## Competition, Cooperation, and Compromise:
## An Annotated Chronology of Shuttle-Mir and Its Background

**by Clay Morgan**

*From the end of the "Space Race" and its competition for the moon, the U.S. and the Soviet space programs worked at improving cooperation. Both politics and pragmatism had impacts on how Shuttle-Mir started up — and on how it played out. The following timeline of discussions and events was compiled mainly from NASA chronicles by Judy A. Rumerman, Sue McDonald, and David S.F. Portree.*

"No one nation can afford … all the technically feasible and worthwhile projects [of spaceflight]."
Leonid Sedov, Chairman of the Soviet Commission,
authorizing *Sputnik* and the start of the Space Race

**1969**

Early July — In the month that Americans will walk on the moon, NASA Astronaut Frank Borman makes a 9-day goodwill tour of Soviet Union space facilities as U.S. President Richard Nixon's representative. Borman suggests to Soviet space leaders that Americans and Soviets should work together aboard a space laboratory in Earth orbit.[1]

July 20 — Apollo 11 Astronauts Neil Armstrong and Edwin "Buzz" Aldrin land the Lunar Module *Eagle* on the Moon's Sea of Tranquility.

July 31 — NASA Administrator Thomas O. Paine writes to Mstislav Keldysh, President of the Soviet Academy of Sciences, suggesting cooperative space ventures.[2]

**1970**

March 7 — U.S. President Richard M. Nixon declares international cooperation to be a specific objective of NASA's post-Apollo space program: "I believe that both the adventures and the applications of space missions should be shared.… Our progress will be faster and our accomplishments will be greater if nations will join together in this effort."[3]

April-September — NASA Administrator Thomas Paine meets with the Soviet space officials in New York City. Their discussions include dockings between future U.S. and Soviet shuttles and space stations. In a July letter, Soviet Academy of Sciences President Mstislav Keldysh responds favorably, so Paine invites two Soviet engineers to NASA's Manned Spacecraft Center (MSC) in Houston to examine the "neuter" docking unit under development for NASA's proposed space station.[4] (In 1963, MSC engineer Caldwell Johnson had proposed the neuter system for the Apollo spacecraft. [5]) Paine writes again to Keldysh in September to propose that a Soviet Soyuz spacecraft dock with NASA's planned Skylab orbital workshop. Soon afterwards, Paine resigns as NASA Administrator, but not before stressing to Keldysh that international space cooperation is official NASA policy and will continue after he departs.[6]

October 26-28 — At Keldysh's invitation, a delegation of NASA engineers led by MSC Director Robert R. Gilruth fly to Moscow for talks on "problems of providing for compatibility of rendezvous and docking systems of manned spacecraft and space stations." Soviet participants include docking system engineer Vladimir Syromiatnikov. Caldwell Johnson displays pictures of the U.S. neuter docking unit. The sides establish three joint working groups to study ways of ensuring docking compatibility in future spacecraft.[7]

**1971**

January 16-21 — NASA Acting Administrator George M. Low leads a delegation to Moscow for wide-ranging space cooperation discussions. Secretary of State Henry Kissinger has instructed Low to propose an early U.S.-Soviet docking mission. On January 25, Low reports that: "Apart from our formal negotiations, I did have one private conversation with Keldysh. I explained ... that we believe it technically possible to modify Apollo spacecraft and Soyuz modules so as to permit them to dock in the 1973-74 period, several years before entirely new systems like the space shuttle would become available. Keldysh was receptive."[8] Nixon and Kissinger want an early international space mission to serve as a highly visible demonstration of their policy of detente (easing of tensions) between the U.S. and the Soviet Union. For NASA, an early international docking mission is desirable because Nixon was shutting down the Apollo program and scaling back and re-directing the agency. Though NASA hopes to fly various post-Skylab missions using Apollo hardware, no other missions were formally scheduled between the last Skylab visit in 1974 and the first Space Shuttle test flight (planned for 1978), so the international docking mission would help fill the gap.[9]

June 21-25 — The joint U.S.-Soviet docking working groups meet for the first time in Houston. During this time, the first space station, Salyut 1, is in Earth orbit with three cosmonauts on board. Citing Salyut's availability, the Soviet side proposes that the U.S. dock an Apollo with a Salyut. They accept that a reciprocal Soyuz docking with the U.S. Skylab station is not possible, but insist on discussing Soyuz dockings with future Skylabs even after the Americans tell them that NASA plans only one Skylab. Minutes of a review of the negotiations for new NASA Administrator James Fletcher held June 2 state: "During the course of the discussions, it became quite apparent that the Soviets plan to have a continuing and long range space station program. It appeared inconceivable to them that we did not also have such a program."[10]

June 29 — Cosmonauts Georgi Dobrovolski, Vladislav Volkov, and Viktor Patsayev, the first Salyut 1 space station crew, set a 24-day space endurance record. Their Soyuz 11 descent module lands automatically in Soviet Kazakhstan, but when ground crews open the hatch they find the cosmonauts dead in their couches. Concerns are raised in the U.S. that the crew died from some previously unknown effect of long-duration spaceflight; however, with unprecedented frankness, the Soviets inform NASA that the crew had died through "a loss of the ship's sealing." The cosmonauts wore no pressure suits, so asphyxiated. On July 1, astronaut Thomas Stafford attends their funeral as President Nixon's representative.

November 29-December 6 — The joint docking working groups meet in Moscow. NASA receives a firm commitment on an Apollo-Salyut mission from the Soviets. Vladimir Syromiatnikov unveils the Soviet version of Caldwell Johnson's neuter docking system, which later becomes known as APAS-75. The system uses mechanical systems (gears, ball screws, and motors) to absorb shocks and position the docking ring, instead of the hydraulic systems in the NASA device; it also has three outward-splayed guide "fingers," as opposed to the NASA system's four. This required docking interface compromises.[11]

**1972**

March — To ensure adequate funding for Space Shuttle development, NASA is obliged to limit post-Apollo missions to the Apollo-Salyut flight and to limit the Apollo-Salyut science budget to $10 million. It becomes clear that Apollo-Salyut will be the only piloted flight between Skylab and Shuttle.[12]

April 4-6 — Soviets withdraw Salyut in favor of Soyuz, citing the expense and difficulty of re-designing Salyut to include a second docking port with the neuter docking system. Low speculates in his report

that "since we will not have a Skylab available for a future flight [by a Soviet craft], they are unwilling to commit a Salyut …" although he hastens to add that the official reason is probably correct.[13]

May 24 — Nixon and Soviet Premier Aleksey Kosygin sign the "Agreement on Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes" (Space Cooperation Agreement). The NASA press release announcing the treaty outlines the near-term docking demonstration between Apollo and Soyuz spacecraft, then looked to the future: "Beyond the test mission which is planned for 1975, the accord provides that future generations of manned spacecraft of both the United States and the Soviet Union will be capable of docking with each other … [making] possible the conduct of cooperative projects, with attendant economies."[14]

Nixon's newly appointed NASA Administrator, James Fletcher, states that the international mission will benefit NASA in the short-term and world spaceflight in years to come: "Workers employed to support test, checkout, and launch activities are now assured of jobs through the launch and flight of the joint mission … the agreement assures retention of the Apollo team, a unique technical and management resource, for work on the Space Shuttle. It is our hope that this first mission is the precursor of future joint manned … efforts which will enable both nations to avoid duplication and reduce the costs of space exploration."[15]

June — The near-term international mission is formally named the Apollo-Soyuz Test Project (ASTP).[16]

**1973**

April — With ASTP formally under way, both sides appear to lose interest in future-oriented talks. Some in the U.S., meanwhile, try to assure that hardware developed for Apollo-Soyuz will not conflict with shuttle requirements and that shuttle design decisions do not conflict with docking compatibility agreements. In a memorandum Caldwell Johnson writes:

"In 1970 the USA and USSR initiated discussions … to assure rendezvous and docking compatibility between their future spacecraft … it was proposed to test those specifications by a spaceflight mission using existing American and Soviet spacecraft, each modified only as necessary…. The proposal was accepted and was formally identified as the Apollo/Soyuz Test Project (ASTP). Both countries immediately discontinued discussion of systems for future spacecraft…. In the meantime NASA … is busily designing the Shuttle, the first of those future spacecraft that we have committed to the achievement of compatible rendezvous and docking with the Soviets. During this period NASA should be factoring the long-term rendezvous and docking specifications into Shuttle; and … Shuttle considerations should be factored into U.S.-U.S.S.R. negotiations."[17]

May 1973-February 1974 — Skylab. Within minutes of launch, the Skylab orbital workshop appears to be lost. Its meteoroid bumper deploys prematurely during ascent and tears free, pulling away one solar array wing and jamming the other. Risky spacewalks salvage the station. Three crews of U.S. astronauts - a total of nine men - live and work aboard Skylab. The third crew (designated Skylab 4) lives on board for 84 days, setting a new world space endurance record. Skylab 4 remains the U.S. record until Norm Thagard's 115-day stay on Mir in 1995.

July 1973 - September 1974 — In July, a group led by U.S. ASTP Project Director Glynn Lunney speaks informally with Soviet ASTP Project Director Konstantin Bushuyev about restarting future-oriented docking system talks. Bushuyev agrees to restart the talks, but efforts to commit him to a date prove fruitless. Johnson meets informally with Syromiatnikov in September. The latter is unrevealing about the form his country's future spacecraft would take, but agrees with Johnson that the ASTP system

could serve as the basis of a future international system. In October the U.S. puts forward Johnson's proposals for future docking system compatibility. The Soviets promise a response in June 1974. They subsequently defer their response to September 1974, then defer it indefinitely.[18]

September 24 — While the Soviets put off talk of post-ASTP cooperation, NASA makes progress with the European Space Research Organization (ESRO). On August 10, 1968, George Mueller, NASA Associate Administrator for Manned Space Flight, had declared an Earth-orbiting space station to be NASA's next major goal after Apollo in a speech at the British Interplanetary Society in London. He presented a concept for "an economical launch vehicle for shuttling between Earth and orbiting space station." This reusable spacecraft soon became known as the Space Shuttle. The venue for Mueller's speech was significant - within months NASA offered Europe an undefined role in Station and Shuttle. After initial discussions in 1969, ESRO began studies in 1970 of how it could fit into NASA's Shuttle plans. On September 24, 1973, NASA and ESRO agree that ESRO should build Spacelab modules for the Shuttle. Much like ASTP, Spacelab grows from Nixon's interest in space cooperation and short-term cost reduction. It is also part of NASA's quest for a space station, for it represents an interim station capability.

**1974**

Mid-1974-early 1975 — Early in this period NASA Deputy Administrator George Low solicits manned space flight elements across NASA to submit ideas for future cooperative piloted space programs. NASA JSC Director Christopher Kraft, Associate Administrator for Manned Space Flight John Yardley, and others suggest international space station studies. For his proposed plan, Kraft assumes the U.S. would proceed with its own station independent of the cooperative efforts. He presents a future cooperation timetable:

- In 1980, to use the Shuttle to rendezvous and dock with "whatever spacecraft the USSR intends to fly at that time." The mission would be modeled on ASTP.
- In 1983, to use the Shuttle to launch a "Soviet precursor station module" containing joint experiments or station test hardware. A joint crew would use the module. Soviet cosmonauts would either be part of the Shuttle crew or would use their own spacecraft to dock with the Shuttle-module assemblage in orbit.
- Later, Soviet space station modules would join to the U.S. station. These would be launched by the Shuttle or by the Soviets. Cosmonauts would reach the station on the Shuttle and in their own craft.

Yardley points out the complementary nature of the planned U.S. and Soviet programs, and advocated a more central Soviet role: " … the most logical approach to future cooperative manned space ventures would be to utilize the truly unique capabilities of each nation's program. With the Space Shuttle, for example, we will have the ideal system for transporting relatively small or medium-size payloads to and from orbit, and to serve as a logistics supply vehicle to a manned low-earth-orbit space station. The Soviets, on the other hand, will in all probability have a capability for boosting much heavier payloads into space. These complementary capabilities open the possibility of a joint international space station with the Soviets building the core module and placing it in orbit. The U.S. in turn would use the Space Shuttle to transport and attach modular elements to the core and also to provide logistics support. The modular elements transported by the Space Shuttle would include those of the U.S., USSR, other nations, or other groups of nations. The cost to the U.S. of such a program should not be great … I would envision that some of the modular components … would be derivatives of Spacelab."[19]

August — After three successful Soyuz Ferry flights, Soyuz-15 fails to dock with Salyut 3. The crew has to return to Earth and land in a thunderstorm.[20] Senator William Proxmire leads a push for a Soyuz

safety review. He pointed to the Soyuz-11 fatalities and Soyuz-15 malfunction and states that "present plans for a joint space mission should be seriously re-examined in light of the continuing difficulty in the Soviet program."[21]

**1975**

April 5 — Another Soyuz mishap. Pyrotechnic bolts misfired and force an emergency landing. [22]

March 24 — NASA Deputy Administrator George Low writes to Soviet Academy President Mstislav Keldysh to propose informal discussion of post-ASTP piloted spaceflight cooperation during the upcoming ASTP Flight Readiness Review. He proposes ideas put forward by his senior managers, including studies of future joint space stations and "such interim steps as a Space Shuttle/Salyut mission, as well as Soviet use of the Shuttle in cooperative projects of mutual value." He informed Keldysh that agreement is needed by January 1976 on docking tunnel diameter, load factors, communications, and atmospheric pressures "[i]f the first NASA Space Shuttle mission is to have rendezvous and docking capability compatible with Soviet spacecraft of the 1979-1980 time period," and added that "I hope that … we can preserve the momentum which has been generated by our cooperation in ASTP."[23]

May 23 — ASTP Flight Readiness Review. The Soviets indicate willingness to continue talks on future cooperative ventures once Apollo-Soyuz is done. They express willingness to discuss further joint manned operations; future opportunities for the sides to accommodate each other's payloads and astronauts; and studies of a future cooperatively developed space station. [24]

June — U.S. ASTP Project Director Glynn Lunney cautions George Low about negotiating space station roles with other nations before the U.S. has defined its own requirements.[25]

July 15-24 — Apollo-Soyuz Test Project. The U.S. Apollo docks successfully with the Soviet Soyuz-19 in Earth orbit. The U.S. crew consists of Tom Stafford, Vance Brand, and Deke Slayton; the Soviet crew is Alexei Leonov and Valeri Kubasov.

August — In preparation for a planned autumn 1975 project planning meeting which the U.S. subsequently postpones, Arnold Frutkin, Chief of the NASA Headquarters International Affairs Office, writes to Academician Vladen Vereshchetin, Vice Chairman for the Council for International Cooperation in the Exploration and Use of Outer Space in the Soviet Academy of Sciences. He elaborates on the May discussions by proposing:

1. The sides establish two joint working groups to begin planning Shuttle-Salyut operations following "the pattern established during the Apollo-Soyuz Test Project" and involving "many of the same personnel on both sides who have performed so well on that project."
2. The U.S. provides flight manifests and user information to the Soviets to allow them to plan Shuttle payloads. Frutkin asks for a similar reference on Salyut.
3. Phased cooperation begins with limited commitments at the start. A Space Station Joint Study Group (SSJSG) would form. After the U.S. and U.S.S.R. completed independent space station studies based on initial SSJSG work, their station concepts would then be "harmonized." A second phase, if judged advisable by both sides, would include joint preliminary design and thus more commitment.[26]

November 25 — The Soviet Union launches Cosmos 782, a biosatellite similar in design to the Vostok 1 spacecraft that launched Yuri Gagarin in 1961. Cosmos 782 is the first of eight Soviet biosatellites to carry U.S. life sciences experiments launched before 1993.

**1976**

August 10 — In anticipation of the planned Shuttle-Salyut meeting with the Soviets in October, Lunney writes to Kraft to suggest flying a cosmonaut on Shuttle to tend a Soviet experiment, perhaps with Soviets paying NASA. He warns Kraft that "[t]hey may bring up Shuttle servicing of Salyut stations - we need to understand what's in it for us." Lunney also points out that international docking discussions are not in keeping with the Shuttle Program's move away from docking as a requirement. At this time, the Shuttle Program is advocating "air-to-air EVA capability" - that is, transferring astronauts between vehicles in space suits. The Shuttle Program also favors grappling devices such as the Remote Manipulator System (RMS) robot arm and other payload handling equipment. By this time, delivery of the planned Shuttle docking system has been pushed off to April 30, 1982. It is later canceled.[27]

October 19-22 — High-level U.S. and Soviet delegations meet in Washington to initiate formal Shuttle-Salyut discussions. Acting NASA Administrator Alan Lovelace leads the U.S. side, while Vereshchetin and Intercosmos Council Chairman Boris Petrov lead the Soviet delegation. The sides agree that Shuttle-Salyut is to be based on mutual scientific benefits.[28] By this time much has changed in the U.S. since the glory days of the moon missions. NASA has shrunk by half, and Nixon has resigned from the U.S. presidency to be replaced by Gerald Ford. The sides agree to work toward a Shuttle docking with a Salyut by 1981, but NASA refuses to sign a formal agreement, in light of the presidential election coming the next month.

May 11 — NASA and the Soviet Academy of Sciences agree to renew the 1972 Space Cooperation Agreement for a second five years. The Agreement calls for the study of a Shuttle docking with a Salyut space station based on the assumption that first docking would take place in 1981. The agreement sets up two working groups: one for "basic and applied scientific experiments," the other for operations. The agreement also points out that the long orbital stay-time of the Salyut-type station and the capabilities of the Shuttle spacecraft commend their use for joint scientific and applied experiments and for further development of means for rendezvous and docking of spacecraft and stations of both nations.[29]

May 18 — U.S. Secretary of State Cyrus Vance and Soviet Foreign Minister Andrei Gromyko formally renew the 1972 Space Cooperation Agreement and endorse the May 11 agreement.

November 1977 into 1978 — Shuttle-Salyut Joint Working Groups meet in Moscow and agree to exchange data on their respective spacecraft and to propose experiments. On December 30, 1977, Petrov provides NASA with technical data on the Salyut 6 space station (launched September 29, 1977), which has two dockings ports, fore and aft. NASA's Shuttle/Salyut Payloads Study Group solicits proposals from the scientific community and contract with ORI, Inc., to produce a detailed report of possible joint experiments. Life sciences are by far the largest joint experiment area identified in ORI's April 1978 report. The Shuttle/Salyut Program is then referred to an U.S. government interagency review.[30]

December — Former astronauts Walter Cunningham and Harrison Schmitt publicly debate ASTP's value, with Schmitt taking the view that the U.S. had gained insights into the Soviet spaceflight while transferring no meaningful technology, and Cunningham maintaining that "we were had!" The U.S. media debate the merits of another joint piloted mission with the Soviets, discussing the value of insights gained by U.S. into Soviet spaceflight versus the possible loss of Shuttle's cutting-edge technology.[31]

December 22 — NASA and the European Space Agency (ESA) announce the names of four European finalists for the position of Payload Specialist on the first flight of the Europe-built Spacelab module. They are: Ulf Merbold of West Germany; Wubbo Ockels and Claude Nicollier of the Netherlands; and Franco Malerba of Italy. Merbold will fly on STS-9/Spacelab-1 in 1983, becoming ESA's first astronaut. “Fly your allies” will become an approach to space cooperation in the 1980s.

**1978**

March 2-10, 1978 — Vladimir Remek, a Czech, becomes the first non-Soviet/non-American space traveler, by visiting Salyut 6 — the first Soviet station with two docking ports, which resupply by Progress freighters and visits by short-duration crews to long-duration resident crews. Remek visits Yuri Romanenko and Georgi Grechko during their 96-day Salyut 6 residency, the first Soviet mission to surpass the 84-day Skylab 4 endurance record established in 1974.

June 5 — NASA Administrator Robert Frosch writes to A.P. Aleksandrov, President of the Soviet Academy of Sciences, to say: “I understand your concern over delays in implementing joint studies of a Shuttle-Salyut mission. Unfortunately we have found that the issues underlying this activity are far more complex than we had at first believed. Discussion and resolution of these issues is taking longer than we expected.[32]

July 13 — President Jimmy Carter's National Security Advisor Zbigniew Brzezinski is worried about technology transfer, and the Carter Administration becomes concerned about Soviet human rights issues. Frosch writes to Brzezinski attempting to assuage his concerns and defending Shuttle-Salyut. [33]

September 7 — Robert Newman, NASA Director of Public Affairs at NASA Headquarters, sends the NASA field centers a prepared statement explaining that Shuttle-Salyut is indefinitely postponed “No further discussions have been scheduled pending a comprehensive U.S. interagency review of the entire subject. We cannot predict when this review will be completed or what the outcome will be.”[34]

December 1978 - December 1979 — The U.S. government interagency review focuses on the probable impacts of abandoning Shuttle-Salyut and proposes means of disengaging from the program. Shuttle-Salyut collapses in December 1979 when the Soviet Union invades Afghanistan.[35]

**Late 1970s**

The U.S. has stopped all docking system development work. In the Soviet Union, meanwhile, Vladimir Syromiatnikov begins work upgrading the APAS-75 system for the *Buran* shuttle, which is in the early stages of development. He writes: “The distinguishing feature of APAS-75 was the ring with three guides arranged outside the docking ring. The units looked beautiful, like blossoming tulips. However, the external dimensions were disproportionately large ... I came to the conclusion that it would be necessary to ... turn the construction inside out. The outer ring with the guides moved inward, and the docking ring became larger. And, although the general dimensions decreased, several other major characteristics of the construction immediately improved. First, the strength and rigidity in the docked condition. Second, the periphery became free and it was possible to arrange “hinge-mounted” components, such as electrical and hydraulic joints. And finally, it became possible to enlarge the transfer tunnel because it was now possible to dismantle the components of the docking mechanism after docking.”[36]

August 15 — Six years after the U.S. performed a parallel feat - rescuing the Skylab space station - the Soviets demonstrate an ability to perform unrehearsed station-saving repairs. The KRT-10 radio

telescope jams over Salyut 6's rear port, preventing planned Progress resupply missions. During only the fifth Soviet spacewalk (the U.S. had performed 38 by this time), Valery Ryumin cuts wires on KRT-10, releasing the 10-meter-diameter antenna and rescuing the station. Ryumin would later become Russia's Shuttle-Mir Phase 1 Director.

**1980**

Summer 1980 — The Carter Administration declares U.S. boycott of the Moscow Olympic Games in response to invasion of Afghanistan.

**1981**

April 12-14 — STS-1: NASA Astronauts John Young and Robert Crippen take Space Shuttle Columbia on its first flight into space.

December — Polish authorities declare martial law in response to the democratization movement Solidarity.

**1982**

April 1982 — President Ronald Reagan allows the Space Cooperation Agreement to expire in protest of Soviet pressure on Poland, where the Solidarity trade union movement is calling for greater democratization.

April 19 — Salyut 7 is launched.

**1983**

December 14 — Some U.S.-Soviet space cooperation remains. Regardless of the 1982 expiration of the Space Cooperation Agreement, Cosmos 1514 becomes the fourth Soviet biosatellite to carry U.S. experiments into orbit.

**1984**

January 1984 — In his State of the Union Address, President Ronald Reagan calls on NASA to build a space station within a decade.

June 27 — In a speech to the Conference on United States-Soviet Exchanges in Washington, D.C., President Reagan preempts a planned Senate initiative calling for increased U.S.-Soviet space cooperation. Reagan tells the conference participants that the U.S. has proposed "a joint simulated space rescue mission." Later that day, Senators Spark Matsunaga, Slade Gorton, Howell Heflin, Ernest Hollings, Daniel Inouye, Robert Packwood, Jake Garn, and Donald Riegle introduced legislation calling upon President Reagan to: "... seek understandings and/or agreements with other nations to plan for space station activities that would permit … emergency assistance in space … examine other opportunities for mutually beneficial international coordination of U.S. permanent space station programs."[37]

Matsunaga, the legislation's principal sponsor, calls for a new common U.S./Soviet docking system, and adds that "encouraging the openness that emergency assistance coordination would require … would provide us a window into Soviet space activities"[38]

October 30 — President Reagan signs Congressional Joint Resolution 236, committing him to "endeavor, at the earliest practicable date, to renew the 1972-1977 agreement between the United States and Soviet Union on space cooperation."[39]

**1985**

January 1985 — **Aviation Week** reports that the Soviets have in the past year rejected or failed to respond to two informal Reagan White House initiatives aimed at boosting U.S.-Soviet space cooperation. Now, however, the U.S. would formally propose a space rescue mission. "Although the mission would have technical merit … " the magazine reports, "the primary objective would be public relations - to act as a tangible focal point for renewed dialogue and cooperation between the U.S. and Soviet Union."[40]

March 2 — The unmanned Salyut-7 space station loses power and contact with Earth.

March 11 — Mikhail Gorbachev comes to power in Moscow bearing reform policies of perestroika (restructuring) and glasnost (openness).

March 24 — Soviet army guards shoot and kill U.S. Army Major Arthur D. Nicholson in East Germany, prompting President Reagan to remove from a speech to the National Space Club a public invitation to the Soviets to carry out a joint piloted space mission. One possibility Reagan would have offered, **Aviation Week** reports, is a joint U.S.-Soviet Space Shuttle mission to rendezvous with and repair the beleaguered Salyut-7 space station.[41]

June-September — Cosmonauts Dzhanibekov and Savinykh rescue Salyut-7 through heroic repairs.

July — Leonov, Kubasov, Stafford, Brand, and Slayton appeared at the National Academy of Sciences as part of a symposium marking the 10th anniversary of ASTP. The symposium, sponsored by the American Institute of Astronautics and Aeronautics and The Planetary Society, called for joint U.S-Soviet Mars exploration, including a piloted expedition. At the same time, the U.S. Congress Office of Technology Assessment released a report stating that cooperation in space could be fruitful; Matsunaga sponsored another Senate bill calling for increased U.S.-Soviet space cooperation; and the Reagan-appointed National Commission on Space (led by former NASA Administrator Paine) examined opportunities for joint piloted solar system exploration.

**1986**

January 28 — A solid rocket booster fault destroys the orbiter *Challenger*, killing its crew of seven astronauts, and grounding the U.S. Shuttle fleet.

February 20 —The Mir Base Block reaches orbit.

March 13-July 16 — Leonid Kizim and Vladimir Solovyov are the first Mir crew and the last Salyut-7 crew. After activating Mir they transfer to Salyut-7 for seven weeks to collect experiment apparatus - and a guitar - and complete work on that station, including two spacewalks. Then they return to Mir before returning to Earth.

October — Negotiations toward a new space agreement begin.

**1987**

April 15 - May 1987 — U.S. Secretary of State George Schultz and Soviet Foreign Minister Eduard Schevardnadze sign the "Agreement on Cooperation in Space Projects" in Moscow. The agreement, implemented between NASA and the Intercosmos Council, U.S.S.R. Academy of Sciences, lists 16 specific areas for cooperative space projects. (A May 1988 amendment will add two additional cooperative areas.) The agreement also creates five U.S./U.S.S.R. Joint Working Groups. These

focus on Space Biology and Medicine, Solar System Exploration, Space Astronomy & Astrophysics, Solar-Terrestrial Physics, and Earth Sciences. Unlike its 1972 and 1977 predecessors, the 1987 Space Cooperation Agreement contains no reference to a piloted joint venture. The scientific links and cooperative structure it establishes or reinforces nevertheless prepares the ground for the piloted joint missions of the late 1990s.[42]

**1988**

September 29 — The Space Shuttle returns to flight with the launch of STS-26 *Discovery*.

November 15 — Soviets launch their own space shuttle, the *Buran*, which orbits Earth twice and then lands — automatically and unmanned. *Buran* will subsequently be shelved, leaving the Soviets without a reusable medium-lift spacecraft to ferry crews and re-supply Mir.

**1989**

August 19 — The Soviet newspaper **Izvestiya** acknowledges that the Soviet Union had lost the race to be first to send a man to the moon in the 1960s.[43]

November 27-28 — Massachusetts Institute of Technology (MIT) and California Institute of Technology (Cal Tech) professors in Moscow plan U.S.-Soviet student exchanges and become the first westerners to see 1960s-vintage Soviet piloted lunar mission hardware. They report that the Soviets are eager for cooperative space ventures.[44]

December 1989-March 1990 — Payload Systems, Inc. (PSI) operates Protein Crystal Growth apparatus on Mir, concluding the first commercial agreement with the Soviet Union to fly an experiment on the Soviet space station.

December 1989 — The U.S./U.S.S.R. Space Biology and Medicine Joint Working Group holds its third meeting since signing the 1987 Space Cooperation Agreement in the Soviet city of Kislovodsk. Participants informally discuss flying U.S. astronauts on Mir and Soviet cosmonauts on the Space Shuttle. Soon after, NASA Deputy Associate Administrator Samuel Keller, who had led the U.S. delegation to Moscow, tells the **Washington Post** that the sides have begun discussions of a flight by a Soviet doctor aboard the Space Shuttle and an American doctor on Mir. The Soviet might conduct experiments in a Spacelab module, while the American might use Mir's planned Medilab module. A Shuttle-Mir docking mission and a Mir-Shuttle tandem flight are also being considered. Proposals would be reviewed by a newly established Intergovernmental Working Group (IWG) on Space Cooperation and the National Space Council before submittal to President George Bush.[45]

**1990**

May 1990 - U.S. Vice President (and National Space Council Chair) Dan Quayle raises possibility of space cooperation in private meeting with Soviet president Mikhail Gorbachev; the latter asks for the U.S. to submit new proposals. Quayle also talks with two VPs of the Soviet Academy of Sciences. The U.S. State Department subsequently negotiates with the Soviets and reports to the Intergovernmental Working Group (IWG) on Space Cooperation, co-chaired by NASA.[46]

**1991**

July 1 — The Warsaw Pact military alliance is dissolved.

July — Oleg Shishkin, Minister of General Machine Building, meets with Dan Quayle to advocate an ambitious cooperative piloted program, including a Shuttle rendezvous with Mir, followed by crew transfer using MMUs, and at a later time, the delivery of U.S. module to Mir.

July 31 — Bush and Gorbachev sign in Moscow a space cooperation agreement which supplements 1987 agreement. A U.S. astronaut would fly aboard a Soviet Soyuz to Mir, reside there to conduct life sciences experiments for up to six months. A Russian cosmonaut would fly aboard a Shuttle Spacelab mission (probably SLS-2) in 1993. The agreement also establishes Manned Flight Joint Working Group and a coordinating mechanism for elevating space cooperation discussions within the Kremlin and White House, including annual high-level consultations.

August 18-22 — A coup d'etat fails in Moscow. Coup rapidly unravels due to popular resistance, orchestrated in part by Russian President Boris Yeltsin.

August 24 — Gorbachev resigns as General Secretary of the CPSU and disbands the CP Central Committee, including the Politburo.

December 25 — Gorbachev resigns as president of the Soviet Union, effectively ending the U.S.S.R. Aboard Mir at this time is Cosmonaut Sergei Krikalev, who will become the first cosmonaut to fly aboard a shuttle on STS-60 in 1994.

**1992**

June 17 — The U.S. and the new Russian Federation renew the 1987 space cooperation agreement. They issue a "Joint Statement on Cooperation in Space" calling for Russian cosmonauts aboard STS-60, U.S. astronauts aboard Mir in 1993, and Shuttle-Mir docking mission in 1994 or 1995. The agreement also opens the door to U.S. commercial purchase of Russian space services.

July 7-8 — NASA Structural/Mechanical working group, led by William C. Schneider, meets with their Russian counterparts in Moscow to discuss the Russian APAS docking mechanism.

July 12-17 — At Quayle's suggestion and Yeltsin's concurrence, NASA Administrator Dan Goldin meets with RSA (Russian Space Agency) General Director Yuri Koptev to visit Russian space facilities and work toward implementation of the June 17 space cooperation agreement.

August 18-21 — Bryan O'Connor (NASA), Boris Ostruomov (RSA), and Valery Ryumin (Energia) meet in Moscow to discuss implementing cooperative human space flight programs.

August 21 — Joint U.S./Russian Flight Design and Operations International Working Group (U.S. Chair Gary Coen; Russian Chair Vladimir Solovyov) meet in Moscow to discuss implementing Shuttle-Mir docking mission.

October 5 — Dan Goldin and Yuri Koptev meet in Moscow to sign the "Implementing Agreement on Human Space Flight Cooperation," which details plans for STS-60 cosmonaut flight, Soyuz flight and long-duration Mir stay by astronaut, and Shuttle-Mir docking with Russian Mir crew exchange and U.S. long-duration astronaut pickup.

**1993**

January 12 — NASA Headquarters designates the STS-70 Shuttle mission to dock with Mir Spacelab-Mir 1 (SL-M1).

January 20 — Docking mission designation in Shuttle manifest was changed from STS-70 to STS-71.

April 3-4 — Summit between newly elected U.S. President Bill Clinton and Russian President Boris Yeltsin in Vancouver, British Columbia, Canada. Sides agree to consider an "enhanced" Shuttle-Mir Program.

April 28-May 30 — U.S. and Russian representatives meet to discuss expanding U.S./Russian cooperation beyond the baseline Shuttle/Mir program. They agree to consider:

- A baseline of two 3-month and four 6-month U.S. flights aboard Mir through 1997, with astronauts delivered to the station by Soyuz-TMs and Shuttles.
- Outfitting Spektr module with less than 1000 kilograms of U.S. experiment hardware and adding it to Mir in January 1995 before the first Shuttle-Mir mission.
- Retrofitting Priroda module with 1500-2000 kilograms of U.S. experiment hardware and launching in early 1995. Due to time constraints, the sides recommended that Priroda be equipped with experiment hardware available or "well into the development process."
- Allowing about 3 hours of cosmonaut time per day and 1 to 2 kilowatts of electricity for U.S. experiments.
- The sides also discuss using joint EVAs to extend Mir's useful lifetime through the end of 1997. (Russians stated that to accommodate this program, Mir would need work for which NASA should pay.)[47]

May 14 — Johnson Space Center Director Aaron Cohen establishes the U.S./Russian Programs Office "[t]o accommodate the evolving and increasing relationship between NASA and the Russian space community." Donald Puddy is made Special Assistant for U.S./Russian Programs responsible for "oversight of all joint programs between the United States and Russia."[48]

July 22 — Soyuz-TM 16 undocks from the Kristall APAS-89 port and lands. U.S. observers are present as part of NASA's effort to assess Soyuz-TM suitability as a lifeboat for a space station..

July 27-28 — Energia's US office holds the "Space Station Mir: A Technical Overview" symposium at Hyatt Hotel, Dulles Airport, Herndon, Virginia.

August 16 — Arnauld Nicogossian, NASA Administrator for Space and Life Sciences, distributes a memorandum for the record on "accommodation of U.S. science on Mir 1 and beyond." He reviews information provided by Russian negotiators since May and finds science accommodation lacking.

September 2 — First U.S.-Russian Joint Commission on Energy and Space (Gore-Chernomyrdin) meeting. U.S. and Russia agree to begin Phase 1 of ISS cooperation immediately, with expansion of Shuttle-Mir to include up to 2 years of total U.S. stay time on Mir, with length of crew stay time and number of Shuttle flights dependent on details of experiments to be defined by November 1, 1993; use of Spektr and Priroda with U.S. experiments on board; solar dynamic power system work initiated with demonstration targeted for 1996; joint life support systems; common space suit. RSA-NASA contract would be negotiated to handle financing.[49]

September 7 — NASA submits Program Implementation Plan for Alpha Station to White House. Calls for use of twin "Salyut Space Tug" (TKS-based) vehicles for on-orbit propulsion and Soyuz-based assured crew rescue vehicles.

September 7 — Transition plan includes Russian study calling for "Russian/U.S./International Partners" configuration.

November 1 — The Addendum to the Program Implementation Plan for Alpha merges Alpha and Mir-2, establishing ISS and Phases 1, 2, and 3.

November — NASA holds Critical Design Review.

December 15-16 — Gore-Chernomyrdin commission formally agrees to expand Shuttle-Mir to include: up to 10 Shuttle flights to Mir and four or more long-duration stays for a total of 24 months by U.S. astronauts on Mir; Shuttle-Mir as Phase 1 of 3-phase ISS program including an International Space Station with U.S., Russian, European, Japanese, and Canadian contributions. Phase 2 is early ISS assembly; Phase 3 is later assembly and operations.

December 16 — Goldin and Koptev sign the Contract for Human Space Flight Activities (Phases 1 and 2), (Letter Contract NAS15-10110) a framework to which detail and clarification would be added during the contract definitization process. Provides for definitized contract to be negotiated by June 15, 1994.[50]

**1994**

January 24 — Proposed NASA Definitized Contract and supporting materials are submitted to RSA. NASA subsequently aids RSA with counter-proposal preparation through telecons and exchanges of letters.

January 31 — Spacehab submits unsolicited proposal.

February 3-11 — STS-60 *Discovery* flight; Sergei Krikalev is first cosmonaut on a Space Shuttle.

February 4-11 — "Team Zero" meetings occur.

February 19 — NASA provides RSA additional materials to assist RSA in preparing its counter-proposal for the Definitized Contract.

February 23 — Office of Life Sciences and Microgravity Science Applications issues Research Announcement soliciting space biology, space physiology, and life sciences technology investigations on board Mir, 1995-1997. Proposals due May 15, 1994, with final selections announced in August 1994.[51]

March — U.S. astronauts Norman Thagard and Bonnie Dunbar report to Star City, Russia, for training.

March — No money is transferred to RSA on Letter Contract by early this month because of RSA delays in setting up required U.S. accounts.

April — RSA responds to NASA's proposed Definitized Contract. NASA Negotiating Team formed.

May 10-18 — NASA Negotiating Team arrives in Moscow.

May 24-25 — First meeting of the Task Force on the Shuttle-Mir Rendezvous and Docking Missions held at JSC. The Task Force, often called the Stafford Committee for its chairman, Tom Stafford, is

created by the NASA Advisory Council "to review Shuttle-Mir planning, training, operations, rendezvous and docking, and management, and provide … reports containing specific recommendations to the [NASA] Advisory Council." Creates four working groups: Management; Phase 1; Crew Systems, Training, and Operations; and Vehicle Systems.[52]

May 29-June 21 — RSA Negotiating Team is in Houston.

June 6 — Randy Brinkley, Space Station Program Manager, delegates Phase 1 management to Space Shuttle Program.

June 13 — Brewster Shaw, Director of Space Shuttle Operations, requests that John B. Malone, NASA Langley Structural Materials Division, be designated to head up a team of his choosing to review the methodologies and processes in Shuttle-Mir load/stress analysis. Results of the review are due to be presented to Tommy Holloway, Space Shuttle Program Office by August 1, 1994.[53]

June 21 — Shaw announces creation of Phase 1 Management Group (POMG); Tommy Holloway is designated to establish group and act as chairman.[54]

June 21 — Contracting Officers for RSA (Zhulin) and NASA (Evey) sign Definitized Contract, Houston.

June 23 — Gore-Chernomyrdin meet in Washington, D.C. Goldin and Koptev sign Definitized Contract between RSA and NASA. Gore and Chernomyrdin jointly announce contract that provides $400 million for specified deliverables spanning FY 1994 through FY 1997, with approximately $305 million for Phase 1 and $95 million for selected Phase 2 goods and services. The contract includes:

- Up to 21 additional months of flight time aboard Mir for U.S. astronauts;
- Up to nine more Shuttle dockings with Mir after STS-71;
- Use of Russian Spektr and Priroda modules for U.S. experiments;
- Implementation of joint U.S.-Russian research program with Russian cosmonaut involvement onboard Mir;
- Joint technology development for solar dynamics, EVAs, and life support;
- Extension of Mir lifetime beyond 1995 to allow time for U.S. Mir operations;
- Docking Module to permit repeated Shuttle dockings with Mir; and
- Docking mechanisms for Shuttle-Mir and ISS.

The goals of these joint activities are defined as:

- Reducing ISS program risk by gaining experience conducting joints operations and programs
- Demonstrating ISS technologies
- Studying and developing interoperability (ability to exchange and use each other's systems - space suits specifically mentioned) where possible
- Conducting U.S. long-duration research earlier than otherwise possible.

June 29 — Phase 1 Management Group (POMG) holds "kickoff" meeting.

July 12-13 — NASA Advisory Council Task Force on the Shuttle-Mir Rendezvous & Docking Missions holds second meeting.

September 12 — Final report released on Shuttle-Mir Docking Loads Methodology Independent Review Team (Malone Committee). Holloway's comments include 25 recommendations. [55]

September 20 — Holloway creates a Phase 1 Spacehab Working Group with Tom McPherson as chairman to negotiate a contract with Spacehab.[56]

October 3 - March 1995 — Mir Principal Expedition 17. Cosmonauts Alexandr Viktorenko, Yelena Kondakova, Valeri Polyakov. Kondakova would later fly to Mir on STS-84.

October 11 — Russian ruble collapses.

October 11-12 — Third meeting of the NASA Advisory Council Task Force held on the Shuttle-Mir Rendezvous & Docking Missions.

October 19 — ***Aerospace Daily*** reports Phase 1 Program office formed; headed by Tommy Holloway. Holloway reports directly to Jeremiah Pearson, Associate Administrator for the NASA Headquarters Office of Space Flight.

November 2 — Valery Ryumin informs Tommy Holloway that the October 15, 1994, launch target for Priroda will not be met because the Spektr module was postponed to May 10, 1995.[57]

November 3-14 — STS-66 mission tests tools, devices, and procedures for Shuttle-Mir missions.[58]

November 3-10 — Team Zero meeting 4, Moscow

November 4 — *Soyuz-TM* 19 undocks. Merbold and the *Mir*-16 crew of Yuri Malenchenko and Talgat Musabayev return to Earth. Viktorenko and Kondakova remain on Mir with Valeri Polyakov, who had launched in *Soyuz-TM* 18 on January 8, 1994.

November 18 — Mir completes 50,000 orbits, covering 1.9 billion kilometers since February 19, 1986.

November 22 — Two NASA contracts with Spacehab, Inc., commence on this date; the first for SPACEHAB module modifications for Phase 1, the second for SPACEHAB Integration and Operations. McDonnell Douglas, SPACEHAB's partner building hardware, contracts with Alenia of Italy to build SPACEHAB double module hardware on November 28.[59]

December 7-14 — Team Zero meeting 5, Houston

December 16 — Gore and Chernomyrdin sign a customs agreement providing for duty-free clearance of goods shipped to Russia for space cooperation. Also agreed is formation of a Joint Medical Policy Board to coordinate development of a common system of medical support.[60]

**1995**

January 1995 — Astronauts Shannon Lucid and John Blaha report to Star City to begin training.

February 27, 1995 — The Phase 1 Payload Steering Committee reviews JSC Space & Life Sciences plans for Mir mission 21-25 and STS-71, 74, 76, 79, 81, 84, 86, 89, and 91.[61]

February 3-11, 1995 — STS-63 *Discovery*. "Near-Mir" mission, during which *Discovery* performs a "fly around" of Mir.

March 1 — Fourth report of the NASA Advisory Council Task Force issued on the Shuttle-Mir Rendezvous & Docking Missions - based on trip to Russia by General Tom Stafford. Goldin requested December 6, 1994, that Stafford lead a team of NASA Advisory Council Task Force on the Shuttle-Mir Rendezvous & Docking Missions members and technical advisors to Russia to review flight safety for Mir-18 and STS-71.

March 3 — The Space Station Program Safety Review Panel reviews the possibility of Russian and U.S. launch/return hardware being supported by minimal documentation, using STS-71 as pathfinder for the process.[62]

March 14 — Norman Thagard launches aboard Soyuz-TM 21 from Baikonur on Mir-18 expedition with Vladimir Dezhurov and Gennadi Strekalov.

March 16 — Soyuz-TM 21 docks with Mir. Thagard begins NASA-1.

March 15-17 — Team Zero meets in Moscow.

March 17 — Russian Prime Minister Viktor Chernomyrdin pledges support for continued US/Russian space cooperation.

March 22 — Soyuz-TM 20 undocks. Polyakov returns to Earth (with Viktorenko and Kondakova) having spent 438 days in space. This is a new world record, which gives him a cumulative spaceflight total of more than 600 days.

March 31 — Joint Program Review

April — ESA Freezer onboard Mir is running warm, indicating that it needs to be defrosted.

April 3-4 — Utkin Independent Review Team is at JSC for briefings related to STS-71 Shuttle operations.[63]

April 11 — Progress-M 27 docks, bringing of food, water, fuel, and U.S. equipment, including defrost kit of ESA freezer, water transfer hardware to support STS-71, and Japanese quail eggs.

April 14 — Russians sign Mir Extension protocol that will assist NASA in receiving more complete information on Mir upgrades, repairs, and planned maintenance.[64]

April 18 — Strekalov and Dezhurov remove the shower (a failure, it was used as a sauna) to make room for gyrodynes in Kvant 2.

April 19 — Mir-18 crew deploys the German GFZ laser retro-reflector satellite from the science airlock.

Late April — On Mir, quail egg fixation occurs; incubator performs well. Spektr due to launch between May 19 and 25. Mir-18 EVAs will not begin until May 12, forcing U.S. science timeline replanning. Mir crew installs battery delivered by Progress-M 27 in Kristall; unable to repair humidity fan using replacement delivered by Progress. ESA freezer still frosting up blood samples moved to thermoelectric freezer, urine and saliva left ambient, with hopes to refreeze later.

Early May — On Mir, ESA freezer is still off; ground working on recovery procedure; procedures for freezer servicing radioed to Thagard.

May 12 — Dezhurov and Strekalov complete an EVA of 6 hours 8 minutes to work on Kristall array transfer.

May 13 — Cosmonauts are reported to be very tired after the EVA. Take rest day.

May 15 — Strekalov and Dezhurov change their EVA suits batteries and replenish consumables.

May 16, 1995 — Dezhurov and Strekalov conduct an EVA of 6 hours 52 minutes. Kristall array transfer.

May 17 — Tommy Holloway responds to Malone Review Team recommendations.[65]

May 20 — The next scheduled EVA is delayed two days to give the cosmonauts more time to rest.

May 22 — Strekalov and Dezhurov conduct an EVA of 5 hours 15 minutes. Kristall array transfer.

May 29 — Strekalov and Dezhurov conduct EVA of 21 minutes for Konus unit transfer.

May 30 — Kristall moved from end port to side port. Kristall-Mir node cavity (vestibule) can not be completely re-pressurized. Most probable cause is a foreign object, perhaps some thermal insulation, in between the collars.

May 30 — STS-71 Phase 1 Flight Readiness Review, Valery Ryumin on hand.

June 1 —Spektr module arrives and docks at end port.

June 2 — Dezhurov and Strekalov conduct EVA of 23 minutes. Konus unit transfer. Spektr moved to a side port.

June 6 — Thagard breaks the Skylab 4 endurance record.

Week ending June 9 — Russian and U.S. managers and specialists take part in program management training at JSC, sharing information on management practices and facilities.[66] Spektr array does not deploy properly. EVA announced, then canceled.

June 18-20 — Team Zero meeting 7, Houston

Week ending June 23 — Semenov provides NASA with official notification that Mir is ready for STS-71 docking.[67]

June 27 — First Stafford-Utkin report published.

June 27 - July 7 — STS-71 Atlantis. Anatoly Solovyev and Nicolai Budarin replace Norm Thagard, Vladimir Dezhurov, Gennady Strekalov on Mir. On July 4, Soyuz TM-21 is undocked and kept at about 65 meters away to photograph Atlantis and Mir. Atlantis undocks, with Dezhurov and Strekalov onboard, and does a fly-around at 500 meters. A jolt produced by Orbital Docking Systems springs causes Mir's attitude control computer to shut down, which causes Mir's attitude control gyrodynes to slow down. This forces a manual redocking by Soyuz-TM 21 earlier than planned.

July 14 — Solovyev and Budarin conduct an EVA of 5 hours 34 minutes for leak inspection and Spektr array deployment.

July 17 —Kristall moved from end port to side port.

July 19 — Solovyov and Budarin conduct an EVA of 3 hours 8 minutes. Install Mir Infrared Atmospheric Spectrometer (MIRAS). Fifth meeting of the NASA Advisory Council Task Force on the Shuttle-Mir Rendezvous and Docking Missions (Stafford Group) convenes.

July 21 — Solovyev and Budarin conduct an EVA of 5 hours 35 minutes and install MIRAS.

July 22 — Progress-M 28 docks. Cargo includes gyrodyne and 350 kg of gear for Reiter, ESA astronaut for Mir 20.

July - August — Mir-19 crew works on Incubator and Svet Greenhouse scientific investigations. Only half of Greenhouse lights continue to work, but plants grow well, reach height of 8 cm.

August 9, 1995 — NASA announces Brewster Shaw is leaving as Director of Space Shuttle Operations at NASA JSC, effective August 18, 1995. Tommy Holloway will replace Shaw as Manager, Space Shuttle Program. Astronaut Frank Culbertson becomes Acting Director, Phase 1 Program..

Week ending August 11, 1995 — Optizon, a planned advanced tech experiment (Liquid Phase Sintering), scheduled for NASA-2 using Optizon-1 furnace on Mir has become “substantial issue” because Energia wants more NASA money before it will let NASA-2 use the furnace. Russian Projects Office working with RSA liaison Valeri Grigoriev to resolve issue.[68]

Week ending September 1, 1995 — Initial Moscow hotel surveys are completed. Negotiations will begin with up to six hotels to get lower prices for NASA and contractor people.[69]

September 3 — Soyuz TM-22 launches from Baikonur.

September 4 — Progress -M 28 undocks from Mir.

September 5 — Soyuz TM-22 docks, delivering Mir-20 crew of Yuri Gidzenko, Sergei Avdeyev, Thomas Reiter (EuroMir95). Manual controller malfunction in Svet Greenhouse puts plants in peril. Saved by rapid US and Russian team work.

September 11 — Soyuz TM-21 undocks and returns Mir-19 cosmonauts to Earth.

September 18 — The Phase 1 Transfer Tiger Team briefs Phase 1 Acting Director Frank Culbertson on cargo transfer bag options. Culbertson selects the JSC-manufactured Shuttle Middeck Soft Stowage Cushion Bag to serve as the Shuttle-Mir Stowage/Transfer Bag. Seventy bags will be procured at a cost of $70,000.[70]

September 21 — Fifth report of the NASA Advisory Council Task Force on the Shuttle-Mir Rendezvous & Docking Missions published. Dr. Bradford Parkinson, NASA Advisory Council Chairman, had asked Task Force to examine results from STS-71 and preparations for STS-74; NASA's presence in Russia; and NASA's automated data processing and telecommunications infrastructure in Russia.

September 25-28 — Team Zero meeting 8, Moscow sides agree to return a Russian Orlan-DMA space suit to Earth on STS-79.

October 6 — RSA, ESA, and Energia agree to extend the Euromir 95/PE-20 mission by 44 days (from 135 days to 179 days) because of Russian financial problems and a shortage of Soyuz launch vehicles.

Week ending October 12 — Energia accepts that NASA Optizon use is part of its contract.[71]

October 20 — Progress-M 29 docks. EVA conducted of 5 hours 11 minutes to install sample collectors.

October 31 — Ethylene Glycol-based coolant leak in Kvant. Leads to temporary breakdown of Vozdukh primary air-regeneration system.

Week ending November 2 — Phase 1 logistics quick-response studies initiated after Russian request to fly replacement parts on STS-74 to repair cooling system hardware failure in the Kvant module. Russians report repairs made - quickly, actually - but seek to fly additional hardware to improve their margins.[72]

November 3 — Leak fixed.

November 12-20 — STS-74 Atlantis. Docking Module and Cooperative Solar Array are delivered.

December 8 — EVA of 37 minutes for Konus transfer.

December 19 — Progress-M 29 undocks.

December 20 — Progress-M 30 docks.

**1996**

Early 1996 — Mike Baker replaces Ron Sega as Director of Operations - Russia (DOR).

Week ending January 11 — Culbertson establishes Phase 1 Tiger Team headed by MSWG chair Peggy Whitson to "evaluate possible scenarios and resources … if a decision is made to pursue additional missions to the Mir Station beyond September 1997."[73]

January 26-30 — "NASA-RSA Human Space Flight Cooperation Principles and Action Plan" covering multi-entry Russian visa problems for NASA employees and contractors. Also, sides agree to add two Shuttle-Mir flights in 1998: STS-90 (became STS-89) and unmanifested STS-91, bringing the total number of Shuttle missions to dock with Mir to nine.[74]

February 8 — EVA of 3 hours 6 minutes to retrieve samples collectors.

February 20 — Mir's 10th anniversary

February 21 — Phase 1 Director Frank Culbertson attends launch of Soyuz-TM 23, carrying Mir-21 crew of Yuri Onufriyenko and Yury Usachev.

February 23 —Soyuz TM-23 docks with Mir.

February 29 — Soyuz TM-22 undocks, taking Mir-20 crew back to Earth.

March 11 — Phase 1 program directors are at KSC for STS-76 Flight Readiness Review.

March 15 — EVA of 5 hours 51 minutes to install second Strela boom.

March 22-31 — STS-76 *Atlantis* delivers Shannon Lucid to Mir, to begin NASA-2. On March 27, STS-76 astronauts Clifford and Godwin conduct EVA of 6 hours 2 minutes to install MEEP space exposure panels on Mir Docking Module. They test ISS common foot restraint and tether hooks. On March 31, *Atlantis* departs early because of weather, lands in California.

April 23 — Priroda module launches, takes rapid course to Mir to save power. It has no solar arrays; relies on batteries.

April 26 — Priroda docks. Only big module to dock without difficulties.

April 29 — Anatoly Solovyev, first Director of Operations - Houston, takes up his duties.

May 7 — Progress-M 31 docks.

May 16 — A NASA communications center staffed by TechTrans International and managed by NASA's Moscow Technical Liaison Office is opened on the 6th floor of the Renaissance (Penta) Hotel in downtown Moscow. The center is equipped with computers, fax, copier, and telephone for NASA and contractor use. A NASA office is established at RSC Energia.[75]

May 21— Onufriyenko and Usachev conduct EVA of 5 hours 20 minutes. Transfer and install MCSA; film first part of Pepsi commercial.

May 24 — Onufriyenko and Usachev conduct EVA of 5 hrs, 34 min.

Late May — Lucid photographs eruption of Monster volcano.

May-June — Two Soyuz-U launchers are lost, raising concerns about ability to re-supply Mir following NASA-2 extension.

May 30 — Onufriyenko and Usachev conduct EVA of 4 hours 20 minutes. Install outside Priroda U.S.-built Modular Optoelectrical Multispectral Scanner (MOMS).

Early June — Mir took action to lower temperatures experienced in some modules caused by high sun angles. Mir is turned to put Spektr's solar arrays back toward Sun. Lucid moves from Spektr to Priroda to sleep.

June 5 — Phase 1 Program Requirements Control Board approves funding for modifications to OV-103 (*Discovery*) to support Phase 1.

June 6 — Onufriyenko and Usachev conduct EVA of 3 hours 34 minutes. Replace cassettes in the Swiss/Russian Kozma experiment; install Particle Impact Experiment (PIE), Mir Sample Return Experiment (MSRE), and SKK-11 cassette, which exposes construction materials to space conditions.

June — Onufriyenko and Usachev conduct EVA of 5 hours 42 minutes. Install Ferma-3 (Rapana) 5.9-m (structure on Kvant's underside; manually deploy saddle-shaped Travers Synthetic Aperture Radar antenna on Priroda; and film final segment of the Pepsi commercial

July 1 — While disassembling Shuttle solid rocket boosters used on STS-78, engineers observe soot in field joints. Culbertson tells Ryumin about it in an informal July 3 memo because "the worst case … is a potentially serious problem for our joint schedule, you should be aware of the situation."

July 10 — Hurricane Bertha menaces KSC. *Atlantis* goes back to Vehicle Assembly Building.

Week ending July 11 — Team led by Charlie Precourt assesses impacts of STS-79 slip to September for Lucid, Star City, payloads, etc.

July 11 — Candle Flame in Microgravity (CFM) Experiments onboard Mir.

July 12 — NASA announces Lucid flight extended because of STS-78 SRB seal problem. Culbertson writes a formal letter to Aleksandr Botvinko, RSA, and Yuri Semenov, Energia, to inform them of decision to re-stack STS-79 SRBs and re-schedule launch to about September 15. Warns them that this will impact schedule of future flights. NASA publicly announces Lucid flight extension.

July 15 — Lucid breaks Norm Thagard's record (115 days) for longest U.S. space stay.

Week ending July 25 — Dryden Flight Research Center facilities are upgraded to full duplex, giving generally good communications with Mir. Facilities at Dryden and Wallops are used by NASA TsUP personnel to supplement Russian system.[76]

Late July — Lucid gets early start on on-orbit inventory and pre-packing for STS-79.

August 3 – Progress-M 32 docks.

August 16 — Soyuz-TM 24 launches from Baikonur with Mir-22 crew of Valeri Korzun, Alexandr Kaleri, and French cosmonaut Claudie Andre-Deshays.

August 18 — Soyuz-TM 24 docks.

Week ending September 1 — DARA (German space agency) briefs Phase 1 managers on planned German flight to Mir in December 1996 with 20-day Mir stay. DARA wants their astronaut returned on Shuttle.[77]

September 2 — Soyuz-TM 23 undocks and takes Mir-21 crew and Andre-Deshays back to Earth

September 7 — Lucid breaks Yelena Kondakova's record for longest stay in space by a woman. 179 days.

September 16-26 — STS-79 *Atlantis*. Shannon Lucid replaced by John Blaha, who begins NASA-3. Lucid completes 188 days in Earth orbit.

November — NASA begins advising the Russians of close approaches between the Mir space station and space objects, including orbital debris, when American astronauts are onboard.[78]

November 22 — Progress-M 33 docks.

December 2 — Korzun and Kaleri conduct EVA of 5 hours 57 minutes. Install MCSA power cable; move Rapana girder to the top of the new Strombus girder on Kvant's underside.

December 9 — Korzun and Kaleri conduct EVA of 6 hrs, 36 min. Install new omnidirectional Kurs antenna on the Docking Module; reattach a cable to amateur radio antenna, which they knocked loose during their first EVA.

**1997**

January 12-22 — STS-81 *Atlantis*. Jerry Linenger replaces John Blaha on Mir, and begins NASA.

February 10 — Soyuz-TM 25 launched from Baikonur, with Mir 23 crew of Vasili Tsibliyev and Alexandr Lazutkin, with German astronaut Reinhold Ewald.

February 12 — Soyuz-TM 25 docks.

February 24 — Oxygen-generating canister fire onboard Mir.

March 4 — Progress-M 33 fails to dock.

March 7 — Primary Elektron oxygen generator fails. Secondary Elektron produces too much hydrogen, forcing resort to canisters (3 per man per day needed. 200 on board, or 2-month supply).

March 19 — Orientation (gyrodyne) system failure.

April 8 — Progress-M 34 docks.

April — House Science Committee adopts amendment to FY98-99 NASA authorization bill (HR 1275) sponsored by committee Republican chairman James Sensenbrenner and ranking Democratic representative George Brown. NASA must certify that Mir meets or exceeds NASA safety standards.

Mid-April 1997 — Coolant system leaks.

April 29 — EVA of 4 hours 57 minutes to install the OPM, remove the U.S. Mir Sample Return Experiment and Particle Impact Experiment.

May 9 — Wilbur Trafton, Associate Administrator for Space Flight, invites RSA to fly one cosmonaut each on STS-89 and STS-91, to continue learning experience of STS-63, 71, 84, and 86. “We anticipate that working together during these additional Shuttle missions will further strengthen our partnership for the future construction and utilization of the International Space Station.”

May 15-24 — STS-84 Atlantis. Michael Foale replaces Jerry Linenger, and begins NASA-5.

June 25 — Progress-M 24 collides with Mir. Spektr depressurizes.

July 2 — Progress M-34 deorbited after controllers regain control and test to see what went wrong.

August 5 — Soyuz-TM 26 launches from Baikonur with Mir-24 crew of Anatoly Solovyev and Pavel Vinogradov.

August 14 — Soyuz-TM 25 returns Mir 23 crew to Earth. The premature firing of Soyuz-TM 25 landing rockets at altitude of 5.8 km causes a rough landing for the crew. Soyuz landing system is subsequently modified.[79]

August 22 —Anatoly Solovyev and Pavel Vinogradov conduct an international EVA of 5 hours 30 minutes. Install new hatch cover to permit electricity and data transmission (control) between damaged Spektr module and remainder of Mir; survey depressurized Spektr interior.

August 28 — NASA moves STS-86 launch date to permit Wolf to complete training and to consider request for Spektr hatch sealing cover.

September 6 — Anatoly Solovyev and Mike Foale conduct 6-hour EVA to inspect exterior of damaged Spektr module and manually turn solar arrays on Spektr to improve power generation.

September 22 — Salyut 5B Central Computer fails due to overheating. Crew uses a replacement part from a decommissioned unit, and add a fan to increase cooling. This permits STS-86 docking.

September 25-October 6 — STS-86 *Atlantis*. David Wolf replaces Michael Foale, and begins NASA-6. *Atlantis* brings replacement computer parts. On Oct. 1, Scott Parazynski and Vladimir Titov conduct the first joint U.S.-Russian EVA (5 hours 1 minute) from U.S. airlock; remove MEEP space exposure experiments from Mir (installed on STS-76); transfer Spektr repair "cap" to Mir; test SAFER self-rescue backpack; test common U.S.-Russian foot restraint and tethers.

October 10 — Andy Thomas is named as final Mir U.S. crewmember.

October 15 — NASA announces that Salizhan Sharipov is officially added to the STS-89 crew.

October 20 — Anatoly Solovyev and Pavel Vinogradov conduct an EVA of 6 hours 38 minutes. Connect data transmission (control) cables to solar arrays in damaged Spektr module.

November 3 — Solovyev and Vinogradov conduct an EVA. Remove Kvant 1 solar array install carbon dioxide system exterior cap

November 6 — Solovyev and Vinogradov conduct an EVA of 6 hours 19 minutes. Transfer new solar array from Docking Module to Kvant; seal damaged Kvant 2 hatch.

November 22 — Salyut 5B computer installed during STS-86 overheats and fails. Replaced by a spare.

**1998**

January 1 — Cosmonauts toasted in the new year with plastic champagne bottle. Vladimir Solovyev tells reporters: "1997 was a pretty difficult year for us."[80]

January 2 — Failure in Salyut 5B central exchange module. Replaced with spare.

January 8 — Computer failure. Solovyev and Vinogradov conduct EVA. Inspect damaged Kvant 2 outer hatch; remove OPM on Docking Module for return to Earth.

January 14 — EVA Anatoly Solovyev and David Wolf conduct an EVA of 3 hours 52 minutes. Test SPSR spectrometer; inspect Mir exterior with camera; accumulate joint U.S.-Russian EVA experience

January 22-31 — STS-89 *Endeavour*. Andy Thomas replaces David Wolf on Mir, and begins STS-7.

January 29 — Soyuz-TM 27 launches from Baikonur, with Mir-25 crew of Talgat Musabayev and Nikolai Budarin, plus Frenchman Leopold Eyharts (CNES) for short stay on Mir.

January 31 — Soyuz-TM 27 docks.

February 19 — Soyuz-TM 26 undocks and lands.

April 1 — Musabayev and Budarin conduct an EVA of 6 hours 40 minutes. Install support strut on damaged Spektr module solar array.

April 6 — EVA. Musabayev and Budarin conduct an EVA of 4 hours 30 minutes. Install support strut on damaged Spektr solar array; begin installation of replacement VDU thruster package.

April 11 — Musabayev and Budarin conduct an EVA of 6 hours 25 minutes. Detach VDU thruster package from Sofora boom and discard; replace boom jet adapter plate.

April 17 — Musabayev and Budarin conduct an EVA of 6 hours, 33 minutes. Remove and stow Rapana girder; unstow new VDU thruster package from Progress-M 38 and position for installation.

April 22 — Musabayev and Budarin conduct an EVA of 6 hours 21 minutes. Install VDU on Sofora boom.

June 2-12 — STS-91 *Discovery*. Andy Thomas returns to Earth, ending NASA-7.

August — Phase 1 ends.

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