cable inserts in the manual velocity control unit (БРУС).

    B. Install containers in the FGB cargo storage areas

    C. Install СУБК equipment to support the Rokviss science experiment.

    D. Installation of a soundproofing casing to system " Air ".

    E. Perform the following IVA tasks to augment SM for the ATV proximity operations.

        (1) Install equipment (ATV control panel (ПУ), ATV ПУ support structure, cables with electrical connectors) to support monitoring and control of ATV rendezvous and docking operations using the ATV control panel. This equipment is to be removed after testing.

        (2) Replace TV color display (ИТЦ) with the liquid crystal display (ИТ-ЖК).

        (3) Install the МБРЛ system equipment (PCE monoblock, cables) to be removed after testing.

        (4) Install МБРЛ АФУ equipment (БУАП, БКТ, cables) with the БУАП to be removed and the hook-up to be disassembled after testing.

15. Perform medium priority U.S./Russian payloads operations.

16. Perform Space Integrated Global Positioning System/ Inertial Navigation System firmware upgrade.

17. Perform low priority U.S./Russian medical operations (average of 1 crew hour/week).

18. Perform low priority On-Board Training (OBT) (average of 0.75 crew hours/week).

19. Perform low priority Public Affair Office activities (average of 1.75 crew hours/week).

20. Perform remaining maintenance.

21. Perform remaining U.S./Russian payload operations.

22. Perform remaining Mobile Servicing System (MSS) Start-of-Life On-orbit Checkout Requirements (OCRs).

23. Reboost ISS with Progress as required.

Spacewalks

Two spacewalks are planned during Expedition 9 by Commander Gennady Padalka and Flight Engineer and NASA International Space Station Science Officer Mike Fincke. The first is tentatively scheduled on July 22, the other is tentatively scheduled on Aug. 25. The spacewalks are designed to continue the external outfitting of the Zvezda Service Module and to install cameras, communications gear and navigational aids to Zvezda for next year's arrival of the European Space Agency's unpiloted Automated Transfer Vehicle (ATV).

The following activities are to be accomplished during the Expedition 9 spacewalks:

Russian Extravehicular Activity No. 10 (July 22):

- Install handrail limiters on stand-offs of the Pirs Docking Compartment (DC)-1 ring handrails (EVA hatch 1)
- Install flexible handrails on the DC-1
- Inspect and take imagery of DC-1 (if on timeline)
- Remove Kromka panel No. 2; install Kromka panel No. 3
- Perform ATV support operations:
  - Install backup TV camera
  - Remove laser retro reflectors Nos. 1, 2, 3, 4, 5 and 6 from the Service Module assembly compartment
  - Install three updated laser retro reflectors and one internal videometer target
  - Install equipment for the air-to-air radio link antennas and perform routing of cables for their connection using cable fasteners

Russian Extravehicular Activity No. 11 (Aug. 25):

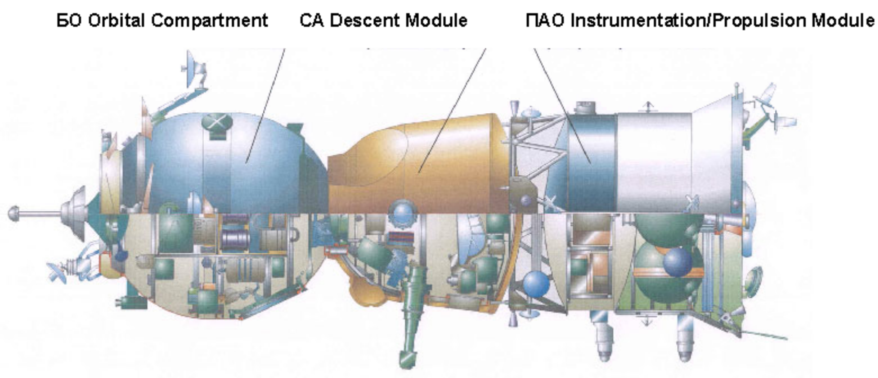
- Replace the Zarya flow control panel
- Install four safety tether fairleads on Zarya's handrails
- Perform ATV support operations:
  - Install equipment for the air-to-air radio link antennas, with routing of cables for their connection using cable fasteners
  - Remove all covers from antennas

- Install Pressure Control and Exposure Monitor Sensor on DC-1
- Install protective components on the brackets of the DC-1 ring handrails (EVA hatch No. 2) (if on timeline)

Padalka made two spacewalks during his other mission on the Russian Mir Space Station. The spacewalks will be the first for Fincke.

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

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

Instrumentation/Propulsion Module

This module contains three compartments: Intermediate, Instrumentation and Propulsion.

The intermediate compartment is where the module connects to the Descent Module. It also contains oxygen storage tanks and the attitude control thrusters, as well as electronics, communications and control equipment. The primary guidance, navigation, control and computer systems of the Soyuz are in the instrumentation compartment, which is a sealed container filled with circulating nitrogen gas to cool the avionics equipment. The propulsion compartment contains the primary thermal control system and the Soyuz radiator, 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. All the new components in the Soyuz TMA can spend up to one year in space.

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

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

Soyuz Launcher

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

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 complete, 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 and 46 degrees north latitude and 63 degrees east longitude. Two launch pads are dedicated to Soyuz missions.

Final Launch Preparations

The assembled launch vehicle is moved to the launch pad on a horizontal 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

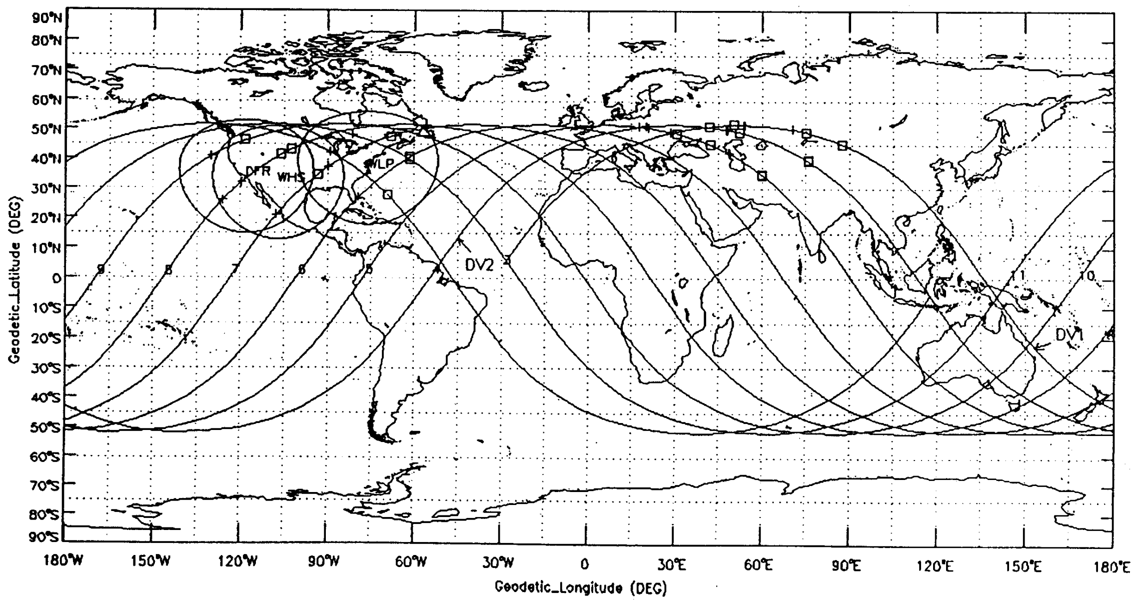
FLIGHT DAY 1 OVERVIEW	
Orbit 1	**Post insertion: Deployment of solar panels, antennas and docking probe**
	- Crew monitors all deployments
	- Crew reports on pressurization of OMS/RCS and ECLSS systems and crew health. Entry thermal sensors are manually deactivated
	- Ground provides initial orbital 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 8 / ESA Soyuz 7 Landing

For the third time in history, an American astronaut will return to Earth from orbit in a Russian Soyuz capsule. With Russian Soyuz Commander Alexander Kaleri at the controls of the Soyuz 7 craft currently docked at the International Space Station's Pirs Docking Compartment, Expedition 8 Commander and NASA ISS Science Officer Mike Foale, Kaleri and European Space Agency Soyuz astronaut Andre Kuipers of the Netherlands will touch down in the steppes of north Kazakhstan to complete their mission. Foale and Kaleri will be wrapping up almost 200 days in orbit, while Kuipers will return after a brief 11-day flight under a commercial contract between ESA and the Federal Space Agency (of Russia).

The grounding of the Space Shuttle fleet following the Columbia accident on Feb.1, 2003, required that the Expedition 8 crew land in a Soyuz capsule, as did the Expedition 6 and 7 crews in May and October 2003. The Soyuz always provides an assured crew return capability for residents aboard the ISS.

A year ago, as Expedition 6 Commander Ken Bowersox, Soyuz Commander Nikolai Budarin and NASA ISS Science Officer Don Pettit re-entered the atmosphere in their ISS Soyuz 5 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.

Russian engineers solved the problem and last October's landing by Expedition 7 Commander Yuri Malenchenko, NASA Flight Engineer Ed Lu and European Space Agency astronaut Pedro Duque was on target. As a precaution, however, the departing Expedition 8/ESA 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.

Additionally, the Soyuz 7 capsule that carried Foale, Kaleri and Duque into orbit on Oct. 18 was outfitted with an electronic safeguard that will prevent the problem from happening again. That same fix is being incorporated in all future Soyuz vehicles.

About three hours before undocking, Foale, Kaleri and Kuipers will bid farewell to the new Expedition 9 crew, Commander Gennady Padalka and Flight Engineer Mike Fincke. The departing crew will climb into the Soyuz vehicle, closing the hatch between Soyuz and Pirs. Kuipers will be seated in the Soyuz' left seat and will be the flight engineer for entry and landing. Kaleri will be in the center commander's seat, and Foale will occupy the right seat.

After activating Soyuz systems and getting approval from Russian flight controllers at the Russian Mission Control Center outside Moscow, Kaleri will send commands to open hooks and latches between Soyuz and Pirs which held the craft together since the Soyuz' arrival last year on Oct. 20.

Kaleri will fire the Soyuz thrusters to back away from Pirs, and six minutes after undocking and 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 move away from 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 4 ½ 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 three minutes after module separation.

About eight 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 before 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 1,000 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 Kaleri 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 a U.S. flight surgeon 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 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 a recovery staging site in Kazakhstan. 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 about seven hours between landing and return to Star City.

Assisted by a team of flight surgeons, the crew will undergo more than two weeks of medical tests and physical rehabilitation before Foale and Kaleri return to the U.S. for additional debriefings and follow-up exams. Kuipers' acclimation to Earth's gravity will be quicker because his flight was relatively short.

Key Times for Expedition 9/8 International Space Station Events

Expedition 9 / ESA Soyuz Crewmember Launch on 8 Soyuz:

April 18 at 10:19 p.m. CT, 319 GMT on April 19, 7:19 a.m. Moscow time on April 19, 9:19 a.m. Baikonur time on April 19 (rounded off from the exact launch time of 3:18:47 GMT).

Expedition 9 / ESA Soyuz Crewmember Docking to ISS:

April 21 at midnight CT, 500 GMT on April 21, 9 a.m. Moscow time on April 21.

Expedition 9 / ESA Soyuz Crewmember Hatch Opening to ISS:

April 21 at 1:25 a.m. CT, 625 GMT, 10:25 a.m. Moscow time.

Expedition 8 / ESA Soyuz Crewmember Hatch Closing:

April 29 at 12:36 p.m. CT, 1736 GMT on April 29, 2136 p.m. Moscow time on April 29, 12:36 a.m. Astana Time on April 30.

Expedition 8 / ESA Soyuz Crewmember Undocking from ISS:

April 29 at 3:46 p.m. CT, 2046 GMT on April 29, 12:46 a.m. Moscow time on April 30, 3:46 a.m. Astana time on April 30.

Expedition 8 / ESA Soyuz Crewmember Deorbit Burn:

April 29 at 6:04 p.m. CT, 2304 GMT on April 29, 3:04 a.m. Moscow time on April 30, 6:04 a.m. Astana time on April 30.

Expedition 8 / ESA Soyuz Crewmember Landing:

April 29 at 6:58 p.m. CT, 2358 GMT on April 29, 3:58a.m. Moscow time on April 30, 6:58 a.m. Astana time on April 30.

Soyuz Entry Timeline

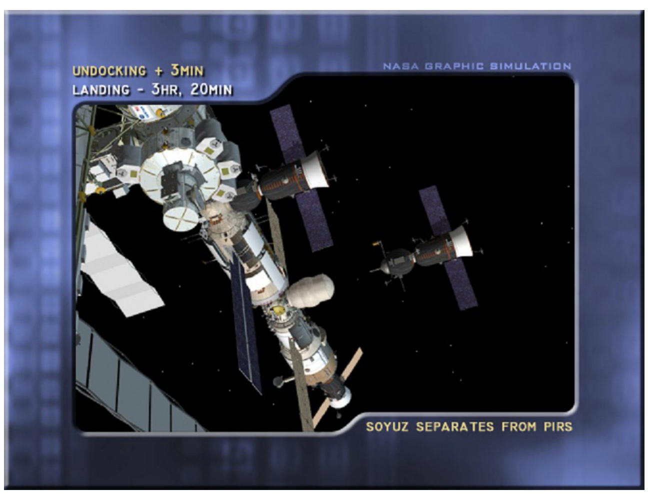
Separation Command to Begin to Open Hooks and Latches:

Undocking + 0 minutes

3:43 p.m. CT April 29, 2043 GMT April 29, 12:43 a.m. Moscow time April 30, 3:43 a.m. Astana time April 30.

Hooks Opened / Physical Separation of Soyuz from Pirs Nadir Port at .1 Meter/Second:

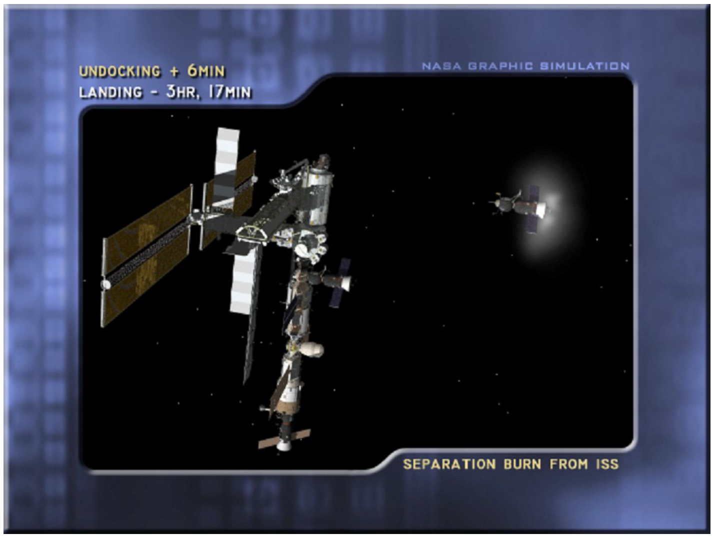
Undocking + 3 minutes



3:46 p.m. CT April 29, 2046 GMT April 29, 12:46 a.m. Moscow time April 30, 3:46 a.m. Astana time April 30.

Separation Burn from ISS (15-second burn of the Soyuz engines, .57 meters/sec; Soyuz distance from the ISS is ~20 meters):

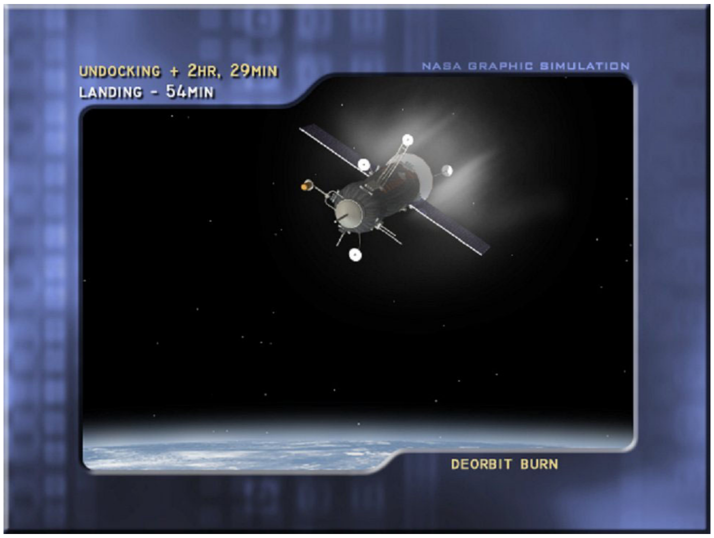
Undocking + 6 minutes



3:49 p.m. CT April 29, 2049 GMT April 29, 12:49 a.m. Moscow time April 30, 3:49 a.m. Astana time April 30.

Deorbit Burn (about 4:21 in duration; Soyuz distance from the ISS is ~19 kilometers):

Undocking approximately + 2 hours, 30 mins.



6:04 p.m. CT April 29, 2304 GMT April 29, 3:04 a.m. Moscow time April 30, 6:04 a.m. Astana time April 30.

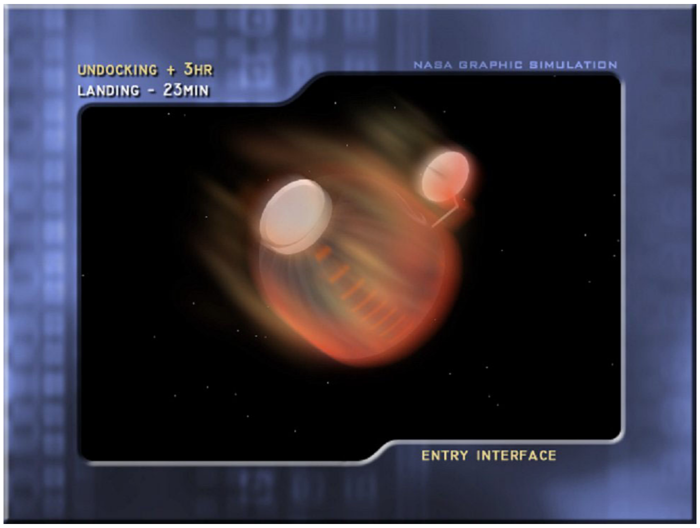
Separation of Modules (~28 minutes after deorbit burn):

Undocking + ~2 hours, 57 mins.

6:32 p.m. CT April 29, 2332 GMT April 29, 3:32 a.m. Moscow time April 30, 6:32 a.m. Astana time April 30.

Entry Interface (400,000 feet in altitude; 3 minutes after module separation; 31 minutes after deorbit burn):

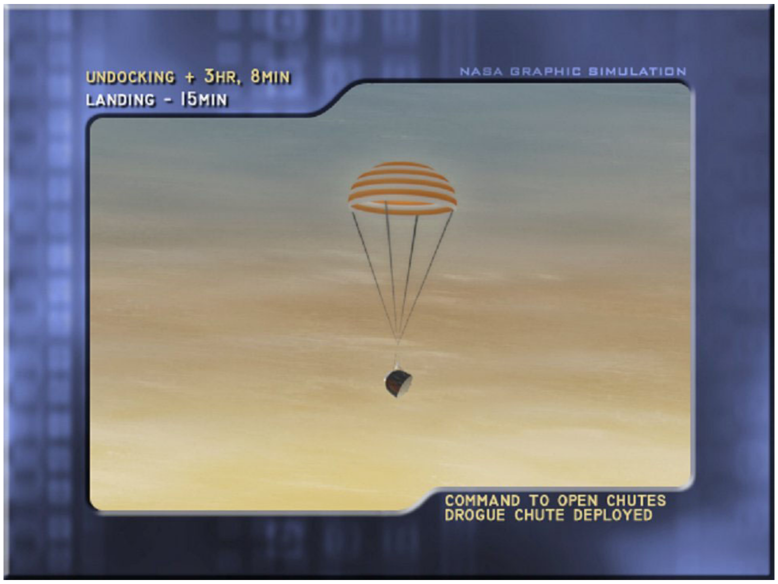
Undocking + ~3 hours



6:35 p.m. CT April 29, 2335 GMT April 29, 3:35 a.m. Moscow time April 30, 6:35 a.m. Astana time April 30.

Command to Open Chutes (8 minutes after entry interface; 39 minutes after deorbit burn):

Undocking + ~3 hours, 8 minutes



6:43 p.m. CT April 29, 2343 GMT April 29, 3:43 a.m. Moscow time April 30, 6:43 a.m. Astana time April 30.

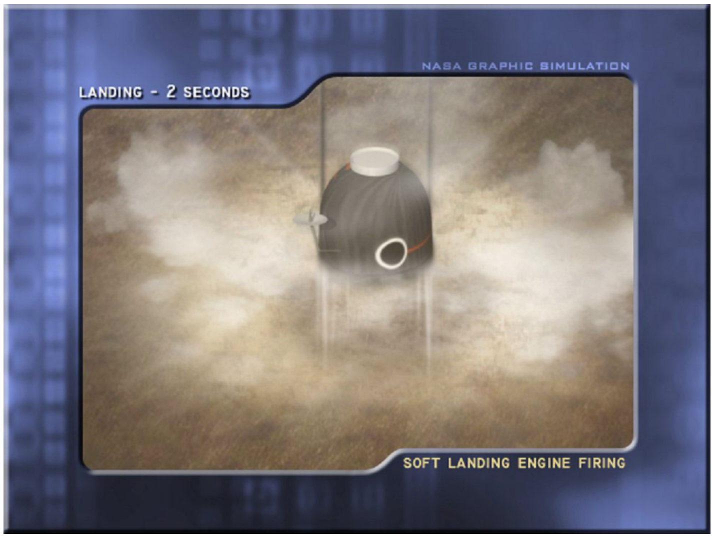
Two pilot parachutes are first deployed, the second of which extracts the drogue chute.

The drogue chute is then released, measuring 24 square meters, slowing the Soyuz down from a descent rate of 230 meters/second to 80 meters/second.

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

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

Landing - approximately 2 seconds



Landing (54 minutes after deorbit burn):

Undocking + ~3 hours, 23 minutes

6:58 p.m. CT April 29, 2358 GMT April 29, 3:58 a.m. Moscow time April 30, 6:58 a.m. Astana time April 30.

Science Overview

Expedition 9, the ninth science research mission on the International Space Station, is scheduled to begin in April 2004, when the crew arrives at the Station aboard a Russian Soyuz spacecraft. It is designated the 8S mission for the eighth Soyuz to visit the Space Station. A crew of two will replace Expedition 8 crewmembers Michael Foale and Alexander Kaleri, who are scheduled to return home in April on another Soyuz spacecraft (7S), docked at the Station.

During Expedition 9, two Russian Progress cargo flights, called 14P and 15P for the $14^{th}$and 15^{th} Progress vehicles, are scheduled to dock with the Space Station. The Progress supply ships will transport supplies to the Station and also may carry scientific equipment.

Gennady I. Padalka, Expedition 9 commander, participates in a training session in the International Space Station Destiny laboratory mockup/trainer in the Space Vehicle Mockup Facility at the Johnson Space Center. Padalka represents the Federal Space Agency (of Russia). Trainers Karin Bliss and David Pogue assist Padalka.

Much of the research complement for Expedition 9 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. Most equipment and samples can remain on board the Station with minimal or no detrimental effects.

Expedition 9 crewmembers are Commander Gennady Padalka and Flight Engineer Edward Michael Fincke, who also will serve as NASA Space Station Science Officer. 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 Andre Kuipers (above) will fly with the Expedition 9 crew to the Station to conduct research for a nine-day period, then return to Earth with the Expedition 8 crew. Kuipers will conduct European experiments inside the Microgravity Science Glovebox – a science facility built by the European Space Agency in collaboration with NASA's Marshall Space Flight Center in Huntsville, Ala.

Astronaut Edward Michael (Mike) Fincke, Expedition 9 NASA ISS science officer and flight engineer, participates in an experiment training session in the ISS Destiny laboratory mockup/trainer at JSC.

The Expedition 9 crew could have 300 hours devoted to payload activities. Space 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 9 will replace Expedition 8 colleagues in the International Space Station's Payload Operations Center – the world's primary science command post for the Space Station – at the Marshall Center. Controllers work in three shifts around the clock, seven days a week in the Payload Operations Center, which links researchers around the world with their experiments and the 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) takes advantage of the crew in space to observe and photograph natural and man-made changes on Earth. The photographs record observable Earth surface changes over time, as well as more fleeting events such as storms, floods, fires and volcanic eruptions. Together they provide researchers on Earth with vital, continuous images needed to better understand the planet.

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.

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 Expeditions 2, 4, 5, 7 and 8. It was also performed during five joint NASA/Russian Mir Space Station missions. Crewmembers answer a questionnaire and send data back to Earth. The information gained will help define the effects of these personal factors and will lead to improved training and in-flight support of future space crews.

Behavioral Issues Associated with Isolation and Confinement: Review and Analysis of Astronaut Journals obtains information on behavioral and human factors relevant to the design of the equipment and procedures and sustained human performance during long-duration missions. Study results will provide data on which to base decisions concerning the priority that should be placed on the various behavioral issues to prepare for future missions.

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 Expeditions 5, 7 and 8. These samples can be processed several times with different experiment settings, allowing investigators to study different phenomena.

Materials on the 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 have been growing since Expedition 6. Crystals were also grown on Expeditions 2, 4 and 5, then returned to Earth for analysis. 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.

The **Capillary Flow Experiment (CFE)** will study how fluids behave in low gravity. Since fluids behave differently in low gravity, this information will be valuable for engineers who are designing spacecraft cooling systems, life support systems and the many other types of equipment that use fluids to operate.

For the **Cell Biotechnology Operations Support Systems Fluid Dynamics Investigation (CBOSS - FDI)**, crewmembers will conduct a fluid-mixing test using CBOSS fluid samples. 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. These fluid-mixing tests will be conducted to improve future experiments.

Education Payload Operations (EPO) includes educational activities that will focus on demonstrating science, mathematics, technology, engineering or geography principles. EPO is designed to support the NASA Mission to inspire the next generation of explorers.

Viscous Liquid Foam - Bulk Metallic Glass (Foam) 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 – a system of fine particles suspended in a fluid – in a microgravity environment, where the effects of sedimentation and convection are removed. Crewmembers will evenly mix the samples, photograph the growth and formations of the colloids, and downlink the images for analysis.

Pre- and Post-flight Human Physiology - Many continuing experiments will use pre- and post-flight measurements of Expedition 9 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.

Biopsy allows researchers to take biopsies of their calf muscles before and after their stay on board the 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.

Chromosomal Aberrations in Blood Lymphocytes of Astronauts (Chromosome) will study space radiation on humans. The expected results will provide a better knowledge of the genetic risk of astronauts in space and can help to optimize radiation shielding.

Experiments Requiring Transport by Soyuz or Progress Vehicles

Expedition 9 also may include these experiments:

Yeast - Group Activation Pack (Yeast - GAP) – 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.

Dust Aerosol Measurement Feasibility Test (DAFT) will release particles in the Space Station atmosphere to test the ability of different equipment to measure the levels of dust and air quality.

Destiny Laboratory Facilities

Several research facilities are in place aboard the Station to support Expedition 9 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 9 operations.

The Destiny lab also is outfitted with five **EXPRESS** Racks. EXPRESS (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 9 experiments and payload operations, click on:

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

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 9 Research

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	
Commercial	КНТ-20	GCF-JAXA	Kit GCF-02	Protein crystallization	
Commercial	КНТ-29	ROKVISS	ROBOTIK manipulator mono unit, controller, transmitter-receiver with antenna on mechanicl приемопередатчик с антенной на механическом адаптере	Отработка функционирования шарнирных элементов	EVA Will need help from US crewmember
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	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	

Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
Biomedical	МБИ-2	Diurez	Urine receptacle kit; KB-03 container; *Nominal Hardware:* Kriogem-03 freezer; Plazma-03 kit; Hematocrit kit	Study of fluid-electrolyte metabolism and hormonal regulation of blood volume in microgravity	During ISS-9, ISS-10 crews rotation
Biomedical	МБИ-4	Farma	Saliva-F kit	Study of specific pharmacological effects under long-duration space flight conditions	
Biomedical	МБИ-5	Kardio-ODNT	*Nominal Hardware:* Gamma-1M equipment; Chibis countermeasures vacuum suit	Comprehensive study of the cardiac activity and blood circulation primary parameter dynamics	Will need help from US crewmember
Biomedical	МБИ-7	Biotest	*Nominal Hardware:* Gamma-1M equipment; Hematocrit kit	Biochemical mechanisms of metabolic adaptation to space flight environment	During ISS-8, ISS-9 crews rotation During ISS-9, ISS-10 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 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 During ISS-9, ISS-10 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)	Study of space flight impact on microorganisms-substrates systems state related to space technique ecological safety and planetary quarantine problem	

Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
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-8	Plasmida	Rekomb-K hardware Biocont-T hardware Kriogem-03M freezer *Nominal hardware:* Kriogem-03 freezer	Study of microgravity conditions influence on plasmid DNA transmission frequency	During ISS-8, ISS-9 crews rotation (is conducted jointly with *Kon'yugatsiya* experiment)
Biomedical	БИО-10	Mezhkletochnoe vzaimodeistvie (Intercellular interaction)	Fibroblast-1 kit Aquarius hardware (+37°C during 24 hours) Glovebox *Nominal hardware:* Kriogem-03 freezer KB-03 container	Study of microgravity influence on cells surface behavior and intercellular interaction	During ISS-8, ISS-9 crews rotation
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	Yersinia Bioradiation dosimetry in space flight	
Biomedical	РБО-3 РБО-3-1 (1 stage) РБО-3-3B (3 stage) (SDTO 16006A)	Matryeshka-R	Passive detectors unit Phantom set Matryeshka equipment (monoblock)	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	
Study of Earth natural resources and ecological monitoring	Д33-2	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	Luch-2 biocrystallizer	Anti-idiotypic antibodies as adjuvant-active glycoproteid mimetic	
Biotechnology	БТХ-4	Vaktsina-K		Structural analysis of proteins-candidates for vaccine effective against AIDS	

Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
Biotechnology	БТХ-20	Interleukin-K		Obtaining of high-quality 1α, 1β interleukins crystals and interleukin receptor antagonist - 1	
Biotechnology	БТХ-10	Kon'yugatsiya (Conjugation)	Rekomb-K hardware Biocont-T hardware Kriogem-03M freezer *Nominal hardware:* Kriogem-03 freezer	Working through the process of genetic material transmission using bacteria conjugation method	During ISS-8, ISS-9 crews rotation
Biotechnology	БТХ-11	Biodegradatsiya	Bioproby kit	Assessment of the initial stages of biodegradation and biodeterioration of the surfaces of structural materials	
Biotechnology	БТХ-12	Bioekologiya	Bioekologiya kit; (Kits 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	
Technical Studies	ТЕХ-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	ТЕХ-8	Toksichnost	Test-system "Biotoks-10A"	Development of a system for express monitoring of water toxicity in space flight	
Technical Studies	ТЕХ-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	ТЕХ-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	ТЕХ-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

Category	Experiment Code	Experiment Name	Hardware Description	Research Objective	Unique Payload Constraints
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
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	
Complex Analysis. Effectiveness Estimation	КПТ-3	Econ	"Rubinar" hardware "Econ" kit *Nominal Hardware:* Nikon D1 digital camera, Laptop №3	Experimental research on evaluation of ISS RS utilization availabilities for ecological monitoring	
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	EVA
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; osciloscop 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

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

Advanced Diagnostic Ultrasound in Microgravity

Principal Investigator: Dr. Scott Dulchavsky, Chair, Department of Surgery, Henry Ford Health System, Detroit, Mich.

Overview

Advanced Diagnostic Ultrasound in Microgravity (ADUM) will be used to determine the ability of minimally trained Station crewmembers to perform advanced ultrasound examinations after using a computer-based training program. The crewmember being “examined” will be immobilized on the Crew Medical Restraint System backboard. The other crewmember will then examine him using the Human Research Facility ultrasound equipment under the direction of a doctor in the Mission Control Center in Houston. Verification of these advanced ultrasound techniques and telemedicine strategies could have widespread applications in emergency and rural care situations on Earth.

Flight History

ADUM was first tested with remote guidance from the ground control team during Expedition 5. The experiment was done during Expedition 8.

Flight Operations

The Ultrasound Imaging System provides three-dimensional image enlargement of the heart and other organs, muscles and blood vessels. It is capable of high-resolution imaging in a wide range of applications, both research and diagnostic, such as:

- Echocardiography, or ultrasound of the heart
- Abdominal ultrasound, deep organ
- Vascular ultrasound
- Gynecological ultrasound
- Muscle and tendon ultrasound
- Transcranial ultrasound
- Ultrasound contrast studies
- Small parts ultrasound

The ultrasound equipment located in the Human Research Facility provides three-dimensional imaging of the heart and other organs, muscles and blood vessels. (NASA/JSC)

The only maintenance to be performed by Space Station crewmembers on the ultrasound system is vacuuming an inlet air debris screen as necessary.

Benefits

Ultrasound techniques developed by NASA to examine International Space Station crewmembers are finding new uses in treating medical emergencies on Earth. The procedures can be readily learned by non-physicians and can provide an accurate diagnostic tool when coupled with Internet, telephone or wireless transmission of ultrasound images to remote experts. Developers are investigating satellite phone technology to allow the technique to be expanded for use on ambulances or at accident sites

More Information

For more information and photos on the Human Research Facility, visit:

http://www.scipoc.msfc.nasa.gov/
http://www.spaceflight.nasa.gov/
hrf.jsc.nasa.gov

Effect of Prolonged Spaceflight on Human Skeletal Muscle (Biopsy)

Experiment Name: Effect of Prolonged Spaceflight on Human Skeletal Muscle

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: Bradley Rhodes, NASA Johnson Space Center, Houston, Texas

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 9 science experiments please visit the Web at:

www.scipoc.msfc.nasa.gov
www.spaceflight.nasa.gov

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, D.C.

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 will examine bubble removal and 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 on board 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 9 experiments is available at:

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

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/

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 complement 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.

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

Operations 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 systems 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 Center 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 more than 14,000 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.

No other NASA program gives students such direct control of an instrument flying on a spacecraft orbiting Earth, and as a result of this, students assume an unparalleled personal ownership in the study and analysis of their Earth photographs.

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

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 9 science experiment, visit the Web at:

www.scipoc.msfc.nasa.gov

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

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 spaceflight.

The Expedition 9 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; Center of Science and Industry, Columbus, Ohio.

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

Payload

During Increment 9, four payload items will be used in educational demonstrations. The hardware consists of the following: Blues Harp, Crazy Maze, Bits and Pieces Puzzle, and Chicken Shake. Two crewmembers are needed to perform and videotape educational demonstrations using these items.

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.

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 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 more than 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 about 1.5 million tomato seeds. The seeds are all Heinz 9478 F1, which received no special handling or treatment before 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 Web site. 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.

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

Science Objectives

Earth Science Toward Exploration Research (ESTER) is designed to allow both ground-controlled and crewmember-directed imaging of high priority sites on the Earth's surface. Many of the defined sites are follow-ups to some of the long-duration observations conducted from the Shuttle and Mir. The sites include river deltas, glaciers, smog, reefs, areas with water level changes, cities and rifts. ESTER will also record imagery of unplanned, dynamic events such as storms, floods, fires, and volcanic eruptions. The images synthesized into new data sets will yield more integrated insights into global changes that can be recorded from low-Earth orbit. Targets are predetermined and uplinked to the crew or ground-commanded to the Electronic Still Camera in the Window Observational Research Facility (WORF) on a weekly basis.

Hardware Description

ESTER's primary hardware configuration will be an Electronic Still Camera (ESC) mounted in the WORF and commanded through the payload data communications system for two days out of the week. Near real-time image downlink will facilitate viewing by the user community to determine if the site data collection objective was met. In the event the U.S. Lab window is not available for crewmember-directed imaging, the ESC, 70mm, and 35mm cameras, which are standard ISS photographic equipment, can take specific sites out of other windows.

Flight Operations Summary

The crew flight operations include setting up the ESC and computer connections in the WORF and opening the U.S. Laboratory research window shutter when appropriate while WORF operations are activated. At other times, the crew will be taking images using the digital ESC and the 70mm and 35mm film cameras.

Increment 9 Objectives

Once the Window Observational Research Facility is launched and operational (no earlier than ULF1), ESTER will become a functioning payload. ESTER is designed to allow both ground-controlled and crewmember-directed imaging of high priority sites on the Earth's surface. Many of the defined sites are follow-ups to some of the long-duration observations conducted from the Shuttle and Mir. The sites include river deltas, glaciers, smog, reefs, areas with water level changes, cities and rifts. ESTER will also record imagery of unplanned, dynamic events such as storms, floods, fires, and volcanic eruptions. The images synthesized into new data sets will yield more integrated insights into global changes that can be recorded from low-Earth orbit.

For Increment 9, ESTER Get-Ahead will be a training session for the ground crew. Operational issues in using the 400 mm lens on the ESC and drifting times in the ESC and on-board computers will be evaluated. These lessons learned will be incorporated into acquiring specific sites more accurately.

Hardware Description

ESTER Get-Ahead's primary hardware configuration will be an Electronic Still Camera (ESC) with a 400 mm lens mounted in the U.S. Lab Window on the IMAX bracket, and commanded through the payload data communications system for four days out of the week. Near real-time image downlink will facilitate viewing by the ground crew to determine if the site data collection objective was met.

The 400 mm lens images a smaller area of the ground in each frame, so timing is important. The 400 mm lens was tested in an ESTER Get-Ahead on Increment 5 and successfully captured quality images.

Flight Operations Summary

The crew flight operations include setting up the ESC on the IMAX bracket and computer connections in the U.S. Lab window and opening the U.S. Laboratory research window shutter when appropriate.

Fluid Merging Viscosity Measurement (FMVM)

Experiment Name: Fluid Merging Viscosity Measurement (FMVM)

Mission: To be delivered on Progress 13P; 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 crewmembers to conduct the experiment but still contain the liquid.

For each test, crewmembers 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

Viscous Liquid Foam - Bulk Metallic Glass (Foam)

Experiment Name: Viscous Liquid Foam- Bulk Metallic Glass (Foam)

Mission: To be delivered on Progress 14P; experiment to be conducted during International Space Station 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 crewmembers 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

Group Activation Packs (GAP) Yeast Experiment

Principal Investigator: Dr. Cheryl Nickerson, Tulane University Health Sciences Center, New Orleans

Co-Investigator: Dr. Timothy Hammond, Tulane University Health Sciences Center, New Orleans: Veterans Affairs Medical Center, New Orleans

Project Manager: Dr. Beverly Girten, NASA Ames Research Center, Mountain View, Calif.

Hardware Provider: BioServe Space Technologies, Boulder, Colo.

The objective of this jointly sponsored research aboard the International Space Station is to examine the global effects of spaceflight on microbial gene expression and cell survival. Using a special form of brewer's yeast, such as the type used to make bread or beer, the genes that determine cell survival in space will be identified. Molecular biologists have added "signature tags" to every gene in the yeast genome so that the effects of microgravity on each gene can be studied. Knowledge of the genes that enable microbial survival in space will aid in understanding the molecular mechanisms of the cellular response to microgravity.

Earth Benefits and Applications

Understanding gene expression patterns and how they are altered when cells are grown in the low-gravity or microgravity environment inside the International Space Station will help scientists learn how cells respond to gravity. By deepening the understanding of the molecular mechanisms of the genetic response in yeast to microgravity and identifying which genes enable cell survival could help scientists improve techniques for pharmaceutical testing, drug development processes, produce new biological products, and potentially produce tissues that can be implanted inside humans to replace diseased tissues or organs.

The challenges in studying human cells or cells from other mammals is that the genome, i.e., 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.

Scientists will study yeast cells, which are eukaryotic cells- i.e., cells that contain a distinct nucleus bound by a cell membrane and other membrane bound organelles. Mammalian cells have a similar eukaryotic structure. The benefit of using yeast cells is that a yeast cell is far simpler than a mammalian cell in that its entire genome has been completely sequenced and is widely considered a benchmark microbe for basic research. Because yeast is considered a model organism in the area of cell culture, results from culturing yeast in microgravity can be used to infer changes that may occur in other similar organisms. An enhanced understanding of the molecular mechanisms of the genetic response in yeast to microgravity and identifying which genes enable cell survival may have clinical applications in microbial products that are widely used in biological and commercial applications.

Eight Fluid Processing Apparatuses (FPAs) contained in a Group Activation Pack. Each FPA contains growth medium, fixative, and dried down yeast cells.

Science

The *Saccharomyces cerevisiae* yeast cells will be cultured within Group Activation Packs (GAPs). A GAP is 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.

Four Group Activation Packs will be flown on board the Russian Progress launch vehicle. Each GAP contains eight Fluid Processing Apparatuses (FPAs) that hold the yeast cultures, liquid growth medium, and fixative. The fixative is used to preserve the cells after they have grown for three days in space.

To activate the experiment, the International Space Station crewmember will insert a hand crank into the top of the GAP and turn it. This will cause the yeast cells to mix with the liquid growth medium and begin growing. Following the growth period, the hand crank will be inserted into the top of the GAP again and turned. This will allow fixative to mix with the growing yeast colony, thus resulting in cell preservation.

The preserved cells will be placed in a special stowage container. They will be returned to Earth where scientists will compare them to identical yeast cells grown inside a ground control unit. By comparing the yeast genes expressed during ground-based growth with those expressed when the organism is grown in space, scientists can determine how microgravity alters the genetic expression profile and survival of cells.

This experiment is being sponsored in part by both NASA’s Fundamental Space Biology (FSB) Program and Space Product Development Division (SPD).

Fundamental Space Biology is NASA’s program for the study of fundamental biological processes through spaceflight and ground-based research. By bringing together state-of-the-art science and technology, FSB seeks to answer the most basic questions regarding the evolution, development, and function of living systems.

The experiment objective for the FSB-sponsored portion of the mission is to identify the *Saccharomyces cerevisiae* genes that provide a selective advantage or disadvantage for cell survival in the space environment. The genes that convey a survival advantage and those that determine survival disadvantage in response to spaceflight will be identified.

NASA’s Space Product Development Division is responsible for NASA's commercial product development program to encourage and increase the United States' industry involvement and investment in the utilization of space for the development of new or improved products and processes that have Earth-based applications as well as relevance to NASA’s missions. This is accomplished by conducting industry-driven, high-technology applied research, which will lead to improved commercial products and services.

The commercial partners involved in this research are interested in the following potential applications of this research:

- The design of commercial bioreactor systems that optimize the ability to maintain long-term, large volume cultures of diverse cell types for pharmaceutical and medical applications or for other pharmaceutical applications.
- Improved pharmaceutical testing capabilities.
- Production of improved or unique biologics.
- Development of implantable tissues.

First International C. elegans Experiment (ICE-First) Caenorhabditis elegans Gene Expression and Muscle Physiology in the Space Environment

NASA Investigator: Dr. Catharine A. Conley, NASA Ames Research Center, Mountain View, Calif.

NASA Project Manager: Dr. Beverly Girten, NASA Ames Research Center, Mountain View, Calif.

Overview

A small, soil dwelling, bacteria eating, unsegmented worm may be an important key in mankind's endeavor to explore space. Historically, the study of simple multicellular model organisms has provided crucial understanding of biological processes, ultimately leading to better understanding of human biology. The goal of this flight is to use the nematode worm Caenorhabditis elegans as a model organism for spaceflight biology.

C. elegans is a common, well-studied organism used in biomedical research as a model for human development, genetics, aging, and disease. The recent award of a Nobel Prize in Medicine to three pioneering worm researchers has demonstrated the value that has been placed on the worm as a model system by the scientific and medical communities.

C. elegans is a primitive, free living (non-parasitic) organism that shares many essential biological characteristics found in human biology. The worm is conceived as a single cell that undergoes a complex process of development, starting with embryonic cleavage, proceeding through morphogenesis and growth to the adult. It has a nervous system with a 'brain' (the circumpharyngeal nerve ring), muscles, and a gut. It exhibits behavior and is capable of rudimentary learning. It produces sperm and eggs, and reproduces, although normally as a hermaphrodite. After reproduction, the worm gradually ages, loses vigor and finally dies.

C. elegans can be grown in either liquid culture or on solid substrate. All 959 somatic cells of its transparent body are visible with a microscope, and its average life span in the lab is a mere 2-3 weeks. Thus, C. elegans provides the researcher with an ideal compromise between complexity and tractability.

ICE-First is an international collaboration with participants from France, Canada, Japan and the United States. Results from the NASA spaceflight experiment will provide an understanding of how the spaceflight environment, notably radiation and microgravity, influence 1) worm development throughout the life cycle 2) the expression of known and novel genes by performing full genome microarray analysis 3) worm muscle physiology.

Science

For the NASA component of ICE-First, worms will be grown in a chemically defined, liquid, axenic culture media referred to as C. elegans Maintenance Media (CeMM). Worms will be cultured in several collapsible gas-permeable bags for the 10-day sortie flight to the International Space Station (ISS). The culture conditions and the requirements for worm growth are well established from ground-based studies. The life cycle from egg to egg of worms in the axenic media takes approximately 7 days and is dependent upon the temperature. Worm cultures will be maintained on orbit at a consistent 20 degrees Celsius. For this experiment, live worm cultures will be returned to Earth. Immediately upon return, the movement of worms will be recorded using a microscope video system. The specimens will then be analyzed for gene expression, larval development, and muscle anatomy.

Earth Benefits and Applications

The importance of C. elegans on Earth is demonstrated by its wide use in biomedical research as a model for human development, aging, and disease. C. elegans is an excellent model organism for such investigations because it is one of the few eukaryotes with a fully-sequenced genome. Therefore, data obtained from this study will allow extrapolation to astronauts living in a space environment and to individuals on Earth.

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 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.

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.

Materials on the International Space Station Experiment (MISSE)

Overview

The Materials on the 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.

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.

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 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 9 science experiment, visit the Web at:

www.scipoc.msfc.nasa.gov

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

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

Pore Formation and Mobility Investigation (PFMI)

Experiment Name: Pore Formation and Mobility During Controlled Directional Solidification in a Microgravity Environment 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

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: Bradley Rhodes, NASA Johnson Space Center, Houston

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 International Space Station.

Experiment Operations

Bone loss in the spine and hip will be determined by comparing pre-flight and post-flight measurements of crewmembers' spine and hip bones 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.

Dutch Soyuz Mission DELTA

European Space Agency astronaut André Kuipers of the Netherlands, in the framework of the Dutch Soyuz mission DELTA, is scheduled to fly into space on April 19. DELTA stands for Dutch Expedition for Life Science, Technology and Atmospheric Research. Kuipers' 11-day flight will include nine days on the International Space Station. The Dutch Ministry of Education, Culture and Science, and the Dutch Ministry of Economic Affairs have financed the cost within the framework of an agreement between ESA and the Federal Space Agency (of Russia).

Kuipers will carry out a full program of educational, scientific and cultural activities during his stay on the ISS. The mission consists of a scientific program, with the Dutch ESA astronaut spending much of his time on the ISS on experimental activity. Kuipers is a medical doctor and a great degree of this activity will focus on human physiology and biology. The mission also has a strong educational focus and Kuipers will spend a lot of his time carrying out activities with the objective of stimulating primary and secondary school pupils, and students of technology and space. This will help bring the European human space program and research performed in space to a wider public.

From a European perspective, the DELTA mission is important because it increases ESA's astronaut experience ahead of the launch of Columbus, Europe's own laboratory, to the Space Station. The ongoing development of Columbus and its research facilities will benefit from the hands-on experience Kuipers will get during his stay on the ISS.

Kuipers' flight is the result of longstanding cooperation between Europe and Russia. It is one outcome of a framework agreement signed between ESA and the Federal Space Agency in May 2001, paving the way for European astronauts to fly to the ISS on Russian Soyuz vehicles.

The cooperation between ESA and the Federal Space Agency allows for European astronauts to take up positions normally occupied by 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 four ESA astronauts have participated in Soyuz missions – Claudie Haigneré (France), Roberto Vittori (Italy), Frank De Winne (Belgium) and Pedro Duque (Spain).

Two other European astronauts, Umberto Guidoni (Italy) and Philippe Perrin (France), have participated in missions with the Space Shuttle to the ISS in the framework of bilateral agreements with NASA.

These missions are an important bridge between the end of Spacelab and the start of Columbus because, according to the international agreements ruling the Space Station, European astronauts will not get automatic access to the Space Station until ESA's Columbus module becomes operational.

A sign of the growing experience between ESA and the Federal Space Agency (of Russia) is that for the second time on a Soyuz mission to the ISS a European, German ESA astronaut Gerhard Thiele, is acting as backup to the prime European astronaut.

The experimental program encompasses a series of experiments in the fields of human physiology, biology, microbiology, physical science, Earth observation, education and technology. They will be performed in the Russian Zvezda module and in NASA's Destiny laboratory.

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

Experimental Program in Human Physiology

Name	Description	Team Members
CIRCA	An experiment measuring blood pressure and heart rate to evaluate cardiovascular deterioration in space flight.	J. Karemaker, J. Gisolf, G.A. van Montfrans, W. Stok (The Netherlands) C. Gharib, M.A. Custaud (France)
ETD	An Eye Tracking Device will be used to measure the effects of weightlessness on the body's coordination, balance, orientation and posture to assess their relation to space sickness during space flight.	A.H. Clarke (Germany) J.E. Bos (The Netherlands) T. Haslwanter (Switzerland)
HEART	Measuring the heart, blood pressure and blood flow to help predict difficulty in standing upright after extended time in weightlessness.	J. Karemaker, J.J. van Lieshout, J. Gisolf, W. Stok (The Netherlands) P. Arbeille, C. Gharib (France)
MOP	A study of the effects of weightlessness on motion and an astronaut's susceptibility to space sickness.	J.E. Bos, S. Nooij, W. Bles, E. Groen, W. Ockels (The Netherlands)
MUSCLE	Testing the hypothesis that the deterioration of certain deep muscles in conditions of weightlessness leads to lower back pain in astronauts.	C.J. Snijders, P.F.G. Hermans, A.L. Pool Goudzwaard (The Netherlands) C.A. Richardson, J.A. Hides (Australia)

Experimental Program in Biology

Name	Description	Team Members
ACTIN	Research into the effects of weightlessness on the protein actin in mammalian cells.	J. Boonstra (The Netherlands)
FLOW	How bones are affected by weightlessness, particularly by mineral loss.	J. Klein-Nulend, R.G. Bacabac, J.P. Veldhuijzen, J. van Loon (The Netherlands)
ICE-first	A set of experiments studying nematode worms in weightlessness and developing links to human physiology in space.	A. Rose (Canada) L. Ségalat, J. Vassy (France) N. Ishioka, A. Higashitani, S. Honda, Y. Honda, H. Kagawa (Japan) B. Girten, C. Conley (USA)
KAPPA	Study of the influence of weightlessness on the activation of the NF-kB protein, which regulates the body's immune system.	M.P. Peppelenbosch, H.V. Versteeg (The Netherlands)
TUBUL	Studying how plant cells behave in space under conditions of weightlessness to provide further knowledge on the role played by gravity in plant growth processes on Earth.	M.C. Emons, B. Sieberer (The Netherlands)

Experimental Program in Microbiology

Name	Description	Team Members
SAMPLE	Monitoring of microbial contamination on board the Space Station to determine its long-term effects in a weightless environment, particularly the health risks that could be posed to astronauts on extended missions.	H.J.M. Harmsen, G.W. Welling, J. Krooneman, J. v.d. Waarde (The Netherlands) P. Landini (Switzerland)

Experimental Program in Physical Science

Name	Description	Team Members
ARGES	High energy lamps – increasingly used on Earth to light roads and sports stadiums – can become less efficient and unstable as gravity gradually causes the gaseous contents to de-mix or separate. This experiment is designed to test them under conditions of weightlessness to help develop improved types of lamp.	G.M.W. Kroesen, M. Haverlag (The Netherlands)

Experimental Program in Earth Observation

Name	Description	Team Members
LSO	Observation of sprites caused by lightning strikes in the Earth's upper atmosphere to gain a better understanding of the meteorological phenomenon.	E. Blanc **(**France) Dr. P.F.J. van Velthoven (The Netherlands)

Technology Demonstrations

Name	Description	Team Members
HEAT	Testing heat transfer in a grooved heat pipe in weightlessness, for development of more efficient heat pipes for future use in thermal control of spacecraft and on Earth.	J.C. Legros, L. Barremaecker (Belgium) G. Grommers (The Netherlands)
MOT	Testing of accelerometer for use within a telemetry device implanted in laboratory animals to accurately measure physiological parameters.	G.J. van Essen, M.B. Jansen (The Netherlands)
SUIT	Testing of a special suit with small vibrating elements to assist astronauts with orientation.	J.B.F. van Erp, H.A.H.C. van Veen, M. Ruijsendaal (The Netherlands)

Experimental Program in Education

Name	Description	Team Members
ARISS	Providing a live radio link from the Space Station to children from Dutch and Belgian schools to increase their awareness of space and demonstrate how science in space can improve life on Earth.	G. Bertels **(**Belgium)
BugNRG	A study of the output of bacterial fuel cells in weightlessness, testing the assumption that the cells have a greater efficiency in space than on Earth.	S. de Vet, R. Rutgers (The Netherlands)
GraPhoBox	Experiment using seeds from a mustard plant to study the effects of light and gravity on the growth processes of plants.	K. Buizer (The Netherlands)
SEEDS	School pupils will grow seeds on Earth and compare the results with those of similar seeds grown in space, showing the influence of gravity and light on seed germination.	J. van Loon, K. Weterings (The Netherlands)
VIDEO-3	Demonstrating the effects of weightlessness on the human body – including blood pressure and circulation, fluid shift, and orientation awareness – through video footage filmed by André Kuipers.	S. Ijsselstein, J. van Loon (The Netherlands) M. Paiva (Belgium)

Short Description of Experiments

Experimental Program in Human Physiology

CIRCA

The CIRCA experiment aims to measure the pattern of blood pressure and heart rate in an astronaut during a 24-hour period. The combined data from two different instruments used in this experiment will enable the experiment team to improve their understanding of how the cardiovascular system (system of heart and blood vessels in the body) adapts to a weightless environment. The experiment will do so by taking repeated measurements of blood pressure using devices attached to the upper arm and to the finger.

Carrying out this experiment in space will help to determine how much of the earthbound day-night difference in blood pressure is due to gravity and how much to activity. It is important to obtain data on cardiovascular function under weightless conditions, not only for the benefits it may have for the future of human spaceflight, but also because this information has clinical relevance on Earth. In particular it is of use in the study of patients who suffer from autonomic control disturbances as well as the study of the deconditioning that occurs when patients are confined to their bed for longer periods.

ETD

Listing’s plane can be described as a coordinate framework, which defines the movement of the eyes in the head. On Earth it appears to be dependent on inputs from the vestibular system, which controls the body’s balance, orientation and posture. The main scientific objectives of the ETD experiment are:

- To measure the orientation of Listing’s plane in a weightless environment
- To determine how Listing’s plane is linked to the coordinate frame of reference of the vestibular system as reflected by the vestibulo-oculomotor response. This response allows the eyes to stay visually fixed during natural head movements by making compensatory eye movements

The experiment will be carried out using the Eye Tracking Device (ETD), which consists of a headset that includes two digital camera modules for binocular recording of horizontal, vertical and rotational eye movements and sensors to measure head movement.

This type of research can provide further insight into problems with balance experienced by astronauts following re-entry and vestibular disorders on Earth such as Meniere's disease, and related vestibular symptoms such as vertigo and nausea.

HEART

The objective of this ground-based experiment is to predict orthostatic intolerance, i.e., the inability to stand upright, of astronauts who have spent a long period in a weightless environment. The predictions will be based on physical parameters such as blood pressure measurements, measurements from electrocardiograms, and the use of ultrasound equipment to measure brain blood flow and the expansion and contraction of the thoracic cavity (the thoracic cavity is the area enclosed by the ribs, which holds the heart and lungs). The data obtained will serve as an astronaut's input characteristics to a computer model of the circulation.

The results obtained from this research will help scientists define a set of preflight tests that predict who is more liable to manifest post-flight orthostatic intolerance, and consequently to develop reliable in-flight countermeasures. These developments are also important within clinical medicine where it is necessary to improve the rehabilitation of patients after prolonged periods of bed rest. Moreover the new knowledge may help in the diagnosis of patients who experience repeated spells of unexplained dizziness.

MOP

The main scientific objective of this experiment is to gain insight into the process of how the body's vestibular system adapts to the absence of gravity. In humans, the vestibular system together with visual information determines the body's coordination, posture and balance and the perception of movement and orientation.

The adaptation in the vestibular system will be assessed by comparing the perception of motion against the real movement of the body. To this end, the astronaut will be asked to fill out a short questionnaire every day during the spaceflight, wherein he reports his motion sensation as a result of head movements around the three principal axes and any discomfort regarding space sickness. Another objective is to correlate an astronaut's susceptibility to space sickness with a susceptibility to sickness induced by centrifugation.

Besides the benefits this research could have in developing countermeasures to space sickness experienced by astronauts during the early phases of spaceflight, this type of research could have positive implications for research on Earth. These include studies on the balance system carried out to help people with equilibrium disorders, motor function development in children and the development of new methods for evaluating a patient's ability to use visual cues for maintaining balance and orientation.

MUSCLE

The main scientific objective of this experiment is to test the hypothesis that the atrophy of certain deep abdominal muscles in weightlessness leads to low back pain in astronauts. In the act of, for example, bending forwards at the waist, muscles would normally act to counter prolonged strain on one of the pelvic ligaments.

In weightlessness it is assumed that this counteractive process is gradually weakened due to atrophy of these muscles. To test the hypothesis, the (expected) development of low back pain will be recorded by means of a questionnaire, which records specific information including the location of any low back pain, its acuteness and its length of duration.

Increased knowledge of the correlation between muscle use/disuse and back pain will allow scientists to develop countermeasures for this problem not only in space but also on Earth. Low back pain is probably one of the most diffuse ailments suffered by humans on Earth, and data from this experiment could help in the prevention or alleviation of low back pain.

Experimental Program in Biology

ACTIN

This experiment aims to study the effect of weightlessness on the structure and metabolism of the protein actin in mammalian cells. Actin is an important molecule for cell shape and movement. It is also one of two proteins involved in muscle contraction and is found in both skeletal and non-skeletal muscle.

Preliminary experiments suggest that the actin filaments are altered under weightless conditions. It is the aim of the proposed research to identify the gravity sensitive component that underlies the metabolism of the actin filaments.

By identifying the gravity sensitive cell component in mammalian cells, scientists will be able to better understand the role played by gravity here on Earth on the cell development processes in mammals. Also, for future human long-duration spaceflight, this kind of research will provide information regarding whether extended exposure to weightlessness (or an altered gravity different to that experienced on Earth) has permanent effects on the function of cells in humans and other mammals.

FLOW

In the bone formation process, bone cells called osteocytes produce certain signalling molecules that are responsible for maintaining bone health. Osteocytes produce these signalling molecules in response to stresses in bone under loading. The specific aim of this research is to test whether bone cells under weightlessness conditions have decreased sensitivity to stress by measuring the amount of signalling molecules they produce when stressed in space.

Osteocytes are the bone cells that are sensitive to mechanical stress. In this experiment, osteocytes will be compared to osteoblasts (bone-forming cells) and periosteal fibroblasts (the cells found around bones from which connective tissue develops such as ligaments and tendons). Osteocytes, osteoblasts and periosteal fibroblasts will be cultured with and without gravity.

The results obtained from this research will help to improve prevention programs of bone demineralisation, which occurs during prolonged human spaceflight. It is also useful in studying disuse osteoporosis, a condition affecting many elderly people on Earth, where bones weaken due to loss of minerals.

ICE-first

ICE-first consists of several experiments, which will be investigating the effects of spaceflight on a model organism of the nematode family (*Caenorhabditis elegans*) and develop links to human physiology in space. The organism chosen is known to be able to mate, reproduce and develop apparently normally during spaceflight.

These experiments will include studies into the effect that radiation has on genetic stability, muscle growth and endurance, the development of nematode worm larvae in space, cell migration during development, the sensitivity of specific cell elements to weightlessness, and an analysis of almost the complete genome of the nematode worm.

These types of experiments will help clarify the role of several genes or proteins when the development occurs in the absence of gravity. This could pave the way to use further mutants to help research on muscular, nervous and genetic diseases. This research could provide direction of where to develop research in the future.

KAPPA

NF-κB is a protein that acts as a principal regulator of inflammation and immunity in the body. This experiment will study how NF-κB is transferred to the nucleus of a type of white blood cell, called a monocyte, in weightlessness. It will further study the activation of a protein called I-κB, which inhibits the activity of NF-κB, and study the activation of several enzymes in weightlessness.

Multiple studies have suggested that the weightless environment may affect the signalling of NF-κB. By carrying out this experiment in space, this can provide an insight into the activity of the NF-κB protein and knowledge on how to affect its activity more effectively.

It is almost impossible not to be able to identify a major health problem in which NF-κB is not prominently involved. It is implicated in autoimmune diseases like rheumatoid arthritis, and diseases such as multiple sclerosis, coronary heart disease and cancer. The results obtained from this experiment may lead to more in-depth research, which could eventually provide the countermeasures to many illnesses suffered by humans on Earth.

TUBUL

The cytoskeleton is an arrangement of microtubules, and actin filaments within a cell, which serve to provide support to the cell's structure and to transport components from one part of the cell to another. The role of the cytoskeleton ultimately determines a plant's final shape and ultimately how well it functions as a complete organism. The TUBUL experiment aims at identifying the role that gravity plays in the organization and dynamics of the microtubules in living plant cells grown in space.

The cytoskeleton is of interest to space researchers because it is supposed to be the gravity-sensing element of cells. Very little research has thus far been aimed at the effects of gravity on the physical aspects of the cytoskeleton organization and the effect this has on cell division and cell elongation.

Understanding how plant cells behave under weightless conditions can provide further knowledge on the plant growth processes on Earth and the role played by gravity. This could have an impact on agricultural processes and long-term human space missions in the future. This type of research is also useful in the development of fundamental/theoretical biology.

Experimental Program in Microbiology

SAMPLE

The first objective of the experiment is to evaluate which microbial species could unwantedly develop under the growth conditions in life support systems used for human spaceflight. The focus is on potentially infective and destructive microbes, and on the origin and distribution of species on different sample sites of the ISS. The second objective is to investigate how microbial species adapt to weightlessness. Is there adaptation to weightlessness by microbes and, if so, what kind of adaptation: long-term physiological adaptation or genetic selection? Does weightlessness affect the adhesive properties of microbes? To investigate this adaptation, an *E. coli* bacteria will be grown in space inside a tube. The bacteria will be analyzed back on Earth.

Uncontrolled growth of microbes on the walls and/or in the air and water systems can be a potential health risk to the crews on board the ISS and crews on future long-term missions. It is therefore necessary to monitor the microbial contamination and growth in the ISS to avoid such hazards for the future. It is also helpful in providing further insight into the effect that weightlessness has on genetic modification.

Experimental Program in Physical Science

ARGES

High-Intensity Discharge (HID) lamps are gaining ground in the lighting industry because of their high-energy efficiency. The main objectives of this experiment are to determine which factors are critical in the onset of instabilities in HID lamps and to characterise the separation of individual gaseous elements inside. The gaseous elements inside these lamps begin to de-mix or separate away from each other over time. When this separation occurs the resulting distribution of light is non-uniform in the illuminated area. Furthermore, instabilities that might occur in the lamp could cause cracks inside allowing the gaseous contents to leak into the outer bulb of the lamp, thus making the lamp no longer functional.

This experiment will help in the development of more efficient HID lamps in the future for use in space and on Earth. This could have a large impact within the lighting industry as HID lamps are widely used for all kinds of applications, including highways, sports stadiums, building exteriors and shops.

Experimental Program in Earth Observation

LSO

Sprites are a meteorological phenomenon discovered in 1989, which have the appearance of a luminous glow extending from 30 to 90 km altitude above thunderstorms. Sprites have a duration from a few milliseconds to few hundred milliseconds.

They occur after positive lightning strikes in relation to intense electric fields between the thunderclouds and the ionosphere (above 100 km). The aim of this experiment is to observe sprites during storms, determine the energy emitted by them in the visible and near infrared spectrum using digital microcameras, and compare this to nightly emissions of lightning. It is also planned to compile statistical data to determine the frequency of occurrence of sprites and their distribution over the Earth.

Technology Demonstrations

HEAT

In the weightlessness of space, heat pipes play an important role in the overall thermal control of the systems and subsystems being used to transfer heat from hot surfaces (e.g., electronic devices) to cold surfaces (e.g., radiative panels). The main aim of this technology demonstration is the characterization of the heat transfer performance of a grooved heat pipe in weightlessness. This demonstration will further validate the existing mathematical model used to evaluate the performances of new heat pipes and prove that the grooved heat pipe design being evaluated is an appropriate design that can cope with the formation and trapping of vapor bubbles in the pipe. This technology demonstration could lead to the possible development of more efficient heat pipes to be used in future space platforms and here on Earth.

MOT

A mouse telemetry system is being developed for the European Space Agency that can be implanted into the abdomen of a mouse. This radio sensor-transmitter will enable investigators to measure the body temperature, heart rate, and body acceleration in three directions of 5 to 10 free-moving mice in a cage. The aim of this technology demonstration is to calibrate the accelerometers, which will be used in the Mouse Telemetry System, by having the astronaut move them in different directions. This will test the sensors under weightless conditions by taking recorded movements of the subject.

Radio-telemetry has now become an effective, low stress method to measure physiological parameters in laboratory animals. This approach for monitoring physiological functions in laboratory animals provides less discomfort for the animals combined with a high accuracy of the measurements.

SUIT

The aim of the SUIT project is to support the astronaut with a vibrotactile suit to help with orientation in space. This suit consists of numerous small vibrating elements covering the torso. These elements inform the astronaut of a given predefined direction within the ISS by vibrating in that direction. As the vibration of one of these elements is directly mapped to the astronaut’s body position, this makes it a fast and intuitive way to present spatial information. The SUIT project uses this principle to present the astronaut with orientation information.

The major goal of the SUIT project is to develop a support system for astronauts that improves safety, performance and comfort. The data gathered from this experiment in a weightless environment is of key importance to establish what part tactile information plays in orientation behavior when sensory information is missing from the otoliths of the inner ear.

This study could help provide a useful method of orientation for astronauts, especially if taking part in extravehicular activities (spacewalks). It could further help provide countermeasures for space sickness suffered by most astronauts and provide positive inputs to Earth-based research (e.g., studies on the balance system carried out to help people with equilibrium disorders).

Experimental Program in Education

ARISS

The objectives of this activity are to provide a live radio link from the ISS to selected children from Dutch and Belgian schools to allow them to have the experience of interacting with someone in orbit around the Earth. Students will prepare questions and direct them to ESA astronaut André Kuipers. The schools selected are the winners of a competition, which invites schoolchildren to either create a picture of an astronaut in the ISS or write a story about an astronaut in the ISS depending on their age.

The radio contact will be provided by ARISS, Amateur Radio on the ISS, an international working group of volunteering amateur radio operators. The radio contact will be established during a pass of the Space Station over The Netherlands.

This exercise serves as an educational tool for making children aware of space, a topic that is often not covered in school syllabuses. It is important to bring space to the children to provide them with a better understanding of the benefits of space and how science in space can also improve life for us here on Earth.

BugNRG

The BugNRG experiment will study how weightlessness influences the efficiency of bacterial fuel cells. The aim is to acquire precise data on the output of these fuel cells in space.

Some bacteria are capable, in the right circumstances, of converting carbohydrates into electrons and carbon dioxide. This process can be used as a source of energy in these so-called bacterial fuel cells. When placed inside a two-chamber fuel cell, these bacteria can produce an electrical current. The output of this cell can be measured and recorded to study the properties of the fuel cells.

In spacecraft and space stations, the generation, use and conservation of energy is of major importance. The development of new and more efficient fuel cells helps to expand the possibilities of future robotic and human space missions, which will have a greater complexity and longer duration.

GraPhoBox

On Earth, two major stimuli that affect plant growth are light and gravity. With respect to light, shoots grow toward light. This is called phototropism. Root growth direction, however, is affected by gravity. This is called gravitotropism. This experiment will assess the effect of phototropism and gravitotropism on plants to observe if there is a link between the two.

Seeds from a variety of mustard plants common in genetic research will be studied. These seeds will be germinated in low intensity light and without light both on the ground under Earth's gravity and under weightlessness on the ISS.

By understanding the growth processes of plants in more detail, we can help to develop an understanding of the mechanisms that allow for a faster and therefore increased growth rate of plants on Earth. In the future this could lead to a positive impact in food production levels and methods. Furthermore, the ability to grow food in space would help to expand the possibilities for future long-term human space missions.

SEEDS

The main goal of this student experiment is to involve as many students as possible in an activity that shows that science is fun. The objective of this experiment is to demonstrate the influence of gravity and light on the germination and growth of plants to young people (10–15 year olds) and others. By engaging students in the comparable on-ground experiment, they will experience that the weightless environment of space could open new possibilities. Experiment kits were distributed up to one month before launch to schools or other distribution channels.

This experiment will allow the students to gain experience in experimentation through hands-on activities. It teaches them how to observe and analyze scientific phenomena and how to compare data obtained from various sources. Secondly, it provides a way to teach students the growth mechanism of plants on Earth and how gravity and sunlight play a role in the process. Thirdly, it introduces them to the fascinating world of weightlessness and its role in scientific research.

VIDEO-3

The main scientific objectives of this experiment are to demonstrate some of the effects of weightlessness on the human body (e.g., blood pressure and circulation, fluid shift, orientation awareness) by means of filming four basic physiology experiments under weightless conditions on board the ISS.

For all four experiments comparable on-ground experiments will be performed by secondary school pupils in selected Dutch and European schools to familiarize pupils with the differences between the Earth and space environments.

The footage taken of both the on-ground and in-space experiments will be used to develop educational material (a DVD) fitting the European curriculum of the target 12- to 18-year-old age group. The DVD will be distributed to secondary schools in the Member States of the European Space Agency.

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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