EXPEDITION FOUR
International Space Station

Science, Assembly and Spacewalks

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Overview

Science, Spacewalks, Assembly Set for E4

A continuing increase in science activities, a total of as many as eight spacewalks, the first piece of a truss that will form the backbone of the station and new software to support routing of power and data to and from it will be landmarks of the flight of the Expedition Four crew aboard the International Space Station.

Expedition Four crewmembers are cosmonaut and commander Yury Ivanovich Onufrienko, 40, a colonel and former senior pilot in his country's air force and veteran of a mission to the Russian space station Mir; astronaut Daniel Bursch, 44, a Navy captain and former test pilot with three shuttle flights to his credit, and Carl Walz, 46, an Air Force colonel, a former test pilot and veteran of three spaceflights.

New scientific experiments which were not on Increment Three include research in the biological sciences, physical sciences, and research in human physiology, much of it looking at effects of long-duration spaceflight. A number of experiments will continue from the previous increment.

As many as four of the spacewalks are to be conducted by members of the Expedition Four crew. Two of them will be early in the increment, from the new Pirs docking compartment using Russian Orlan suits. Two may be done later in Expedition Four, using U.S. spacesuits. Four other spacewalks are scheduled during the STS-110/8A flight of Atlantis, no earlier than the end of February, midway through the increment.

Those four spacewalks will focus on connecting the S0 Truss to the station's U.S. laboratory Destiny. The S0 Truss is scheduled to be brought to the station on Atlantis. It will be the first segment of the station's truss that eventually will support, among other things, four virtually identical solar wing assemblies. Among them will be the solar wings now atop the P6 truss, which already make the station the most powerful spacecraft ever.

In terms of activities, Expedition Four can be divided into three major segments. Early in the increment the focus will be on the first two spacewalks. The middle of the mission centers on the new software upload in preparation for arrival of the S0 Truss and its arrival, installation and checkout, and the final two spacewalks. As the end of Expedition Four approaches, the orientation changes to the arrival of a Russian taxi crew bringing a new Soyuz crew return vehicle to the station and preparation for the arrival of the Expedition Five crew, no earlier than early May.

Through all these activities, scientific investigations will continue.

The first two spacewalks are scheduled for mid-January. The first will be by Onufrienko and Walz and the second by Onufrienko and Bursch.

Among tasks by Onufrienko and Walz on the first spacewalk are those relating to transfer of the Strela cargo boom to the Pirs docking compartment. The boom and other Strela components were attached to the station's Pressurized Mating Adaptor 2 on previous shuttle flights.

During the second spacewalk, tasks assigned to Onufrienko and Bursch include:

Installation of thruster deflectors on the Zvezda service module.

Installation of contamination-control system experiments pallets on the docking compartment and Zvezda.

Installation of four antennas, for Ham Radio and Glisser TV, on Zvezda.

Retrieval of the old Kromka materials experiment and installation of new samples.

Photograph the Zvezda solar array flaps.

About six weeks before the arrival of STS-110/8A flight the second mission segment, preparations of the space station and the Expedition Four crew for its arrival will begin. Uplink of the new, extensive software load should be complete about four weeks before Atlantis arrives. The software will support the new configuration of the station – with the truss – including power distribution and a variety of other systems. It should be activated and verified well before Atlantis arrives.

The Expedition Four crew also will be doing on-orbit training with the station's robotic arm, Canadarm2, to maintain proficiency for the S0 Truss installation. They also will verify the function of the arm after the software changes.

The four spacewalks during Atlantis' visit to the station will be dedicated to S0 Truss installation. Once that is completed, crewmembers will verify that all the connections have been made correctly.

One or two more spacewalks may be done after Atlantis departs. They will be done in U.S. spacesuits out of the joint airlock Quest by Walz and Bursch and will use Canadarm2. Scheduled for April, the spacewalks will finish any needed S0 Truss installation and activation work. They also will do "get-ahead" tasks relating to future truss construction.

The third Expedition Four segment is the home stretch. About two weeks after the final spacewalks, Expedition Four crewmembers will conduct the first of a series of air-to-ground conferences with their Expedition Five successors, which will include astronaut Peggy Whitson and two cosmonauts. Those conferences are part of lengthy preparations for Expedition Four's return home, which include everything from packing personal belongings to detailed cataloging of station and scientific equipment and procedures. They also will prepare station equipment and discards for return to Earth in Endeavour.

They also will begin planning and preparation for the arrival of a taxi crew in a new Soyuz crew return vehicle, the fourth Soyuz to be docked at the station for that purpose. They will orient the taxi crew and work with them during their six-day stay. The taxi crew is to depart in late April in the third Soyuz, which has been attached to the station since before Expedition Four crewmembers' arrival.

The Soyuz is scheduled to undock two days before the scheduled launch of Endeavour on the STS-111/UF-2 mission that will take Expedition Four crewmembers home.

Other tasks of Expedition Four crewmembers include maintenance replacement or enhancement. Electrical outlets will be replaced, as will the treadmill exercise device and its vibration isolation system in the Zvezda service module. Filters will be installed in thermal loops, more radiation shielding will be installed around Zvezda sleep stations and radiation monitors will be replaced.

Throughout the fourth increment, heavy emphasis will be placed on research in life sciences, Earth sciences and microgravity sciences. One reason crewmembers and controllers on the ground are able to do this is the growing maturity of the station. Increment three reaped some of the scientific benefits, and increment four stands to reap even more.

Here are the missions to the International Space Station during Expedition Four:

- STS-108 (UF-1) will rotate the Expedition Three and Expedition Four crews and bring a Multipurpose Logistics Module with equipment and supplies to the station.

- 7P will be the seventh Russian unpiloted supply spacecraft to be launched to the station with equipment, supplies, water and fuel.

- STS-110 (8A) will bring the S0 Truss, the center of what will become the ISS backbone, to the station.

- 4S will be the fourth Russian Soyuz spacecraft to be brought to the station by a ferry crew. The ferry crew will return to Earth in S3, the Soyuz that was at the station for several months.

- STS-111 (UF-2) will rotate the Expedition Four and Expedition Five crews and bring a Multipurpose Logistics Module with equipment and supplies to the station.

Expedition Four Crew

Commander: Yury Onufrienko

Col. Yury Ivanovich Onufrienko, 40, a test cosmonaut and former senior pilot in his country's air force, commanded the Mir 21 expedition in 1996. Fellow crewmembers included Astronaut Shannon Lucid and ISS Expedition Two Commander Yury Usachev. As ISS commander, he will have overall responsibility for expedition safety and success of the space station and the Expedition Four crew. Onufrienko graduated from the V.M. Komarov Eisk Higher Military Aviation School for Pilots in 1982 with a pilot-engineer's diploma, and from Moscow State University in 1994 with a degree in cartography. Upon graduation from aviation school, he served as a pilot and senior pilot in the Air Force. In 1989 he was named a cosmonaut candidate. Onufrienko was commander of the Mir 21 expedition from Feb. 21 to Sept. 2, 1996. He was named a Hero of Russia, and holds two Armed Forces medals. He also is a Chevalier in the French Legion of Honor.

Flight Engineer: Daniel Bursch

Daniel W. Bursch is a Navy captain, a former test pilot and test pilot school instructor, and a veteran of three spaceflights. He is a Naval Academy graduate and holds an M.S. in engineering from the Naval Postgraduate School. He has more than 3,100 flight hours in 35 aircraft types. He attended the Naval Postgraduate School in Monterey, Calif., from July 1989 until his selection to the astronaut program in 1990. He initially was assigned to the Astronaut Office Operations Development Branch, working on controls and displays for the shuttle and space station and subsequently worked as a capcom in mission control. Bursch was on STS-51, the Advanced Communications Technology Satellite and Shuttle Pallet Satellite flight, in September 1993. He also flew on STS-68, the Space Radar Lab-2 flight launched in September 1994, and on STS-77, the fourth Spacehab mission, in May 1996.

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Flight Engineer: Carl Walz

Air Force Col. Carl E. Walz, a former test flight engineer and flight test manager, was selected as an astronaut in 1990 and is a veteran of three spaceflights. He holds B.S. and M.S. degrees in physics and enjoys sports and music – he is lead singer for MAX-Q, the astronaut rock-n-roll band. For three years after his 1979 graduation, Walz was responsible for analysis of radioactive samples from the Atomic Energy Detection System at McClellan AFB, Calif. He spent five years as a test flight engineer at the Combined Test Force at Edwards AFB, Calif., and subsequently served as a flight test manager. Walz flew with Bursch on STS-51, the Advanced Communications Technology Satellite and Shuttle Pallet Satellite flight, in September 1993. He also was a mission specialist on STS-65, the second International Microgravity Laboratory Spacelab module, in July 1994, and on STS-79, a mission to the Russian space station Mir, in September 1997.

EVAs

Expedition Four International Space Station Spacewalks

During the Expedition Four crew's planned five-month stay aboard the International Space Station, at least two, and possibly as many as four, spacewalks are planned from the station without the space shuttle present. Two spacewalks using Russian Orlan spacesuits and associated equipment are planned during the second month of the crew's stay.

Commander Yury Onufrienko, a veteran of six spacewalks during missions on the Russian Mir space station, will participate in both spacewalks that will use Russian Orlan suits and originate from the station's Pirs docking compartment, accompanied outside the station on the first by Flight Engineer 1 Carl Walz, a veteran of one previous spacewalk conducted from the space shuttle, and on the second by Flight Engineer 2 Dan Bursch.

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The first spacewalk using Russian spacesuits will relocate the cargo boom for the Russian Strela crane. The cargo boom was stowed on the exterior of the station's Pressurized Mating Adapter 1 during space shuttle mission STS-101 in May 2000. The boom will be moved by Onufrienko and Walz to join the rest of the Strela equipment on the exterior of the Pirs compartment.

The second spacewalk using Russian spacesuits will have Onufrienko and Bursch install deflector shields to prevent potential contamination of some areas by the Zvezda module's jet thrusters; install external amateur radio antennas and equipment to accommodate a type of amateur television broadcasting, and change out a variety of external material samples that are part of ongoing experiments to characterize the environment outside of the station and gauge the effects on various products.

The spacewalks that will use U.S. gear and originate from the Quest airlock, to be conducted by Walz and Bursch, are planned to take place late in Expedition 4, after space shuttle mission STS-110. That flight will install a central truss segment on the Destiny laboratory. The content of the spacewalks is flexible and may be used to finish work from that truss installation or perform get ahead activities related to station assembly, depending on the situation.

Science Overview

ISS Expedition Four: Science Operations Overview

The number of science investigations aboard the International Space Station will almost double during Expedition Four, and new equipment will make the research outpost even more productive.

New experiments and science facilities will be ferried to the orbiting outpost during Expedition Four. The research complement will grow from 18 to 26 NASA payloads, seven of them new to the ISS Program. Of the 26, two are in fundamental biology, seven in human life sciences, six in microgravity science, six in space product development, and five are sponsored by the Office of Space Flight.

New experiments are expected to lead to new insights in the fields of plant growth, embryo development, the long-term effects of spaceflight on humans, biotechnology, medicine, agriculture, electronics and pharmaceutical manufacturing. Several experiments begun on earlier expeditions will return to Earth, while several others will continue operating during Expedition Four.

The three Expedition Four crewmembers are scheduled to devote nearly 500 hours to research. Those are in addition to the hours devoted by the station’s ever-present “fourth crewmember” – controllers and scientists on the ground who will continue to plan, monitor and operate experiments from the control centers around the country. In addition, the autonomous payloads will accrue several thousand hours of operational time.

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

New Experiments

Expedition Four shuttle flights will bring with them several new experiments, as well as several experiments making repeat flights aboard the station to continue their research. These include:

Biomass Production System (BPS) and **Photosynthesis Experiment and System Testing Operation** (PESTO): The main goal of BPS is to validate equipment necessary to grow wheat and Brassica in microgravity and eventually develop a dedicated Plant Research Unit for the space station. The secondary objective is to study the effects of microgravity on wheat photosynthesis and metabolism.

Astronauts in EVA Radiation Study (EVARM): Spacewalking astronauts will wear three active dosimeter badges in pockets sewn into their spacesuits to determine the levels of radiation received to the skin, eyes and blood-forming organs.

Protein Crystal Growth Enhanced Gaseous Nitrogen Dewar (PCG-EGN): Making its fourth space station flight, this passive experiment is designed to demonstrate a low-cost platform for growing biological materials and studying optimum growth conditions.

Protein Crystal Growth Single Thermal Enclosure System (PCG-STES) **Diffusion – controlled Crystallization Apparatus for Microgravity** (DCAM): This experiment provides a controlled temperature environment to grow large, well-ordered protein crystals in microgravity using vapor diffusion. By examining the crystals' molecular structure on Earth, scientists hope to learn more about key biological functions.

Protein Crystal Growth Single Thermal Enclosure System (PCG-STES) **Protein Crystallization for Microgravity** (PCAM): A reflight of an Expedition Two experiment, this experiment uses the "sitting drop" method of vapor diffusion to grow biological macromolecular crystals in microgravity. Scientists hope the near-weightlessness conditions of low gravity will allow the growth of larger crystals, which may show greater atomic structural detail than crystals grown on Earth.

Advanced Astroculture 02 (ADVASC): A reflight of an Expedition Two experiment facility, this commercial endeavor will be used to grow Arabidopsis from seed to maturity. A new feature on this flight will be the capability to collect samples of the growing plants while they're growing in space.

Commercial Generic Bioprocessing Apparatus (CGBA): A reflight of the Expedition Two experiment looking at bacterial fermentation and antibiotic production in space.

Commercial Biomedical Testing Module (CBTM): This experiment will help determine the effectiveness of a natural protein called osteoprotegerin as a possible countermeasure for osteoporosis. This "sortie" experiment will remain aboard the shuttle on the UF1 flight.

Commercial Protein Crystal Growth (CPCG): This is the second flight for this commercial experiment to use microgravity to grow larger, high-quality crystals of proteins for use in postflight X-ray analysis.

Zeolite Crystal Growth Furnace (ZCG): The goal of this commercial experiment is to grow larger crystals in microgravity with possible applications in chemical processes, electronic device manufacture and other applications on Earth.

Microencapsulation Electrostatic Processing System (MEPS): This commercial experiment is aimed at developing a process for producing large quantities of multi-layered microcapsules of drugs that could be placed in the human body.

Continuing Experiments

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:

Space Acceleration Measurement System and **Microgravity Acceleration Measurement System**, designed to measure vibrations caused by crew, equipment and other sources that could disturb microgravity experiments.

Active Rack Isolation System International Space Station Characterization Experiment, designed to test an experimental device comprised of “powered shock absorbers” to protect delicate microgravity experiments from vibrations caused by equipment, crew activities and other sources.

Experiment on Physics of Colloids in Space, a fluids experiment that could lead to new materials and products. Colloids are found in numerous products, such as paint, milk, ink, copy machine toner and are used in many manufacturing processes, such as polishing silicon for computer chips and removing bitter tastes from wine and fruit juices.

Earth Knowledge Acquired by Middleschool students, a program that lets students take pictures using an electronic camera on the space station. Students use the Internet to assign targets to the station camera and receive pictures, which they then use in a variety of classroom projects.

Hoffman Reflex, an experiment to study changes in neurovestibular function with the goal of determining if exercise could be made more effective on long-term space flights;

Crew Interactions experiment to identify and characterize interpersonal and cultural factors that may affect crew and ground support personnel performance during space station missions.

Crew Earth Observations experiment to photograph natural and manmade changes on Earth.

Cell Biotechnology Operations Support Systems 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.

Renal Stone, studying a possible countermeasure for kidney stone formation.

Pulmonary Function in Flight experiment, examining long-term lung function in microgravity.

Sub-regional Assessment of Bone Loss in the Axial Skeleton in Long-term Space Flight experiment, measuring bone loss and recovery on crewmembers on the International Space Station.

Xenon 1, a study of blood flow and ability of the body to adjust to the return to Earth after spaceflight.

Materials International Space Station Experiment, attached to the outside of the space station to expose hundreds of sample materials to the space environment. By examining how the coatings fare in the harsh environment of space, researchers seek new insight into developing materials for future spacecraft, as well as making materials last longer on Earth.

Returning Experiments

Four payloads or sets of experiment samples are returning to Earth on STS-108 at the end of Expedition Three. Cell tissue growth samples grown on the space station during Expedition Three as part of the **Cellular Biotechnology Operations Support System** and biological materials grown in the **Dynamically Controlled Protein Crystal Growth** experiments will be returned to Earth for study, while the experiment hardware remains on board to process additional samples during Expedition Four. A pair of Expedition Three experiments, the **Advanced Protein Crystallization Facility** and the **Dreamtime** High Definition TV camera, will be returned to Earth.

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Facility/ Experiment	Mission Information	Duration	Location on ISS	Research Area
Biomass Production System and Photosynthesis Experiment and System Testing Operation (PESTO)	Up on 8A Down on UF-2	2 months	EXPRESS Rack 4 Destiny module	Fundamental biology
Astronauts in EVA Radiation Study (EVARM)	Up on UF-1 Down on ULF-1	Expedition Four through Six	U.S. spacesuits during operation; stored in Human Research Facility when not in use	Human life sciences
Protein Crystal Growth-Enhanced Gaseous Nitrogen (PCG-EGN) Dewar	Up on 8A Down on UF-2	2 months	FGB	Microgravity biotechnology
Protein Crystal Growth-Single Thermal Enclosure (PCG-STES) 007 Diffusion-controlled Crystallization Apparatus for Microgravity (DCAM) and PCG-STES 008 Protein Crystallization Apparatus for Microgravity (PCAM)	Up on UF-1 Down on 8A	4 months	EXPRESS Rack 4 Destiny module	Microgravity biotechnology
Cellular Biotechnology Operations Support System	Up on 7A.1 and UF1 Down on UF1 and 8A	3 months	BTR1-EXPRESS Rack 4 Destiny	Cell science

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Facility/ Experiment	Mission Information	Duration	Location on ISS	Research Area
(CBOSS)			module BSTC-EXPRESS Rack 4 Destiny module	
Advanced Astroculture (ADVASC) 02	02: Up on UF-1 and down on 8A	4 months	EXPRESS Rack 4 Destiny module	Space product development
Commercial Generic Bioprocessing Apparatus (CGBA)	Up on 8A Down on UF2	2 months	EXPRESS Rack 4 Destiny module	Space product development
Commercial Biomedical Testing Module (CBTM)	Up and down on UF-1	Sortie flight/no expedition ops	Shuttle middeck	Space product development
Commercial Protein Crystal Growth (CPCG)	Up on 8A Down on UF-2	2 months	EXPRESS Rack 4 Destiny module	Space product development
Zeolite Crystal Growth Furnace (ZCG)	Up on UF-1	Permanent	EXPRESS Rack 2 Destiny module	Space product development
Microencapsulation Electrostatic Processing System (MEPS)	Up on UF-1	Expedition Four through Six	EXPRESS Rack 4 Destiny module	Space product development

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 completed space station will boast six fully equipped laboratories, nearly 40 payload "racks" or experiment storage facilities, and more than 15 external payload locations for conducting experiments in the vacuum of space.

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)

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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:
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ISS - 4 Russian Payloads Table

Category	Experiment Name	Research Objective	Hardware Used	Up/Down Flight or Vehicle	Power (Watts)	Unique Payload Constraints	No. of crew members	On-orbit Crew Time (hours)
Commercial	КНТ-1 "GTS" – Global Timing System	Verification of Global Timing System	Electronic unit; Antenna unit with attachment mechanism.	Existing On-orbit	30	Imagery Requirements:	No operator	continuous
Commercial	КНТ-2 "MPAC&SEED" (NASDA)	Recording meteoroid and man-made particle impacts and exposure of material specimens on ISS RS Service Module exterior surface.	Micro particles collection device and materials exposure array MPAC&SEED Special returnable cassette; Adopter frame with interface;	Existing On-orbit	None		No operator	continuous
Commercial	КНТ-3 "HDTV" (NASDA)	Experiment in receiving HDTV images.	- Video camera HDTV - Interface unit	Existing On-orbit	45	Imagery Requirements:	CDR	11 h 00 min 22 sessions
Commercial	КНТ-4 "Vzgliad" (Glance)	Photo and video material acquisition with Kodak logo inside and outside of ISS	- Kodak photo camera - Digital Video Camcorder - Kodak logo	Existing On-orbit Progress M 8, Союз 4	None	Imagery Requirements:	CDR	5 h 00 min 10 sessions
Geophysical	ГФИ-1 "Relaksatsiya" (Relaxation)	Study of the chemiluminescent chemical reactions and atmospheric light phenomena that occur during high-velocity interaction between the exhaust products from space vehicles and atmosphere at orbital altitudes and during the entry of space vehicles into the Earth's upper atmosphere.	- "Fialka-MV-Kosmos" spectral-zonal ultraviolet system.	Existing On-orbit	60		CDR	3 h 30 min 3 sessions
Geophysical	ГФИ -8 "Uragan"	Experimental testing and verification of the ground-space system for predicting, reducing damage, and eliminating the impact of natural and man-made catastrophes.	Binocular telescopic device Rubinar *Standard equipment:* - photo camera Hasselblad - video complex LIV.	Existing On-orbit	5 onboard systems	Imagery Requirements: Shared	CDR	3 h 00 min 6 sessions
Geophysical	ГФИ-10 Molnia-SM	Study of atmosphere, ionosphere, and magnetosphere electromagnetic interaction related to storms and seismic activities using video-photometric systems	BFS-3M video-photometric system	Existing On-orbit Progress M-8	45		CDR	2 h 00 min 6 sessions
Biomedical	МБИ-2 "Diurez"	Study of fluid and electrolyte metabolism and volume hormonal regulation in microgravity.	- Urine collection devices kit *Standard equipment:* - Kriogen-03/1 refrigerator - Plazma-03 kit - Gematokrit-03 kit - Reflotron-4 equipment	Progress M-8	onboard systems	Imagery Requirements: None	CDR FE (US)	3 h 10 min 20 min
Biomedical	МБИ-3 "Parodont"	Study of periodontal tissue condition under space flight conditions.	- "Saliva-A Parodont" kit; - Kit with "Parodont" test tubes: *Standard equipment:* - "Kriogem-03/1" refrigerator.	Progress M-8	onboard systems	Imagery Requirements: None	CDR	40 min
Biomedical	МБИ-4 "Farma"	Study of the specificities of pharmacological effects under long-duration space flight conditions	- Saliva-F kit *Standard equipment*: - Reflotron-4 kit	Progress M-8	onboard systems	Imagery Requirements: None	CDR	1 h 40 min
Biomedical	МБИ-5 "Kardio-ODNT"	Integrated study of the dynamics of the primary parameters of cardiac activity and blood circulation, using a lower body negative pressure (LBNP) apparatus.	*Standard equipment:* - "Gamma-1M" equipment - "Chibis" LBNP device (ПВК)	Existing On-orbit	onboard systems	Imagery Requirements: Restricted	CDR FE (US)	6 h 30 min 3 h 30 min 2 sessions

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Category	Experiment Name	Research Objective	Hardware Used	Up/Down Flight or Vehicle	Power (Watts)	Unique Payload Constraints	No. of crew members	On-orbit Crew Time (hours)
Biomedical	МБИ- Biotest	Biochemical profile of human in spaceflight	- "Plasma-03" consumables kit - КВ-03 container *Standard equipment:* - Kriogen-03/1 refrigerator - Plazma-03 kit - Gematokrit-03 kit Reflotron-4 equipment	Progress M-8	-	Imagery Requirements: None	CDR FE (US)	15 min (US astronaut's assistance will be needed for 15 min)
Biomedical	МБИ-8 Profilaktika (Countermeasure)	Study of mechanisms and efficiency of countermeasures for preventing muscular skeletal apparatus degradation in microgravity.	Akusport kit Lactate kit TEEM-100M gas analyzer *Nominal hardware:* Reflotron-4 complex TVIS treadmill VB-3 bicycle ergometer Bungee cords set Gamma-1M equipment Laptop Kardiokasseta-2000 set Power unit Tsentr	Existing On-orbit	15 onboard systems		CDR FE (US)	10 h 00 min 3 h 00 min 2 sessions
Biomedical	РБО-1 "Prognoz"	Development of a method for real-time prediction of dose loads on the crews of manned space stations.	*Standard equipment:* - Р-16 radiometer; - ДБ-8 dosimeters (4 units)	Existing On-orbit (Progress M 4)	onboard systems	Imagery Requirements: None	No operator	continuous
Biomedical	РБО -2 "Bradoz"	Bioradiation dosimetry during spaceflight. The purpose of the experiment is to use dosimeters to measure ionizing space radiation. Seeds of plants will be also be used.	"Bradoz" kit	Progress M-8	onboard systems	Imagery Requirements: Shared	No operator	0h 30min
Biotechnology	БТХ-1 Glikoproteid	Alpha virus glycoproterin E1-E2 isolation and investigation	- Bio-crystallization equipment – CPCF	Progress M-8	None .		CDR	1 h 40 min
Biotechnology	БТХ-2 Mimetik-K	Anti-idiotypical antibodies as mimetics of adjuvantly active glycoproteins.						
Biotechnology	БТХ-3 KAF	Crystallization of CaflM protein and its structure with C-terminal peptide Cafl to create medicines and vaccines against yersinioses						
Biotechnology	БТХ-4 Vaktsina-K	Structural study of candidate-proteins in vaccines against AIDS.						
Biotechnology	БТХ-11 Biodegradatsia	Evaluation of biodegradation initial stages and biodamage of structure materials surfaces	*Biodegradatsia -GO1 kit* *Biodegradatsia – GO2 kit*	Progress M-8	None		CDR	2 h 00 min
Technical Studies	ТЕХ-3 Akustika-M	Acoustic study of ISS crew voice communication optimization	*Akustika-M equipment*	Progress M-8	None		CDR	3 h 00 min 2 sessions
Technical Studies	ТЕХ-5 "Meteoroid" (SDTO 16002-R)	Recording meteoroid and man-made particle impacts on the exterior surface of ISS RS Service Module.	*Standard MMOD monitoring system:* - ММК-2 electronic unit; - Stationary capacitor sensors КД1, КД2, КД3, КД4; - removable capacitor sensor (КДС)	Existing On-orbit	onboard systems	Imagery Requirements:	No operator	continuous
Technical Studies	ТЕХ-13 "Tenzor" (SDTO 12001-R)	Determining ISS dynamic properties	*Standard equipment:* - ISS RS motion control system (СУД) sensors (micro accelerometers); - star tracker; - GPS GLONAS satellite systems .	Existing On-orbit	onboard systems	Imagery Requirements:	No operator	6 sessions

Category	Experiment Name	Research Objective	Hardware Used	Up/Down Flight or Vehicle	Power (Watts)	Unique Payload Constraints	No. of crew members	On-orbit Crew Time (hours)
Technical Studies	TEX-14 “Vektor-T” (SDTO 12002-R)	Study of the ISS system for high-accuracy motion prediction through the use of GPS receiver and GLONASS satellite radio-navigation systems data periodically transmitted to the ground.	*Standard equipment:* - ISS RS СУД sensors; - ISS RS orbit radio tracking (РКО) system; - GPS and GLONASS satellite systems.	Existing On-orbit		Imagery Requirements:	No operator	10 sessions
Technical Studies	TEX-15 “Izgib” (Bending - SDTO 13002-R)	Study of the effect of onboard system operating modes on ISS flight conditions by measuring vibration disturbances, sources, and vibration fields in the ISS modules.	*Standard equipment:* - ISS RS accelerometers and rotational speed sensors	Existing On-orbit		Imagery Requirements:	No operator	10 sessions
Technical Studies	TEX-16 “Privyazka” (Alignment - SDTO 12003-R)	Determination of science instruments orientation in space with allowance for deformation of the ISS hull. Information will be collected simultaneously from station attitude sensors and high-accuracy instruments to allow the development of a model of the station construction error under different attitudes, including non-uniform sunlight exposure and vibrations.	*Standard equipment:* - ISS RS СУД sensors (micro accelerometers);	Existing On-orbit		Imagery Requirements:	No operator	10 sessions
Technical Studies	TEX-17 “Iskazhenie” (Distortion - SDTO 16001-R)	Determine the factors affecting the accuracy of ISS attitude determination using a magnetometer. Magnetometer data will be used in mathematical simulations of magnetic interference on the ISS to improve attitude determination accuracy.	*Standard equipment:* ISS RS Service Module СУД attitude control sensors and control loop magnetometers.	Existing On-orbit		Imagery Requirements:	No operator	12 sessions
Technical Studies	TEX-22 “Identifikatsiya” (Identification) (SDTO 13001-R)	Identification of sources of perturbations in the ISS Microgravity environment by measuring disturbances during vehicle dockings/undockings, cosmonaut exercises, and operations of onboard systems..	*Standard micro acceleration measurement system:* - linear optical accelerometer (АЛО-034 – 44 ea.) with cables; - micro acceleration measurement device (ИМУ-128 – 10 ea.) with cables.	Existing On-orbit		Imagery Requirements:	No operator	3 sessions
Technical Studies	TEX-3 “Skorpion”	Monitoring of environmental parameters inside station compartments at various places and clarification of the conditions for conducting scientific and technical experiments	Skorpion equipment (СКР-1)	TBD	6	Imagery Requirements:	CDR	1 h
Technical Studies	TEX-32 Kolibri	Educational project		Existing On-orbit	None			1 h
Technical Studies	ИКЛ-1В Platan	Search for low energy heavy nuclei of solar and galactic origin	Platan-M equipment	Existing On-orbit	None		CDR FE (US)	40 min 40 min EVA
Technical Studies	ПКЕ-1В “Kromka”	Study of the dynamics of extracting contaminating particles from the control jets during pulse activations and verifying the effectiveness of devices to protect ISS exterior surfaces from contamination.	Cassette with exposed samples (КЭО) with packing (passive hardware).	Existing On-orbit	None	Imagery Requirements:	CDR FE (US)	1h 35 min 1h 35 min EVA

Expedition Four

Category	Experiment Name	Research Objective	Hardware Used	Up/Down Flight or Vehicle	Power (Watts)	Unique Payload Constraints	No. of crew members	On-orbit Crew Time (hours)
Study of Earth natural resources and ecological monitoring	ДЗЗ-2 "Diatomea"	Study of stability of geographic location and frontiers configuration of the biologically productive oceanic waters observed by the crews of the space station	Photo camera Nikon F5 Video camera DSR-PD1P Dictaphone laptop №3 "Diatomea" kit	Existing On-orbit	None		CDR	3 h
Technical Studies	КНТ-15 "Spika-S"	Investigation of spaceflight factors impact on electronic components' tolerance to radiation.	"Spika-S" equipment	Existing On-orbit	7		CDR	1h 40 min
Biomedical	БИО-1 "Полиген"	Detection of genotype properties that determine individual differences in the tolerance of biological objects to long-duration space flight factors.	"Drosophila" kit	Союз 4 Союз 3	-			1 h 30 min
							Total	72 h 00 min
Total							CDR FE (US)	62 h 40min 9 h 20 min

Experiments

Advanced Astroculture™ (ADVASC)

Principal Investigators: Tad Theno and Eric Brunsell, chief program scientists for Space Explorers Inc., and Dr. Weijia Zhou, Wisconsin Center for Space Automation and Robotics (WCSAR), University of Wisconsin-Madison

Co-Principal Investigator: Dr. Bratislav Stankovic, WCSAR

Overview

The first ADVANCED ASTROCULTURE™ plant growth unit was used successfully to grow plants during Expedition Two. These plants were returned to investigators on Earth on the STS-104 space shuttle mission in July 2001.

During their stay on the International Space Station during Expedition Two, the plants went through seed germination, plant growth and development, seed formation, and seed maturation -- completing an entire lifecycle. Of the 91 Arabidopsis seeds that were launched, about 90 percent germinated in space; and about 70 percent of the seeds grew to produce siliques that contained mature seeds. An average of 24 siliques per plant were produced, each containing an average of 36 seeds. The majority of siliques were rated as mature, while the others were moderately mature.

Operations

ADVANCED ASTROCULTURE™ provides a completely enclosed, environmentally controlled plant growth chamber. It requires no power during shuttle ascent and descent. Before the flight, scientists plant seeds in a root tray using a dry rooting material called Arcillite, a type of crushed clay. The seed tray is then attached to the ADVANCED ASTROCULTURE™ growth chamber. Reservoirs in the growth unit are loaded with water and nutrient solutions that plants need to live while aboard the ISS.

The equipment is configured as two single middeck lockers that insert separately into a space station EXPRESS Rack. One locker contains the support systems. The other contains the plant growth chamber and ancillary hardware. This arrangement allows the support system to remain on board, while the shuttle transports plant growth units to and from the station with different experiments.

For the Expedition Four experiment, the payload has been modified. A hatch was added so the crew can remove plant tissue while the plants are growing on board the station. The plant samples will be stored in tissue fixation tubes, designed by NASA's Kennedy Space Center. Then, they will be placed inside the station's Biotechnology Refrigerator. The plant tissues' RNA genetic information will be preserved, which will allow scientists and the commercial partner to study microgravity impact on plants' gene expression levels after the plants are returned to Earth.

Expedition Four

The objectives of the Expedition Four ADVANCED ASTROCULTURE™ experiments are (1) to validate plant life support technologies used in the ADVASC payload; (2) to produce the second generation of seeds in space from the first generation produced during Expedition Two; and (3) to conduct a gene expression analysis to determine whether microgravity may alter plant gene expression levels.

Experiments

Active Rack Isolation System (ARIS)—
ARIS ISS Characterization Experiment (ARIS ICE)

Principal Investigator: Jim Allen, The Boeing Co., Houston, Texas.

Project Manager: Albert Reville, The Boeing Co., Huntsville, Ala.

Program Manager: Naveed Quraishi, International Space Station Program Office, NASA Johnson Space Center, Houston, Texas.

Overview

Even in the virtually gravity-free environment of the International Space Station, tiny potential vibrations or disturbances—such as those caused by crew exercise—can upset the delicate balance of sensitive science experiments. The Active Rack Isolation System (ARIS) acts as a vibration absorber to help isolate them. By acting as a buffer between the experiment and these vibrations, ARIS protects delicate experiments housed in EXPRESS Rack No. 2 from outside influences that could potentially affect research results. The EXPRESS Rack, which stands for EXpedite the PRocessing of Experiments to the Space Station, is a standardized payload rack system that transports, stores and supports experiments aboard the space station.

A related experiment to the ARIS system, the ARIS ISS Characterization Experiment (ARIS ICE), is a separate payload created to characterize ARIS' on-orbit performance. In addition to generating controlled disruptions on and off the rack, ARIS ICE will enable real-time monitoring of the on-orbit vibration isolation capabilities of various ARIS configurations.

History/Background

A prototype of the ARIS system was tested during the STS-79 mission, a 1996 flight during which Space Shuttle Atlantis docked with the Russian Space Station Mir. To simulate the weight of future scientific payloads, five lockers within the ARIS rack on STS-79 were filled with 375 pounds of Russian food packages delivered to the Mir crew during the mission. After the ARIS system was activated, the astronauts conducted an extensive series of tests that indicate ARIS was successful in reducing the impact of off-board disturbances.

Benefits

The ISS will permit long-duration microgravity experiments in an environment similar to Earth-based laboratories—minus the gravity. The ARIS system will enhance the ability of scientists to conduct these experiments. By countering vibrational disturbances that could potentially damage the research results of certain delicate experiments, ARIS will play a key role in the success of this permanent laboratory in space.

Experiments

Cellular Biotechnology Operations Support System (CBOSS)

Principal Investigators:	Jeanne L. Becker, Ph.D., University of South Florida, Tampa; Timothy G. Hammond, M.B., B.S., Tulane University Medical Center, New Orleans; J. Milburn Jessup, M.D., University of Texas Health Science Center, San Antonio, Texas; Peter I. Lelkes, Ph.D., Drexel University, Philadelphia, Pa.
Program Manager:	Dr. Neal Pellis, Manager, Cellular Biotechnology Program Office, NASA Johnson Space Center
Project Manager:	Melody Anderson, Cellular Biotechnology Program Office, NASA Johnson Space Center
Payload Experiment Developer:	Fred R. Williams, Life Sciences Systems and Services, Wyle Labs, Inc.

Overview

The objective of the Cellular Biotechnology Operations Support System (CBOSS) is to provide a controlled environment for the cultivation of cells into healthy, three-dimensional tissues that retain the form and function of natural, living tissue. CBOSS will enable investigations on normal and cancerous mammalian cells, including ovarian and colon cancer cells, neural precursor and human renal cells. The system is comprised of the Biotechnology Specimen Temperature Controller, the Biotechnology Refrigerator, the Gas Supply Module and the Biotechnology Cell Science Stowage. The crew will periodically record scientific data, add fresh media to the tissue culture modules and process samples for return to Earth. The crew also will perform preventative maintenance.

Background/Flight History

The first cellular experiment flew aboard the space shuttle in the mid-1990s during STS-70 and STS-85. Long-duration cellular biotechnology experiments also were conducted in the Biotechnology System Facility on the Russian space station Mir from 1996 through 1998. This experiment also flew on the space station during Expedition Three.

Benefits

Bioreactor cell growth in microgravity permits cultivation of in vitro tissue cultures of size and quantity not possible on Earth. Such a capability provides unprecedented opportunities for breakthrough research in human diseases, including various types of cancer, diabetes, heart disease and AIDS.

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

http://microgravity.msfc.nasa.gov

http://scipoc.msfc.nasa.gov

Experiments

Crew Earth Observations (CEO)

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

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

Overview

By allowing photographs to be taken from space, the Crew Earth Observations (CEO) experiment provides people on Earth with 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 One, STS-97 (ISS Assembly Flight 4A), and is planned to continue through 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. 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 one 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.

Experiments

Commercial Generic Bioprocessing Apparatus (CGBA)

Principal Investigators: Dr. Louis Stodiek, BioServe Space Technologies, University of Colorado, Boulder, and Dr. Raymond Lam, Bristol-Myers Squibb Pharmaceutical Research Institute, Wallingford, Conn.

Project Manager: Cooperative agreement managed by John West, Office of Space Product Development, NASA Marshall Space Flight Center, Huntsville, Ala., and technical management by BioServe at the University of Colorado, Boulder

Overview

The goal of the research conducted in the Commercial Generic Bioprocessing Apparatus (CGBA) payload is to develop commercial uses of the unique microgravity environment for the field of life sciences. The CGBA hardware is able to support many standard biological laboratory techniques that have been adapted to operate in space. The experiments are designed to further our understanding of how gravity influences various biophysical and biochemical actions. Applications of this knowledge are geared toward creating or improving various biologically derived products, as well as enhancing the processes used to create them.

History/Background

The CGBA is a commercial payload sponsored by NASA's Space Product Development Program at the Marshall Space Flight Center. BioServe Space Technologies builds and manages the apparatus. BioServe is a NASA Commercial Space Center jointly located within the Aerospace Engineering Sciences Department at the University of Colorado in Boulder and the Division of Biology at Kansas State University in Manhattan. Bristol-Myers Squibb Pharmaceutical Research Institute in Wallingford, Conn., is BioServe's sponsoring commercial partner for this research. Since 1991, BioServe has flown payloads in space on 16 shuttle flights, two Mir flights and during Expedition Two.

Benefits

Gaining a better understanding of what is causing the stimulated production of antibiotics in space is helping scientists to design experiments that attempt to mimic this increase in productivity on Earth. These experimental techniques may lead to the development of methods for improving production efficiency in terrestrial pharmaceutical processing facilities.

Additional information on CGBA can be found at:

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

Experiments

Commercial Protein Crystal Growth (CPCG)

Principal Investigators: Dr. Larry DeLucas, Center for Biophysical Sciences and Engineering, University of Alabama at Birmingham, Ala.

Project Manager: Steve Lide, NASA's Marshall Space Flight Center, Huntsville, Ala.

Overview

The Commercial Protein Crystal Growth (CPCG) payload consists of 1,008 individual experiments in the High Density Protein Crystal Growth Assembly. This assembly will be stored in a Commercial Refrigerator Incubator Module for temperature control. The payload will be transferred to the International Space Station and the experiments will be activated. The crystal growth experiments, which require minimal crew interaction, will continue through the duration of the mission. The High Density Protein Crystal Growth System represents a major increase in capacity over the Center's previous crystal growth hardware, which contained only 128 individual experiments.

History/Background

Protein crystal growth experiments have been conducted by the Center for Biophysical Sciences and Engineering on 38 previous space shuttle missions, beginning in 1985. CPCG also flew aboard the space station during Expedition Two.

Benefits

Structural studies using microgravity-grown protein crystals may provide information that can be used in the development of new drugs. Many of the crystallization experiments conducted on the space shuttle have yielded crystals that furthered structural biology projects. With the advent of genomic information from humans and many other species, the roles proteins play in diseases and degenerative conditions is becoming more clear and the need for information about the structure of these proteins more critical.

Additional information and photos on this experiment is available at:

http://mix.msfc.nasa.gov/IMAGES/MEDIUM/9805360.jpg

http://mix.msfc.nasa.gov/IMAGES/MEDIUM/9401631.jpg

http://www.cmc.uab.edu/

Experiments

EarthKAM (Earth Knowledge Acquired by Middle School Students)

Principal Investigator: Dr. Sally Ride, University of California, San Diego, Calif.
Project Manager: Brion J. Au, NASA Johnson Space Center, Houston, Texas

Overview

EarthKAM (Earth Knowledge Acquired by Middle school students) is a NASA-sponsored educational program that enables students to photograph and examine the Earth from the vantage point of the International Space Station. EarthKAM is operated by the University of California, San Diego and NASA field centers. Using a digital camera mounted at the optical quality window in the station's Destiny Lab, EarthKAM students are able to remotely photograph the Earth's coastlines, mountain ranges and other geographic items of interest from the unique vantage point of space.

Experiment Operations

EarthKAM students determine the images they want to acquire, then their requests are collected and compiled into a "Camera Control File" at the University of California in San Diego. This file is then sent to a Station Support Computer aboard the ISS. This laptop activates the camera at specified times, taking the desired images and transferring them to the camera's hard disk card, which is capable of storing up to 81 images. The laptop computer then transfers these images to its own hard drive, storing them until they can be sent to Earth via the station's Operations Local Area Network (OPS LAN). Approximately one hour after receiving the images from the ISS, the EarthKAM team posts the images at http://www.earthkam.ucsd.edu/ for easy access by participating schools.

Flight History/Background

In 1994, Dr. Sally Ride, a physics professor, former NASA astronaut and the first American woman to fly in space, started what is now EarthKAM with the goal of integrating education with the space program. EarthKAM flew on five space shuttle flights before being taken to the space station. Since 1996, EarthKAM students from schools in the United States, Japan, Germany and France have taken thousands of photographs of the Earth.

The EarthKAM camera was installed in February 2001 during STS-98 as part of the Expedition One, ISS Mission 5A. After the Expedition One crew mounted the camera at the Destiny Lab window, the payload required no further crew interaction for nominal operations.

Benefits

By integrating Earth images with inquiry-based learning, EarthKAM offers students and educators the opportunity to participate in a space mission and develop teamwork, communication and problem-solving skills. Educators also use the images alongside suggested curriculum plans for studies in physics, computers, geography, math, earth science, biology, art, history, cultural studies and more.

Experiments

Protein Crystal Growth Single-locker Thermal Enclosure System Housing the Diffusion-controlled Crystallization Apparatus for Microgravity

Principal Investigator: Dr. Daniel Carter, New Century Pharmaceuticals, Inc. Huntsville, Ala.

Project Manager: Todd Holloway, 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 of important macromolecules and possibly contribute to the development of new 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 structure and the biological processes in which they are involved. Understanding these structures may impact the studies of medicine, agriculture, the environment and other biosciences.

Operations

The STES for the structural biology experiment is an incubator/refrigerator module that can house different devices for growing biological crystals in microgravity. During the STS-108 mission, two of these STES units will be flown, one housing the Diffusion-controlled Crystallization Apparatus for Microgravity (DCAM) and the other housing the Protein Crystallization Apparatus for Microgravity (PCAM). Once on board the International Space Station, the units will be located in the U.S. lab EXPRESS Rack 4. The experiments are scheduled to return to Earth aboard the STS-110 mission in March 2002.

The STES unit houses the DCAM, which is designed to grow crystals by dialysis and/or liquid-liquid diffusion. Eighty-one structural biology experiments are housed on three trays in the DCAM. Each sample container in the experiment is a little larger than a plastic can for 35mm film. The inside of the container is molded into two cylindrical chambers joined by a tunnel. The smaller chamber contains a buffer/precipitant solution. The end cap for this chamber holds the biological sample solution, covered by a semi-permeable membrane. This membrane allows the precipitant solution in the larger chamber to pass into the biological sample solution. A plug filled with porous material separates the two chambers and controls the rate of diffusion. Exposure to the precipitant causes the biological sample to crystallize.

Benefits

With science being performed on the ISS, 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 three-dimensional structure of macromolecules. Once the structure of a particular macromolecule is known, it may become much easier to determine how these compounds function.

Experiments

Astronauts in EVA Radiation Study (EVARM)

Principal Investigator: Ian Thomson, Thomson & Nielsen Electronics, Ltd., Ottawa, Canada

NASA Project Manager: Michelle Kamman, Johnson Space Center, Houston, Texas

CSA Project Manager: Ron Wilkinson, Canadian Space Agency, Ottawa, Canada

Overview

Space travel can be dangerous for humans because of the large amounts of radiation to which they can be adversely exposed. This concern is particularly true for spacewalkers who venture outside the shielded walls of spacecraft protected by only a spacesuit. Construction and maintenance of the space station will require hundreds of hours of space-walking time over the life of the program. Very high doses of radiation can kill cells and damage tissue, leading to cancer, cataracts and even injury to the central nervous system.

Monitoring devices have been flown on many space shuttle missions and Russia's space station Mir to learn more about how to protect crews from the effects of radiation. But these devices were not specifically designed to study radiation dosages encountered during spacewalks. The Astronauts in EVA Radiation Study (EVARM) will be the first to measure radiation dosage encountered by the eyes, internal organs and skin during specific spacewalks and relate it to the type of activity, location and other factors.

Flight History/Background

Scientists have been measuring radiation in the Earth's upper atmosphere and beyond since balloon launches in the 1940s. Radiation experiments have been part of many human space missions, measuring radiation exposure to spacecraft and space travelers. The Canadian Space Agency and the principal investigator for the experiment flew a similar radiation monitoring experiment on three missions aboard Russia's space station Mir in the mid-1990s. That experiment used passive dosimeters that were read after they were returned to Earth. The dosimeters were placed in the cosmonauts' sleeping quarters but were not carried on spacewalks.

Benefits

EVARM will help scientists better understand and predict radiation exposure encountered by astronauts during spacewalks and compare that to specific activities. For instance, scientists believe that spacewalkers who work close to the massive structure of the station will receive a lower radiation dosage than spacewalkers working at the end of the shuttle or station robot arms. The results of the investigation may offer ways to mitigate exposure to radiation during spacewalks. In addition, this space experiment will help further the technology used for radiation sensors on Earth.

Expedition Four

More information on the EVARM and other Expedition Four experiments is available at:

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

http://www.thomson-elec.com

http://www.space.gc.ca/csa_sectors/space_science/space_life_sciences/evarm/default.as

Experiments

EXPRESS Racks

Project Manager: Annette Sledd, NASA's Marshall Space Flight Center, Huntsville, Ala.

Overview

The EXPRESS Rack is a standardized payload rack system that transports, stores and supports experiments aboard the International Space Station. EXPRESS stands for EXpedite the PRocessing of Experiments to the Space Station, reflecting the fact this system was developed specifically to maximize the station's research capabilities. The EXPRESS Rack system supports science payloads (including commercial payloads) in several disciplines, including biology, chemistry, physics, ecology and medicine.

Operations

With its standardized hardware interfaces and streamlined approach, the EXPRESS Rack enables quick, simple integration of multiple payloads aboard the space station. The system is comprised of elements that remain on the ISS, as well as elements that travel back and forth between the space station and Earth via the space shuttle. EXPRESS Racks stay on orbit continually, while experiments are exchanged in and out of the EXPRESS Racks as needed – remaining on the space station for three months to several years.

A total of eight EXPRESS Racks are to be used on the space station. The first two were installed during Expedition 2 on the STS-100 mission (ISS Assembly Flight 6A) in April 2001. EXPRESS Racks 4 and 5 were installed during STS 105 (7A.1) in August 2001 at the beginning of Expedition Three 3. Express Rack No. 3 is to be installed in April 2002.

Benefits

By housing, supporting and transporting these experiments, the EXPRESS Rack could play a key role in the development of better medicines, more powerful computer chips or lighter metals. Similarly, by reducing the time, complexity and expense historically associated with orbital research, the EXPRESS Rack system will help universities and industry achieve these advances more quickly and for less money.

More information on EXPRESS Racks and the ISS can be found at:

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

http://liftoff.msfc.nasa.gov/Shuttle/ msl/science/express.html

http://www.spaceflight.nasa.gov

http://flightprojects.msfc.nasa.gov/ fd31.html

Experiments

Human Research Facility Rack 1

Project Manager: Dennis Grounds, NASA Johnson Space Center, Houston, Texas

Overview

The Human Research Facility, the first rack-sized payload to be installed in the U.S. Laboratory module of the International Space Station, provides an on-orbit laboratory that will enable life science researchers to study and evaluate the physiological, behavioral and chemical changes in human beings induced by spaceflight.

The Human Research Facility is a rack that provides services and utilities to experiments and instruments installed within it. These include electrical power, command and data handling, cooling air and water, pressurized gases and vacuum.

The first of two Human Research Facility racks was transported to the ISS on Mission 5A.1 during Expedition Two. The second will launch in 2002 and will also be located in the U.S. laboratory Destiny.

History/Background

Experiments conducted on board Spacelab, the space shuttle and the Russian space station Mir have required unique equipment to be transported for individual investigations. The Human Research Facility is unique to the ISS because its standardized equipment can support multiple experiments, reducing the amount of equipment transported to and from the space station.

The development phase began in 1996 with the formation of a science-working group made up of non-NASA researchers and medical practitioners. They defined the needs of prospective science experiment investigators and assisted NASA in designing and developing the rack and its hardware.

Benefits

Areas of concern to human well-being and performance, such as renal stone risk, bone density deterioration and the effects of ionizing radiation, will be studied using the Human Research Facility system and hardware. The human research will contribute to improving the scientific foundation of our understanding of the processes related to life, health and disease; strengthening the scientific underpinning of programs to assure safe and productive human spaceflight; and developing various applications of space technologies relevant to solutions of scientific and medical problems on Earth.

Experiments

Effects of Altered Gravity on Spinal Cord Excitability (H-Reflex)

Principal Investigator: Dr. Douglas Watt, McGill University, Montreal, Canada
Project Engineer: Luc Lefebvre, McGill University, Montreal, Canada

Overview

Experiments performed on space shuttle missions and on Skylab and Mir have shown that exposure to weightlessness causes changes in a person's neurovestibular system—changes related to the inner ear, equilibrium and awareness of body or limb orientation. In the H-Reflex experiment, also carried out on Expedition Two and Expedition Three crewmembers, researchers for the Canadian Space Agency are seeking additional information on changes to the human neurological system that occur during long-duration space flights. Researchers already know prolonged weightlessness results in a loss of muscle strength and decreased bone density. Currently, the only known treatment for this problem is in-flight exercise. But does exercise work on a long space flight?

A goal of the H-Reflex experiment is to help researchers determine if exercise could be made more effective on long space flights. The experiment measures spinal cord excitability—its ability to respond to stimuli. Researchers believe that spinal cord excitability decreases during prolonged space flight. If this proves true, they hypothesize that in-flight exercise would be less effective and the crews will have to work harder and longer to achieve any benefit. If spinal cord excitability does decrease on prolonged flights, researchers may be able to reverse the effect and lower the amount of exercise now required in space and thus increase crewmember productivity during the flight.

History/Background

Related experiments flew on eight previous space shuttle missions (STS-9, STS-41G, STS-61, STS-40, STS-42, STS-52, STS-58 and STS-78), on Skylab, and on Expedition Two and on Expedition Three.

Benefits

Studies such as the H-Reflex experiment will enable researchers to better understand and assess the physiological risks of long-duration space flight and help them better prepare crews for those flights. By knowing how a crewmember's body is affected in space, scientists can reduce the risk of acute and chronic health problems, increase productivity and make the spacecraft more habitable. Benefits from the H-Reflex study range from the obvious—potential improvement of crewmember health—to the less obvious—the potential for improving health care on Earth.

Experiments

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

Principal Investigator: Dr. Nick Kanas, Veterans Administration Medical Center, San Francisco, Calif.

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 and on Expedition Two and Expedition Three — 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.

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.

Experiment

Microgravity Acceleration Measurement System (MAMS)

Project Manager: William Foster, Glenn Research Center

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. During Expedition Three, it was preinstalled in the rack, which was placed in the laboratory during Expedition Two, ISS Flight 6A. At the start of Expedition Three, MAMS was relocated to EXPRESS Rack No. 4.

The MAMS accelerometer sensor is a spare flight sensor from the Orbital Acceleration Research Experiment (OARE) 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.

Experiment

Space Acceleration Measurement System II (SAMS-II)

Project Manager: William M. Foster, Glenn Research Center

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. For Expedition Two, five sensors were placed in the EXpedite the PRocessing of Experiments to the Space Station Racks (EXPRESS) with experiments before launch.

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.

Experiments

Materials International Space Station Experiments

Overview

The Materials International Space Station Experiments (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.

Johnson Space Center, Marshall Space Flight Center, Glenn Research Center, the Materials Laboratory at the Air Force Research Laboratory and Boeing Phantom Works are participants with Langley in the project.

History/Background

The MISSE experiments are 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 in August 2001. The second two PECs will be launched to the ISS about 18 months later.

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

Benefits

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

Experiments

Physics of Colloids in Space (PCS)

Principal Investigator: Prof. David Weitz, Harvard University, Cambridge, Mass.
Co-Investigator: Prof. Peter Pusey, University of Edinburgh, Edinburgh, UK
Project Manager: Michael Doherty, NASA Glenn Research Center, Cleveland, Ohio

Overview

A colloid is a system of fine particles suspended in a fluid. Paint, milk and ink are some common examples. Though these products are routinely produced and used, scientists still have much to learn about the underlying properties of colloidal systems. Understanding their properties may allow scientists to manipulate the physical structures of colloids -- a process called “colloidal engineering” -- for the manufacture of new materials and products.

The PCS experiment began during Expedition Two with International Space Station Mission 6A (STS-100, April 2001) and is to conclude with the return of the samples on Flight UF-2. It gathers data on the basic physical properties of colloids by studying three different colloid sample types. This experiment represents the first in-depth study of the growth and properties of colloidal superlattices -- formed from mixtures of different-sized colloidal particles -- performed in a microgravity environment. Scientists hope to better understand how colloid structures grow and behave with the long-term goal of learning how to control their growth to create new materials.

The experiment will focus on the growth and behavior of three different classes of colloid mixtures of tiny manmade particles of either polymethyl methacrylate or silica or polystyrene; these will include samples of binary colloidal crystal alloys, samples of colloid-polymer mixtures and samples of colloidal gels. Binary colloidal crystal alloys are dispersions of two different size particles in a stabilizing fluid. Colloid-polymer mixtures are solutions of mono-disperse particles mixed with a polymer in a stabilizing fluid, where the phase behavior -- solid, liquid and gas -- is controlled by the concentration of the polymer. Colloidal gels include aqueous solutions of particles, in this case aggregated on-orbit with a salt solution, to form fractal structures. The structure, stability and equilibrium properties of all the samples, as well as their structure, dynamics and mechanical properties, are being studied.

History/Background

The first generation experiments by these investigators in microgravity were Glovebox experiments with binary colloidal crystal alloys and colloid-polymer mixtures, flown on the Russian space station Mir and on the STS-95 mission in October 1998.

Experiments

Protein Crystal Growth—Enhanced Gaseous Nitrogen Dewar (PCG-EGN)

Principal Investigators:	Dr. Alexander McPherson, University of California, Irvine
Project Manager:	Raymond A. French, NASA's Marshall Space Flight Center, Huntsville, Ala.

Overview

The Enhanced Gaseous Nitrogen Dewar is a stainless steel and aluminum container assembly, similar to a thermos bottle, for carrying biological crystallization experiments aboard the space shuttle to the International Space Station. Approximately 500 plastic tubes, each containing a specific crystal-growth experiment, can fit inside the dewar assembly. The primary purpose of these experiments is to grow crystals of biological macromolecules in the low-gravity environment of space. These macromolecules include proteins, viruses and nucleic acids.

Background/Flight History

The EGN hardware is an upgrade from similar hardware and experiments flown on the Russian space station Mir. The upgraded EGN hardware incorporates devices for recording the temperatures inside the dewar and storing that data. The upgraded EGN flew to the space station during Expeditions One and Two.

Benefits

In order to better understand the basic processes of living things, scientists must first understand the structure and function of certain macromolecules. As the low-gravity environment of space often improves the quality of biological crystals beyond those grown on Earth, researchers expect the EGN experiments to contribute to their understanding of the three-dimensional and chemical structure of proteins, viruses and nucleic acids. Knowledge of precise three-dimensional molecular structure is important for protein engineering and drug design.

Additional information on the Enhanced Gaseous Nitrogen Dewar and biological crystal growth is available at:

http://www.microgravity.nasa.gov/
http://www.structure.uci.edu/frames/index.htm
http://crystal.nasa.gov/technical/egn.html

Experiments

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

Principal Investigators:	Dr. Daniel Carter and Dr. Craig Kundrot, New Century Pharmaceuticals, Huntsville, Ala.
Project Manager:	Todd Holloway, NASA's Marshall Space Flight Center, Huntsville, Ala.

Overview

The STES is an incubator/refrigerator module that can house different devices for growing biological crystals in microgravity. Each STES unit houses six Protein Crystallization Apparatuses for Microgravity (PCAM), which are designed to grow the actual crystals. The fundamental goal for growing biological macromolecular crystals is to determine their structure and the biological processes in which they are involved. Scientists select macromolecules, crystallize them, and analyze the atomic details 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.

Background/Flight History

The STES hardware has previously flown on six shuttle missions (STS-63, 67, 73, 83, 85, 95) and during Expedition Two.

Benefits

Structural biological experiments conducted in the PCG-STES will enable the more accurate mapping of the three-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 on the STES and biological crystal growth is available at:

http://crystal.nasa.gov/

http://www.microgravity.nasa.gov/

http://www.ssl.msfc.nasa.gov/msl1/images/pcambig.jpg

Experiment

PuFF - The Effects of EVA and Long-Term Exposure to Microgravity on Pulmonary Function

Principal Investigator: John B. West, M.D., Ph.D., Univ. of Calif. - San Diego
Project Manager: Suzanne McCollum, NASA Johnson Space Center, Houston

Overview

Little is known about how human lungs are affected by long-term exposure to the reduced pressure in spacesuits during spacewalks or long-term exposure to microgravity. Changes in respiratory muscle strength may result. The Pulmonary Function in Flight (PuFF) experiment focuses on the lung functions of astronauts both while they are aboard the International Space Station and following spacewalks.

The first PuFF test was performed on the Expedition Three crew two weeks into their mission, then once monthly thereafter. Crewmembers also perform a PuFF test at least one week before each spacewalk. Following each spacewalk, the crewmembers will perform another PuFF test, either on the day of the spacewalk or on the following day.

PuFF uses the Gas Analyzer System for Metabolic Analysis Physiology instrument in the Human Research Facility rack, along with a variety of other equipment. Data is stored in a personal computer located in the HRF rack and then transmitted to the ground.

History/Background

The PuFF experiment builds on research conducted during several Spacelab missions during the last decade. Comprehensive measurements of lung function in astronauts were first made during Spacelab Life Sciences-1 in June 1991.

Benefits

Gravity affects the way the lungs operate and may even exaggerate some lung disorders, such as emphysema and tuberculosis. In space, changes in lung anatomy may cause changes in lung performance. By performing lung experiments on astronauts living aboard the International Space Station, scientists hope to find new ways to not only protect the health of future space travelers, but to gain a better understanding of the effects of gravity on the lungs of people who remain on Earth.

To read more about the Expedition Four science experiments, visit the Web at:

www.scipoc.msfc.nasa.gov

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

Experiments

Renal Stone Risk During Space Flight: Assessment and Countermeasure Validation

Principal Investigator: Dr. Peggy A. Whitson, Johnson Space Center, Houston, Texas
Project Manager: Michelle Kamman, Johnson Space Center, Houston, Texas

Overview

Exposure to microgravity results in a number of physiological changes in the human body, including alterations in kidney function, fluid redistribution, bone loss and muscle atrophy. Previous data have shown that human exposure to microgravity increases the risk of kidney stone development during and immediately after spaceflight. Potassium citrate, a proven Earth-based therapy to minimize calcium-containing kidney stone development, will be tested during Expedition Four as a countermeasure to reduce the risk of kidney stone formation. This study also will assess the kidney stone-forming potential in humans based on mission duration, and determine how long after space flight the increased risk exists.

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

Benefits

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

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

www.scipoc.msfc.nasa.gov
http://spaceflight.nasa.gov/station/science/index.html

Experiments

Sub-regional Assessment of Bone Loss in the Axial Skeleton in Long-term Space Flight

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

Overview

As demonstrated by Skylab and Russian space station Mir missions, bone loss is an established medical risk in long-duration space flight. 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 preflight and postflight measurements of crewmembers' spine and hipbones using Quantitative Computed Tomography -- a three-dimensional technique that examines the inner and outer portions of a bone separately. It can determine if the loss was localized in a small sub-region of the bone or over a larger area.

Bone recovery will be assessed by comparing tomography data taken before and after flight and one year later. Results will be compared with ultrasound measurements and Dual X-Ray Absorptiometry taken at the same times. The measurements will include Dual X-Ray Absorptiometry of the spine, hip and heel, and ultrasound of the heel. The experiment began with the Expedition Two crewmembers. ISS crews through Expedition Six will be measured. 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 sub-groups.

Experiments

Xenon 1: Effects of Microgravity on the Peripheral Subcutaneous Veno-arteriolor Reflex in Humans

Principal Investigator: Dr. Anders Gabrielson, National University Hospital, Copenhagen, Denmark.

Project Manager: Suzanne McCollum, Johnson Space Center, Houston

Overview

When a person stands, there is a pooling of blood in the lower part of the body and legs. If blood circulation is impeded, this leads to a reduced filling of the heart, which in turn results in a decrease in blood pressure and possibly fainting or swooning. An important mechanism which is activated to protect the circulation is a reflex in muscle and skin called local veno-arteriolar reflex.

Activation of these local reflexes results in constriction of the small blood vessels in skin and muscle tissue, which increases the resistance to blood flow and helps maintain blood pressure during upright posture.

After being in the microgravity environment of space, the body's ability to regulate blood pressure while standing is reduced. This is called orthostatic intolerance, which can severely inhibit the functional capacity of crewmembers during re-entry and landing. The Xenon 1 study will investigate the mechanism of this syndrome, specifically the extent to which the blood vessels are active in maintaining normal blood pressure, laying an important foundation for the development of treatments for orthostatic intolerance.

To study orthostatic intolerance, a tracer material, ^{133}Xenon, will be injected just below the skin in the lower leg above the ankle. Arterial blood pressure will then be recorded continuously to calculate how blood vessels help regulate arterial blood pressure and prevent orthostatic hypotension, or dizziness when standing. The rate at which the Xenon is removed from the area by the circulatory system will also be measured. These measurements will be done on each of the Expedition Four crewmembers 30 days before their launch and repeated one day after they return to Earth.

Benefits

Understanding the local veno-arteriolar reflex following exposure to microgravity could lead to future treatments to ensure normal blood circulation for ISS crewmembers returning to Earth, enhancing mission effectiveness and crewmembers' safety.

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

www.scipoc.msfc.nasa.gov

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

Experiments

Zeolite Crystal Growth Furnace (ZCG)

Principal Investigator: Dr. Al Sacco, Jr., Center for Advanced Microgravity Materials Processing, Northeastern University, Boston, Mass.

CSC Manager: Jeneene Sams, NASA Space Product Development Program, Marshall Space Flight Center, Huntsville, Ala.

Overview

Zeolites have a rigid crystalline structure with a network of interconnected tunnels and cages, similar to a honeycomb. While a sponge needs to be squeezed to release water, zeolites give up their contents when they are heated or under reduced pressure. Zeolites have the ability to absorb liquids and gases such as petroleum or hydrogen but remain as hard as a rock. Zeolites form the backbone of the chemical processes industry, and virtually all the world's gasoline is produced or upgraded using zeolites. Industry wants to improve zeolite crystals so that more gasoline can be produced from a barrel of oil, making the industry more efficient and reducing America's dependence on foreign oil.

Operations

The Zeolite Crystal Growth Furnace is designed for relatively low-temperature growth of crystals in solutions. Before the flight, two solutions will be loaded into metal, Teflon-lined, cylindrical containers (autoclaves). The furnace will be delivered during STS-108. The crew will install the hardware into a double middeck locker in EXPRESS Rack 2. The hardware will be checked out during UF-1 before the shuttle delivers samples during STS-110 in March 2002. When the autoclaves containing the sample solutions arrive, the crew will unstow them and load them in the furnace. At the end of the specified processing time, the crew will power down the furnace, unload the autoclaves containing the crystals and stow them for return to Earth.

Flight History/Background

A simpler version of this experiment has flown successfully on three space shuttle missions: STS-50 in 1992, STS-57 in 1993 and STS-73 in1995. During these earlier flights, zeolite crystals grown in space were larger and of better quality than crystals grown in a similar facility on the ground.

Benefits

Research with zeolites has the potential to reduce our dependence on foreign oil and the pollution associated with producing gasoline and other petroleum products. In the future, zeolites may even be used for storing new fuels that are cheaper and cleaner. Hydrogen is one candidate fuel that might be stored and transported safely using zeolites. Since hydrogen is the most abundant element in the universe, and it's pollution-free, it is an ideal fuel. Scientists are seeking a solution to the efficient storage of hydrogen, and zeolites and zeo-type materials are being tested as possible storage media.

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