Mir Principal Expedition 21

Commander Yuri Onufrienko (1st flight)

Flight Engineer Yuri Usachev (2nd)

Launched and landed in Soyuz-TM 23-
February 21 - September 2, 1996
194 days in space

Cosmonaut Researcher Shannon Lucid (5th)

Launched on Atlantis (STS-76)-March 22, 1996

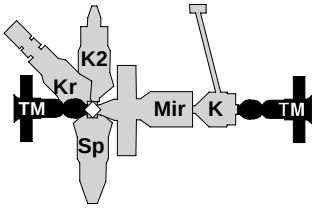
Landed in Atlantis (STS-79)-Sept. 26, 1996
188 days in space

Crew code name: Skif

Highlights: Onufrienko and Usachev began their mission without the third crew member, American astronaut Shannon Lucid, who would join them in late March during STS-76, the third Atlantis-Mir docking mission. On one of the seven EVAs of Mir 21, U.S. astronauts walked outside Mir for the first time; on two others, the cosmonauts installed a new solar array on the Kvant module. The last permanent module was added to the complex—Priroda, with its large complement of Earth science experiments.

February 23-29, 1996

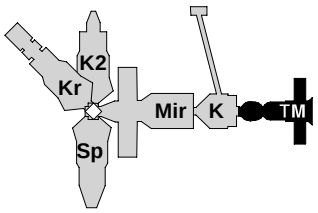
Kristall Kvant 2
Soyuz-TM 22 - Mir - Kvant - Soyuz-TM 23
Spektr



Soyuz-TM 23 delivers Mir 21 crew. The Soyuz module docked on February 23 at the +X docking port at the rear of the Kvant module. About an hr and a half after docking, the hatches were opened and Onufrienko and Usachev were greeted by the Mir 20/Euromir 95 crew, who would remain with them a week to familiarize them with current conditions and projects on the station. The week of joint operations also included work with crop breeding experiments and Earth observation spectrometry. The Mir 20 crew made preparations for their departure, including checks of Soyuz-TM 22 systems and sessions in the Chibis negative-pressure suit to condition them for return to Earth gravity.[143] Two days before the return flight, a water leak appeared in the Mir base block, but the cosmonauts solved it with advice from ground support.[144]

February 29 - March 23, 1996

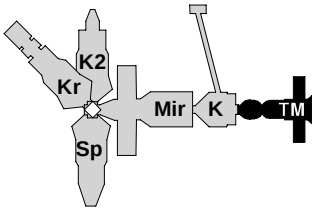
Kristall Kvant
- Mir - Kvant - Soyuz-TM 23
Spektr



Mir 20/Euromir Mission ends. On February 29, Gidzenko, Avdeyev, and Reiter donned their Sokol launch and entry suits and entered Soyuz-TM 22. They landed safely about 105 km from Arkalyk. Recovery teams had erected facilities for rapid medical tests before the crew was returned to Star City that evening. Their mission had lasted 179 days, 1 hr, and 42 min.[145] Reiter thus achieved a record for spaceflight duration by a West European.

First EVA for Mir 21. On March 15, Onufrienko and Usachev exited the Kvant 2 EVA hatch for their first space walk. Because

February 29 - March 23, 1996



Concluded

the existing Strela could not be used to reach the Kristall module in its current location, they installed a second Strela boom on the Mir base block, on the side opposite the Strela already in place. In the 5-hr, 51-min EVA, they also prepared cables and electrical connectors on the surface of the Kvant module for the May installation of the Mir Cooperative Solar Array.[146, 147] The array was stored on the surface of Docking Module that was installed on Kristall last November.

STS-76 Mission Highlights

March 22 - 31, 1996
Kevin Chilton, Commander
Rick Searfoss, Pilot
Ron Sega, Payload Commander, Mission Specialist
Rich Clifford, Mission Specialist
Linda Godwin, Mission Specialist
Shannon Lucid, Mission Specialist (joins the Mir 21 crew as Cosmonaut Researcher)

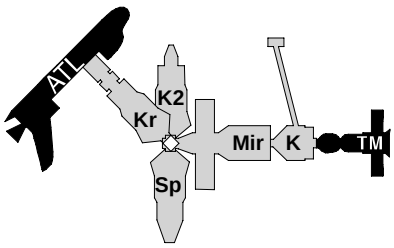
Highlights: The chief objectives of STS-76 were its third docking of Atlantis with the Mir station, the first space walk by U.S. astronauts during a Shuttle-Mir docking, and the delivery to the station of a new Mir-21 crew member, biochemist/pilot Shannon Lucid. Lucid was the first American woman to serve as a Mir station researcher.

Atlantis launched. The U.S. Space Shuttle Orbiter Atlantis was launched from Kennedy Space Center on March 22 at 7:00 a.m. CST for its sixteenth flight. During the ascent phase, flight controllers detected a small leak in one of Atlantis's three redundant hydraulic systems, but after the system was shut off when Atlantis reached orbit, the leak stopped. The approximately 20% loss of that one system's hydraulic fluid would not adversely affect the mission because the hydraulic system would not be used again till the descent phase.[148]

Preparations for docking. During the first two days of the mission, Chilton and Searfoss began jet firings to guide Atlantis's journey toward Mir. The crew prepared for the docking by checking out communications equipment and docking and alignment aids. They also activated Spacehab and began orbital operations for Biorack experiments. Godwin and Clifford checked out the space suits and equipment for their upcoming EVA.[149]

Atlantis approaches Mir. On mission day 3, when Atlantis was within 8 miles of the station, Chilton fired the orbital maneuvering system engines in the terminal phase initiation (TI) burn. As the two spacecraft completed another orbit, Atlantis approached Mir from below along the R-bar, using rendezvous radar to track its approach rate and measure its distance.[150]

March 23-28, 1996



Atlantis
Kristall Kvant 2
- Mir - Kvant - Soyuz-TM 23
Spektr

Third Atlantis/Mir docking. Chilton took manual control at one-half mile below the Mir, executing a 180° yaw rotation to align Atlantis with the Docking Module on Kristall. He used the ODS centerline camera as an aid in refining and maintaining the alignment. At 8:34 p.m. CST on March 23, he achieved contact, adding Atlantis to a space station complex that then totaled 230 t. After confirmation of docking, leak checks, and pressurization of the docking vestibule, the hatches were opened and the two crews greeted each other. Shortly afterward, the Atlantis crew installed ducts to aid in circulating air between the two spacecraft during the docked phase.[151, 152]

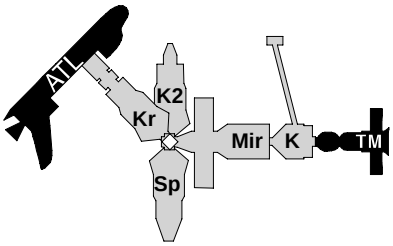
Lucid joins Mir 21 crew. Lucid officially became a Mir 21 crew member at 7:30 a.m. CST on March 24, after a joint "go" from the Russian and U.S. mission control centers. She became the first in a planned continuous U.S. astronaut presence on the station until 1998.[153]

New supplies brought up on Atlantis. In the joint portion of the mission, the two crews loaded into the station more than 1 t of U.S. science equipment, almost 2 t of Russian supplies, and 15 containers of water totaling about 1.5 t. Approximately a ton of excess equipment, waste, and science payload was transferred from Mir to Atlantis.[154] From their vantage point in orbit, the crews were treated to a good view of comet Hyakutake.[155] Some of the spacecraft hardware items brought up by Atlantis were a replacement gyrodyne, a seat liner kit for Lucid to be placed in a Soyuz module if emergency return to Earth was required, and three Russian storage batteries which had been replenished on Earth.[156]

Experiment supplies. Some of the new supplies and equipment for onboard experiments included replacement hardware for the Mir glovebox stowage experiments, Mir electric field characterization hardware to measure radio interference inside and around the complex, and a liquid phase sintering experiment that would use the Optizon furnace to bond different metals.[157]

Spacehab module work. On flight days 4, 5, and 7, the crew worked on the Biorack in the Spacehab module in the Orbiter payload bay. The Biorack contained eleven experiments to investigate the effects of microgravity and cosmic radiation on plants, animal tissues, bacteria, and insects. The various experiments were designed by France, Germany, the U.S., Switzerland, and the Netherlands.[158]

March 23-28, 1996



Concluded

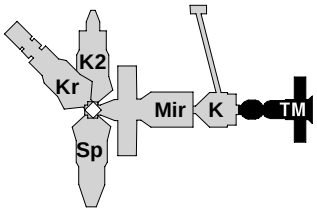
Pre-EVA procedures. In preparation for the EVA, Atlantis's cabin air pressure was lowered from 14.7 to 10.2 psi. The hatches were closed between Mir and Atlantis and Atlantis and Spacehab throughout the EVA to allow for sustained cabin depressurization The Mir crew, including Lucid, stayed inside Mir, and the Atlantis crew stayed inside the Orbiter cabin, with Sega coordinating the space walk activities from inside.[159]

SAFER backpacks worn. Attached to their regular portable life support system (PLSS) backpack, Godwin and Clifford donned new self-contained backpacks with propulsion systems to allow enough free-flight capability to return an untethered astronaut to the spacecraft in an emergency. The device, called the simplified aid for EVA rescue (SAFER), was designed for EVAs on docked vehicles which would be unable to quickly retrieve a drifting spacewalker. The backpack was test-flown on STS-64 in September 1994.[160]

First EVA by U.S. astronauts at Mir. On March 27, Godwin and Clifford performed their 6-hr EVA in Atlantis's cargo bay and on the exterior of the Mir Docking Module. Their major task was to secure four experiment canisters to handrails on the Docking Module. The experiments, collectively called the Mir Environmental Effects Payload (MEEP), were designed to record data on orbital debris in the environment near Mir, to collect samples of the debris, and to test potential International Space Station materials by exposing them to the low Earth orbit environment. The four passive experiment canisters would be retrieved by a later STS crew after almost 2 years of data collection. During their work on the Docking Module, the astronauts also evaluated new tether hooks and foot restraints that could be used on both Mir and Shuttle Orbiter exteriors, prototypes of International Space Station EVA equipment. They also retrieved the Mir-mounted camera that had been used in docking alignment during STS-74 in November 1995.[161, 162]

March 28 - April 26, 1996

Kristall Kvant 2
Mir - Kvant - Soyuz-TM 23
Spektr



Atlantis leaves Mir again. The STS-76 and Mir 21 crews bid each other farewell on the morning of March 28. They closed the hatches to their spacecraft, and the astronauts began preparations for undocking and return to Earth. With the steering jets to both spacecraft shut down, Atlantis separated from the Mir Docking Module. Then Chilton reactivated the jets and slowly moved away from Mir. At 600 ft out, he began a fly-around, circled the station twice while the crews took pictures of each others' spacecraft, then moved to another orbit.[163]

STS-76 mission ends at Edwards Air Force Base, California. Weather conditions at Kennedy Space Center in Florida on March 30 were unfavorable for landing, so the crew instead spent an extra day on Earth observation photography. Atlantis landed at Edwards Air Force Base, California, at 7:29 a.m. CST on March 31 after a 9-day, 5-hr mission. However, on a return home interview, Godwin remarked "Our mission won't really be over until [Lucid lands] in August." [164, 165]

Mir 21 continues with full crew. The daily flight plan, or cyclogram, for the Russian-U.S. crew was provided 4 days ahead of schedule by TsUP. A group of NASA science experts in Moscow served as consultants on science activities. The first week after Atlantis's departure, the crew focused on the Optizon Liquid Phase Sintering Experiment (OLiPSE), processing 70 samples of different metals at high temperatures. The crew also conducted life sciences research and Earth observation photography. Space Acceleration Measurement System (SAMS) monitors were placed throughout the station to record movements that might disrupt experiments. Radiation dosimeters in various locations provided another measurement of the station's internal environment. A leak in a coolant loop in the core module was detected in mid-April, but the crew was unable to find the exact location. That loop was turned off and the alternate loop was used.[166]

Priroda on the way to Mir. The long-awaited launch of Priroda, earlier announced for March 10 so that the module would be in place when Lucid arrived at Mir, had been moved forward at least twice—once because of late delivery from the Khrunichev factory, and once because a commercial Proton launch in early April took precedence.[167] But on April 23, Priroda was launched from Baikonur atop an SL-13 Proton rocket for a 3-day orbital trip to Mir. One of the two battery-powered electrical systems on the spacecraft dropped off-line, eliminating the backup power source for the automatic docking system. If the primary electrical system had also malfunctioned, the Mir crew would have immediately initiated a manual docking.[168]

Priroda

Specifications

mass-19,700 kg
length-approx. 12 m
max. diameter-4.35 m
pressurized vol.-66 m3

Description

Last of the six permanent habitable Mir modules, Priroda (fig. 11) was, like Spektr, designed by RKK Energia in the mid- to late-1980s, and was built and assembled in the Khrunichev plant between 1989 and 1991, with launch originally planned for 1991 or 1992.

Priroda was designed to carry a deployable solar array, but during launch delays, more solar arrays were planned and designed for addition to other parts of Mir, so the array was not included in the launch configuration.

The module's two propulsion systems included one for orbit correction during the flight to Mir and rendezvous with Mir, and one for berthing and stabilization during the docking phase. [169]

All other systems on Priroda, including its Kurs automatic docking system, were powered during the independent flight phase by two redundant sets of large batteries, 168 in all. An electrical connector failure during flight to Mir caused concern over loss of access to the backup set of batteries, but the module docked with no problems. Once the module had been relocated to the +Z port (with its Lyappa arm, also powered by the batteries), the electrical systems were connected to the station's power supply from solar arrays on other modules. The Mir 21 crew bagged the disconnected batteries shortly afterwards and later stowed them in Progress-M 31 for destructive return into Earth's atmosphere.

The Priroda module includes an unpressurized instrument compartment and an instrument/payload compartment, both of which are covered by a payload shroud that protected the module and external equipment from aerodynamic effects during launch.

The unpressurized compartment is mated to the base of the module aft of the instrument/payload compartment, and it extends to partially surround that compartment. It contains propulsion system components, EVA restraints, and scientific equipment. On the opposite end are the docking system and an intravehicular hatch opening into the instrument/payload compartment.

The instrument/payload compartment, the main portion of the module, has an inner habitation and work compartment and an outer instrumentation compartment. The two are separated by aluminum-magnesium coated plastic panels that form a fire break and contribute significantly to the module's environmental control system by allowing conditioned air to flow through the crew's working area before it returns to the instrumentation compartment. The compartment is divided lengthwise into three sections, one that houses spacecraft systems and two that house primarily payload systems and the pressurized working area for the crew.[170]

The Priroda mission is to conduct Earth sciences studies through a variety of remote sensing equipment and to develop and verify remote sensing methods. The experiments were designed to not only gather valuable data on land surface, ocean, atmosphere, and ecology, but also to

provide a basis for development of optimal methods of data gathering and analysis and optimal combinations of instruments.[171]

The experiments, contributed by twelve nations, cover the microwave, visible, near infrared, and infrared spectral regions using both active and passive sounding methods. Active microwave equipment on board is the synthetic aperture radar (SAR), Travers III, to be deployed after docking to Mir.

Passive microwave equipment includes

- Radiometer complexes IKAR-N, consisting of 5 nadir-looking radiometers, and IKAR-D, a four-channel scanning radiometer
- Panorama radiometer complex IKAR-P, a three-channel radiometer and a five-channel radiometer

Optical Instruments are

- Infrared spectrometers ISTOK-1 (Lambda-scanning)(Russia, Czechia): MOS-A and MOS-B, with 17 channels (Germany)
- Spatial high resolution multispectral and stereo scanner MOMS-2P (Germany)
- Conical scanner MSU-SK, 5 channels
- Pushbroom multichannel scanner MSU-E
- A surveying TV camera
- "OZONE-M," for determination of ozone profiles from occultation measurements
- Lidar "Alisa" for active optical sounding (France)

The payload compliment also includes equipment for medical and microgravity experiments, contributed mostly by the United States.[172]

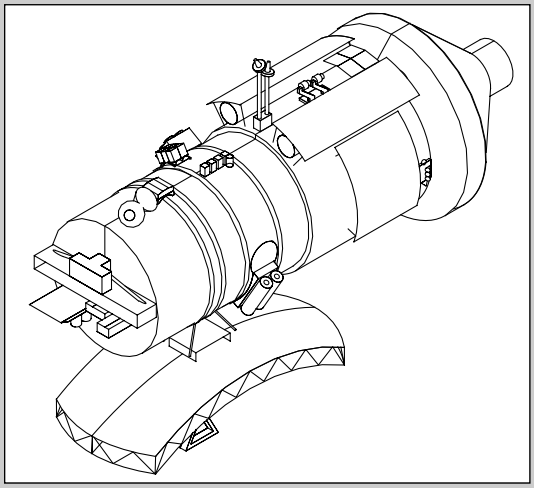
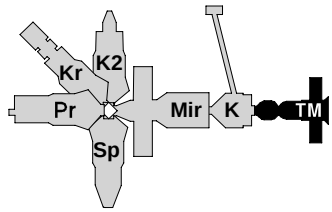


Figure 11. The Priroda module, launched on April 23, 1996, was the last permanent module added to the Mir complex.

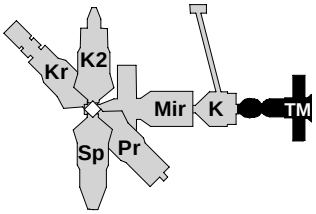
April 26-27, 1996



Kristall Kvant 2
Priroda - Mir - Kvant - Soyuz-TM 23
Spektr

Successful docking. The Kurs automatic docking system on Priroda worked flawlessly, as did the electrical system. No problems were encountered on the April 26 docking of the new module at the -X port at the front of the Mir base block.[173]

April 27 - May 7, 1996

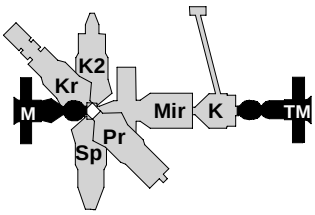


Kristall Kvant 2
Mir - Kvant - Soyuz-TM 23
Spektr Priroda

Priroda at permanent docking spot. On April 27, from inside the station, the Mir 21 crew controlled Priroda's repositioning with the Lyappa arm to the +Z docking port, directly across from the Kristall module.[174] Thus the Mir complex, with its six habitable modules and Docking Module, attained its final basic configuration. Henceforth the shape of the complex would change only temporarily, with dockings by Progress, Soyuz, and Space Shuttle Orbiter vehicles.

Batteries prepared for disposal. Because of concern about possible sulfur dioxide leaks from the malfunctioning battery system, a test of the module's atmosphere was made before the crew entered. Once inside Priroda, the crew's first task was to unbolt the batteries, cap their connectors, and place them in plastic bags—again because of possible sulfur dioxide leakage. The 168 batteries would later be placed in Progress-M 31 for disposal. The crew began connecting Mir power sources to Priroda systems and troubleshooting the battery system problem.[175]

May 7 - August 1, 1996



Kristall Kvant 2
Progress-M 31 - Mir - Kvant - Soyuz-TM 23
Spektr Priroda

Progress M-31 brings new supplies. A new Progress cargo spacecraft was launched from Baikonur on May 5 and docked under control of the Kurs automatic system at the -X port of Mir on May 7 (fig. 12). For the first time in the station's history, all ports of the base block were occupied at the same time. The crew began unloading the vehicle that week, in addition to continuing their science experiments and Priroda activation. They successfully tested the new Mir interface-to-payload systems (MIPS) hardware for downlinking data to the ground and replaced three nickel-cadmium batteries in the Priroda power system. However, a power controller for the system failed, and ground controllers began monitoring and controlling battery charging. The crew finally isolated the coolant loop leak in the core module, but there was no health risk associated with the leak, and repair was not immediately scheduled.[176]

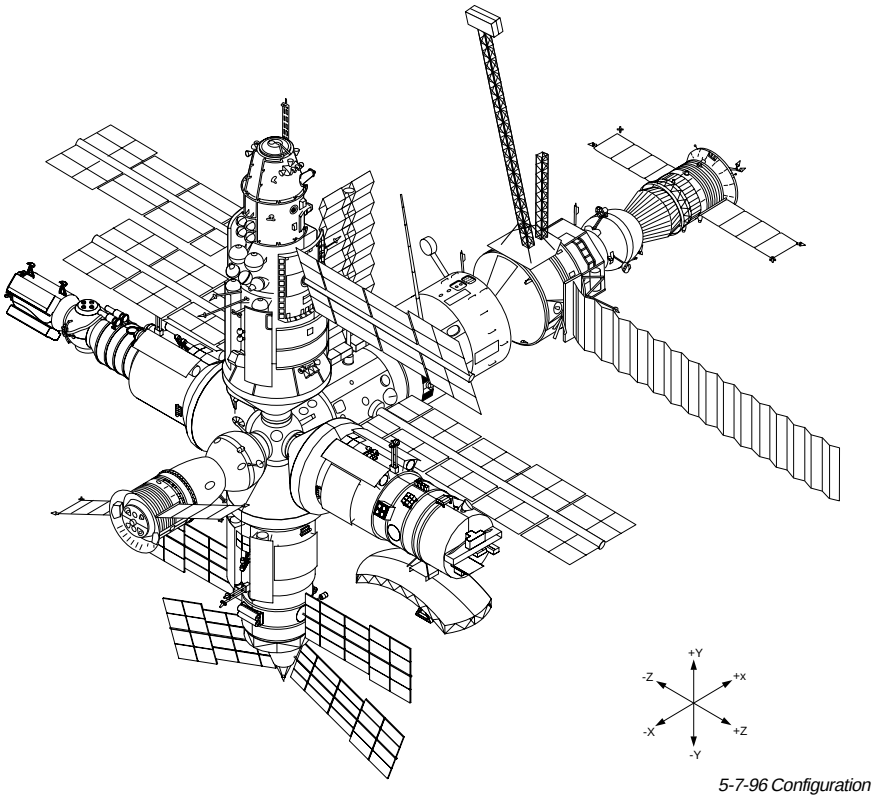
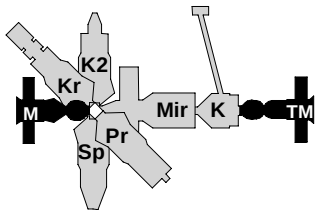


Figure 12. The Mir complex on May 7, 1996, with all base block ports occupied. Priroda had docked with the station initially on April 26 and subsequently had been relocated to the +Z port. Progress-M 31 docked at the -X port to complete the configuration.

May 7 - August 1, 1996



Continued

Cooperative Solar Array installed during Mir 21 crew's second and third EVAs. Onufrienko and Usachev left the station early on May 20 to remove the Mir Cooperative Solar Array from its stowed position on the exterior of the Docking Module at the base of Kristall. They used the new Strela boom installed during their March 15 EVA to reach the array and move it to the Kvant module, where they positioned its cables in preparation for final installation during their next EVA. During the 5-hr, 20-min EVA, they inflated an aluminum and nylon model of a Pepsi Cola can, which they filmed against the backdrop of Earth. The soft drink company paid for the procedure and planned to use the film in a television commercial.[177, 178, 179] On May 25, in their third space walk of the mission, the cosmonauts were outside the station for 5 hr, 43 min, completing the solar array installation on Kvant. After all connections were made, the array unfurled upon command from inside the station.[180]

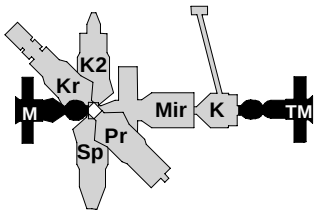
Mir 21 crew greets STS-77 crew. As the cosmonauts prepared for yet another space walk, Lucid continued testing and activating U.S. equipment in Priroda and Spektr. She also conducted materials experiments, including two runs of the Liquid Diffusion-II payload to study molten metals in space. All the crew members exchanged greetings with the astronauts aboard Endeavour on Shuttle mission STS-77 and held a conference with U.S. and Russian news media.

Camera installed on Priroda exterior during fourth Mir 21 EVA. On May 30, Onufrienko and Usachev installed the Modular Optoelectronic Multispectral Scanner (MOMS), a German remote sensing camera, on the Priroda module. The camera, designed to collect Earth atmosphere and environment data, had been flown earlier on two Shuttle missions, STS-7 in June 1983 and STS-41B in February 1984. After the installation, Lucid activated the system by remote command from inside the station. During the 5-hr EVA, the cosmonauts also installed a new handrail on Kvant-2 to facilitate movements in future space walks.[181]

More experiments installed during fifth EVA. The Particle Impact Experiment and the Mir Sample Return Experiment, U.S. space science experiments brought to orbit inside Priroda, were installed on the exterior of Kvant 2 during a June 6 EVA lasting about 3.5 hr. The cosmonauts also replaced a cassette in the Komza experiment on the surface of Spektr.[182, 183]

Rapana girder assembled on Kvant in sixth EVA. On June 13, the cosmonauts spent over 5 hr outside Mir, installing and deploying a Rapana girder on the surface of the Kvant module as a platform for installing future experiments on the station exterior. The 5-m structure was deployed in four sections. Another activity during this EVA was manual deployment of the Travers radar antenna on the exterior of Priroda. The large antenna had failed to deploy fully by commands from inside the station.[184, 185]

May 7 - August 1, 1996



Concluded

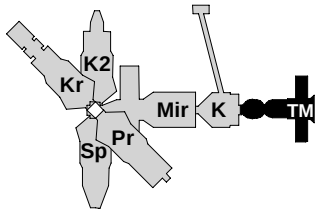
Science work continues. In addition to assisting the cosmonauts during EVAs from inside the station, Lucid continued activating equipment, such as the Biotechnology System Facility for long-term biotechnology studies, and conducting experiments such as the Humoral Immunity experiment to study spaceflight effects on the human immune system. The crew also monitored various aspects of the spacecraft environment. They took air samples in Spektr and the core module using the Solid Sorbent Air Sampler (SSAS) and the Grab Sample Container (GSC). They recorded effects of spacecraft motion with the SAMS equipment and began evaluation of the Microgravity Isolation Mount (MIM).[186]

Fourth Shuttle docking with Mir delayed. On July 12, NASA announced the decision to postpone the July 31 launch of the STS-79 mission, in which Atlantis was to dock with Mir for the fourth time, until mid-September. In the interim, NASA planned to replace the solid rocket boosters to be used in the launch because of a postflight discovery that hot gas had seeped into the joints of the boosters used in STS-78 launch in June. In spots the gas penetrated the J-joints to, but not past, the capture feature O-rings. An investigation revealed that the most probable cause of the leakage was use of a new adhesive and cleaning fluid, also used on the boosters for STS-79. Although the boosters were judged safe to fly, a decision was made to replace them in order further study the J-joint failure and to improve the safety margin of the joint.

U.S. record surpassed and counting. On July 15, Lucid surpassed the space duration record for a U.S. astronaut, set by Norm Thagard with his 115 days on Mir Principal Expedition 18 in 1995. With the delay of STS-79, her flight record would be even longer than originally anticipated.

Greenhouse work. The crew assembled the Svet facility for the Fundamental Biology Greenhouse plant experiment during the latter part of July. A temporary limitation of power in Kristall caused a delay in the first planting, but was solved when ground planners instructed the crew to plug an extension cord into Spektr's power supply. Station maintenance during the last week of July included replacement of a vacuum valve assembly on the carbon dioxide removal system. On July 26, the oxygen generation system began sporadic malfunctioning. The crew activated the backup oxygen system on August 1.[187]

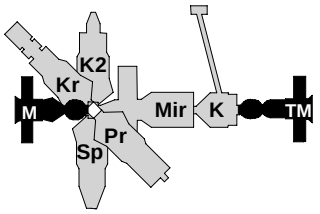
August 1-2, 1996



Kristall Kvant 2
- Mir - Kvant - Soyuz-TM 23
Spektr Priroda

Progress-M 31 departs. On August 1, at 16:45 UTC, Progress-M 31 left the -X port for destructive reentry into Earth's atmosphere.

August 2-18, 1996



Kristall Kvant 2
Progress-M 32 - Mir - Kvant - Soyuz-TM 23
Spektr Priroda

And Progress-M 32 arrives. Launched on July 31 with fresh supplies and hardware for the upcoming Cassiopee mission experiments, Progress-M 32 docked at the -X port on August 2.

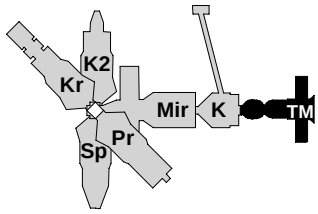
Gyrodynes refurbished. The Mir 21 crew began setting up experiments for the upcoming mission. They also refurbished the gyrodyne system, maintaining station attitude by thruster firings August 5-7 while the gyrodynes were not available.

August experiment work. The seeds for the first crop of dwarf wheat were planted in the Greenhouse on August 5. Earth observations were made of areas of the United States, Europe, and Asia. Lucid continued to run experiments, including

- Queen's University Experiment in Liquid Diffusion (QUELD), using a furnace to analyze the formation of alloys in space. To record the effects of the furnace experiment, she took SAMS data and Enhanced Dynamic Load Sensors (EDLS) data.
- Candle Flame in Microgravity (CFM), to study the physiochemical processes of combustion. She reported that the appearance of flame in microgravity was quite different from that on Earth.
- Anticipatory Postural Activity (POSA) experiment, to measure how muscles work in microgravity, for use in studies of physiological adaptations to spaceflight.
- Forced Flow Framespread test, to examine the flame-spreading properties of solid fuels.
- Solid Sorbent Air Sampler for Volatile Organic Compounds, to evaluate the Mir environment and provide data for development of advanced life support systems.
- Tissue Equivalent Proportional Counter (TEPC), a radiation-dosage measurement device.[188]

Life on Mars? The crew was excited when they received news from the ground about NASA's August 6 announcement of the evidence of primitive life forms in a Martian meteorite found in

August 2-18, 1996

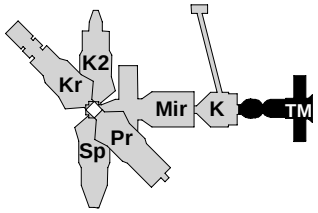


Concluded

Antarctica. Lucid said in a television interview on August 12 that she and her crew mates were enthusiastic about the idea of human flights to Mars.

Soyuz-TM 24 launched. On August 17, Soyuz-TM 24 was launched from Baikonur with the new crew for Mir Principal Expedition 22.

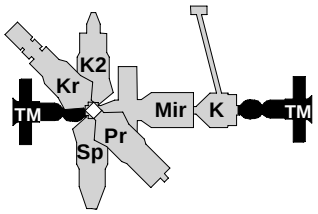
August 18-19, 1996



Kristall Kvant 2
Mir - Kvant - Soyuz-TM 23
Spektr Priroda

Progress-M 32 bows out. To free the -X port for docking of the approaching Soyuz-TM 24, the Progress module was undocked on August 18 under automatic control and moved to a parking orbit. There it would remain until the departure of Soyuz-TM 23 with the homeward-bound Mir 21 crew on Sept 2.

August 19 - September 2, 1996



Kristall Kvant 2
Soyuz-TM 24 - Mir - Kvant - Soyuz-TM 23
Spektr Priroda

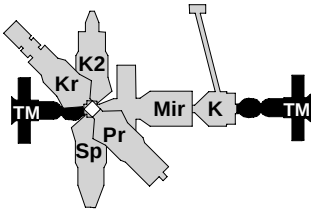
Mir 22 crew arrives. Soyuz-TM 24 docked at the -X port on August 19. New arrivals were Mir 22 Commander Valery Korzun and Flight Engineer Alexander Kaleri. Visiting French Space Agency (CNES) Cosmonaut Researcher Claudie Andre-Deshays accompanied them to Mir for a 2-week program of a scientific investigations collectively called Cassiopee. She would return to Earth with the Mir 21 crew. (A few days before the launch of Soyuz-TM 24, the commander of the Mir 22 primary crew, Gennady Manakov, had been grounded because of possible heart problems. Flight Engineer Pavel Vinogradov would also have to forego Mir 22 because the two had trained together.)

Multinational activities. Once again, three nations were represented on Mir. Cassiopee, the fifth CNES-RSA joint mission, would be under the cooperative control of TsUP in Moscow and CADMOS in France.

Cassiopee mission. Andre-Deshays, Korzun, and Kaleri worked on the following experiments:

- PHYSIOLAB, a study of cardiovascular physiology using LBNP devices

August 19 -
September 2, 1996



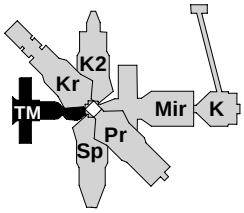
Concluded

- COGNILAB, tests of neurosensory system responses in microgravity
- FERTILE, egg-based studies to determine the role of gravity in embryonic development
- ALICE II, experiments in fluid dynamics (hydrodynamic and thermal properties of fluids at critical point)
- CASTOR, analyses of structural dynamics in space using
  -- DYNLAB, to measure the vibrations in the Mir modules
  -- TREILLIS, a 2-m-long metallic trellis, to validate mathematical simulations of structural damping modes [189]

Mir 21 Closeout. The Mir 21 crew continued preparations for departure, packing items for return to Earth and handing over responsibilities to the new crew. Lucid, who would remain on the station until the arrival of Atlantis on STS-79 in mid-September, also monitored continuing experiments. She reported that the dwarf wheat crop was about 2 in. tall 3 weeks after planting.

September 2-3, 1996

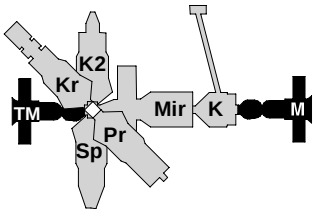
Kristall Kvant 2
Soyuz-TM 24 - Mir - Kvant
Spektr Priroda



Mir 21 crew goes home. Onufrienko, Usachev, and Andre-Deshays departed Mir on September 2 in the Soyuz-TM 23 spacecraft and safely landed in Central Asia. Onufrienko and Usachev had been in space 194 days, Andre-Deshays 17 days.

September 3-18, 1996

Kristall Kvant 2
Soyuz-TM 24 - Mir - Kvant - Progress-M 32
Spektr Priroda



Progress-M 32 redocks. A day later, September 3, Progress-M 32, which had been in a parking orbit for 2 weeks after it undocked from the -X port to make way for Soyuz-TM 24, successfully redocked at the +X port. This configuration would remain until the September 18 docking of Atlantis with Mir, during which John Blaha would replace Lucid as the U.S. astronaut aboard the station.