NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE SHUTTLE MISSION
STS-91

PRESS KIT
JUNE 1998

SHUTTLE MIR MISSION-09 (S/MM-09)
ALPHA MAGNETIC SPECTROMETER (AMS)

STS-91 INSIGNIA

STS091-S-001 -- This is the insignia for the STS-91 mission -- the ninth flight of the Shuttle-Mir Phase One docking missions. The crew will bring back Andrew S. W. Thomas, the last long-duration American crew member flown on the Russian Space Station Mir. This mission marks the end of the Shuttle-Mir Phase One Program and will open the way for Phase Two: construction of the International Space Station (ISS). The crew patch depicts the rendezvous of the space shuttle Discovery with the space station Mir. The flags of the United States and Russia are displayed at the top of the patch and both countries are visible on the Earth behind the two spacecraft. The names of the American crewmembers surround the insignia on the outer areas, with the name of cosmonaut Valeriy Ryumin in Cyrillic at the lower right. The Alpha Magnetic Spectrometer (AMS) is an international payload planned to fly in the payload bay of Discovery. Two thin golden streams flowing into the AMS represent charged elementary particles. The detection of antimatter in space will help scientists better understand the physics and origins of the universe.

The NASA insignia design for space shuttle flights is reserved for use by the astronauts and for other official use as the NASA Administrator may authorize. Public availability has been approved only in the form of illustrations by the various news media. When and if there is any change in this policy, which we do not anticipate, it will be publicly announced.

PHOTO CREDIT: NASA or National Aeronautics and Space Administration.

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NINTH SHUTTLE-MIR DOCKING MISSION HIGHLIGHTS - STS-91

The first phase of the cooperative effort in space exploration between the United States and Russia will be completed in June 1998 with the launch of Space Shuttle Discovery on the ninth and final docking mission with the Russian Space Station Mir. The flight, designated STS-91, will deliver logistics and supplies to Mir and will bring home NASA Astronaut Andrew Thomas, who has been on the Russian complex since late January.

Flying on STS-91 is an experiment by Nobel laureate Dr. Samuel C. C. Ting, the Alpha Magnetic Spectrometer (AMS) experiment. In 1995, Dr. Ting's research proposal for the AMS space experiment was formally selected by the U.S. Department of Energy. The AMS will fly for the first time on the STS-91 mission and a second time on the International Space Station. Professor Ting has been among the world's leading researchers in the field of high-energy particle physics for decades. He has received many awards and honors for his research, including the Nobel Prize in Physics in 1976 for the discovery of the "J" sub-atomic particle.

The AMS experiment is the first of a new generation of space-based experiments which use particles instead of light to study the Universe. The experiment will help answer questions about the creation, growth and future of the universe. It will also help probe further into questions surrounding the "Big Bang theory".

Researchers will use the AMS detector to search for both antimatter and "dark matter" to answer two specific questions: First, if equal amounts of matter and antimatter were produced at the beginning of the universe as described by the Big Bang scenario, and the galaxies we now see are made only of matter, where has the antimatter gone? Second, since the mass of a galaxy seems to be greater than the visible mass of all its stars, gas and dust, is there dark matter of a new kind that has eluded discovery?

The STS-91 crew will be commanded by Charlie Precourt, who will be making his fourth shuttle flight and third trip to Mir. The pilot, Dominic Gorie, will be making his first flight. There are four mission specialists assigned to STS-91. Franklin Chang-Diaz is serving as Mission Specialist-1 and the Payload Commander and will become the third human to fly in space six times. Wendy Lawrence is making her third space flight as Mission Specialist-2 and flight engineer and is visiting Mir for the second time in less than a year. Janet Kavandi is Mission Specialist-3 and will be making her first flight. Valeri Ryumin, a veteran Russian cosmonaut and manager of the Russian Mir program, will serve as Mission Specialist-4. STS-91 will be Ryumin's fourth space flight, his first aboard the Space Shuttle. After Discovery docks to Mir and Thomas once again becomes a shuttle crewmember, he will be designated as Mission Specialist-5 for the remainder of the mission as he completes his second space flight.

Discovery is targeted for launch on June 2, 1998, from NASA's Kennedy Space Center Launch Complex 39-A. The current launch time of 6:10 p.m. EDT may vary slightly based on calculations of Mir's precise location in space at the time of liftoff. The STS-91 mission is scheduled to last 9 days, 19 hours, 53 minutes. An on-time launch on June 2 and nominal mission duration would have Discovery landing back at Kennedy Space Center on June 12 at 2:03 p.m. EDT.

STS-91 will be the first time Discovery docks with the Mir. The first eight docking missions were conducted by Atlantis and Endeavour.

Discovery's rendezvous and docking with the Mir begins with the precisely timed launch, setting the shuttle on a course for rendezvous with the orbiting Russian facility. Over the next two to three days, periodic firings of Discovery's small jet thrusters will gradually bring Discovery to its linkup to Mir.

The STS-91 mission is part of the Phase One program, consisting of nine Shuttle-Mir dockings and seven long-duration flights of U.S. astronauts aboard the Russian space station.

This series of missions has expanded U.S. research on Mir by providing astronauts with a laboratory in orbit for long-term research, similar to the kind of continuous research capability which will exist on the new

International Space Station. By the time Discovery lands, U.S. astronauts will have spent almost 1,000 days aboard Mir, including more than 26 continuous months since the arrival of Shannon Lucid on the STS-76 mission in March 1996.

For the STS-91 mission, Discovery carries the single SPACEHAB module in the payload bay of the orbiter. The module houses experiments to be performed by the astronauts and serves as a cargo carrier for the items to be transferred to Mir and those to be returned to Earth.

During the docked phase of STS-91, astronauts and cosmonauts will transfer from the Mir to the Shuttle the science samples collected by Thomas and his Mir colleagues. Crew members will also transfer hardware and supplies to Mir to support the crew and future science investigations. This continued research will focus on studies in of advanced technology, human life sciences, and microgravity research.

The research from the advanced technology discipline will evaluate new technologies and techniques using the Mir space station and the Shuttle as a test bed. This research will enhance knowledge base for implementation on the International Space Station and other space vehicles.

Human life sciences research consists of investigations that focus on the crew members adaptation to weightlessness in terms of skeletal muscle and bone changes, cardiovascular acclimatization, and psychological interactions. This set of investigations will continue the characterization of the integrated human response to a prolonged presence in space.

Microgravity research has the general goal of advancing scientific understanding through research in materials science. The QUELD furnace will heat capsules containing metallic binary systems, bring them to room temperature, and return them to Earth for analysis of the effects of microgravity on diffusion processes. This experiment will be performed using the Microgravity Isolation Mount (MIM).

Also flying in Discovery’s cargo bay will be four Get Away Special (GAS) and two Space Experiment Module (SEM) payloads that will examine the effects of microgravity on various plants and materials, study the way materials processing changes in space, look at new ways to extract oil from the Earth and clean up accidental spills in the environment as well as investigate the degree to which DNA is damaged by exposure to cosmic radiation in a space environment.

The current Russian cosmonaut crew aboard Mir began its mission on January 31 when Mir 25 Commander Talgat Musabayev and Flight Engineer Nikolai Budarin were launched from the Baikonur Cosmodrome in Kazakhstan along with French researcher Leopold Eyharts. They arrived on Mir on January 31. Eyharts returned to Earth three weeks later with Mir 24 cosmonauts Anatoli Solve and Pave Vinogradov. Musabayev and Budarin are scheduled to return to Earth on or about August 10 when they are replaced by the Mir 26 crew of Commander Gennadi Padalka, Flight Engineer Sergei Avdeyev and researcher Yuri Baturin, who are scheduled to be launched August 2 for an docking on August 4.

STS-91 will be the 24th flight of Discovery and the 91st mission flown since the start of the Space Shuttle program in April 1981.

(END OF GENERAL RELEASE; BACKGROUND INFORMATION FOLLOWS.)

MEDIA SERVICES INFORMATION

NASA Television Transmission

NASA Television is available through the GE2 satellite system which is located on Transponder 9C, at 85 degrees west longitude, frequency 3880.0 MHz, audio 6.8 MHz.

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

Status Reports

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

Briefings

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

Internet Information

Information on STS-91 is available through several sources on the Internet. The primary source for mission information is the NASA Shuttle Web, part of the World Wide Web. This site contains information on the crew and its mission and will be regularly updated with status reports, photos and video clips throughout the flight. The NASA Shuttle Web's address is:

http://shuttle.nasa.gov

If that address is busy or unavailable, Shuttle information is available through the Office of Space Flight Home Page:

http://www.osf.hq.nasa.gov/

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

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

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

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

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

http://www.nasa.gov/ntv

Status reports, TV schedules and other information also are available from the NASA Headquarters FTP (File Transfer Protocol) server, ftp.hq.nasa.gov. Log in as anonymous and go to the directory /pub/pao. Users should log on with the user name "anonymous" (no quotes), then enter their E-mail address as the password. Within the /pub/pao directory there will be a "readme.txt" file explaining the directory structure:

- Pre-launch status reports (KSC): ftp.hq.nasa.gov/pub/pao/statrpt/ksc
- Mission status reports(JSC): ftp.hq.nasa.gov/pub/pao/statrpt/jsc
- Daily TV schedules: ftp.hq.nasa.gov/pub/pao/statrpt/jsc/tvsked.

NASA Spacelink, a resource for educators, also provides mission information via the Internet. Spacelink may be accessed at the following address:

http://spacelink.nasa.gov

Access by Compuserve

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

STS-91 QUICK LOOK

Launch Date/Site:	June 2, 1998/KSC Launch Pad 39-A
Launch Time:	6:10 P.M. EDT (approximately)
Launch Window:	5-10 minutes
Orbiter:	Discovery, (OV-103), 24th flight
Orbit Altitude/Inclination:	173 nautical miles, 213 n.m. For Mir docking / 51.6 degrees
Mission Duration:	9 days, 19 hours, 53 minutes
Landing Date:	June 12, 1998
Landing Time:	2:03 P.M. EDT
Primary Landing Site:	Kennedy Space Center, FL
Abort Landing Sites:	Return to Launch Site Kennedy Space Center, FL Transoceanic Abort Sites Zaragoza, Spain Ben Guerir, Morocco Moron, Spain Abort-Once Around Kennedy Space Center, FL
Crew:	Charlie Precourt, Commander (CDR), 4th flight Dom Gorie, Pilot (PLT), 1st flight Franklin Chang-Diaz, Payload Commander, 6th flight Wendy Lawrence, Mission Specialist 2 (MS 2), 3rd flight Janet Kavandi, Mission Specialist 3 (MS 3), 1st flight Valeri Ryumin, Mission Specialist 4 (MS 4), 4th flight Andy Thomas, Mission Specialist 5 (MS 5), docking-landing, 2nd flight
EVA Crewmembers (if required):	Franklin Chang-Diaz (EV 1), Janet Kavandi (EV 2)
Cargo Bay Payloads:	Orbiter Docking System Spacehab Module Alpha Magnetic Spectrometer (AMS) Space Experiment Module (SEM) GAS Canisters
In-Cabin Payloads:	Commercial Protein Crystal Growth Solid Surface Combustion Experiment

CREW RESPONSIBILITIES

Payloads	Prime	Backup
Rendezvous	Precourt	Gorie
Rendezvous Tools	Gorie	Others
Orbiter Docking System	Lawrence	Gorie
Spacehab Systems	Kavandi	Chang-Diaz, Ryumin
Spacehab Science	Chang-Diaz	Kavandi
Alpha Magnetic Spectrometer	Chang-Diaz	Kavandi
EVA (if required)	Chang-Diaz (EV 1)	Kavandi (EV 2)
Intravehicular Crewmember	Lawrence	------
Transfers	Lawrence	Ryumin, others
Earth Observations	Gorie	Kavandi, Ryumin
Ascent Seat on Flight Deck	Chang-Diaz	------
Entry Seat on Flight Deck	Kavandi	------
Commercial Protein Crystal	Lawrence	Gorie
Solid Surface Combustion	Gorie	Lawrence
Get Away Special (GAS)	Precourt	Lawrence

STS-91 ORBITAL EVENTS SUMMARY

(based on a June 2, 1998 launch; times are approximate)

Event	MET	Time of Day (EDT)
Launch	0/00:00	6:10 PM, June 2
Spacehab Activation	0/02:30	8:40 PM, June 2
Discovery/Mir Docking	1/18:49	12:59 PM, June 4
Hatch Opening	1/20:30	2:40 PM, June 4
Crew News Conference/Farewell	4/18:35	12:45 PM, June 7
Final Hatch Closure	5/14:15	8:25 AM, June 8
Discovery/Mir Undocking	5/17:51	12:01 PM, June 8
Final Separation Burn	5/19:13	1:23 PM, June 8
Deorbit Burn	9/18:45	12:55 PM, June 12
KSC Landing	9/19:53	2:03 PM, June 12

DEVELOPMENTAL TEST OBJECTIVES/ DETAILED SUPPLEMENTARY OBJECTIVES/ RISK MITIGATION EXPERIMENTS

DTO 685:	Ascent/Entry Kneeboard Situational Awareness Display
DTO 690:	Urine Collection Device
DTO 700-11:	Orbiter Space Vision System Flight Unit Testing
DSO 700-15:	Integrated GPS/Inertial Navigation System Test
DSO 1118:	Micrometeoroid/Orbital Debris Photo-TV Survey of Mir
DSO 802:	Educational Activities
RME 1312:	Real-Time Radiation Monitoring Device
RME 1319:	Inventory Management System
RME 1320:	Radiation Monitoring Experiment-III
RME 1331:	Shuttle Condensate Collection for International Space Station

PAYLOAD AND VEHICLE WEIGHTS

	Pounds
Orbiter (Discovery) empty and 3 SSMEs	182,610
Shuttle System at SRB Ignition	4,514,510
Orbiter Weight at Landing with Cargo	259,834
Spacehab Module	22,251
Alpha Magnetic Spectrometer	9,196
Orbiter Docking System	4,016
Remote Manipulator System	994

MISSION SUMMARY TIMELINE

Flight Day 1
Launch/Ascent
OMS-2 Burn
Payload Bay Door Opening
Spacehab Activation
Alpha Magnetic Spectrometer (AMS) Activation and Checkout

Flight Day 2
Water Bag Fills
Spacehab Module Setup and Secondary Science Activity
Rendezvous Tool Checkout
Orbiter Docking System Checkout

Flight Day 3
Discovery/Mir Docking
Hatch Opening and Welcoming Ceremony
Thomas Transfers to the Shuttle
Logistics Transfers

Flight Day 4
Logistics Transfers
Spacehab Science Activity

Flight Day 5
Remote Manipulator Checkout
Spektr Gas Release
Logistics Transfers
Spacehab Science Activity

Flight Day 6
Logistics Transfers
Spacehab Science Activity
Crew News Conference and Farewell Ceremony

Flight Day 7
Final Farewells and Hatch Closure
Undocking, Flyaround and Spektr Gas Release
Final Separation Burn
Transfer Item Stowage

Flight Day 8
AMS Data Collection
Secondary Experiments
Off Duty Time

Flight Day 9
AMS Data Collection
Secondary Experiments
Educational Video Recording

Flight Day 10
AMS Data Collection
Cabin Stow
Flight Control System Checkout
Reaction Control System Hot-Fire
Spacehab Module Teardown

Flight Day 11
Final Cabin Stow
Spacehab Deactivation
Deorbit Prep
Deorbit Burn
KSC Landing

SHUTTLE ABORT MODES

Space Shuttle launch abort philosophy aims toward safe and intact recovery of the flight crew, Orbiter and its payload. Abort modes for STS-89 include:

- Abort-To-Orbit (ATO): Partial loss of main engine thrust late enough to permit reaching a minimal 105-nautical mile orbit with the orbital maneuvering system engines.

- Abort-Once-Around (AOA): Earlier main engine shutdown with the capability to allow one orbit of the Earth before landing at Kennedy Space Center, Fla.

- Transoceanic Abort Landing (TAL): Loss of one or more main engines midway through powered flight would force a landing at either Zaragoza or Moron in Spain or Ben Guerir in Morocco.

- Return-To-Launch-Site (RTLS): Early shutdown of one or more engines, and without enough energy to reach a TAL site, would result in a pitch around and thrust back toward Kennedy until within gliding distance.

STS-91 MIR RENDEZVOUS, DOCKING, UNDOCKING AND SPEKTR GAS RELEASE

Discovery's rendezvous and docking with the Russian Space Station Mir actually begins with the precisely timed launch of the Shuttle on a course for the Mir, and, over the next two days, periodic small engine firings that will gradually bring Discovery to a point eight nautical miles behind Mir on docking day, the starting point for a final approach to the station.

Mir Rendezvous & Docking-- Flight Day 3

About two hours before the scheduled docking time on Flight Day three of the mission, Discovery will reach a point about eight nautical miles behind the Mir Space Station at which time the astronauts conduct a Terminal Phase Initiation (TI) burn, beginning the final phase of the rendezvous. Discovery will close the final eight nautical miles to Mir during the next orbit. As Discovery approaches, the shuttle's rendezvous radar system will begin tracking Mir, providing range and closing rate information to Discovery's astronauts. The crew members will also begin air-to-air communications with the Mir crew using a VHF radio.

As Discovery reaches close proximity to Mir, the Trajectory Control Sensor, a laser ranging device mounted in the payload bay, will supplement the shuttle's onboard navigation information by supplying additional data on the range and closing rate. As Discovery closes in on the Mir, the shuttle will have the opportunity for four small successive engine firings to fine-tune its approach using its onboard navigation information. Flying a slightly modified rendezvous profile for improved efficiency, Discovery will aim for a point directly below Mir, along the Earth radius vector (R-Bar), an imaginary line drawn between the Mir center of gravity and the center of Earth. Approaching along the R-Bar, from underneath the Mir, allows natural forces of Earth's gravity to assist in braking Discovery's approach. During this time, the crew will begin using a hand-held laser ranging device to supplement distance and closing rate measurements made by other shuttle navigational equipment.

Discovery will intercept the R-Bar at a point 600 ft below Mir. Commander Charlie Precourt will fly the shuttle from the aft flight deck controls as Discovery begins moving up toward Mir. Because of the approach from underneath Mir, Precourt will have to perform very few braking firings. However, if such firings are required, the shuttle's jets will be used in a mode called "Low-Z," a technique that uses slightly offset jets on Discovery's nose and tail to slow the spacecraft rather than firing jets pointed directly at Mir. This technique avoids contamination of the space station and its solar arrays by exhaust from the shuttle steering jets.

Using the centerline camera fixed in the center of Discovery' docking mechanism, Precourt will align Discovery's docking mechanism with the Docking Module mechanism on Mir, continually refining this alignment as he approaches within 300 feet of the station.

When Discovery is 170 feet from the station, the Shuttle will briefly stop and perform a stationkeeping maneuver to maintain its distance from Mir. At that time, a final go or no- go decision to proceed with the docking will be made by flight control teams in both Houston and the Russian Mission Control Center in Korolev, outside Moscow.

At a distance of about 30 feet from docking, Precourt will again stop Discovery briefly to adjust the docking mechanism alignment, if necessary.

When Discovery proceeds with docking, the shuttle crew will use ship-to-ship communications with Mir to inform the Mir crew of the shuttle's status and to keep them informed of major events, including confirmation of contact, capture and the conclusion of damping. Damping, the halt of any relative motion between the two spacecraft after docking, is performed by shock absorber-type springs within the docking device. Mission Specialist Wendy Lawrence will oversee the operation of the Orbiter Docking System from onboard Discovery.

Undocking, Separation and Spektr Gas Release

Once Discovery is ready to undock from Mir, the initial separation will be performed by springs that will gently push the shuttle away from the docking module. Both the Mir and Discovery will be in a configuration called "free drift" during the undocking, which keeps the steering jets of each spacecraft shut off to avoid any inadvertent firings.

Once the docking mechanism's springs have pushed Discovery away to a distance of about two feet from Mir, and the two spacecraft are clear of one another, Discovery' steering jets will be turned back on to increase the separation distance between the two vehicles.

The shuttle will continue to back away through a corridor similar to that used during approach until it reaches a distance of approximately 240 feet below the Mir. Pilot Dom Gorie will then perform a nose forward flyaround of the station.

During the flyaround, about 20 minutes after undocking, Discovery will reach a point about 240 feet directly in front of the Mir, on what is known as the velocity vector. About three minutes prior to sunrise, Mir 25 Commander Talgat Musabayev and Flight Engineer Nikolai Budarin will release a tracer gas comprised of acetone and biacetyl into the depressurized Spektr module using a special device attached to the Spektr’s modified hatch.

The release of gas into Spektr should last about 20 minutes, enabling Discovery’s astronauts to document any ionization glow from the gas through the hole in Spektr’s hull prior to sunrise and any fluorescent glow from the gas after sunrise. If lighting conditions are right, the gas could appear as a dull green cloud. The test is designed to pinpoint the location of the breach in Spektr’s hull resulting from last year’s collision of a Progress resupply ship with the Russian station. Two days earlier, a similar release of gas into Spektr will be conducted by the cosmonauts while Discovery is docked to Mir to test the gas release system and enable the crew members to document any areas of special interest for the flyaround experiment.

Finally, almost an hour and a half after undocking, Gorie will fire Discovery’s jets one more time as the shuttle passes directly above the Mir to separate from the Russian station for the final time.

SPACEHAB

STS-91 will be the sixth in a series of Shuttle-Mir missions which will carry a SPACEHAB single module onboard. The SPACEHAB single module is a pressurized, mixed-cargo carrier designed to augment the Orbiter Middeck by providing a total cargo capacity of up to 4,000 pounds. SPACEHAB is connected to the Orbiter through a modified Spacelab tunnel adapter, and in the aft half of the unit, contains systems necessary to support the habitat for the astronauts, such as ventilation, lighting, and limited power.

The module accommodates various quantities, sizes, and locations of experiment hardware. Attachment locations are available on the bulkheads, the rack support structures and on the top exterior surfaces. Standard experiment accommodations include lockers and racks, and for Earth and space viewing, there is the capability to mount to the optical viewport on the module top panel. Also, there are attachment capabilities on the flat top of the module exterior, in order to provide direct access to space.

Russian Logistics -- A double rack will be dedicated to some of the Russian Logistics and three Russian Storage Batteries will be mounted on the aft bulkhead of the SPACEHAB module for transfer to Mir. During docked operations, the crew will remove the batteries and transfer them to Mir. Numerous Russian Logistics items, totaling approximately 2,600 pounds, will be carried in the SPACEHAB. Items include food and water containers, clothing and sleeping articles, Personal Hygiene Aids (PHAS), a variety of film cases, and Cosmonaut Return Packages.

American Logistics -- Water (1200 lbs.) Will be transferred from the Shuttle to Mir; a cosmonaut family package, phase 1 program gifts and crew gifts will be transferred from the Shuttle to Mir; and new film will be swapped for film already shot onboard Mir.

Science and Technology -- The SPACEHAB Universal Communication System (SHUCS) payload will be used to send and receive telephone voice and faxes, as well as provide video images of the crew from the SPACEHAB module, to test the improved availability of payload uplink and downlink communications with the ground. On STS-91, the crew will have scheduled voice and fax contacts that are pre-approved by the Flight Control Team. SHUCS “round-trip” latency of 0.7 - 1.2 seconds allows file transfer, commanding, up/downlink fax and voice communications globally via three ground stations and the INMARSAT satellite system.

STS-91 AND MIR 25
BACKGROUND AND SCIENCE OVERVIEW

Scientific research has always been a major objective of both the United States and Russian space programs. The Phase 1 NASA-Mir science program is a joint research program between Russia and the US which was initiated to conduct long duration space research in the most efficient manner possible, utilizing both countries' resources and personnel. Using the Russian space station Mir as a platform for jointly developed hardware and science investigations allows US researchers to conduct experiments in microgravity for several months at a time. This currently is not possible to do within the US space program, since the average Shuttle mission lasts only a 1-2 weeks.

Long duration space flight presents a unique opportunity for the US, as many human adaptation to spaceflight experiments, along with crystal growth, space sciences, and other biological investigations cannot be performed within the short time span of a typical Shuttle mission. In return for the use of facilities on their space station, the Russian Space Agency has access to 9 Shuttle flights that dock to the station. These Shuttle flights allow additional resupply for both station maintenance and science experiments, along with transportation of an American crewmember to the Mir. The American is trained as a Mir crewmember to perform routine maintenance on the station, in addition to performing joint science activities, and will be a permanent resident until his replacement arrives on the next Shuttle. The Shuttle provides a unique opportunity for the Russian space program, since large science payloads can now be delivered to the Mir, along with providing significant refrigerator and freezer space for samples taken to the station or returned to Earth.

Both partners in this program are being given the opportunity to do things that they could not do independently. This international cooperation provides a wealth of knowledge about space flight, and is the first of its kind on this magnitude. Not since the days of Apollo-Soyuz has an international cooperation between space programs returned so much. These first steps coupling both programs to increase their respective yields leads directly to the framework for the International Space Station, which is slated for launch in 1998.

The American long duration astronauts perform the majority of the experiment operations while on orbit, while their Russian counterparts primarily concern themselves with station upkeep and maintenance. All are equal contributors to the joint program and have dedicated their time during intensive training in both the US and Russia, as well as by staying on board the Mir for several months.

Dr. Norm Thagard was the American who took the first step in this era of joint space cooperation by staying onboard the Mir for 116 days (which set the space duration record for an American). He was also the first astronaut to travel to Mir on a Soyuz rocket, with his Mir 18 crewmates. Dr. Thagard was followed by Dr. Shannon Lucid, who stayed on the Mir for 188 days, breaking Dr. Thagard's record and setting a new record as the longest stay in space for a woman. Colonel John Blaha replaced Dr. Lucid in September 1996. Dr. Jerry Linenger replaced Col. Blaha in January 1997. Dr. C. Michael Foale replaced Dr. Linenger in May 1997 and he was replaced by Dr. David Wolf in September 1997. Dr. Andy Thomas replaced Dr. Wolf in January 1998, and will remain on Mir until June, when STS-91 will retrieve him. These American crewmembers' stays on Mir have demonstrated to the world the commitment of both countries to work together for the betterment of human kind through scientific advancement.

STS-91 marks the ninth and final mission to dock an American Space Shuttle with Russia's Mir space station. This mission will retrieve Astronaut Andrew Thomas from Mir and will return him to Earth. In addition to the NASA 7 crewmember, the Shuttle will transport approximately 370 pounds of research equipment and supplies to the station. The other crewmembers of STS-91 include: Charles J. Precourt, Commander; Dominic L. Gorie, Pilot; and Mission Specialists Wendy B. Lawrence, Franklin Chang-Diaz, Janet Kavandi, and Valeri Ryumin (Russian Space Agency).

During the docked phase of STS-91, astronauts and cosmonauts will transfer from the Mir space station to the Shuttle the science samples collected by the Mir 25/NASA 7 crew. After return to Earth, the samples will be analyzed by researchers on the ground. Crewmembers will also transfer hardware and supplies to Mir in support of the health and well being of the Mir 25 crew and future investigations on the station. This continued research will focus on studies in the areas of Advanced Technology, Human Life Sciences, and Microgravity Research.

The commercial initiated research from the Advanced Technology discipline will evaluate new technologies and techniques using the Mir space station and the Shuttle as a test bed. Such research in reduced gravity will contribute to an enhanced knowledge base for implementation on the International Space Station and other space vehicles.

Human Life Sciences research consists of investigations that focus on the crewmembers' adaptation to weightlessness in terms of skeletal muscle and bone changes, cardiovascular acclimatization, and psychological interactions. This set of investigations will continue the characterization of the integrated human response to a prolonged presence in space.

Microgravity research has the general goal of advancing scientific understanding through research in materials science. The QUELD furnace will heat capsules containing metallic binary systems, bring them to room temperature, and return them to Earth for analysis of the effects of microgravity on diffusion processes. This experiment will be performed using the Microgravity Isolation Mount (MIM).

The success of all the past Shuttle/Mir missions is due to the dedication of all the researchers involved in these different areas, as well as all the mission support personnel, crew trainers, and the crew themselves. The Phase 1 program is a difficult and unique program because of its international scope and length of mission duration, but it is providing both an excellent scientific return, and a training ground for future operations on the International Space Station.

ADVANCED TECHNOLOGY

ASTROCULTURE™ (ASC)

Experiment Objectives

- Determine if plants can grow from seed to mature plants that produce seed in a microgravity environment
- Compare plants derived from space seeds with plants derived from Earth seeds

Experiment Description

The Astroculture™ (ASC) flight experiment is a space-based controlled environment chamber that provides all the conditions required to support plant growth in microgravity. The main payload components include subsystems required to provide temperature, humidity, and carbon dioxide control in an isolated chamber. A unique LED lighting system is used to meet plant light requirements. Ethylene released by the plants is removed from the atmosphere of the plant chamber with a photocatalytic oxidation unit that does not require any consumables. The ASC payload is configured as a standard Priroda locker and contains a single board computer which provides data download and video observation/recording capabilities.

Flight Protocol

The Astroculture™ unit was transferred to the Mir during the docked phase of STS-89. The ASC system is designed to operate in a fully automated mode with continuous power.

The NASA crewmember will perform a daily monitoring of the ASC, as well as, a weekly download and downlink of plant data and video from the ASC. Crew interaction with ASC will be done via the MIPS System, built-in LCD displays and LED indicators, and ASC Video System. The ASC will remain on orbit until the unit is returned on STS-91.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-89, NASA 7

Investigator:

Raymond Bula, Wisconsin Center for Space Automation and Robotics, Univeristy of Wisconsin

ADVANCED TECHNOLOGY

X-RAY DETECTOR TEST (XDT)

Experiment Objectives

- To measure the rates of incidence of cosmic rays which would be expected to strike a future diffraction system in space
- Provide data for predicting the level of noise which would be produced by cosmic rays striking any of the critical elements of this system

Experiment Description

The XDT experiment is being flown in an effort to understand the high energy radiation environment of space. The XDT system consists of three detectors which will measure the incidence rate of cosmic rays and induced background levels expected for future x-ray crystallography systems to be flown in the International Space Station. Besides the detectors, it includes a microcomputer system and flash disk mass storage devices to allow virtually autonomous operations during several months of data-taking on-board Mir.

Flight Protocol

The XDT system was activated and operated on-board STS-89 for four consecutive days. Once Shuttle operations were concluded, the XDT system was deactivated, transferred to the Mir and reactivated for long duration operations. Although the XDT is designed to operate in a fully automated mode with continuous power, the NASA crewmember will perform a weekly monitoring of the XDT to ensure experiment integrity. The XDT will remain on orbit until the unit is returned on STS-91.

Mission Assignment	**Previous Phase 1 Missions**
STS-91	STS-89, NASA 7

Investigator:

Lawrence DeLucas, University of Alabama Center for Macromolecular Crystallography

ADVANCED TECHNOLOGY

OPTIZON LIQUID PHASE SINTERING EXPERIMENT (OLiPSE)

Experiment Objectives

- Study the formation of defects or voids in the sintered metal samples.
- Analyze the effects of wetting and alloy formation
- Study grain sizes and shapes.

Experiment Description

Liquid Phase Sintering (LPS) is a process in which a liquid coexists with a particulate solid. This experiment seeks to understand and quantify phenomena within LPS that are dominated by gravity. The industrial importance of “defect trapping in microgravity” is also being investigated.

Flight Protocol

The experiment consists of heating samples of compressed metal powders to the melting point of one of the constituents, holding the temperature approximately 50°C above the melting point for a predetermined period of time, and then letting the sample cool.

The following types of materials are planned for use in the OPTIZON Furnace: Copper (melting point 1375 K), Silver (melting point 1234 K), and mixtures of Copper and Silver. These mixtures are cold compressed at high pressures and installed in quartz ampoules. The ampoules are to be vented to the vacuum during furnace processing. The furnace is to be vented to vacuum during the entire heat up and cool down phase with heating and cooling following Onyx programs.

Mission Assignment

Mir 25

Previous Phase 1 Missions

STS-76, NASA 2, Mir 21
STS-86, Mir 24b, NASA 6
STS-89

Investigator:

James Smith, University of Alabama at Huntsville

EARTH SCIENCES

VISUAL EARTH OBSERVATIONS

Experiment Objective

- Monitor observable Earth surface changes and image ephemeral events (hurricanes, plankton blooms, volcanic eruptions) to incorporate into a 30+ year database of human observations

Experiment Description

The Earth's surface is changing dramatically everyday, but due to our limited view, these large scale phenomena cannot be easily observed or recorded. A space station is a platform available for continual observations from low-Earth orbit. Sites are selected to document geologic structures using variable sun angles, seasonal events such as biomass burning, longer-term changes like the rise and fall of lake levels, gradual changes in land-use patterns, dynamic patterns in the ocean surface waters, and globally distributed episodic events like tropical storms, floods, forest fires, volcanic eruptions, and dust storms.

Flight Protocol

Site selection is a joint US/Russian activity based on long-term planning of known regions of interest, and near-term replanning of targets based on the trajectory and attitude of the space vehicle, current events, and weather patterns. Photography of special, unpredictable events, such as tropical storms, floods, forest fires, volcanic eruptions, and dust storms, will be requested of the crew as they occur in real-time during NASA 7. Film was taken to Mir on STS-89, and the film will be returned to Earth by STS-91.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-74, STS-76, Mir 21, NASA 2
STS-79, Mir 22, NASA 3
STS-81, Mir 23, NASA 4
STS-84, Mir 24, NASA 5
STS-86, Mir 24, NASA 6, STS-89
Mir 25, NASA 7

Investigators:

Kamlesh Lulla, Ph.D., NASA/Johnson Space Center
Cynthia Evans, Ph.D., Lockheed-Martin Corporation
Lev Desinov, Ph.D., Russian Academy of Sciences

EARTH SCIENCES

VISUAL OBSERVATIONS - WINDOW SURVEY OF MIR COMPLEX

Experiment Objective

- Imaging of Mir windows and window environment using hand held photography

Experiment Description

Hand held photographs of the window surfaces in the KVANT-2, Base Block, and Spektr (if available) modules will be performed using a Nikon F-3 camera to document characteristics that may affect Earth Observation photography.

Flight Protocol

Associated hardware for this flight was transported to Mir by STS-89. All photographs will be returned to Earth for post-flight analyses on STS-91.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-84, Mir 24, NASA 5
STS-89, Mir 25, NASA 7

Investigators:

Kamlesh Lulla, Ph.D., NASA/Johnson Space Center
Premkumar Saganti, Ph.D., NASA/Johnson Space Center

EARTH SCIENCES

TEST SITE MONITORING

Experiment Objective

- Monitor land cover changes and conditions, lake levels, etc., At selected test sites in support of global change research

Experiment Background

Environmental monitoring of several rapidly changing regions on Earth will provide vital information to scientists from many different research disciplines. Data obtained from this investigation will be compared to the information in a historical database of these areas to assess the nature and rate of change. Routinely, at least seasonally, data will be collected from the Aral Sea, Galveston Bay (Texas), the region of South Florida and the Northern Bahamas, and the Panama Canal Zone. Monitoring of rapidly changing regions provides information to several interdisciplinary studies. Scientists will then be able to extend observations from historical databases and ground-based studies to produce a more comprehensive assessment of the nature and rate of the changes in these selected areas of the Earth. Data collection will be planned based on orbit trajectory, attitude, and weather conditions.

Flight Protocol

During the Mir 25/NASA 7 mission, the sites of interest will be photographed at regular intervals. Weather information, such as cloud cover, sun angles, and any other information will be provided to the crew to guide their photographic sessions. Film was taken to Mir on STS-89, and the film will be returned to Earth by STS-91.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-74, STS-76, Mir 21, NASA 2
STS-79, Mir 22, NASA 3
STS-81, Mir 23, NASA 4
STS-84, Mir 24, NASA 5
STS-86, Mir 24, NASA 6, STS-89
Mir 25, NASA 7

Investigators:

Kamlesh Lulla, Ph.D., NASA/Johnson Space Center
Cynthia Evans, Ph.D., Lockheed-Martin Corporation
Lev Desinov, Ph.D., Russian Academy of Sciences

HUMAN LIFE SCIENCES

CREWMEMBER AND CREW-GROUND INTERACTIONS DURING NASA-MIR (INTERACTIONS)

Experiment Objective

- Complete three standard mood and interpersonal group climate questionnaires: Profile of Mood states, Group Environment Scale, and Work Environment Scale

Experiment Description:

During future space missions involving a space station or a trip to Mars, international crews will be engaged in complicated activities over long periods of time. A number of interpersonal issues must be addressed in order to ensure healthy crewmember interaction and optimal performance.

A review of the literature of space analog studies on Earth, reports from previous space missions, and the principal investigator's own work involving astronauts and cosmonauts have isolated crew tension, cohesion, and leadership as important interpersonal issues. This experiment also correlates the mood of the crew to that of the ground control team, and also has a critical incident log to help identify stressful periods.

Flight Protocol

Crewmembers and ground personnel will complete computerized mood, experience, and interpersonal group climate questionnaires along with the critical incident log throughout the course of the Mir 25/NASA 7 mission. Mir crew data will be correlated with ground crew data once the questionnaires and logs are returned to Earth on STS-91.

Mission Assignments

Mir 25
STS-91

Previous Phase 1 Missions

STS-76, STS-79, Mir 22, NASA 3
STS-81, Mir 23, NASA 4
STS-84, Mir 24, NASA 5
STS-86, Mir 24, NASA 6
STS-89, NASA 7

Investigators:

Nick A. Kanas, M.D., University of California, San Francisco
Vyacheslav Salnitskiy, M.D., Institute of Biomedical Problems

HUMAN LIFE SCIENCES

MAGNETIC RESONANCE IMAGING (MRI)

Experiment Objective

- Measure and analyze the bone marrow of the spine before and after space flight, and compare the results from actual long duration stays in weightlessness to data from bed rest studies with and without exercise.
- Measure the muscle volumes of the calf, thigh, back, and neck before and after space flight, and compare the results from actual long duration stays in weightlessness to data from bed rest studies with and without exercise.
- Measure the size of the intervertebral discs before and after long duration space flight to determine if spinal discs remain expanded, or enlarged beyond their normal size, after return to Earth's gravity.
- Document the occurrence of back discomfort during and after flight and study its association with expansion of the spinal discs caused by space flight

Experiment Description

When muscles are not used regularly, they begin to deteriorate and weaken, a condition known as atrophy. Measurements on the crew of the Spacelab-Japan mission (STS-47) showed that there was significant muscle atrophy after only eight days in weightlessness. Bed-rest studies have documented the degree of atrophy after several months of muscle inactivity. This investigation will document the degree of muscle weakening after long-duration space flight following a stay on the Mir space station.

The spine, or backbone, supports the body against gravity. During upright activity on Earth, the downward pull of gravity actually compresses the spine and the spinal discs. However, weightlessness results in expansion of the spine which causes the astronauts to become taller and is believed to cause back pain and discomfort. This investigation will also study the relationship between spinal expansion and back pain in astronauts. These measurements will be made before and after space flight using Magnetic Resonance Imaging (MRI).

Flight Protocol

An MRI examination will be performed on the back and legs preflight to establish baseline data. It is then repeated three times post-flight to determine the extent of changes in the body due to space flight and the crewmembers' readaptation to the Earth environment. Both during and after the Mir 25 and NASA 7 mission, crewmembers will complete questionnaires to record any perceived back discomfort. The questionnaires that were taken to Mir on STS-89 will be returned after their completion on STS-91.

Mission Assignments

Mir 25
STS-91

Previous Phase 1 Missions

STS-74, STS-76, Mir 21, NASA 2
STS-79, Mir 22, NASA 3
STS-81, Mir 23, NASA 4
STS-84, Mir 24, NASA 5
STS-86, Mir 24, NASA 6
STS-89, NASA 7

Investigators:

Adrian Leblanc, Ph.D., Baylor College of Medicine
Inessa Kozlovskaya, M.D., Russian Institute for Biomedical Problems

HUMAN LIFE SCIENCES

AUTONOMIC INVESTIGATIONS (CARDIO)

Experiment Objective

- Explore and define the mechanisms by which the autonomic nervous system regulates the circulation to support tissue perfusion, particularly the brain, during short term and long term adaptation to microgravity and after return to Earth.

Experiment Background

There is little evidence to suggest major systemic cardiovascular dysfunction in microgravity, but clinically highly significant cardiovascular abnormalities become apparent during and immediately after return to Earth gravity. Adequate understanding of these mechanisms can only be achieved by physiological studies that examine specific cardiovascular regulatory mechanisms and relate findings in microgravity to results obtained on Earth before and after space flight. The results of this investigation are expected to have a clinical significance and will provide a basis for new and effective approaches to the prevention of post-flight orthostatic intolerance. There are also compelling general scientific reasons to take advantage of the access to microgravity to study the dynamic aspects and integration of neural regulation of the cardiovascular system. The unique environment of space, with the absence of hydrostatic gradients and the reduction in the overall level of physical activity, drastically alters the operating conditions of the cardiovascular system. Analysis of the effects of microgravity on specific aspects of neural regulatory mechanisms as proposed in the present application has the potential to provide new information on the properties on important physiological control mechanisms.

Flight Protocol

Associated hardware for this flight was transported to Mir on STS-89. Holter monitoring will be conducted over several twenty-four hour periods during the NASA 7 mission. Holter monitoring information will be recorded on Holter data tapes which will be returned to Earth for post-flight analyses on STS-91.

Mission Assignment	**Previous Phase 1 Missions**
Mir 25	None.

Investigators:

C. Gunnar Blomqvist, M.D., Ph.D. University of Texas Southwestern Medical Center
Dwain L. Eckberg, M.D. McGuire Research Institute

HUMAN LIFE SCIENCES

BONE MINERAL LOSS AND RECOVERY AFTER SHUTTLE/MIR FLIGHTS (BONE)

Experiment Objective

- Determine the regional losses and the rate and extent of recovery in bone mineral density and lean body mass
- Determine the muscle strength of the back and lower extremities of the crewmember before and after flight

Experiment Background

Previous studies have shown that long duration exposure to microgravity causes bone loss. In the absence of gravity, bone mass decreases in the load-bearing regions of the skeleton. The occurrence of this condition in space mimics osteoporosis, a medical condition characterized by brittle bones. By learning more about the process of bone mineral loss and recovery, researchers hope to be able to implement effective countermeasures in space, and develop more effective treatments for those who suffer from bone disorders on Earth.

This investigation will measure the space flight-induced losses in bone mineral density and lean body mass of long duration crewmembers, and will determine the rate and extent of recovery after returning to Earth.

Flight Protocol

In this study, preflight and post-flight blood and urine samples will be obtained to measure hormones involved in bone formation and resorption and other indicators of bone metabolism. Muscle strength testing will be performed in conjunction with bone density measurements to study the relationship between muscular fitness and changes in bone density. Bone density and muscle strength measurements will be obtained periodically for up to three years post flight to gain important information regarding the rate of bone recovery after return to Earth's gravity.

Mission Assignment

Mir 25

Previous Phase 1 Missions

Mir 18, Mir 21, NASA 2
Mir 22, NASA 3
Mir 23, NASA 4
Mir 24, NASA 5
Mir 24, NASA 6, NASA 7

Investigators:

Linda Shackelford, M.D., NASA/Johnson Space Center
Victor Oganov, M.D., Institute of Biomedical Problems

HUMAN LIFE SCIENCES

ASSESSMENT OF HUMORAL IMMUNE FUNCTION DURING LONG-DURATION SPACEFLIGHT (IMMUNITY)

Experiment Objective

- This experiment examines the humoral component of the immune system in the microgravity environment. Specifically, the study investigates the antibody production in response to an antigen introduced by vaccination and the reaction time of the immune response.

Experiment Description

Experiments concerned with the effects of space flight on the human immune system are important to protect the health of long duration crews. The human immune system involves both humoral (blood-borne) and cell-mediated responses to foreign substances known as antigens. Humoral responses include the production of antibodies and specialized blood cells which appear to be suppressed during long duration space missions. These immunity products can be measured in samples of the saliva and blood serum.

Flight Protocol

The antigen and associated equipment was transferred to Mir on STS-89. After immunization of the crewmember during the NASA 7 mission, blood and saliva samples are collected and processed periodically over 4 weeks. These samples are then frozen and returned for analysis on STS-91. The results are compared to pre- and post flight blood and saliva samples, as well as samples collected just prior to immunization.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-76, NASA 2
STS-79, NASA 3
STS-81, NASA 4
STS-86, NASA 6
STS-89, NASA 7

Investigators:

Clarence Sams, Ph.D., NASA/Johnson Space Center
A. T. Lesnyak, Institute of Biomedical Problems

HUMAN LIFE SCIENCES

RENAL STONE RISK ASSESSMENT DURING LONG-DURATION SPACE FLIGHT (RENAL-2)

Experiment Objective

- The purpose of this experiment is to determine the in-flight risk of renal stone formation during prolonged exposure to microgravity, and to determine which risk factors are affected by flight duration.

Experiment Description

It has been suggested that space flight increases the risk of kidney stone formation, and the risk is proportional to the time spent in space. This risk is assessed using methods similar to those used on Earth: urine samples are collected over time and analyzed. The concentrations of ions and minerals present in the urine indicate the chances for renal stone formation. Samples are taken prior to launch, in flight, and after return to Earth. These samples are compared to determine if an increased risk of renal stone formation exists in microgravity. The results from this study will provide a better understanding of renal stone formation, which may lead to ways of counteracting the formation of these stones both in space and on Earth.

Flight Protocol

Associated hardware for this flight was transported to Mir on STS-89. Urine will be collected over several twenty-four hour periods during the NASA 7 mission, then it will be preserved and returned to Earth for post-flight analyses on STS-91. A metabolic log will be kept to monitor food, fluid, medication intake, and exercise to assess any environmental contributions to renal stone formation.

Mission Assignments

Mir 25
STS-91

Previous Phase 1 Missions

STS-76, Mir 21, NASA 2
STS-79, Mir 22, NASA 3
STS-86, Mir 24, NASA 6
STS-89, NASA 7

Investigators:
Peggy Whitson, Ph.D., NASA/Johnson Space Center
German Arzamazov, M.D., Institute of Biomedical Problems

INTERNATIONAL SPACE STATION RISK MITIGATION

COSMIC RADIATION AND EFFECTS ACTIVATION MONITOR (CREAM)

Experiment Objective

- Monitor the energy disposition of spectra in silicon due to primary and secondary radiation as a function of time, orbital location and shielding.
- Obtain collateral data on mission integrated dose, particle influences, and induced radioactivity.
- Improve and test space environment and radiation shielding codes used to predict single event upset rates in electronics and background rates in sensors.

Experiment Background

The Mir modules, and the forth coming International Space Station, represent opportunities to explore new radiation environments in order to obtain data on different shielding levels and the effects of radiation on larger spacecraft. The Cosmic Radiation Effects and Activation Monitor (CREAM) measures the Linear Energy Transfer (LET) effects within silicon and provides information relevant to single event upsets (SEUs) on avionics equipment.

Flight Protocol

The associated hardware for this experiment was transported on STS-89. After transfer to Mir, the CREAM hardware will be deployed and photographed at predetermined locations on Mir. Once initiated, the CREAM Active Monitor will begin a standard two week data collection period at one of two predetermined locations on Mir. Once the data collection period is completed, the Active Monitor is moved to the other location for data collection. The Active Monitor will be exchanged between these locations and allowed to collect data for the remainder of NASA 7. Prior to undocking, specified NASA 7 CREAM hardware, along with the NASA 6 CREAM hardware, will be transferred to STS-91/Discovery for return to Earth.

Mission Assignment	**Previous Phase 1 Missions**
STS-91	STS-86, NASA 6 STS-89, NASA 7

Investigators:

Peter Truscott, Defense Evaluation and Research Agency, Ministry of Defense of the UK
Michael Golightly, NASA/ Johnson Space Center

INTERNATIONAL SPACE STATION RISK MITIGATION

SPACE PORTABLE SPECTROREFLECTOMETER (SPSR)

Experiment Objective

- Determine effects and damage mechanisms of the Mir space environment on materials.
- Provide flight testing of spacecraft materials by measuring total hemispherical reflectance from 250-2500 n.m.
- Provide data to validate ground test facilities and prediction models for material behavior in space.
- Develop and test a reusable flight instrument for the study of the behavior of material in the space environment.

Experiment Description

The Space Portable Spectroreflectometer provides an in-space inspection instrument for non-destructive, quantitative engineering evaluation of spacecraft interior. The SPSR measures total hemispherical reflectance as an identification of effects of the space environment on materials such as thermal control coatings, viewing windows, reflectors, and solar power systems. It will provide valuable data for determining how materials degrade when exposed to the space environment within the Shuttle/Mir implementation framework.

Flight Protocol

The SPSR will be utilized during various Extravehicular Activity (EVA) operations to check spacecraft surfaces for optical performance. Reflectance data gathered by the SPSR will be stored in the units Data Acquisition and Control System (DACS), to be transferred to a Mir Interface to Payloads System (MIPS) computer for storage on optical disk and to the ground via telemetry. The SPSR will return on STS-91.

Mission Assignment	**Previous Phase 1 Missions**
STS-91	STS-86, Mir 24b, NASA 6 STS-89

*Investigators:**:***

Ralph Carruth NASA/Marshall Space Flight Center
Dr. Stanislov Naumov, RSC Energia

INTERNATIONAL SPACE STATION RISK MITIGATION

TEST OF PCS HARDWARE (TCPS)

Experiment Objective

- To quantify the Single Event Upsets (SEUs) that occur on the Mir and to test a software system for detecting and monitoring SEUs.

Experiment Background

The TPCS is an International Space Station (ISS) Risk Mitigation experiment designed to provide information on the effects of space radiation on computer systems, namely single event upsets (SEUs) that occur when the computer hardware suffers from space radiation strikes in volatile memory. Exposure of the TPCS system to the radiation environment of low earth orbit will allow examination of the effects of radiation on the communications and data storage methods used within the Portable Computer System (PCS).

Flight Protocol

At specified intervals during the NASA 7 mission, the TPCS software is activated to measure and record SEUs that occur during testing. The data will be stored on the TPCS hard drives and returned on STS-91 for post flight analysis.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-86, Mir 24, NASA 6
STS-89, NASA 7, Mir 25

Investigator:

Rod Lofton, NASA/Johnson Space Center

INTERNATIONAL SPACE STATION RISK MITIGATION

RADIATION MONITORING EQUIPMENT (RME)

Experiment Objective

- Study the exposure to ionizing radiation on humans in space
- Measure the shielding provided in various locations inside the Mir space station

Experiment Background

Exposure of crew, equipment, and experiments to the ambient space radiation environment in low Earth orbit poses one of the most significant health problems to long term space habitation. The RME will measure the radiation exposure in two different locations in the Mir, and by comparing the exposure data, the investigators are hoping to gain information about the local “East-West” radiation effect. This effect counters popular theory which states that the radiation levels are equal throughout the station, only varying due to shielding. Data obtained from previous missions have indicated that the local “east” side of the station has a lower radiation dose than the local “west” side. Comparisons will be made with measurements from previous space missions and predictions from mathematical models, and will hopefully lead to lowered crew exposure rates by taking advantage of this effect.

Flight Protocol

The radiation monitoring units will be transported to Mir on STS-91, and returned on the same Shuttle. The two units will operate side by side for approximately 12 hours, then for the next 48 hours the units will operate in opposing ends of the Mir space station. At the end of this time, the units will operate in different locations within the same Mir module for approximately 30 hours, and then for the balance of the remaining docked time, the two units will be relocated to a new module location.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-84
STS-86

Investigators:

Mike Golightly, NASA/Johnson Space Center
Francis Afinidad, NASA/Johnson Space Center
Vladislav Petrov, Institute of Biomedical Problems

MICROGRAVITY

MICROGRAVITY ISOLATION MOUNT FACILITY OPERATIONS (MIM)

Experiment Objective

- Ensure that the Microgravity Isolation Mount (MIM) provides an isolated microgravity condition for conducting experiments

Experiment Background

Experience with the flight of microgravity experiments has demonstrated that the acceleration environment on board spacecrafts is characterized by continual vibrational disturbances termed g-jitters. These g-jitters typically cause disturbance levels significantly higher than is desired for many sensitive experiments. The MIM attempts to provide isolation or controlled disruption for any experiment using this facility.

Flight Protocol

The NASA 7 crewmember will activate and evaluate the MIM Facility for proper function, as well as, prepare the MIM for experiment operations.

Mission Assignment

Mir 25

Previous Phase 1 Missions

Mir 21, NASA 2, Mir 22
NASA 3, Mir 23, NASA 4
Mir 24, NASA 5
Mir 24, NASA 6
NASA 7

Investigators:

Bjarni Trygvasson, Ph.D., Canadian Space Agency
Laurence Venzina , Canadian Space Agency

MICROGRAVITY

PROTEIN CRYSTAL GROWTH (PCG-DEWAR)

Experiment Objective

- Obtain crystals of sufficient size and purity that their quality and other crystallographic properties may be evaluated and compared with corresponding crystals grown on Earth
- Evaluate the effectiveness of crystal growing techniques used in long-duration space flight
- Compare crystals grown using the in-flight methods to crystals grown using the methods typically used on Earth

Experiment Description

Growing crystals in microgravity can provide significant advantages over processes used on Earth. Development of crystals in space is of interest to researchers because the crystals grown are more pure and generally more free of defects than those that crystallize in our gravitational environment on Earth.

Frozen solutions from which the crystals will grow are loaded into a dewar before a Mir docking Shuttle flight and then transferred to the Mir after Shuttle docking. Once on board the Mir, the samples slowly thaw and the crystallization process is initiated. Crystals are grown aboard Mir using several different methods of growth, and the samples are returned to Earth for analysis.

Flight Protocol

The GN_2 dewar is used in this experiment. Quick frozen samples are prepared and placed in the GN_2 dewar to maintain them until post docking. The system is designed so that the nitrogen charge keeps the samples frozen until they are in orbit. As the system absorbs heat, the nitrogen boils away and the chamber approaches ambient temperature. As the samples thaw, crystal growth within the dewar takes place. The unit will be left undisturbed during the entire NASA 7 mission. The crystals are allowed to form throughout the long duration mission and are returned to Earth on STS-91 for analysis. Aside from transfer of the Dewar to Mir, there is little crew interaction with this experiment.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-74, Mir 20
STS-76, Mir 21, NASA 2
STS-79, Mir 22, NASA 3
STS-81, Mir 23, NASA 4
STS-84, Mir 24, NASA 5
STS-86, Mir 24, NASA 6
STS-89, Mir 25, NASA 7

Investigators:

Alexander McPherson, Ph.D., University of California, Riverside
Stan Koszelak, University of California, Riverside
Anatoli Mitichkin, Ph.D., RSC Energia

MICROGRAVITY

SPACE ACCELERATION MEASUREMENT (SAMS)

Experiment Objective

- Measure and record low-level perturbations to the microgravity environment at or near the experiment hardware

Experiment Description

Materials science experiments require a very stable environment to yield the best results. Thruster firings, vehicle dockings, and movements of the crewmembers cause random vibrations and accelerations which can affect an experiment, possibly compromising the results. The Space Acceleration Measurement System (SAMS) records these fluctuations in the microgravity environment so that researchers can apply this information when interpreting the results of an investigation. By characterizing the acceleration environment of the space vehicle, researchers can learn where regions of high acceleration forces exist, avoiding those areas for experiment placement.

Flight Protocol

The SAMS unit was developed by the NASA Lewis Research Center. It measures the accelerations through three triaxial remote sensor heads. Each sensor head contains orthogonally positioned accelerometers. Two optical disk drives in the unit provide the data-recording capability. SAMS will be activated during specific events of interest during NASA 7, such as dockings, and in support of other investigations. The SAMS unit was taken to Mir by a Progress vehicle prior to the Phase 1 Program. The optical disks with the recorded data will be returned on STS-91.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-74, STS-76, Mir 21, NASA 2
STS-79, Mir 22, NASA 3
STS-81, Mir 23, NASA 4
STS-84, Mir 24, NASA 5
STS-86, Mir 24, NASA 6
STS-89, Mir 25, NASA 7

Investigators:

Richard DeLombard, Ph.D., NASA/Lewis Research Center
S. Ryaboukha, Ph.D., RSC Energia

MICROGRAVITY

QUEENS UNIVERSITY EXPERIMENT IN LIQUID DIFFUSION (QUELD)

Experiment Objective

- Measure the diffusion coefficients in some metallic binary system under conditions of microgravity
- Provide further data and increase the understanding of diffusion

Experiment Description

The QUELD is a joint investigation between the US, Canadian, and Russian space agencies. The QUELD unit is a fixed furnace facility that provides an experimental method of measuring the diffusion coefficients in some two metal systems during exposure to microgravity. Accurate diffusion coefficients are of considerable importance in modeling the diffusion process on Earth. During the course of this experiment, diffusion coefficients of selected systems will be placed in graphite crucibles, each contained in a separate stainless steel tube. This tube is rapidly heated to a constant temperature and held there for a given time period. Following this period, the tube is placed in an aluminum chill block and quenched to room temperature.

Flight Protocol

The QUELD unit is supported by the Microgravity Isolation Mount (MIM), which will attempt to isolate the experiment from microaccelerations that exist in the Mir space station. The samples used in the QUELD furnace were previously transported to Mir on STS-84, and will be returned for post flight analysis on STS-91.

Mission Assignment

Mir 25

Previous Phase 1 Missions

STS-74, STS-76, Mir 21, NASA 2
STS-79, Mir 22, NASA 3
STS-81, Mir 23, NASA 4
STS-84, Mir 24, NASA 5
Mir 24, NASA 6, Mir 25, NASA 7

Investigator:

Reginald Smith, Ph.D., Queen's University, Canada

MICROGRAVITY

BIOTECHNOLOGY SYSTEM DIAGNOSTIC EXPERIMENT REFLIGHT (BTDSE)

Experiment Objective

- Ensure the functionality and maintenance of the Biotechnology System Facility for experiment use in microgravity

Experiment Background

The BTS is a facility designed to support long-duration biotechnology experiments in a low-gravity environment on the Mir Space Station. It was launched to the Mir aboard the Priroda module. The facility consists of six modules, four of which are contiguous and house the main facility. The remaining two modules are for passive stowage. All modules are designed for easy changeout in order to accommodate changing science requirements and advancements made during the several year period of its operation. Facility and experiment specific hardware, consumables and biological samples will be transported to and from the facility by the Space Shuttle during scheduled visits to the Mir.

Flight Protocol

The crewmember will have knowledge of BTS nominal, contingency, and malfunction procedures. The BTS Facility is activated and evaluated for proper function using diagnostic hardware. All BTSDE Diagnostic hardware will be returned on STS-91.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-81, Mir 23, NASA 4
STS-89, Mir 25, NASA 7

Investigators:

Steve Gonda, Ph.D., NASA /Johnson Space Center

MICROGRAVITY

BTS COCULTURE (COCULT)

Experiment Objective

- Investigate long-term culture and assembly of two different cell types in microgravity and their role in developing a functional tissue
- Measure and compare cellular development, gene expression, mass transfer, and metabolism in a microgravity produced 3-D coculture to that of a 2-D culture and to a ground simulation 3-D coculture
- Measure and compare gene expression and protein production of the 3-D coculture to the initial monocultures

Experiment Background

BTS-COCULT is a test bed for growth, maintenance and study of long term on-orbit cell growth for the purpose of tissue engineering. In this experiment a human endothelial cell line and a human breast carcinoma cell line will be cultivated first in the Biotechnology Specimen Temperature Controller-Mir (BSTC-M) and then combined and cocultivated in the Engineering Development Unit-Mir (EDU-M) to attempt the first vascularization of a solid tumor in microgravity. The procedures employed in engineering this specific type of tissue model may be of great benefit in the development of engineered tissue models of completely normal tissues in future experiments.

Flight Protocol

Cell cultures in temperature controlled vessels and associated hardware were transported on STS-89, and integrated in the Biotechnology Experiment Module (BEM) in the Biotechnology System (BTS) on Mir. Culture periods will vary with media exchanges, sample fixations, light microscopy, photography and video camera monitoring throughout. Samples will be stored at low temperatures or fixed and will be returned on STS-91 for post flight analysis.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-89, Mir 25
NASA 7

Investigators:

Timothy Hammond, Ph.D., Louisiana State University
Peter Lelkes, Ph.D., University of Wisconsin School of Medicine

MICROGRAVITY

AMBIENT DIFFUSION CONTROLLED PROTEIN CRYSTAL GROWTH (DCAM)

Experiment Objective

- Grow large, well-ordered crystals of many different types of proteins and viruses for analysis and characterization in ground laboratories

Experiment Description

The primary objective of the DCAM experiment is to produce large, high-quality crystals of selected proteins under controlled conditions in microgravity. Crystals of sufficient size and suitable quality are essential for protein crystallographic analysis of molecular structures via x-ray diffraction and computer modeling.

All proteins are preloaded into the DCAM prior to the STS ferry flight. The experiment is self- activated once integrated into Mir, and the crystals will grow for the remainder of the flight.

Flight Protocol

The DCAM is designed for the growth of protein crystals in a microgravity environment. In the DCAM, a “button” holds a small protein sample, which is covered by a semipermeable membrane that allows the precipitant solution to pass into the protein solution to initiate the crystallization process.

The DCAM has no mechanical systems. Diffusion starts on Earth as soon as the chambers are filled. However, the rate is so slow that no appreciable change occurs before the samples reach orbit one or two days later. The DCAM was transported to the Mir on STS-89 and left undisturbed for the duration of NASA 7. The DCAM unit will be returned on STS-91. Such an apparatus is ideally suited for long duration Mir Space Station missions.

Mission Assignment

STS-91

Previous Phase 1 Missions

STS-74, STS-76, Mir 21, NASA 2
STS-79, Mir 22, NASA 3
STS-81, Mir 23, NASA 4
STS-84, Mir 24, NASA 5, STS-89
Mir 25, NASA 7

Investigator:

Dan Carter, Ph.D., NASA/Marshall Space Flight Center

ALPHA MAGNETIC SPECTROMETER (AMS)

AMS AND THE DEPARTMENT OF ENERGY - HIGH ENERGY PHYSICS IN SPACE

As part of its long-standing role in high energy physics research, the U.S. Department of Energy is supporting the scientific leadership and part of the funding for the Alpha Magnetic Spectrometer (AMS) experiment that will fly on the Space Shuttle Discovery and later the International Space Station.

The AMS experiment is the first time a high energy particle magnetic spectrometer will be placed in orbit. As high energy physicists continue to prove the fundamental laws that govern our universe, they ask such basic questions as: What are the ultimate building blocks of matter? What are the fundamental forces through which these basic particles interact? Fifteen Nobel Prizes in Physics have gone to high energy physicists for their discoveries. In 1995, Department of Energy-funded scientists found the top quark, the last to be discovered of the basic particles believed to make up all known matter.

The AMS will continue this scientific journey of discovery in a region here to date untapped by high energy physics research, the environment of space. The space environment provides a copious flux of atomic and subatomic particles which have been naturally accelerated to energies which are impossible to achieve in Earth bond accelerators. The AMS will provide the first
In-situmagnetic detector of these particles and will open a unique and rich new area of experimental high energy physics.

On STS-91, a group of eminent scientists in the field who reviewed AMS for the department unanimously endorsed its scientific merit. Researchers will use the detector to search for both antimatter and "dark matter" to answer two specific questions: First, if equal amounts of matter and antimatter were produced at the beginning of the universe as described by the Big Bang scenario, and the galaxies we now see are made only of matter, where has the antimatter gone? Second, since the mass of a galaxy seems to be greater than the visible mass of all its stars, gas and dust, is there dark matter of a new kind that has eluded discovery?

Secretary of Energy Federico Pena hailed the research that will be done with the AMS experiment as literally "out of this world." He congratulated the experiment's international collaboration of scientists from 37 research institutions, headed by MIT Professor and Nobel Laureate Dr. Samuel Ting. The collaboration designed and built the 3-1/2 ton detector in record time. "I am delighted that the Department of Energy as a science agency has been able to support Dr. Ting during much of his brilliant scientific career and that we are able to help make possible this 'first-of-a-kind' experiment that conceivably could rewrite science textbooks," Secretary Pena said.

Dr. Ting received the 1976 Nobel Prize for his co-discovery of the J particle.

The Department of Energy is the federal government's primary steward for the field of physics that seeks to understand the fundamental nature of matter and energy. The department provides over 90 percent of federal support for high energy physics research in the United States. Its $680 million annual budget for high energy physics is, in turn, part of the $2.5 billion annual funding for basic research that supports the department's science, energy, environmental and national security missions.

High energy physics is basic research that over the years has led to many practical benefits. Advances in medical diagnostic imaging, parallel processing computing and superconducting magnets have come out of the technologies developed to build and use powerful particle accelerators for this research. High energy physicist Allan Cormack shared the 1979 Nobel Prize in Medicine for his role in the development of the CAT scan by applying mathematical methods for reconstructing images of particle collisions from detector data. More recently, the World Wide Web, which has transformed the world of communication and information, was originally developed in the early 1990s so that the thousands of high energy physicists involved in international collaborations could quickly and efficiently communicate electronically.

Much of the experimental work of high energy physicists is done at particle accelerators such as at the Department of Energy's Fermi National Accelerator Laboratory (FERMILAB) outside of Chicago, Illinois, the Department's Stanford Linear Accelerator Center (SLAC) in California, or at high energy physics laboratories in Europe. In these accelerators, subatomic particles collide at velocities approaching the speed of light so researchers can study the resulting reactions and new particles produced.

High energy particles also exist as cosmic rays produced at the beginning of the universe and in supernovae stars and near black holes. The particles AMS will search for cannot be detected on the ground because they are absorbed by the Earth's atmosphere, so the detector must be deployed in space. When installed on the Space Station, the AMS will gather data for three years.

The collaboration between the Department of Energy and NASA on the AMS experiment is the latest partnership in a long history, but this is the first joint effort with a purely scientific mission. The department's facilities have built radioisotope thermoelectric generators and heater units that power and warm spacecraft, such as Viking, Voyager, Galileo and most recently the Cassini space probe to Saturn. The department's national laboratories have provided sensors for reconnaissance satellites that help verify arms control and nonproliferation treaties. Most recently, a Department of Energy laboratory provided the instrument package for the Lunar Prospector that found evidence of ice on the Moon. The AMS collaboration will be the first time such a detector has been put in orbit and reflects a new level of cooperation among particle physicists and astrophysicists as they seek answers to the kinds of questions about the universe humankind has striven to answer at least since the ancient Greeks.

AMS Science

The Alpha Magnetic Spectrometer (AMS) will be the first large magnet experiment ever placed in Earth's orbit. The scientific goal of this high energy physics experiment is to increase our understanding of the composition and origin of the universe. It is designed to detect and catalogue with a high degree of precision high energy charged particles, including antimatter, outside the Earth's atmosphere. The charge of such particles can be identified only by their trajectories in a magnetic field.

The Big Bang scenario describes a universe that began with equal amounts of matter and antimatter. Measurements reveal that galaxies as far as 20 million light years from our galaxy are made of matter, so the unanswered question is, where is the antimatter? Are there entire galaxies of antimatter beyond what we have detected, or did an early small imbalance of matter over antimatter yield a universe of matter? The AMS experiment is sensitive enough to detect minute quantities of antimatter present in cosmic rays coming from outside the galaxy. AMS can measure one anti-particle per 100 million Helium nuclei. Thus, AMS may be the first experiment to detect this antimatter. Such observations could signal the existence of antimatter galaxies.

A related question about the composition of the universe is, where is the "dark matter?" The mass of a galaxy, measured from the motion of gas clouds about its center, is greater than the visible mass of all its stars, gas and dust. The unseen portion is known as dark matter because it is undetected by optical telescopes and other instruments. If the dark matter consists of particles predicted by theory, collisions among them could produce antiprotons and positrons (the electron antiparticle). Scientists hope the energy spectra of the positrons detected by the AMS will indicate or set limits on the nature of the missing matter which has long remained a mystery.

In the 10 days that AMS will orbit the Earth on the Space Shuttle Discovery, AMS will first perform a complete system check to ensure that it will function properly for three years on the Space Station. AMS will also carry out a search for anti-Helium and anti-Carbon nuclei as well as measure the spectrum of antiprotons.

The AMS project is an international scientific collaboration that includes 37 research institutions in (with lead collaborators): China (H. S. Chen), Finland (J. Torsti), France (J. P. Vialle), Germany (K. Luebelsmeyer), Italy (R. Battiston), Portugal (G. Barreira), Romania (A. Mihul), Russia (Y. Galaktionov), Spain (C. Mana), Switzerland (M. Bourquin, H. Hofer), Taiwan (S. C. Lee), the United Kingdom (R. Marshall) and the United States (U. Becker). The U.S. portion of the AMS experiment is sponsored by the U.S. Department of Energy.

AMS - What It Is, How It Works

The Alpha Magnetic Spectrometer is a particle detector that weighs 3-1/2 tons and consists of five major elements: a permanent magnet, time-of-flight scintillators, a silicon microstrip tracker, anti-coincidence counters and an aerogel Cerenkov threshold counter. The AMS also has electronics, a support structure and interfaces to computers on the Space Shuttle and at Johnson Space Center.

The permanent magnet is a cylindrical shell made of blocks of magnetic material called neodymium-ferrous-boron. The blocks are arranged around the cylinder to create a magnetic field confined inside the magnet. The trajectory that a particle takes when it enters the magnetic field allows researchers to determine its charge.

The time-of-flight counters provide the primary trigger when a charged particle or anti-particle passes through the detector. This starts the readout of the tracker and helps measure the particle's velocity.

The silicon microstrip tracker has 1,921 silicon sensors in six layered horizontal planes. The sensors measure the particles' trajectories.

The veto counters flag the entry of any secondary particles into the detector so the signals of these background particles can be rejected. The counters are arrayed in a cylindrical shell between the inner skin of the magnet and the tracker.

The aerogel threshold Cerenkov counter at the bottom of the AMS enhances the detector's capability to identify particles. One hundred sixty-eight phototubes view the 10 cm thick layer of aerogel to measure its index of refraction as particles pass through. This will ensure identification of anti-protons and also help distinguish positrons (anti-electrons) from other particles such as protons, pions and muons.

The electronics recognize that a particle of interest to scientists has passed through the detector, digitize the detector signals, collect the signals from the particle's passage into an "event," and transmit the event data to Earth. The electronics relay commands from Earth to the detector. They also monitor and operate the detector.

The detector rests in a support structure of vertical aluminum I-beams. The entire payload weighs 9200 pounds and will be mounted in the rear of the Space Shuttle payload bay.

NASA will fly AMS twice. During the STS-91 mission, AMS will have 100 hours of dedicated system checkout and data gathering. During the Space Station mission, AMS will be an externally attached payload and gather data for three years. For both missions, commands will be issued and then data collected on the ground in real time. The high inclination and altitude of the Space Shuttle and Space Station missions are vital for the experiment because they provide data collection time near the geomagnetic poles where the influence of the Earth's magnetic field on inbound particles is minimized.

More information about the AMS project is available on the World Wide Web at:
www-lns.mit.edu

STS-91 GET AWAY SPECIALS (GAS) EXPERIMENTS

Flying on the STS-91 Space Shuttle mission will be four Get Away Special (GAS) payloads which were manifested by the Shuttle Small Payloads Project at the Goddard Space Flight Center in Greenbelt, Md. Below is a brief description of those GAS experiments.

G-648

The Atlantic Canada Thin Organic Semiconductors (ACTORS) experiment is sponsored by the Canadian Space Agency's Microgravity Sciences Program. This payload (G-648) prepared by the University of Moncton in New Brunswick will process an important type of semiconductor organic material.

The ACTORS organic materials will be processed in space where the gravitational forces are minimal. Under microgravity, more uniform thin films will be formed. This improvement in uniformity is due to absence of convection, a phenomenon which influences Earth processes. Scientists will be able to compare the thin films produced in microgravity with those produced on Earth.
A better understanding of the role gravity plays in affecting the forming of thin films should lead to improved Earth based manufacturing. The semiconductor material (Perylene Tetracarboxylic Dianhydride) studied has many uses. In particular, it can be used in high sensitivity particle beam detectors and electro-optic device applications.

The principal investigator for the experiment is Dr. Truong Vo-Van of the University of Moncton. The mission manager is Susan Olden form Goddard while Lee Shiflett also from Goddard serves as the technical manager.

G-765

Through G-765, the Canadian Space Agency and several partners are launching an exciting set of space experiments in search of new ways to extract oil from the Earth and clean up accidental spill in the environment.

The purpose of the Microgravity Industry Related Research for Oil Recovery (MIRROR) payload is to use space's microgravity environment to develop new technologies which could have an impact on the Canadian oil industry, environmental clean-up and the world's future oil reserves. For example, researchers from the Petroleum Recovery Institute, Calgary, Alberta in Canada expect the MIRROR space experiments will provide insight into the physical properties of the foams used for extracting oil, which could help scientists and engineers develop more efficient and less costly extraction processes.

In operating oil fields, conventional means of extraction still leave huge amounts of the oil in the ground. Initially, oil is forced to the surface by its own naturally occurring pressure. When the pressure subsides, more oil is artificially forced out of the ground by pumping water or gas into the reserve. This still leaves about two-thirds of the oil trapped in tiny pores of rock beneath the Earth's surface.

The three MIRROR experiments aboard STS-91 are self contained and fully automated. The first experiment is the Diffusion Coefficients of Crude Oil (DCCO). DCCO will aid in developing accurate numerical models for the prediction of oil reservoir properties for DCCO. The experiment is being conducted by Professor Jean-Claude Legros of the Microgravity Research Center in Brussels, Belgium. Next, is the Foam Stability experiment. Scientists will study forces that affect the behavior and longevity of foams of interest to oil companies, as well as aid in the development of new foam products. Dr. Laurier Schramm of the Petroleum Recovery Institute is the principal investigator for this experiment. Lastly, the Capillary Flow experiment will study the magnitude of capillary forces on fluid flow in porous rock/soil and develop techniques to change the flow characteristics in reservoirs or contaminated soils. Dr. D'Arcy Hart of C-Core, St. John's, Newfoundland, Canada is the principal investigator.

Partners for the MIRROR program are the Canadian Space Agency, European Space Agency, Province of Newfoundland & Labrador and the oil industry. The mission manager for this Get Away Special payload is Susan Olden of Goddard. Lee Shiflett, is the technical manager and is also from Goddard.

G-090

Utah State University in Logan, designed the GAS payload G-090 which consists of three experiments built by high school students. On board will be a power supply and computer controls built by Utah State students and several packages of popcorn that will be used for experiments by students at the St. Vincent Elementary School in Salt Lake City**.** The purpose of G-090 is to give high school students an opportunity to design and build GAS experiments with the university students acting as mentors, coordinating integration and building computer and power interfaces.

The first experiment is the Chemical Unit Process (CUP). CUP was built by students at Shoshone-Bannock Junior/Senior High School on the Fort Hall Reservation, Idaho. Students hope to learn how microgravity effects extracting phosphate ions, used widely as a fertilizer, from phosphate ore mined on their reservation. This is the first GAS payload built by Native Americans students**.**
The second experiment, Nucleic Boiling, designed by Box Elder High School in Brigham City, Utah, will study the effects of microgravity on bubble formation and temperature gradients as water is heated to a boil during the flight. This process is affected on Earth by gravity, convection and liquid density.

Moscow (Idaho) High School and Moscow University, Idaho, have formulated a crystal growth experiment that will study the formation and growth of chemical crystals in a microgravity environment.

Lastly, the fourth experiment is a passive experiment from St. Vincent Elementary School in Salt Lake City**.** Students will do experiments comparing traits of popcorn and radish seeds exposed to space with control seeds kept on Earth. This will be done by growing the space seeds and the Earth seeds on the ground to see if there will be any difference in the radishes produced. They will also compare the two popcorn samples by popping them on Earth to see what differences will occur within the two sample groups. The purpose of this experiment is to foster interest in space among young children.

The principal investigator for this payload is Jan Sojka from Utah State University. Susan Olden from Goddard is the mission manager. Charles Knapp, also from Goddard, is the technical manager.

G-743

Broward (Davie, Fla.) And Brevard (Cocoa, Fla.), Community Colleges along with Belen Jesuit Preparatory School in Miami, have constructed a genotoxicology experiment to determine the degree to which DNA is damaged by exposure to cosmic radiation in a space environment.

For this payload experiment, DNA will be extracted from tissues of a variety of vertebrate organisms including chicken, fish and humans. The DNA samples will be loaded into sterile quartz tubes and sealed. Identical control samples will be prepared, but will not be flown in space. The DNA will be tested by measuring the average length of the DNA in each sample.

Also seeds of the mustard plant, Arabodopsis, will be flown in space and then grown on Earth to look for the effects of chromosome damage. Germination (growth) and viability will also be compared to a control population. Most of this work will be done by the high school and college students upon return to Earth.

The G-743 payload team has said that the ultimate experiment objective is to develop a community interest in space exploration activities, and that “from humble beginnings, great things will come”.

The principal investigator for this payload is Rolando Branly from Broward Community College. Technical mentorship is provided by John Bickham at Texas A&M University in College Station, Texas. Susan Olden from Goddard is the mission manager for this payload. Also, from Goddard is Charles Knapp, serving as the technical manager.

SPACE EXPERIMENT MODULE

Two Space Experiment Module (SEM) canisters (SEM-03 and SEM-05) will be flying on Space Shuttle Mission STS-91. Each module contains multiple experiments from middle school, high school and college students around the country. The following SEM experiments will be onboard:

SEM-03:

Shoreham (N. Y.) Wading River High School – The Effect of Microgravity on Crossing-Over in Sordaria Fimicola

The experiment will study the effect of microgravity on the crossover rate (union between strains of a species) of the fungus called Sordaria Fimicola. Genetic cross-over is a form of natural genetic recombination (which is another term for crossovover) without which a species of organisms can experience reduced genetic variability. The students hypothesize that microgravity will generate a
Significant reduction in genetic crossover. If proven true, the implied lack of genetic variability could prove very detrimental to any organism which reproduces in a microgravity environment over a long period of time.

Inside the experiment module, a motor will align Petri dishes containing the fungus and growth medium (food that will sustain the fungus) which will allow contact and breeding to begin. Temperature of the Sordaria will be thermostatically controlled. At two days, seven hours and thirty minutes, active thermal control will be discontinued by the pre-programmed commands of the students and the experiment will continue unpowered. The fungi will be allowed to grow and multiply for the duration of the flight. Upon landing, the fungi will be examined to discover the rate at which cross-over has occurred and compared to ground control data.

Tomasita Young Astronauts Club, Albuquerque, N.M. - Crystal Growth in Microgravity

The purpose of this experiment is to compare the growth of crystals in a microgravity environment to those grown on the ground. Crystals will be measured for purity and the structure will also be examined through the use of a scanning electron microscope located at the University of New Mexico. Also, the growth pattern of crystals in space will be compared to those grown on Earth through a comparison of photographic records. The data will add to the general knowledge of crystal growth behavior in a microgravity environment. Exceptionally pure crystals are regularly grown in space to aid materials, semiconductor and medical research.

Crystals will be grown using a supersaturation method. Pickling alum will be dissolved in distilled water. The solution will be cooled, allowing crystals to form on a piece of Zircon mounted on a piece of platinum wire. The mineral Zircon has the same crystalline structure as crystallized alum and will act as a seed crystal. It is insoluble in water as well so it can be left in the solution at all times.

During the flight, the crystal growth process will be photographed with a specially modified 35 millimeter camera that is controlled by the SEM Module Electronics Unit. Postflight, the samples will be examined for purity and structure with the assistance of the University of New Mexico's Geology Department.

Norfolk (Va.) Public Schools Science and Technology Advanced Research (NORSTAR)

Experiment 1. Effect of Microgravity on development of Daphnia, Eubranchipus and Triops eggs

The purpose of this experiment is to observe the development of Daphnia, Eubranchipus and Triops eggs (freshwater organisms with a shell) after they have been exposed to microgravity. The eggs will be flown in space in a state of suspended animation within a Plexiglas container. On their return to Earth their development into adults will be observed and compared to eggs which developed on Earth. The potential scientific value of the experiment includes: new insights into developmental biology, developing strategies to create artificial diapause in higher animals and altering cell development and differentiation under microgravity conditions

Experiment 2. Separation of Immiscible Fluids in Microgravity

The purpose of the experiment is to observe the behavior (displacement) of immiscible liquids (liquids incapable of being mixed) in a microgravity environment in order to determine whether displacement is due to surface tension, viscosity, or both. The separation of oil and colored water in the experiment will be videotaped in a microgravity environment. During the flight, a 50/50 combination of colored salt water and vegetable oil will be mixed within a Lexan container. A Teflon-coated magnetic stirring device will be used to mix the liquids. Pre-mixing, mixing, and post-mixing phases of the experiment will be videotaped over a two hour period.

The potential scientific value of the experiment includes: benefits to the pharmaceutical industry in preparing medications, and development of better food processing of salad dressings and other foods containing significant amounts of oil and water. This experiment is a reflight of one that flew on STS-80.

Boy Scouts Troop 177 and Four Rivers District, Gambrills, Md. - Merit Badge Madness

The main purpose of this passive experiment is to determine how the environment of space and radiation will affect soil, water, and seed samples and their yield when planted. Each of the soil, water, and seed samples will be contained in test tubes provided by Goddard Space Flight Center.

When the samples are returned to Earth after the spaceflight, each of the samples will be given a battery of tests to identify pH level, which is used to describe the level of acidity or alkalinity of a solution. Seeds will be planted and their growth and yield will be evaluated. Flight samples will be compared with ground samples.

Can Do Project, Charleston, S. C.

Experiment 1. MAVIS - Magnetic Attraction Viewed In Space

The purpose of the investigation is to capture an image of magnetic fields in microgravity and to compare them to the fields of the same magnets on Earth. A Light Emitting Diode will expose sheets of fine grain positive film capturing the shadow pattern (shadowgram) of thin iron filing filled boxes using electromagnets. Patterns will be compared to those captured by the same apparatus on the ground and by a similar experiment on a previous flight (STS-80).

Experiment 2. BEST - Big Experiments in Small Tubes

A variety of passive materials will be flown as part of this experiment. Each sample is contained in a separate color coded "Cryovial”. Samples of photographic film and a particle track detector are also contained in the module. Flown samples will be compared with ground control samples that have been exposed to one of the following: centrifugation, high radiation, liquid nitrogen freezing or passive storage. Student teams will analyze and compare the samples.

Purdue University, West Lafayette, Ind.- Cosmic Radiation Effects on Programmable Logic Devices (CREPLD)

The purpose of this experiment is to determine the effects of cosmic radiation on unshielded Programmable Logic Devices (PLDs). PLDs are integrated circuits which can be programmed to perform many functions. The devices retain their program even when not powered, and they have a long shelf life. The experiment will involve programming sample PLDs prior to flight, running the program inflight, and run the program again postflight. Changes to the program and correlation to cosmic radiation exposure and shielding will be evaluated.

The potential scientific value of these measurements is the determination of the amount of shielding needed for PLDs to be reliable in space. If it is determined that the PLD is largely unaffected by cosmic radiation, future SEM projects and other space experiments could cut costs, experiment volume, and power requirements by using a single PLD to do the work of many fixed-use chips.

Two identical circuits, one flown, one as ground control will use PLDs programmed with a infinite loop program. Additionally, fourteen non-powered Programmable Logic Devices will be flown to provide additional data points. Once the flight PLD is returned to Earth, its program will be compared to the ground control PLD's program. The degree of corruption of the flight program, if any, will be measured.

Woodmore Elementary School, Mitchellville, Md. - WESTAR

An assortment of passive experiment items including seeds, soil, and other organic materials will be flown in polycarbonate vials. The flight samples will be compared with ground samples over a variety of physical characteristics.

SEM-05:

Chesapeake Bay Girl Scout Council, Salisbury, Md. - The Effect of Spaceflight on Food Yield

The effect of spaceflight on food yield is the basis of this passive experiment. A medley of food materials contained in NASA-provided polycarbonate vials are included such as grass, peas, popcorn, and yeast. Once returned to Earth, the space flown samples will be compared to ground samples. Factors such as vitality, growth rate, yield, volume, etc. Will be measured.

Excel interactive Science Museum, Salisbury, Md. - Exposure of the SEM to the Space Environment

The experiment will investigate the effects of the space environment on electronic data storage, electrical circuits, magnetized metals, growth of simple plants, and photographic film sensitivity. Data disks with known data file structure will be analyzed when returned to Earth for data corruption. The magnetic field strength of steel nails will be measured before and after the flight then compared to a ground-based control sample. The signal levels of voice recording electronic circuits wrapped in two different materials will be compared when returned to Earth. Similarly, the pulsing frequency of 555-based pulsing circuits (a type of electronic circuit having a numerical designation) will be measured on their return to Earth. Germination and growth rate of space-exposed grass seed will be investigated. Different photographic film types will be flown and compared for X-ray sensitivity.

Grand Coulee (Wash.) Elementary School- Comparative Microgravity Response of Fungi and Mold

The purpose of the experiment is to study the effect of microgravity on the reproductive and growth mechanisms of simple plant species. Samples of bread and orange peel will be qualitatively and quantitatively compared to ground-based control samples upon their return to Earth.

Olin-Sang-Ruby Union Institute, Ocononmowoc, Wis.- The Effect of Microgravity on Plant Seeds

The experiment aims to be a basis for understanding the growth patterns of microgravity-exposed grains, seed-bearing plants, fruits, nuts, and trees. The growth rate, color, life span and seed production of a diverse variety of seeds will be studied once they are returned to Earth. Additionally, the space-flown seeds will be compared to control seeds that have undergone radiation, sub-zero temperature, centrifugal forces, and storage exposures.

Virginia Parent Teachers and Students Association, Accomac, Va. - Flower Garden in Space

The effect of microgravity and temperature exposure on flower and foliage seeds will be studied. Once returned to Earth, a variety of growth factors of the seeds and resulting seedlings will be qualitatively and quantitatively compared with ground-based control samples.

Wicomico High School, Salisbury, Md. - Effects of Microgravity on Sordaria Fimicola

The purpose of this experiment is to study the effects of microgravity on the reproduction of the fungus Sordaria Fimicola. Also, an aim is to determine what effects, if any, microgravity has on the meiotic process, which is the division of cells resulting in the production of fungus spores. The resulting spores will be examined for any evidence of crossover within the two fungus strains. Additionally, an attempt to map the genes involved in the determination of spore coat color will be made. Separate Petri dishes of a tan strain and wild strain of Sordaria Fimicola as well as dishes containing both strains will be flown and examined once returned to Earth.

COMMERCIAL PROTEIN CRYSTAL GROWTH (CPCG) PAYLOAD

The Commercial Protein Crystal Growth (CPCG) payload is designed to conduct experiments which will supply information on the scientific methods and commercial potential for growing large high-quality protein crystals in microgravity. The CPCG will be installed and operated in the Orbiter middeck. The CPCG payload consists of a Commercial Refrigerator Incubator Module (CRIM), its contents, and various stowed items.

A primary objective of the CPCG payload on this flight is to grow parasitic enzyme crystals in space for the Chagaspace Project. Chagaspace is a joint project between NASA and several universities and institutions, with EARTH College as the coordinating entity to study Chagas disease. Chagas disease affects 16 to 18 million people, mostly in Latin America, with 90 to 100 million at risk. It is estimated that the disease causes approximately 20,000 deaths per year.

Chagas disease is caused by the flagellate protozoan parasite, *Trypanosomacruzi,* and is transmitted to humans by the feces of “kissing bugs.” The parasite has been extending its reach, mostly due to blood transfusion, and has spread to new areas like Europe and the United States.

Growing higher quality crystals in space often yields higher resolution data important for developing drugs against diseases. This study represents the first Latin American experiment performed in space

Below and on the next page is information on the various proteins which are flying as part of the CPCG experiment on STS-91. Also shown is the organization or institution affiliated with each protein experiment along with some background information about each particular study.

PROTEIN	AFFILIATION	COMMENTS
Lysozyme	Dr. Shigeo Aibara Kyoto University, Kyoto Japan	The purpose of this study is to grow orthorhombic lysozyme crystals to compare the molecular order and mosaicity of ground and space grown crystals. Synchrotron radiation will be used to collect x-ray diffraction data.
Proteinase K Proteinase K/substrate Complex	Dr. Christian Betzel DESY, Hamburg, Germany	Previous microgravity-grown crystals diffracted to 0.95 Å and gave the best x-ray data ever collected for this protein complex. The goal of this project to get better structural data for use in designing inhibitors for pharmaceutical applications.
NAD Synthetase Complex	Dr. Yancho Devedjiev Center for Macromolecular Crystallography/Eli Lilly, Inc.	NAD Synthetase is the key enzyme in NAD biosynthesis and is the target for the structure-based design of antibacterial drugs; previous microgravity crystals have produced significant enhancements to the structural data.

PROTEIN	AFFILIATION	COMMENTS
Pseudomonal Surface Protein A	Dr. Mark Jedrzedas Center for Macromolecular Crystallography	This is one of the major virulence factors of Streptococcus pneumoniae; it has proven potential for the development of therapeutic agents against pneumonia.
Influenza Virus N8 and N2 Neuraminidase	Dr. Graeme Laver John Curtin School of Medical Research, Australian National University	Neuraminidase is a protein on the surface of all viral influenza particles; the protein is a target for the structure-based drug design studies involving influenza.
Glyceraldehyde-3-Phosphate Dehydrogenase complexed with Inhibitor 1	Dr. Glaucius Oliva University of São Paulo/União Química Farmaceutica Nacional S/A	This protein is a drug target for the treatment of Chagas' disease. The complex involves Inhibitor 1, which is a small molecule extracted from a Brazilian plant.
Glyceraldehyde-3-Phosphate Dehydrogenase complexed with Inhibitor 2	Dr. Glaucius Oliva University of São Paulo/União Química Farmaceutica Nacional S/A	This protein is a drug target for the treatment of Chagas' disease. The complex involves Inhibitor 2, which is a small molecule extracted from a Brazilian plant.
Glyceraldehyde-3-Phosphate Dehydrogenase complexed with Inhibitor 3	Dr. Glaucius Oliva University of São Paulo/União Química Farmaceutica Nacional S/A	This protein is a drug target for the treatment of Chagas' disease. The complex involves Inhibitor 3, which is a compound synthesized as a structure-based drug design target.
Mutt	Dr. Stephen Quirk Georgia Institute of Technology	This is an enzyme that protects DNA from oxidative damage prior to replication by hydrolyzing damaged DNA precursors. It prevents spontaneous mutations and is found in all organisms.
Clumping Protein-B	Dr. Narayana Sthanam Center for Macromolecular Crystallography/ Inhibitex, Inc.	This protein has been shown to be bind to the α and γ chains of fibrinogen and to be involved in Staphylococcus aureus clumping.
Multiple Adhesion Protein-10	Dr. Narayana Sthanam Center for Macromolecular Crystallography/ Inhibitex, Inc.	This is a surface bacterial adhesion protein and it is involved in the first step of bacterial attack on cells. It is a target in the design of drugs to combat bacterial infections.
Grass Pollen Allergen Phl p 5b	Dr. Wolfgang Weber University of Hamburg, Hamburg, Germany	This allergen induces allergic rhinitis and bronchial asthma. Therefore, it is a target for the design of drugs to block interactions with ige antibodies.

SOLID SURFACE COMBUSTION EXPERIMENT (SSCE)

Principal Investigator: Robert A. Altenkirch, Professor and Dean, Washington State University
Project Manager: Franklin Vergilii, NASA Lewis Research Center, Cleveland, OH
Project Scientist: Kurt Sacksteder, NASA Lewis Research Center, Cleveland, OH

Experiment Description: The SSCE series of experiments are designed to characterize flame spreading in microgravity and its differences from normal gravity behavior, leading to a better understanding of the physical processes involved. The knowledge gained is expected to enhance our understanding of fire behavior, both in space and on Earth. On Earth, gravity causes hot gases produced by flames to rise in the same way that oil floats on water, or helium balloons rise. Air flow induced by gravity is called buoyant convection. This convection brings fresh oxygen to meet the fuel vapor coming from the burning material. The spread rate of the flame is directly affected by the rate at which the fuel and oxygen are mixed with the help of buoyant convection.

Objectives:

- To measure the spread rates and temperatures of flames spreading over solid fuels (i.e. Ashless filter paper and Plexiglas) in microgravity.
- To determine the effect of air pressure and oxygen concentration on flame spread rate and temperature.
- To determine the mechanism of flame spreading in the absence of any forced or convective airflow.
- To validate existing numerical models of the flame spreading process.
- To contribute to improved methods of fire safety and fire control of space travel.

GROWTH AND MORPHOLOGY, BOILING, AND CRITICAL FLUCTUATIONS IN PHASE SEPARATING SUPERCRITICAL FLUIDS (GMSF)

Principal Investigator: John Hegseth, University of New Orleans, LA
Project Manager: Monica Hoffmann, NASA Lewis Research Center, Cleveland, OH
Project Scientist: R. Allen Wilkinson, NASA Lewis Research Center, Cleveland, OH

Objective: To perform three separate experiments that will test current theories and measure properties not possible in Earth's gravity for phase transitions, vapor to liquid and vice-versa, near a unique thermodynamic state, the "critical point."

Experiment Description: All three mission experiments will use a typical gas, pure sulfur-hexafluoride, which has been used both as a refrigerant and an electrical insulator in transformers, compressed to about the density of water by a pressure of about 38 atmospheres and at a temperature of 45.5 degrees Centigrade. At this "critical" pressure, density and temperature, the fluid has unusual properties like infinite capacity to store heat and the ability to conduct heat infinitely fast, which comes from the fluid having many intense density fluctuations. Density fluctuations are common in the dense gases of the Sun and in our atmosphere.

The first experiment will provide data that will help decide which of two different mathematical equations to apply in determining the growth rate of droplets in a homogeneous fluid (uniform in its density) when it is cooled from a state (temperature, pressure and density) where liquid and gas have no separate existence to a state where they are separate. The second experiment will observe the formation of bubble surfaces, their location, shape and rate of shape and size change during gentle boiling of the fluid while going from the state where liquid and gas are separate to the state where the gas and liquid are indistinguishable. The third experiment will look at the pattern and size of the density fluctuations near the "critical" point. That is, many different sized regions of the fluid have measurably different densities that increase and decrease rapidly. Images taken during this experiment will be analyzed to determine if the fluctuation size is random, or obeying some other probability law. To date, this experiment has not been possible to do in ground-based facilities because the fluid collapses under its own weight near the "critical point."

Significance: These microgravity experiments will increase our knowledge in the fundamental science of critical fluids. The theory of critical phase transitions; vapor to liquid, normal to super-fluids with no viscosity and normal to super-conductors with no resistance to electric currents have common theoretical foundations. Further development of the theories to fully predict their behavior will be useful in manufacturing processes and applications. Past fundamental research in critical fluids has enabled us to use supercritical (above critical temperature and pressure) extraction of caffeine from coffee beans using carbon dioxide and the mixing of paint and solvent in manufacturing processes.

SHUTTLE IONOSPHERIC MODIFICATION WITH PULSED LOCAL EXHAUST (SIMPLEX)

The Shuttle Ionospheric Modification With Pulsed Local Exhaust (SIMPLEX) contains no flight hardware. The SIMPLEX experiment will use Orbital Maneuvering System (OMS) thruster firings to create Ionospheric disturbances for observation by the three SIMPLEX radar sites in Arecibo, Kwajalein, and Jicamarca.

The objective is to determine the source of very high frequency (VHF) radar echoes caused by the orbiter and its OMS engine firings. The principal investigator will use the collected data to examine the effects of orbital kinetic energy on ionospheric irregularities and to understand the processes that take place with the venting of exhaust materials.

STS-91 CREWMEMBERS

STS091-S-002 --- The final crew members scheduled to visit Russia's Mir space station pose for a crew portrait during training at the Johnson Space Center (JSC). Pictured with their helmets in front are astronauts Dominic C. Gorie (left) and Charles J. Precourt. Others, from the left, are Wendy B. Lawrence, Franklin R. Chang-Diaz, Janet L. Kavandi, Valeriy V. Ryumin and Andrew S. W. Thomas. Precourt is mission commander, and Gorie, pilot, for Discovery's summer 1998 mission to Mir. Thomas, who will have been serving as a guest researcher on Mir since late January, will return to Earth with the crew members. Lawrence, Chang-Diaz, Kavandi and Ryumin are all mission specialists. Ryumin represents the Russian Space Agency (RSA). Discovery will carry the single module version of Spacehab for the scheduled nine-day mission.

PHOTO CREDIT: NASA or National Aeronautics and Space Administration.

BIOGRAPHICAL DATA

CHARLES J. PRECOURT (COLONEL, USAF)
STS-91 MISSION COMMANDER

PERSONAL DATA - Born June 29, 1955, in Waltham, Massachusetts, but considers Hudson, Massachusetts, to be his hometown. Married to the former Lynne Denise Mungle of St. Charles, Missouri. They have three daughters, Michelle, Sarah, and Aimee. Precourt enjoys golf and flying light aircraft. He flies a Varieze, an experimental aircraft that he built. His parents, Charles and Helen Precourt, reside in Hudson. Her parents, Loyd and Jerry Mungle, reside in Streetman, Texas.

EDUCATION - Graduated from Hudson High School, Hudson, Massachusetts, in 1973; received a bachelor of science degree in aeronautical engineering from the United States Air Force Academy in 1977, a master of science degree in engineering management from Golden Gate University in 1988, and a master of arts degree in national security affairs and strategic studies from the United States Naval War College in 1990. While at the United States Air Force Academy, Precourt also attended the French Air Force Academy in 1976 as part of an exchange program.

ORGANIZATIONS - Member of the Association of Space Explorers, the Society of Experimental Test Pilots (SETP), the Soaring Society of America, and the Experimental Aircraft Association.

SPECIAL HONORS - Defense Superior Service Medal (2); Air Force Meritorious Service Medal (2); Distinguished graduate of the United States Air Force Academy and the United States Naval War College. In 1978 he was the Air Training Command Trophy Winner as the outstanding graduate of his pilot training class. In 1989 he was recipient of the David B. Barnes Award as the Outstanding Instructor Pilot at the United States Air Force Test Pilot School.

EXPERIENCE - Precourt graduated from Undergraduate Pilot Training at Reese Air Force Base, Texas, in 1978. Initially he flew as an instructor pilot in the T-37, and later as a maintenance test pilot in the T-37 and T-38 aircraft. From 1982 through 1984, he flew an operational tour in the F-15 Eagle at Bitburg Air Base in Germany. In 1985 he attended the United States Air Force Test Pilot School at Edwards Air Force Base in California. Upon graduation, Precourt was assigned as a test pilot at Edwards, where he flew the F-15E, F-4, A-7, and A-37 aircraft until mid 1989, when he began studies at the United States Naval War College in Newport, Rhode Island. Upon graduation from the War College, Precourt joined the astronaut program. His flight experience includes over 6,500 hours in over 50 types of civil and military aircraft. He holds commercial pilot, multi-engine instrument, glider and certified flight instructor ratings.

NASA EXPERIENCE - Selected by NASA in January 1990, Precourt became an astronaut in July 1991. His technical assignments to date have included: Manager of ascent, entry, and launch abort issues for the Astronaut Office Operations Development Branch; spacecraft communicator (CAPCOM), providing the voice link from the Mission Control Center during launch and entry for several Space Shuttle missions; Director of Operations for NASA at the Gagarin Cosmonaut Training Center in Star City, Russia, from October 1995 to April 1996, with responsibility for the coordination and implementation of mission operations activities in the Moscow region for the joint U.S./Russian Shuttle/Mir program. He also served as Acting Assistant Director (Technical), Johnson Space Center. A veteran of three space flights, he has logged over 696 hours in space. He served as a mission specialist on STS-55 (April 26 to May 6, 1993), was the pilot on STS-71 (June 27 to July 7, 1995), and was the spacecraft commander on STS-84 (May 15-24, 1997). Precourt is assigned to command STS-91, the final scheduled Shuttle/Mir docking mission, concluding the joint U.S./Russian Phase I Program. STS-91 is scheduled for a May 1998 launch.

SPACE FLIGHT EXPERIENCE - STS-55 Columbia launched from Kennedy Space Center, Florida, on April 26, 1993. Nearly 90 experiments were conducted during this German-sponsored Spacelab D-2 mission to investigate life sciences, materials sciences, physics, robotics, astronomy and the Earth and its atmosphere. STS-55 also flew the Shuttle Amateur Radio Experiment (SAREX) making contact with students in 14 schools around the world. After 160 orbits of the earth in 240 flight hours, the 10-day mission concluded with a landing on Runway 22 at Edwards Air Force Base, California, on May 6, 1993.

STS-71 (June 27 to July 7, 1995) was the first Space Shuttle mission to dock with the Russian Space Station Mir, and involved an exchange of crews (seven-member crew at launch, eight-member crew on return). The Atlantis Space Shuttle was modified to carry a docking system compatible with the Russian Mir Space Station. It also carried a Spacehab module in the payload bay in which the crew performed various life sciences experiments and data collections. STS-71 Atlantis launched from and returned to land at the Kennedy Space Center, Florida. Mission duration was 235 hours, 23 minutes.

STS-84 Atlantis (May 15-24, 1997) carried a seven-member international crew. This was NASA's sixth Shuttle mission to rendezvous and dock with the Russian Space Station Mir. During the 9-day flight, the crew conducted a number of secondary experiments and transferred nearly 4 tons of supplies and experiment equipment between the Space Shuttle and the Mir station. STS-84 Atlantis launched from and returned to land at the Kennedy Space Center, Florida. Mission duration was 221 hours and 20 minutes.

BIOGRAPHICAL DATA

DOMINIC L. PUDWILL GORIE (COMMANDER, USN)
STS-91 PILOT

PERSONAL DATA - Born May 2, 1957, in Lake Charles, Louisiana. Married to Wendy Lu Williams of Midland, Texas. They have two children. He enjoys skiing, hiking, bicycling, golf and family activities. His mother, Shirley Pudwill, resides in Casselberry, Florida. His adoptive father, William Gorie, resides in Palm City, Florida. His father, Paul Pudwill, is deceased. Her mother, Laura Williams, resides in Midland, Texas. Her father, Deen Williams, is deceased.

EDUCATION - Graduated from Miami Palmetto High School, Miami, Florida, in 1975. Bachelor of Science degree in ocean engineering from the U.S. Naval Academy in 1979. Master of science degree in aviation systems from the University of Tennessee in 1990.

SPECIAL HONORS - Distinguished Flying Cross with Combat "V", Joint Meritorious Service Medal, Air Medal (2), Navy Commendation Medal with Combat "V" (2), Navy Achievement Medal, 1985 Strike Fighter Wing Atlantic Pilot-of-the-Year.

EXPERIENCE - Designated a Naval Aviator in 1981. Flew the A-7E Corsair with Attack Squadron 46 aboard the USS America from 1981 to 1983. Transitioned to Strike Fighter Squadron 132 in 1983, flying the F/A-18 Hornet aboard the USS Coral Sea until 1986. Attended the U.S. Naval Test Pilot School in 1987 and served as a Test Pilot at the Naval Air Test Center from 1988 to 1990. Then was assigned to Strike Fighter Squadron 87 flying the F/A-18 aboard the USS Roosevelt until 1992. Participated in Operation Desert Storm, flying 38 combat missions. In 1992 received orders to U.S. Space Command in Colorado Springs for two years before reporting to Strike Fighter Squadron 106 for F/A-18 refresher training. Was enroute to his command tour of Strike Fighter Squadron 37 when selected as an Astronaut Candidate.

Gorie has accumulated over 3500 hours in more than 30 aircraft and has over 600 carrier landings.

NASA EXPERIENCE - Selected as an astronaut candidate by NASA in December 1994, Gorie reported to the Johnson Space Center in March 1995. He completed a year of training and evaluation and then was initially assigned to work safety issues for the Astronaut Office. Gorie next served as a spacecraft communicator (CAPCOM) in Mission Control for numerous Space Shuttle flights. Gorie is currently assigned as pilot on STS-91, the final scheduled Shuttle/Mir docking mission, concluding the joint U.S./Russian Phase I Program. STS-91 is scheduled for a May 1998 launch.

BIOGRAPHICAL DATA

FRANKLIN R. CHANG-DÍAZ (PH.D.)
STS-91 MISSION SPECIALIST

PERSONAL DATA - Born April 5, 1950, in San José, Costa Rica, to the late Mr. Ramón A. Chang-Morales and Mrs. María Eugenia Díaz De Chang. Married to the former Peggy Marguerite Doncaster of Alexandria, Louisiana. Four children. He enjoys music, glider planes, soccer, scuba-diving, hunting, and hiking. His mother resides in Costa Rica.

EDUCATION - Graduated from Colegio De La Salle in San José, Costa Rica, in November 1967, and from Hartford High School in Hartford, Connecticut, in 1969; received a bachelor of science degree in mechanical engineering from the University of Connecticut in 1973 and a doctorate in applied plasma physics from the Massachusetts Institute of Technology (MIT) in 1977.

SPECIAL HONORS - Recipient of the University of Connecticut's Outstanding Alumni Award (1980); NASA Space Flight Medal (1986); the Liberty Medal from President Ronald Reagan at the Statue of Liberty Centennial Celebration in New York City (1986); the Medal of Excellence from the Congressional Hispanic Caucus (1987); NASA Exceptional Service Medals (1988, 1990, 1993); American Astronautical Society Flight Achievement Award (1989); NASA Space Flight Medals (1986, 1989, 1992, 1994). Outstanding Technical Contribution Award, Hispanic Engineer National Achievement Awards Conference (1993). Awarded the Cross of the Venezuelan Air Force by President Jaime Lusinchi during the 68th Anniversary of the Venezuelan Air Force in Caracas, Venezuela (1988). Recipient of three Honoris Causa Doctorates: Doctor of Science from the Universidad Nacional de Costa Rica; Doctor of Science from the University of Connecticut and Doctor of Law from Babson College. Also Honorary faculty from the College of Engineering of the University of Costa Rica. Honorary Citizenship from the government of Costa Rica (April 1995). This is the highest honor Costa Rica confers to a foreign citizen, making him the first such honoree who was actually born there.

EXPERIENCE - While attending the University of Connecticut, he also worked as a research assistant in the Physics Department and participated in the design and construction of high energy atomic collision experiments. Following graduation in 1973, he entered graduate school at MIT, becoming heavily involved in the United States' controlled fusion program and doing intensive research in the design and operation of fusion reactors. He obtained his doctorate in the field of applied plasma physics and fusion technology and, in that same year, joined the technical staff of the Charles Stark Draper Laboratory. His work at Draper was geared strongly toward the design and integration of control systems for fusion reactor concepts and experimental devices, in both inertial and magnetic confinement fusion. In 1979, he developed a novel concept to guide and target fuel pellets in an inertial fusion reactor chamber. More recently he has been engaged in the design of a new concept in rocket propulsion based on magnetically confined high temperature plasmas. As a visiting scientist with the M.I.T. Plasma Fusion Center from October 1983 to December 1993, he led the plasma propulsion program there to develop this technology for future human missions to Mars. In December 1993, Dr. Chang-Díaz was appointed Director of the Advanced Space Propulsion Laboratory at the Johnson Space Center where he continues his research on plasma rockets. He is an Adjunct Professor of Physics at the University of Houston and has presented numerous papers at technical conferences and in scientific journals.

In addition to his main fields of science and engineering, he worked for 2-1/2 years as a house manager in an experimental community residence for de-institutionalizing chronic mental patients, and was heavily involved as an instructor/advisor with a rehabilitation program for Hispanic drug abusers in Massachusetts.

NASA EXPERIENCE - Selected by NASA in May 1980, Dr. Chang-Díaz became an astronaut in August 1981. While undergoing astronaut training he was also involved in flight software checkout at the Shuttle Avionics Integration Laboratory (SAIL), and participated in the early Space Station design studies. In late 1982 he was designated as support crew for the first Spacelab mission and, in November 1983, served as on orbit capsule communicator (CAPCOM) during that flight. From October 1984 to August 1985 he was leader of the astronaut support team at the Kennedy Space Center. His duties included astronaut support during the processing of the various vehicles and payloads, as well as flight crew support during the final phases of the launch countdown. He has logged over 1,800 hours of flight time, including 1,500 hours in jet aircraft. Dr. Chang-Díaz was instrumental in implementing closer ties between the astronaut corps and the scientific community. In January 1987, he started the Astronaut Science Colloquium Program and later helped form the Astronaut Science Support Group, which he directed until January 1989.

A veteran of five space flights (STS 61-C in 1986, STS-34 in 1989, STS-46 in 1992, STS-60 in 1994, and STS-75 in 1996), he has logged over 1,033 hours in space. Dr. Chang- Díaz is currently assigned as a mission specialist on STS-91, the final scheduled Shuttle/Mir docking mission, concluding the joint U.S./Russian Phase I Program. STS-91 is scheduled for a May 1998 launch.

SPACE FLIGHT EXPERIENCE - STS 61-C (January 12-18, 1986) which launched from the Kennedy Space Center, Florida, on the Space Shuttle Columbia. STS 61-C was a 6-day flight during which Dr. Chang-Díaz participated in the deployment of the SATCOM KU satellite, conducted experiments in astrophysics, and operated the materials processing laboratory MSL-2. Following 96 orbits of the Earth, Columbia and her crew made a successful night landing at Edwards Air Force Base, California. Mission duration was 146 hours, 3 minutes, 51 seconds.

On STS-34 (October 18-23, 1989), the crew aboard Space Shuttle Atlantis successfully deployed the Galileo spacecraft on its journey to explore Jupiter, operated the Shuttle Solar Backscatter Ultraviolet Instrument (SSBUV) to map atmospheric ozone, and performed numerous secondary experiments involving radiation measurements, polymer morphology, lightning research, microgravity effects on plants, and a student experiment on ice crystal growth in space. STS-34 launched from Kennedy Space Center, Florida, and landed at Edwards Air Force Base, California. Mission duration was 119 hours and 41 minutes and was accomplished in 79 orbits of the Earth.

STS-46 (July 31-August 8, 1992), was an 8-day mission during which crew members deployed the European Retrievable Carrier (EURECA) satellite, and conducted the first Tethered Satellite System (TSS) test flight. Mission duration was 191 hours, 16 minutes, 7 seconds. Space Shuttle Atlantis and her crew launched and landed at the Kennedy Space Center, Florida, after completing 126 orbits of the Earth in 3.35 million miles.

STS-60 (February 3-11, 1994), was the first flight of the Wake Shield Facility (WSF-1), the second flight of the Space Habitation Module-2 (Spacehab-2), and the first joint U.S./Russian Space Shuttle mission on which a Russian Cosmonaut was a crew member. During the 8-day flight, the crew aboard Space Shuttle Discovery conducted a wide variety of biological materials science, earth observation, and life science experiments. STS-60 launched and landed at Kennedy Space Center, Florida. The mission achieved 130 orbits of Earth in 3,439,705 miles.

STS-75 (February 22 to March 9, 1996), was a 15-day mission with principal payloads being the reflight of the Tethered Satellite System (TSS) and the third flight of the United States Microgravity Payload (USMP-3). The TSS successfully demonstrated the ability of tethers to produce electricity. The TSS experiment produced a wealth of new information on the electrodynamics of tethers and plasma physics before the tether broke at 19.7 km, just shy of the 20.7 km goal. The crew also worked around the clock performing combustion experiments and research related to USMP-3 microgravity investigations used to improve production of medicines, metal alloys, and semiconductors. The mission was completed in 252 orbits covering 6.5 million miles in 377 hours and 40 minutes.

BIOGRAPHICAL DATA

WENDY B. LAWRENCE (COMMANDER, USN)
STS-91 MISSION SPECIALIST

PERSONAL DATA - Born July 2, 1959, in Jacksonville, Florida. She enjoys running, rowing, triathlons and gardening. Her father, Vice Admiral William P. Lawrence (USN, retired), resides in Crownsville, Maryland. Her mother, Anne Haynes, resides in Alvadore, Oregon.

EDUCATION - Graduated from Fort Hunt High School, Alexandria, Virginia, in 1977; received a bachelor of science degree in ocean engineering from U.S. Naval Academy in 1981; a master of science degree in ocean engineering from Massachusetts Institute of Technology (MIT) and the Woods Hole Oceanographic Institution (WHOI) in 1988.

ORGANIZATIONS - Phi Kappa Phi; Association of Naval Aviation; Women Military Aviators; Naval Helicopter Association.

SPECIAL HONORS - Awarded the Defense Superior Service Medal, the NASA Space Flight Medal, the Navy Commendation Medal and the Navy Achievement Medal. Recipient of the National Navy League's Captain Winifred Collins Award for inspirational leadership (1986).

EXPERIENCE - Lawrence graduated from the United States Naval Academy in 1981. A distinguished flight school graduate, she was designated as a naval aviator in July 1982. Lawrence has more than 1,500 hours flight time in six different types of helicopters and has made more than 800 shipboard landings. While stationed at Helicopter Combat Support Squadron SIX (HC-6), she was one of the first two female helicopter pilots to make a long deployment to the Indian Ocean as part of a carrier battle group. After completion of a master's degree program at MIT and WHOI in 1988, she was assigned to Helicopter Anti-Submarine Squadron Light THIRTY (HSL-30) as officer-in-charge of Detachment ALFA. In October 1990, Lawrence reported to the U.S. Naval Academy where she served as a physics instructor and the novice women's crew coach.

NASA EXPERIENCE - Selected by NASA in March 1992, Lawrence reported to the Johnson Space Center in August 1992. She completed one year of training and is qualified for assignment as a mission specialist on future Space Shuttle missions. Her technical assignments within the Astronaut Office have included: flight software verification in the Shuttle Avionics Integration Laboratory (SAIL); Astronaut Office Assistant Training Officer. She flew as the ascent/entry flight engineer and blue shift orbit pilot on STS-67 (March 2-18, 1995). She next served as Director of Operations for NASA at the Gagarin Cosmonaut Training Center in Star City, Russia, with responsibility for the coordination and implementation of mission operations activities in the Moscow region for the joint U.S./Russian Shuttle/Mir program. In September 1996 she began training for a 4-month mission on the Russian Space Station Mir, but in July 1997 NASA decided to replace Lawrence with her back-up, Dr. David Wolf. This decision enabled Wolf to act as a backup crew member for spacewalks planned over the next several months to repair the damaged Spektr module on the Russian outpost. Because of her knowledge and experience with Mir systems and with crew transfer logistics for the Mir, she flew with the crew of STS-86 (September 25 to October 6, 1997). A veteran of two space flights, she has logged 658 hours in space. Lawrence is currently assigned as a mission specialist on STS-91, the final scheduled Shuttle/Mir docking mission, concluding the joint U.S./Russian Phase I Program. STS-91 is scheduled for a May 1998 launch.

SPACEFLIGHT EXPERIENCE - STS-67 Endeavour (March 2-18, 1995) was the second flight of the ASTRO observatory, a unique complement of three telescopes. During this 16-day mission, the crew conducted observations around the clock to study the far ultraviolet spectra of faint astronomical objects and the polarization of ultraviolet light coming from hot stars and distant galaxies. Mission duration was 399 hours and 9 minutes.

STS-86 Atlantis (September 25 to October 6, 1997) was the seventh mission to rendezvous and dock with the Russian Space Station Mir. Highlights included the exchange of U.S. crew members Mike Foale and David Wolf, a spacewalk by two crew members to retrieve four experiments first deployed on Mir during the STS-76 docking mission, the transfer to Mir of 10,400 pounds of science and logistics, and the return of experiment hardware and results to Earth. Mission duration was 259 hours and 21 minutes.

BIOGRAPHICAL DATA

JANET LYNN KAVANDI (PH.D.)
NASA ASTRONAUT

PERSONAL DATA - Born July 17, 1959 in Springfield, Missouri. Married to John Kavandi. They have two children. She enjoys snow skiing, hiking, camping, horseback riding, windsurfing, flying, scuba diving, piano. Her parents, William and Ruth Sellers of Cassville, Missouri, are deceased.

EDUCATION - Graduated from Carthage Senior High School, Carthage Missouri, in 1977; received a bachelor of science degree in chemistry from Missouri Southern State College - Joplin in 1980; master of science degree in chemistry from the University of Missouri - Rolla in 1982; doctorate in analytical chemistry from the University of Washington - Seattle in 1990.

SPECIAL HONORS - Elected to the National Honor Society, 1977. Valedictorian of Carthage Senior High School, 1977. Awarded Presidential Scholarship from Missouri Southern State College, 1977. Graduated magma cum laude from Missouri Southern State College, 1980. Elected to Who's Who Among Students in American Universities and Colleges, 1980; Who's Who of Emerging Leaders in America, 1989-90, 1991-92; and Who's Who in the West, 1987-88. Awarded certificates for Team Excellence and Performance Excellence from Boeing Missile Systems, 1991.

EXPERIENCE - Following graduation in 1982, Dr. Kavandi accepted a position at Eagle-Picher Industries in Joplin, Missouri, as an engineer in new battery development for defense applications. In 1984, she accepted a position as an engineer in the Power Systems Technology Department of the Boeing Aerospace Company. During her ten years at Boeing, Kavandi supported numerous programs, proposals and red teams in the energy storage systems area through power analyses, trade studies, sizing, selection, development, testing and data analysis. She was lead engineer of secondary power for the Short Range Attack Missile II, and principal technical staff representative involved in the design and development of thermal batteries for Sea Lance and the Lightweight Exo-Atmospheric Projectile. Other programs she supported include Space Station, Lunar and Mars Base studies, Inertial Upper Stage, Advanced Orbital Transfer Vehicle, Get-Away Specials, Small Spacecraft, Air Launched Cruise Missile, Minuteman, and Peacekeeper. In 1986, while still working for Boeing, she was accepted into graduate school at the University of Washington, where she began working toward her doctorate in analytical chemistry. Her doctoral dissertation involved the development of a pressure-indicating coating that uses oxygen quenching of porphyrin photoluminescence to provide continuous surface pressure maps of aerodynamic test models in wind tunnels. Commercial imaging technology was used for data collection and analysis. This non-intrusive technique was developed to supplement or replace the more expensive and time consuming pressure tap method. Her work on pressure indicating paints has resulted in two patents to date. In addition to her patents, Dr. Kavandi has published and presented several papers at technical conferences and in scientific journals.

NASA EXPERIENCE - Dr. Kavandi was selected as an astronaut candidate by NASA in December 1994 and reported to the Johnson Space Center in March 1995. Following an initial year of training, she was assigned to the Payloads and Habitability Branch where she supported payload integration for the International Space Station. Dr. Kavandi is currently assigned as a mission specialist on STS-91, the final scheduled Shuttle/Mir docking mission, concluding the joint U.S./Russian Phase I Program. STS-91 is scheduled for a May 1998 launch.

BIOGRAPHICAL DATA

VALERY VICTOROVITCH RYUMIN
RUSSIAN COSMONAUT / STS-91 MISSION SPECIALIST

PERSONAL DATA - Born August 16, 1939 in the city of Komsomolsk-on-Amur in the Russian Far East. Married. Has two daughters and a son. His hobbies include tennis, angling, hunting, walking through forests, and travel.

EDUCATION - In 1958, he was graduated from the Kaliningrad Mechanical Engineering Technical College with the specialty "Cold Working of Metal." In 1966, he was graduated from the Department of Electronics and Computing Technology of the Moscow Forestry Engineering Institute with the specialty "Spacecraft Control Systems."

SPECIAL HONORS - Ryumin has been decorated twice as Hero of the Soviet Union, and has been awarded other Russian and foreign decorations.

EXPERIENCE - From 1958 to 1961, Ryumin served in the army as a tank commander.

From 1966 to the present, he has been employed at the Rocket Space Corporation Energia, holding the positions of: Ground Electrical Test Engineer, Deputy Lead Designer for Orbital Stations, Department Head, and Deputy General Designer for Testing. He helped develop and prepare all orbital stations, beginning with Salyut-1. In 1973, he joined the RSC Energia cosmonaut corps. A veteran of three space flights, Ryumin has logged a total of 362 days in space. In 1977, he spent 2 days aboard Soyuz-25, in 1979, he spent 175 days aboard Soyuz vehicles and the Salyut-6 space station, and in 1980, he spent 185 days aboard Soyuz vehicles and the Salyut-6 space station.

From 1981 to 1989, Ryumin was flight director for the Salyut-7 space station and the Mir space station. Since 1992, he has been the Director of the Russian portion of the Shuttle-Mir and NASA-Mir program.

In January 1998, NASA announced Ryumin's selection to the crew of STS-91, the final scheduled Shuttle-Mir docking mission, concluding the joint U.S./Russian Phase I Program. STS-91 is scheduled for a May 1998 launch.

BIOGRAPHICAL DATA

ANDREW S. W. THOMAS (PH.D.)
STS-89 / MIR-25 / STS-91

PERSONAL DATA - Born December 18, 1951, in Adelaide, South Australia. Single. He enjoys horse riding and jumping, mountain biking, running, wind surfing, and classical guitar playing. His father, Adrian C. Thomas, resides in Hackham, South Australia. His mother, Mary E. Thomas, resides in North Adelaide, South Australia.

EDUCATION - Received a bachelor of engineering degree in mechanical engineering, with First Class Honors, from the University of Adelaide, South Australia, in 1973, and a doctorate in mechanical engineering from the University of Adelaide, South Australia, in 1978.

ORGANIZATIONS - Member of the American Institute of Aeronautics and Astronautics.

EXPERIENCE - Dr. Thomas began his professional career as a research scientist with the Lockheed Aeronautical Systems Company, Marietta, Georgia, in 1977. At that time he was responsible for experimental investigations into the control of fluid dynamic instabilities and aircraft drag. In 1980, he was appointed Principal Aerodynamic Scientist to the company and headed a research team examining various problems in advanced aerodynamics and aircraft flight test.

This was followed in 1983 by an appointment as the head of the Advanced Flight Sciences Department to lead a research department of engineers and scientists engaged in experimental and computational studies in fluid dynamics, aerodynamics and aeroacoustics. He was also manager of the research laboratory, the wind tunnels, and the test facilities used in these studies. In 1987, Dr. Thomas was named manager of Lockheed's Flight Sciences Division and directed the technical efforts in vehicle aerodynamics, flight controls and propulsion systems that supported the company's fleet of production aircraft.

In 1989, he moved to Pasadena, California, to join the Jet Propulsion Laboratory (JPL) and, shortly after, was appointed leader of the JPL program for microgravity materials processing in space. This NASA-sponsored research included scientific investigations, conducted in the laboratory and in low gravity on NASA's KC-135 aircraft, as well as technology studies to support the development of the space flight hardware for future Shuttle missions.

NASA EXPERIENCE - Dr. Thomas was selected by NASA in March 1992 and reported to the Johnson Space Center in August 1992. In August 1993, following one year of training, he was appointed a member of the astronaut corps and was qualified for assignment as a mission specialist on Space Shuttle flight crews.

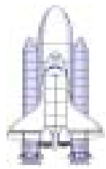
While awaiting space flight assignment, Dr. Thomas supported shuttle launch and landing operations as an Astronaut Support Person (ASP) at the Kennedy Space Center. He also provided technical support to the Space Shuttle Main Engine project, the Solid Rocket Motor project and the External Tank project at the Marshall Space Flight Center. He trained at the Gagarin Cosmonaut Training Center in Star City, Russia in preparation for a long-duration stay aboard the Russian Space Station. Dr. Thomas flew on STS-77 (May 19-29, 1996) and has logged 240 hours and 39 minutes in space. He currently serves as Board Engineer 2 aboard the Russian Space Station Mir.

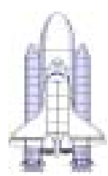
SPACE FLIGHT EXPERIENCE - In June 1995 Dr. Thomas was named as payload commander for STS-77 and flew his first flight in space on Endeavour in May 1996. During this 10-day mission the crew of STS-77 deployed two satellites, tested a large inflatable space structure on orbit and conducted a variety of scientific experiments in a Spacehab laboratory module carried in Endeavour's payload bay. The flight was launched from the Kennedy Space Center on May 19, 1996 and completed 160 orbits 153 nautical miles above the Earth while traveling 4.1 million miles and logging 240 hours and 39 minutes in space.

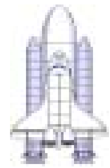
On January 22, 1998, Dr. Thomas launched aboard Space Shuttle Endeavour as part of the STS-89 crew. Following docking, January 25, 1998 marked the official start of his expected 4-month stay aboard Space Station Mir.

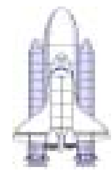
SHUTTLE FLIGHTS AS OF JUNE 1998

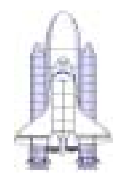
90 TOTAL FLIGHTS OF THE SHUTTLE SYSTEM -- 65 SINCE RETURN TO FLIGHT











STS-90 04/17/98 - 05/03/98				
STS-87 11/19/97 - 12/05/97				
STS-94 07/01/97 - 07/17/97		STS-85 08/07/97 - 08/19/97		
STS-83 04/04/97 - 04/08/97		STS-82 02/11//97 - 02/21/97		
STS-80 11/19/96 - 12/07/96		STS-70 07/13/95 - 07/22/95		
STS-78 06/20/96 - 07/07/96		STS-63 02/03/95 - 02/11/95	STS-86 09/25/97 - 10/06/97	
STS-75 02/22/96 - 03/09/96		STS-64 09/09/94 - 09/20/94	STS-84 05/15/97 - 05/24/97	
STS-73 10/20/95 - 11/05/95		STS-60 02/03/94 - 02/11/94	STS-81 01/12/97 - 01/22/97	
STS-65 07/08/94 - 07/23/94		STS-51 09/12/93 - 09/22/93	STS-79 09/16/96 - 09/26/96	
STS-62 03/04/94 - 03/18/94		STS-56 04/08/83 - 04/17/93	STS-76 03/22/96 - 03/31/96	
STS-58 10/18/93 - 11/01/93		STS-53 12/02/92 - 12/09/92	STS-74 11/12/95 - 11/20/95	
STS-55 04/26/93 - 05/06/93		STS-42 01/22/92 - 01/30/92	STS-71 06/27/95 - 07/07/95	
STS-52 10/22/92 - 11/01/92		STS-48 09/12/91 - 09/18/91	STS-66 11/03/94 - 11/14/94	
STS-50 06/25/92 - 07/09/92		STS-39 04/28/91 - 05/06/91	STS-46 07/31/92 - 08/08/92	STS-89 01/22/98 - 01/31/98
STS-40 06/05/91 - 06/14/91		STS-41 10/06/90 - 10/10/90	STS-45 03/24/92 - 04/02/92	STS-77 05/19/96 - 05/29/96
STS-35 12/02/90 - 12/10/90	STS-51L 01/28/86	STS-31 04/24/90 - 04/29/90	STS-44 11/24/91 - 12/01/91	STS-72 01/11/96 - 11/20/96
STS-32 01/09/90 - 01/20/90	STS-61A 10/30/85 - 11/06/85	STS-33 11/22/89 - 11/27/89	STS-43 08/02/91 - 08/11/91	STS-69 09/07/95 - 09/18/95
STS-28 08/08/89 - 08/13/89	STS-51F 07/29/85 - 08/06/85	STS-29 03/13/89 - 03/18/89	STS-37 04/05/91 - 04/11/91	STS-67 03/02/95 - 03/18/95
STS-61C 01/12/86 - 01/18/86	STS-51B 04/29/85 - 05/06/85	STS-26 09/29/88 - 10/03/88	STS-38 11/15/90 - 11/20/90	STS-68 09/30/94 - 10/11/94
STS-9 11/28/83 - 12/08/83	STS-41G 10/05/84 - 10/13/84	STS-51-I 08/27/85 - 09/03/85	STS-36 02/28/90 - 03/04/90	STS-59 04/09/94 – 04/20/94
STS-5 11/11/82 - 11/16/82	STS-41C 04/06/84 - 04/13/84	STS-51G 06/17/85 - 06/24/85	STS-34 10/18/89 - 10/23/89	STS-61 12/02/93 - 12/13/93
STS-4 06/27/82 - 07/04/82	STS-41B 02/03/84 - 02/11/84	STS-51D 04/12/85 - 04/19/85	STS-30 05/04/89 - 05/08/89	STS-57 06/21/93 - 07/01/93
STS-3 03/22/82 - 03/30/82	STS-8 08/30/83 - 09/05/83	STS-51C 01/24/85 - 01/27/85	STS-27 12/02/88 - 12/06/88	STS-54 01/13/93 - 01/19/93
STS-2 11/12/81 - 11/14/81	STS-7 06/18/83 - 06/24/83	STS-51A 11/08/84 - 11/16/84	STS-61B 11/26/85 - 12/03/85	STS-47 09/12/92 - 09/20/92
STS-1 04/12/81 - 04/14/81	STS-6 04/04/83 - 04/09/83	STS-41D 08/30/84 - 09/05/84	STS-51J 10/03/85 - 10/07/85	STS-49 05/07/92 - 05/16/92
OV-102 Columbia (25 flights)	**OV-099 Challenger (10 flights)**	**OV-103 Discovery (23 flights)**	**OV-104 Atlantis (20 flights)**	**OV-105 Endeavour (12 flights)**