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Mission Highlights STS-91

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June 1998

Discovery's landing begins second phase

As *Discovery* glided out of a cloud-speckled sky and rolled to a smooth landing, bringing the Phase 1 Shuttle-Mir docking program to a close, astronauts and agency managers turned their full attention to the next phase, the construction of the International Space Station.

Commander Charlie Precourt presented three legacies to Phase 1 Program Manager Frank Culbertson and NASA Administrator Daniel Goldin "in hopes that they can pass these to the first crews that go to the International Space Station symbolically leading them with the lessons learned in Phase 1."

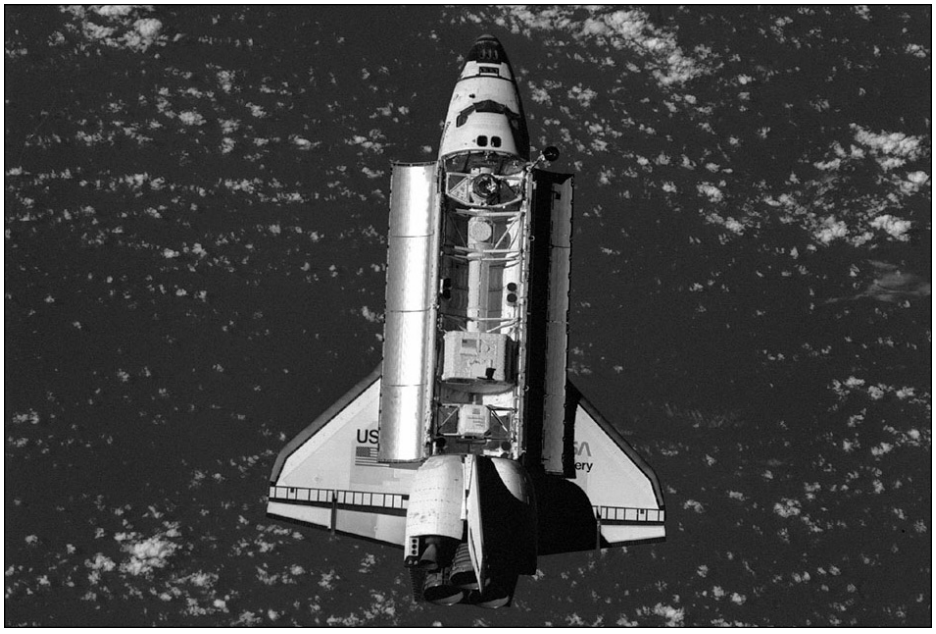
The mementos included an American flag that hung on the wall of Mir for every press event by American astronauts, an EVA tool used by the Russians on Mir, and an optical disk used to collect scientific data during Phase 1.

Culbertson vowed to take good care of the items, and with the help of his Russian counterpart, Valery Ryumin, "put them to good use."

Mission Events

The Shuttle *Discovery* launched from Kennedy Space Center at 5:06 p.m. CDT on June 2, 1998, to begin the last docking mission of the U.S. Space Shuttle to the Russian Space Station Mir.

The actual docking occurred at



NASA Photo 7-726-063c

This perspective of the shuttle affords a clear look at the layout of the cargo bay, revealing the open bay doors; the docking apparatus for connecting to Mir (near cabin), the tunnel; the SPACEHAB module (second element from aft); the Alpha Magnetic Spectrometer (near aft firewall); and the Ku-band antenna for communications (near cabin).

Space Shuttle *Discovery*

June 2–12, 1998

Commander:	Charlie Precourt
Pilot:	Dom Gorie
Mission Specialists:	Franklin Chang-Díaz
	Wendy Lawrence
	Janet Kavandi
	Valery Ryumin
	Andy Thomas

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Astronauts Charlie Precourt and Wendy Lawrence look over a copy of the flight plan.

11:58 a.m. CDT on June 4, with the hatch opening at 1:34 p.m. Following 4 days of docked operations, which saw the transfer of supplies to the Mir and the return to the shuttle of the last American inhabitant of the Russian station, the hatches were again closed at 8:07 a.m. on June 8, and the two vehicles separated at 11:01 a.m. CDT.

In addition to the Mir docking operations, the STS-91 crew conducted a series of on-orbit experiments.

The *Discovery* ended its mission with a landing at the Kennedy Space Center on June 12, 1998, at 1:00 p.m. CDT.

SPACEHAB

The SPACEHAB single module was a pressurized, mixed-cargo carrier designed to augment the Orbiter middeck by providing a total cargo capacity of up to 4,000 pounds. The SPACEHAB Universal Communication System (SHUCS) payload was 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.

STS-91 SCIENCE

The Alpha Magnetic Spectrometer (AMS): The first large magnet experiment ever placed in Earth's orbit. The scientific goal of this high-energy physics experiment was to increase our understanding of the composition and origin of the universe. It was 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.

AMS is intended to look for antimatter supposedly left over after the creation of the universe according to the "Big Bang" theory. It also will look for signs of "dark matter" that has been theorized to constitute most of the universe.

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. NASA will fly AMS twice. During STS-91, 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.

MIT Professor and Nobel Laureate Dr. Samuel Ting headed the experiment. The AMS experiment was an international collaboration of scientists from 37 research institutions. The U.S. Department of Energy sponsored the U.S. portion of the AMS experiment.

SPACE EXPERIMENT MODULE

The Effect of Microgravity on Crossing-Over in Sordaria Fimicola: Studied the effect of microgravity on the union between strains of a species of the fungus called Sordaria Fimicola. The principle investigator was Wading River High School in Shoreham, NY.

Crystal Growth in Microgravity: Added 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. The principle investigator was Tomasita Young Astronauts Club, Albuquerque, NM.

Norfolk, VA, Public Schools Science and Technology Advanced Research (NORSTAR): This payload involved two experiments: The Effect of Microgravity on Development of Daphnia, Eubranchipus and Triops Eggs and the Separation of Immiscible Fluids in Microgravity experiments.

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Astronaut Janet Kavandi checks out the Orbiter Space Vision Systems on the flight deck.

Boy Scouts Troop 177 and Four Rivers District, Gambrills, MD – Merit Badge Madness: Determined how the environment of space and radiation affect soil, water, and seed samples and their yield when planted.

Can Do Project, Charleston, SC: This payload involved the Magnetic Attraction Viewed In Space (MAVIS) and the Big Experiments in Small Tubes (BEST) experiments.

Cosmic Radiation Effects on Programmable Logic Devices (CREPLD): Determined the effects of cosmic radiation on unshielded Programmable Logic Devices (PLDs). PLDs are integrated circuits which can be programmed to perform many functions. The potential scientific value of these measurements was the determination of the amount of shielding needed for PLDs to be reliable in space. The principle investigator was Purdue University, West Lafayette, IN.

WESTAR: An assortment of passive experiment items including seeds, soils, and other organic materials were flown in polycarbonate vials. The principle investigator was Woodmore Elementary School, Mitchellville, MD.

The Effect of Spaceflight on Food Yield: A medley of food materials contained in NASA-provided polycarbonate vials were included and factors such as vitality, growth rate, yield, volume, etc., were measured. The principle investigator was Chesapeake Bay Girl Scout Council, Salisbury, MD.

Exposure of the Space Experiment Module (SEM) to the Space Environment: Investigated the effects of the space environment on electronic data storage, electrical circuits, magnetized metals, growth of simple plants, and photographic film sensitivity. The principle investigator was Excel Interactive Science Museum, Salisbury, MD.

Comparative Microgravity Response of Fungi and Mold: Studied the effect of microgravity on the reproductive and growth mechanisms of simple plant species. The principle investigator was Grand Coulee (Wash.) Elementary School.

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Astronaut Dom Gorie makes a meal at the galley.

The Effect of Microgravity on Plant Seeds: The experiment aimed to be a basis for understanding the growth patterns of microgravity-exposed grains, seed-bearing plants, fruits, nuts, and trees. The principle investigator was Olin-Sang-Ruby Union Institute, Oconomowoc, WI.

Flower Garden in Space: The effect of microgravity and temperature exposure on flower and foliage seeds was studied. The principle investigator was the Virginia Parent Teachers and Students Association, Accomac, VA.

Effects of Microgravity on Sordaria Fimicola: Studied the effects of microgravity on the reproduction of the fungus Sordaria Fimicola. The principle investigator was Wicomico High School, Salisbury, MD.

GET AWAY SPECIALS (GAS) EXPERIMENTS

The Get Away Special program for placing non-interactive experiments on the shuttle continued with four experiments manifested by the Goddard Space Flight Center.

IN-CABIN PAYLOADS

COMMERCIAL PROTEIN CRYSTAL GROWTH (CPCG) PAYLOAD: A primary objective of the CPCG payload was 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. It is estimated that the disease causes approximately 20,000 deaths per year. Growing higher quality crystals in space often yields higher resolution data important for developing drugs against diseases.

SOLID SURFACE COMBUSTION EXPERIMENT (SSCE): 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 principle investigators were Washington State University and NASA Lewis Research Center, Cleveland, OH.

GROWTH AND MORPHOLOGY, BOILING, AND CRITICAL FLUCTUATIONS IN PHASE SEPARATING SUPERCRITICAL FLUIDS (GMSF): Increased our knowledge in the fundamental science of critical fluids. Further development of the theories to fully predict the behavior of these fluids is useful in manufacturing processes and applications. The principle investigators for this experiment were

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STS-91 Mission Specialist Franklin Chang-Díaz, Ph.D., participates in Terminal Countdown Demonstration Test (TCDT) activities. The TCDT is a dress rehearsal for launch.

the University of New Orleans, LA, and the NASA Lewis Research Center, Cleveland, OH.

SHUTTLE IONOSPHERIC MODIFICATION WITH PULSED LOCAL EXHAUST (SIMPLEX):

Determined the source of very high frequency radar echoes caused by the orbiter and its OMS engine firings. The principal investigator used 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.

SPEKTR GAS RELEASE PROCEDURE:

After the undocking of *Discovery* from the Mir Space Station, the release of a tracer gas comprised of acetone and biacetyl into the depressurized Spektr module was initiated. This procedure was designed to enable shuttle astronauts to document the ionization glow from the gas through any hole in Spektr's hull prior to sunrise and any fluorescent glow from the gas after sunrise. If lighting conditions were right, the gas would appear as a dull green cloud. The test was designed to pinpoint the location of the breach in Spektr's hull resulting from last year's collision of a Progress re-supply ship with the Russian station.

Two days earlier, a similar release of gas into Spektr was conducted by the cosmonauts while *Discovery* was docked to Mir to test the gas release system and enable the crew members to document any areas of special interest for the fly around experiment.

CREW BIOGRAPHIES

Commander: Charles J. Precourt (Col., USAF). Precourt, 41, was born in Waltham, MA. He received a bachelor of science degree in aeronautical engineering from the United States Air Force Academy, a master of science degree in engineering management from Golden Gate University, and a master of arts degree in national security affairs and strategic studies from the United States Naval War College. While at the United States Air Force Academy, he also attended the French Air Force Academy as part of an exchange program.

Precourt became an astronaut in July 1991, and is a veteran of four space flights. He served as a mission specialist on STS-55, was the pilot on STS-71, and was the spacecraft commander on STS-84 and STS-91.

Nearly 90 experiments were conducted during STS-55, the German-sponsored Spacelab D-2 mission, to investigate life sciences, materials sciences, physics, robotics, astronomy, and the Earth and its atmosphere.

STS-71, the first space shuttle mission to dock with the Russian Space Station Mir, also carried a Spacehab module in the payload bay in which the crew performed various life sciences experiments and data collections.

STS-84 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 docked vehicles. With the completion of STS-91, Precourt has logged more than 932 hours in space.

Pilot: Dominic L. Pudwill Gorie (Cmdr., USN). Gorie, 41, was born in Lake Charles, LA. He received a bachelor of science degree in ocean engineering from the U.S. Naval Academy, and a master of science degree in aviation systems from the University of Tennessee.

Gorie was designated a Naval Aviator, attended the U.S. Naval Test Pilot School, and served as a Test Pilot at the Naval Air Test Center. He was assigned to Strike Fighter Squadron 87 flying the F/A-18 aboard the USS *Roosevelt*, and participated in Operation Desert Storm. Gorie 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. He was enroute to his command tour of Strike Fighter Squadron 37 when selected as an astronaut candidate.

He became an astronaut in 1994, and with the completion of STS-91 has accumulated more than 236 hours of space flight.

Mission Specialist: Franklin R. Chang-Díaz (Ph.D.). Chang-Díaz, 48, was born in San José, Costa Rica, and received a bachelor of science degree in mechanical engineering from the University of Connecticut, and a doctorate in applied plasma physics from the Massachusetts Institute of Technology (MIT).

Chang-Díaz became an astronaut in 1981, and is a veteran of six space flights (STS 61-C, STS-34, STS-46, STS-60, STS-75 and STS-91). He has logged over 1,269 hours in space.

STS 61-C was a 6-day flight which saw the deploy of the

SATCOM KU satellite, conducted experiments in astrophysics, and operated the materials processing laboratory MSL-2. The STS-34 crew successfully deployed the Galileo spacecraft, 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-46 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.

STS-60 was the first flight of the Wake Shield Facility, the second flight of the Space Habitation Module-2, and the first joint U.S./Russian Space Shuttle mission on which a Russian Cosmonaut was a crewmember. During the 8-day flight, the crew conducted a wide variety of biological materials science, Earth observation, and life science experiments.

STS-75 was a 15-day mission, which saw the reflight of the Tethered Satellite System and the third flight of the United States Microgravity Payload. The crew also worked around the clock performing combustion experiments and research related to microgravity investigations used to improve production of medicines, metal alloys, and semiconductors.

Mission Specialist: Wendy B. Lawrence (Cmdr., USN). Lawrence, 38, was born in Jacksonville, FL, and received a bachelor of science degree in ocean engineering from the U.S. Naval Academy; and a master of science degree in ocean engineering from the Massachusetts Institute of Technology and the Woods Hole Oceanographic Institution.

Lawrence became an astronaut in 1992, and flew as the ascent/entry flight engineer and blue shift orbit pilot on STS-67. 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 backup, Dr. David Wolf, to enable Wolf to act as a backup crew member for planned space walks. 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. A veteran of three space flights, she has logged 894 hours in space.

STS-67 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.

STS-86 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 space walk by two crew members, the transfer to Mir of 10,400 pounds of science and logistics, and the return of experiment hardware and results to Earth.

Mission Specialist: Janet Lynn Kavandi (Ph.D.). Kavandi, 38, was born in Springfield, MO, and received a bachelor of science degree in chemistry from Missouri Southern State College–Joplin, a master of science degree in chemistry from the University of Missouri–Rolla, and a doctorate in analytical chemistry from the University of Washington–Seattle.

Kavandi worked at Eagle-Picher Industries in Joplin, MO, and the

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Inflight picture: bottom center, Wendy Lawrence. Others are (counter-clock-wise from Lawrence) Andrew Thomas, Charles Precourt, Valery Ryumin, Janet Kavandi, Dominic Gorie and Franklin Chang-Díaz.

STS-91
Quick Look

Launch Date:	June 2, 1998
Time:	5:06 p.m. CDT
Site:	KSC Pad 39A
Orbiter:	*Discovery* OV-103—24th flight
Orbit/In.:	173 naut. miles 51.6 degrees
Mission Duration:	9 days, 19 hrs, 54 mns.
Landing Date:	June 12, 1998
Time:	1:00 p.m. CDT
Site:	Kennedy Space Center
Crew:	Charlie Precourt (CDR)
	Dom Gorie (PLT)
	Franklin Chang-Díaz (PLC)
	Wendy Lawrence (MS2)
	Janet Kavandi (MS3)
	Valery Ryumin (MS4)
	Andy Thomas (MS5)
Cargo Bay Payloads:	Orbiter Docking System, Spacehab Module, Alpha Magnetic Spectrometer, Space Experiment Module, Get Away Specials
In-Cabin Payloads:	Commercial Protein Crystal Growth, Solid Surface Combustion
Procedure:	Spektr Gas Release

Boeing Aerospace Company. During her ten years at Boeing, Kavandi supported numerous programs, proposals and red teams in the energy storage systems area. Her work on pressure indicating paints has resulted in two patents to date. In addition, Kavandi has published and presented several papers at technical conferences and in scientific journals. Kavandi became an astronaut in 1995, and with the completion of STS-91, has accumulated more than 236 hours of space flight.

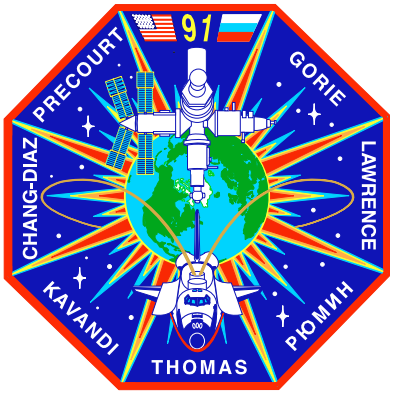
Mission Specialist: Valery Victorovitch Ryumin (Russian Cosmonaut). Ryumin, 59, was born in the city of Komsomolsk-on-Amur in the Russian Far East. He graduated from the Kaliningrad Mechanical Engineering Technical College with the specialty "Cold Working of Metal." He also graduated from the Department of Electronics and Computing Technology of the Moscow Forestry Engineering Institute with the specialty "Spacecraft Control Systems."

Ryumin helped develop and prepare all orbital stations, beginning with Salyut-1. A veteran of four space flights, Ryumin has logged more than 8,924 days in space.

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 programs.

Mission Specialist: Andrew S. W. Thomas (Ph.D.). Thomas, 46, was born in Adelaide, South Australia. He received a bachelor of engineering degree in mechanical engineering, with First Class Honors, from the University of Adelaide, South Australia, and a doctorate in mechanical engineering from the University of Adelaide, South Australia.

Thomas became an astronaut in 1992, and was the payload commander for the STS-77 mission which deployed two satellites, tested a large inflatable space structure on orbit, and conducted a variety of scientific experiments in a Spacehab laboratory module. On January 22, 1998, Dr. Thomas launched 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. He returned to Earth on STS-91 with a combined missions total of more than 3,615 hours of space flight.



The STS-91 crew patch depicts the rendezvous of the Space Shuttle *Discovery* with the Russian 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 crew members surround the insignia on the outer areas, with the name of Cosmonaut Valery Ryumin in Cyrillic at the lower right.

The Alpha Magnetic spectrometer (AMS) is an international payload that flew in the payload bay. 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.