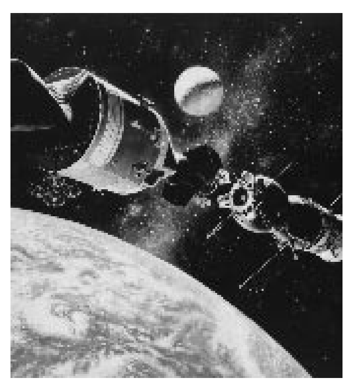
The Cooperative Experience to Date 3

PUBLIC SECTOR

Cooperation on civil space projects with the world's other space superpower has been discussed and sometimes pursued since the beginning of the Space Age, although during the Soviet period, competition generally dominated.[1] Before 1991, the ability to pursue cooperation was frequently compromised by the vicissitudes of the Cold War because the linkage between space cooperation and broader superpower relations frequently worked to restrict even modest projects. For example, the United States allowed the government-to-government agreement on the cooperative use of space to lapse in 1982 over Soviet imposition of martial law in Poland.

Although linkage to political concerns continues, it currently works to stimulate rather than limit cooperative activity. Moreover, with serious space-budget shortfalls across the rest of the spacefaring world, most observers of the U.S. space program consider extensive international cooperation, involving Russia as well as traditional partners, essential to the achievement of national goals in space. This section briefly traces the history of public sector space cooperation between the United States and the



[1] For a detailed review of international cooperation and competition up to 1985, see U.S. Congress, Office of Technology Assessment, *International Cooperation and Competition in Civilian Space Activities*, ISC-239 (Washington, DC: U.S. Government Printing Office, June 1985). See also U.S. Congress, Office of Technology Assessment, *U.S.-Soviet Cooperation in Space*, TMI-STI-27 (Washington, DC :U.S. Government Printing Office, July 1985). The standard political history of this period in science and technology, with particular attention to space cooperation and competition between the United States and the Soviet Union, is Walter A. McDougall, . . . *The Heavens and the Earth: A Political History of the Space Age* (New York: Basic Books, Inc., 1985).

Soviet Union (and later, its successor states) and describes its status through early 1995.

The Early Years: 1958-1971

Even before the launch of Sputnik 1, the United States sought to engage the Soviet Union in space cooperation on two broad fronts-diplomatically, through proposals to guarantee the peaceful use of outer space, and scientifically, through the machinery of the International Geophysical Year (IGY).[2] Both countries explicitly linked their initial satellite efforts to the IGY. After Sputnik 1, both the Eisenhower Administration and Congress gave heightened emphasis to calls for scientific collaboration.[3] Relatively little tangible cooperation resulted, however, because the competitive element predominated on both sides.

BOX 3-1: The Apollo-Soyuz Test Project

- The objective of ASTP was to develop and demonstrate compatible rendezvous and docking systems for U.S. and Soviet manned spacecraft. The docking mechanism to be used during the seven-flight Shuttle-Mir program is an Improved variant on the ASTP design.
- On July 17, 1975, three U.S. astronauts and two Soviet cosmonauts docked Soyuz 19 with an Apollo spacecraft that was carrying the jointly developed docking module. Soyuz 19 and Apollo undecked after two days of symbolic visits between spacecraft.
- ASTP was widely praised as a symbol of detente, while also criticized at the time as an expensive symbolic gesture that was wasting scarce U.S. space funds.
- Follow-on Shuttle-Salyut mission preparations were suspended in 1978 amid worsening U.S.-U.S.S.R. relations.

SOURCE. Off Ice of Technology Assessment, 1995.

Even before his inauguration, President John F. Kennedy commissioned an extensive study of potential space cooperation with the Soviet Union and signaled this interest both in his Inaugural Address and in his first State of the Union message, as part of a broader effort to engage the U.S.S.R. in cooperation in relatively nonsensitive areas. The study arrived at the White House on April 14, 1961, two days after Yurii Gagarin's first orbital flight.

The space-cooperation study contained more than 20 individual proposals, ranging from arms-length scientific collaboration to proposals forestablishing a joint lunar base. U.S. prestige around the world suffered dramatically because of Gagarin's flight, and as a result. the balance of U.S. attention shifted to competition, particularly after President Kennedy's announcement of the Apollo Program on May 25, 1961. However, a first, modest agreement on space cooperation between Moscow and Washington was reached in 1962; it provided for a limited exchange of weather-satellite data, coordinated satellite measurements of the Earth's magnetic field, and communications experiments involving the U.S. Echo II satellite. Results were mixed, and cooperation in satellite meteorology, in particular, was slow to begin.

Civil Space Agreements, Apollo-Soyuz, and Shuttle-Salyut: 1971-1982

The race to the Moon ended in 1969. Meanwhile, in 1967, the United States and the Soviet Union reached a political accommodation in the United Nations (U. N.) Outer Space Committee, resulting in the U.N. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies.

[2] The IGY was established in 1957 by the International Council of Scientific Unions to pool international efforts in studying the Earth, the oceans, the atmosphere, and outer space.

[3] For a detailed discussion of Cooperation before 1974, see Dodd L. Harvey and Linda C. Ciccoritti, *U. S.-Soviet Cooperation in Space (Miami, FL: University of Miami, Center for Advanced International Studies, 1974).*

Early in the 1970s, the general political thaw between the United States and the U.S.S.R. extended to space cooperation. A series of senior-level meetings between the National Aeronautics and Space Administration (NASA) and U.S.S.R. Academy of Sciences delegations in 1970-71 resulted in agreements on the organization of the Apollo-Soyuz Test Project (ASTP) and on cooperation in satellite meteorology; meteorological sounding rockets; research on the natural environment; robotic exploration of near-Earth space, the Moon, and the planets; and space biology and medicine. The 1972 Agreement on Cooperation in the Peaceful Exploration and Use of Outer Space, signed at the summit by Presidents Richard M. Nixon and Alexei Kosygin, formalized these understandings and endorsed the Joint Working Group (JWG) structure that had emerged to implement ASTP and to develop specific cooperative projects (see box 3-1 and photo above).

Work on ASTP proceeded relatively smoothly, although both sides approached the flight with suspicion and caution. Meanwhile, modest but mutually satisfactory cooperation-largely restricted to exchanges of data and coordinated experiments of various types-was developing in the areas of space science and applications, particularly in space biology and medicine.

Not long after the successful ASTP flight in 1975 (figure 3-1), the two countries agreed to pursue a follow-on rendezvous and docking activity involving the U.S. Space Shuttle (which had not yet flown) and the Soviet Salyut Space Station (figure 3-2). Shuttle-Salyut was the centerpiece of the renewal of the intergovernmental agreement between the U.S.S.R. and the United States in 1977 under President Jimmy Carter, which otherwise extended the 1972 agreement's provisions. Although extensive science planning for Shuttle-Salyut was completed in 1978, U.S. enthusiasm for the venture began to wane as relations cooled because of conflicts over human rights in the U.S.S.R. and, later, Soviet international actions. Concern about the possible technology-transfer implications of ASTP led to an extended interagency review, which found the program innocent

NASA Administrator James Fletcher with Apollo 16 astronauts, briefs President Richard Nixon on the Apollo-Soyuz Test Project.

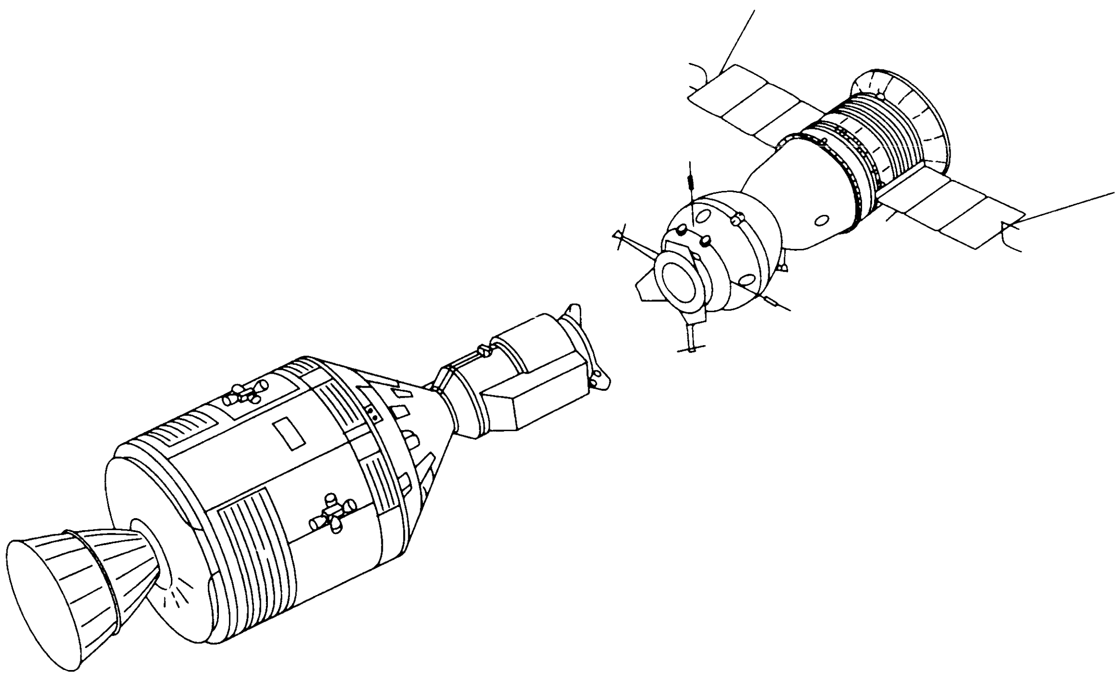
of any technology losses, though it acknowledged that the Soviets had probably learned a good deal about NASA's management of large projects. The study also recommended a careful, arms-length approach to additional cooperation, with structured interagency review of all proposals.

In 1978 and 1979, U.S. (and perhaps Soviet) interest in Shuttle-Salyut diminished further. The White House decided not to schedule the next technical meeting,. which the United States had agreed to host. In 1979, President Carter mandated a sharp reduction in remaining activity under the 1977 agreement, following the Russian intervention in Afghanistan. In late 1981, with the imposition of martial law in Poland, the Reagan Administration announced that in retaliation, the civil space agreement would be allowed to lapse in May 1982.

■ Hiatus and Improvisation: 1982-1987

In the absence of an agreement, U.S. officials authorized only low-profile cooperation, with approval on a case-by-case basis by the White House. Despite this stricture, a certain amount of activity continued. COSPAS-SARSAT, a satellite-aided search-and-rescue project involving cooperation between the SARSAT partners (the United States, Canada, and France) and the Soviet COSPAS program, was judged by the White House to have overriding humanitarian value and

FIGURE 3-1: Apollo and Soyuz Join in Space



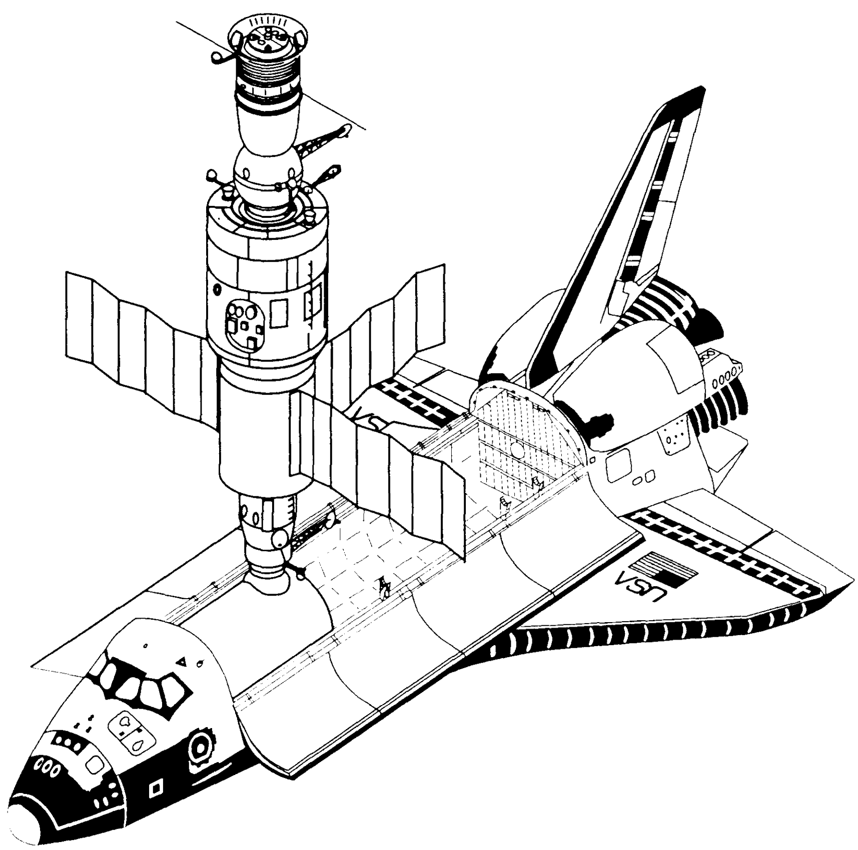
SOURCE: David S.F. Portree, *Mir Hardware Heritage,* Houston, TX, 1994

operated uninterrupted.[4] NASA was allowed to continue to pursue cooperation in space biology and medicine, which, along with planetary data exchanges, had produced the most valuable scientific results under the 1972 and 1977 agreements; U.S. biomedical instrumentation flew on Soviet biosatellite missions in 1983 and 1985. Planetary-data exchanges also continued, principally involving studies of the atmosphere and surface of Venus.

In 1981, the space agencies of the United States, the U. S. S.R., Europe, and Japan formed the Inter-Agency Consultative Group (IACG) for Halley's Comet, an informal coordinating framework for the upcoming Halley's Comet apparition. Both the United States and the Soviet Union were members of the IACG, and NASA's Deep Space Network provided most of the tracking support for the European Space Agency's (ESA's) Giotto and for the Venus and Halley encounters of the U. S. S.R.'s VEGA-1 and 2. U.S. scientists also participated in data exchanges and joint analyses with Soviet counterparts through the IACG. In addition, several U.S. or partly U.S. instruments actually flew on the Soviet spacecraft, by virtue of

[4] SARAT stands for Search and Rescue Satellite-Aided Tracking, and COSPAS is from the Russian for "Space System for the Search of Vessels in Distress."

FIGURE 3-2: Conceptual Drawing of the Shuttle Docked with Salyut



SOURCE David S.F. Portree, *Mir Hardware Heritage,* Houston, TX, 1994

agreements negotiated with third parties who, in turn, concluded agreements with the U.S.S.R.[5]

As the Reagan Administration began to feel its way toward an improved relationship with the U. S. S.R., the first tentative steps were taken toward resumption of more formal, high-profile space cooperation. In January 1984, days before President Ronald Reagan's State of the Union address, in which he invited U.S. friends and allies to participate in the construction of a space station, the U.S. privately proposed to the Russians the idea of a simulated space-rescue mission involving the U.S. Space Shuttle and the Salyut-7 Space Station. Publicly and privately, the Russians were cool to the idea, perhaps because of the perceived asymmetry of a mission in which the Space Shuttle would simulate a rescue of cosmonauts from Mir. That summer and for the next two years, the U.S.S.R. also insisted on a linkage between progress in space arms control and a willingness

[5] In one instance, a U.S.-built flight instrument for the Vega mission was actually subjected to formal interagency review and approved for export to Russia on the ground that it was "not sophisticated" enough to be considered space hardware. A second instrument for the Phobos missions to Mars was on its way through a similar review process in December 1984, when the builder of the first instrument publicly proclaimed that he had outmaneuvered the Washington bureaucracy, angering the reviewing agencies and foreclosing further approvals at that time.

to consider expanded civil space cooperation, effectively precluding forward movement on the latter.

In mid-1986, however, the situation changed dramatically. In an exchange of letters between General Secretary Mikhail Gorbachev and President Reagan, Gorbachev dropped the arms-control requirement. Moscow accepted a U.S. proposal for an exploratory meeting in Moscow in September, at which U.S. and Russian delegations discussed and agreed upon a 16-item list of areas for expanded cooperation. The agreement text itself was negotiated in Washington at the end of October 1986, and in April 1987, rather than wait for a summit meeting, the two sides signed the agreement at the foreign minister level.

Glasnost and the End of the Soviet Era: 1987-1991

The 1987 agreement, which owed much of its restrictive structure and provisions to the 1970s experience, differed importantly from its predecessors by including an annex with a list of 16 approved areas for cooperation. It resurrected the JWG structure and authorized the formation of groups in space biology and medicine, solar system exploration, astronomy and astrophysics, space physics, and earth sciences. The JWGs were expected to meet at least annually. Amendments to the annex, announced at a succeeding summit in May 1988, authorized the exchange of instruments for flight on robotic spacecraft, as well as the exchange of planning data on future missions. Interagency approval was not forthcoming, however, for activity in human spaceflight going beyond research in space medicine or for higher-profile robotic cooperation in Mars exploration.

In August 1991, the United States and the U.S.S.R. achieved an important milestone with the flight of the U.S. Total Ozone Mapping Spectrometer (TOMS) on a Soviet Meteor-3 polar-orbiting meteorological satellite. More than two years elapsed between the agreement in principle and the conclusion of the U.S.-U.S.S.R. Memorandum of Understanding on the flight, a delay largely attributable to intensive U.S. interagency negotiations on technology-transfer controls. Finally, against the background of the political evolution in Eastern Europe and Russia, and given the importance of continuity in the collection of atmospheric ozone data, a compromise was reached. Shortly after the successful launch, while U.S. engineers and scientists were still in Moscow for checkout activities, the abortive anti-Gorbachev coup was launched, signaling the beginning of the end for the Soviet Union.

Current Cooperation in Space Science and Applications

The U.S.S.R.'s collapse and the emergence of separate Russian, Kazakhstani, and Ukrainian states dramatically changed the political context for space cooperation. The linkage between political interests and cooperation remains as strong as before, but the balance of forces in that linkage has changed substantially. Previously, politics provided a context for cooperation, limits on what could be done (for both political and technology-transfer-control reasons), and an occasional stimulus to pursue cooperative activities that might not otherwise have had sufficient budgetary priority (such as ASTP). Program managers constantly faced the reality that the political linkage could work to disrupt cooperative undertakings, as events in Afghanistan and Poland had during 1982-87.

Today, the U.S. desire to promote economic and political stability in Russia and to provide tangible incentives for positive Russian behavior in areas such as preventing proliferation of missile and other military technologies is a powerful engine behind cooperation. As a result, the United States has made unprecedented commitments of resources to Russia,[6] including large payments in exchange for Russian products and services, and it

[6] See "The Financial Dimension," later in this chapter.

is now willing to place Russian hardware and launch services on the critical path of keystone NASA projects, particularly the space station. Only a few years ago, the *Report of the Advisory Committee on the Future of the U.S. Space Program* opposed placing **any** foreign cooperative contribution in the critical path of U.S. projects,[7] and NASA managers had resisted allowing even such a long-time ally as Canada to play a similar role on the space station without extensive agreement provisions against default.

Recognizing the risks inherent in this situation, particularly given Russian[8] political and economic instability, NASA has sought to put arrangements in place to hedge against any Russian default on commitments. Generally speaking, in robotic space science and applications, Russian participation is not essential to specific projects, making contingency planning possible and cost-effective.

On June 17, 1992, a new civil space agreement was concluded at the first summit between President George Bush and Russian President Boris Yeltsin. Drafted and quickly agreed to in preparation for the summit, the agreement was substantially enabling and permissive rather than restrictive.[9] For the first time since 1977, it raised the prospect of cooperation in human spaceflight, including "Space Shuttle and Mir Space Station missions involving the participation of U.S. astronauts and Russian cosmonauts." For the first time, the agreement also foresaw cooperation in space technology and explicitly raised the possibility of "working together in other areas, such as the exploration of Mars."

The 1992 agreement sanctioned a very significant increase in activity across the entire range of cooperative space science and applications projects between NASA (the U.S. lead agency) and the Russian Space Agency (RSA), the Russian Academy of Sciences, and several other Russian agencies.[10]

In a joint statement accompanying the agreement, the two governments also agreed to "give consideration to" a specific exchange of astronaut-cosmonaut flight opportunities and to a Shuttle-Mir rendezvous and docking mission. Finally, the government announced that NASA would be giving a contract to a Russian enterprise, Scientific Production Organization (NPO) Energia, principally to study the potential use of the Soyuz-TM spacecraft as an interim crew-rescue vehicle for Space Station Freedom.[11]

On July 20, 1992, NASA Administrator Daniel Goldin and RSA General Director Yuri Koptev released a Memorandum of Discussion on talks held in Moscow, which elaborated on the understandings reached in June. The two agency heads also agreed to expand the JWG structure set up by the 1987 agreement by adding biomedical life-support systems to the JWG on Space Biology and Medicine and by creating a Mission to Planet Earth JWG to concentrate on earth science flight projects. They added study of a Russian-provided rendezvous and docking system to the NPO Energia contract signed in June and discussed the flight of U.S. instruments on a spare lander for the Russian Mars '94 mission.

[7] *Report of the Advisory Committee on the Future of the U.S. Space Program* (Washington, DC: U.S. Government Printing Office, December 1990), p. 8.

[8] For simplicity, "Russia" is used throughout this chapter to denote the United States' cooperative partner because the overwhelming majority of U.S. cooperative projects to date are with Russia. Where a general statement is made that does not apply as well to Ukraine, the distinction will be made clear. Where Kazakhstan is meant, it will be explicitly identified.

[9] Text of the 1992 agreement and subsequent implementing agreements are in appendix A.

[10] Summary tables describing cooperative activities approved by each of the six joint working groups and under way as of the end of 1994 are in appendix B.

[11] This role reversal from the 1984 U.S. proposal for a simulated space-rescue mission seems to have gone unremarked at the time.

Both the astronaut-cosmonaut exchange and the Mars '94 agreement were finalized on October 5, 1992, when Administrator Goldin and General Director Koptev signed agreements on human spaceflight and Mars '94 cooperation following meetings in Moscow.

Cooperation under the JWG structure has proceeded relatively smoothly since the signing of the 1992 agreement. The first Russian instrument to fly on a U.S. spacecraft, the KONUS gamma-ray-burst detector, was launched November 1, 1994, on the U.S. Wind spacecraft, part of the International Solar Terrestrial Physics (ISTP) Program. On December 16, 1994, NASA and RSA signed an agreement for the reflight of TOMS and for the flight of the third version of the Stratospheric Aerosols and Gas Experiment instrument (SAGE-III) on Russian polar-orbiting meteorological satellites. NASA views the Russian commitment to provide the launch, operations, and supporting science for SAGE, in particular, as a significant Russian contribution to the U.S. Earth Observing System (EOS) program. It was also agreed at the December meeting that Version 0 of the U.S. EOS Data and Information System (EOSDIS) will be interconnected with appropriate Russian counterparts.[12]

In 1993, the proposed cooperation on the Mars '94 mission was scaled down to the provision of a single U.S. instrument for each of the two landers, after the Russian developers of the spacecraft proved unable to accommodate a third lander on schedule; subsequently, reportedly because of budgetary, technical, and production difficulties, the Mars '94 launch slipped to 1996. At the June 1994 meeting of the U.S.-Russian Commission on Economic and Technological Cooperation (hereafter, for brevity, the Gore-Chernomyrdin Commission), the principals directed NASA and RSA to study "Mars Together," potential cooperative Mars-exploration options involving launches by each side during the 1998 and 2001 launch windows, and a concept for joint exploration of the Sun and Pluto, called "Fire and Ice." At the December 1994 Gore-Chernomyrdin meeting, the principals decided only to continue joint studies and "agreed that all such planning should take into consideration appropriate budgetary and financial constraints." [13]

The United States and Russia have continued to play key roles in the multilateral IACG, which is now occupied mainly with the ISTP Program, and Russia has joined the Committee on Earth Observation Satellites (CEOS), the most important multilateral coordinating body for Earth remote-sensing-satellite operators. Both countries are also key players in the International Mars Exploration Working Group (IMEWG).

For the most part, U.S.-Russian cooperation under the JWG structure has followed the established pattern of past NASA international cooperative projects—adherence to principles such as clean interfaces and general avoidance of technology transfers—but there has been one important departure. Even before the dissolution of the Soviet Union, U.S. officials recognized that some U.S. subsidy of Russian hard-currency expenses would be required to keep cooperation on track. More recently, NASA has found ways to provide limited injections of hard currency through writing small contracts for engineering-model hardware and services such as preparing interface-control documents. NASA program managers generally believe that cooperation is not currently possible without such stimuli, but they express a strong desire to return to the traditional, no-exchange-of-funds partnership model as soon as this is feasible.

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[12] Private correspondence from Charles Kennel, NASA Associate Administrator for Mission to Planet Earth, to Ray Williamson of OTA, Feb. 16, 1995. In his letter, Kennel also noted that NASA will pay the marginal costs for integration and test for the SAGE flight and the TOMS reflight, expected to total $5 million to $6 million.

[13] U.S.-Russian Commission on Economic and Technological Cooperation, "Joint Statement on Aeronautics and Space Cooperation," Dec. 16, 1994, pp. 2-5. See also Peter B. deSelding, "Russian Woes Hampering Mars Project," *Space News*, pp. 2, 20, Dec. 19-25, 1994.

Human Spaceflight and the International Space Station

Background

In early 1993, President Bill Clinton ordered that Space Station Freedom be redesigned to reduce construction and operating costs.[14] In response, NASA formed a redesign team, including members named by its existing partners as well as NASA and industry participants, which developed a set of three options (A, B, and C) to fit within cost profiles provided by the White House. To be able to consider potential applications for Russian hardware in the revised design, NASA quietly brought in a small team of senior Russian engineers to serve as "resources" for the redesign process, but their inputs to the first phase, in the spring of 1993, were very limited.

In June 1993, President Clinton selected Option A (a scaled-down modular space station) with some elements of Option B (the design closest to Space Station Freedom), and he allowed three months for NASA's "transition team" to create a new, merged design. Again, the existing partners were involved directly in the redesign process, and an enlarged team of Russian "consultants" was much more actively involved than it was in the spring. On the diplomatic front, a series of contacts between NASA and RSA over the summer of 1993, and between the two governments, led to a White House announcement at the end of the first meeting of the Gore-Chernomyrdin Commission on September 2, 1993, that Russia and the United States foresaw Russia joining the space station partnership.[15] As an essential part of the package, the United States committed to pay $400 million over four years for Russian space hardware, services, and data in support of the joint spaceflight program leading to the development of the International Space Station.

On November 1, NASA and RSA agreed on an addendum to the September 7, 1993, Space Station Program Implementation Plan. The program set out in the addendum is organized into three phases. Phase One (1994-97) is fundamentally an expansion of the program agreed to in the Human Spaceflight Agreement of October 1992 into a program of seven to 10 shuttle flights to Mir[16] (see figure 3-3 and photo on page 51), as well as five medium- to long-duration flights on Mir by U.S. astronauts. Phase Two (1997-98) involves U.S., Russian, and Canadian elements and achieves the ability to support three people in 1998 with the delivery of the Soyuz-TM crew-rescue vehicle (see photo on page 52). Phase Three (1998-2002) completes assembly of the station, including European and Japanese components (see photo on page 53 and figure 3-4).[17]

In December 1993, a formal invitation to participate in the space station project was issued by the existing partnership and accepted by the Russians. Also in December, at the second meeting of the Gore-Chernomyrdin Commission, the Human Spaceflight Agreement was amended to provide for the full Phase One program, and an initial letter contract was signed to begin implementation of the $400 million commitment.

Since that time, a series of negotiations with the Russians and the existing space station partners has produced significant progress toward a new set of agreements governing the partnership. In June 1994, at the third session of the Gore-Chernomyrdin Commission, NASA Administrator

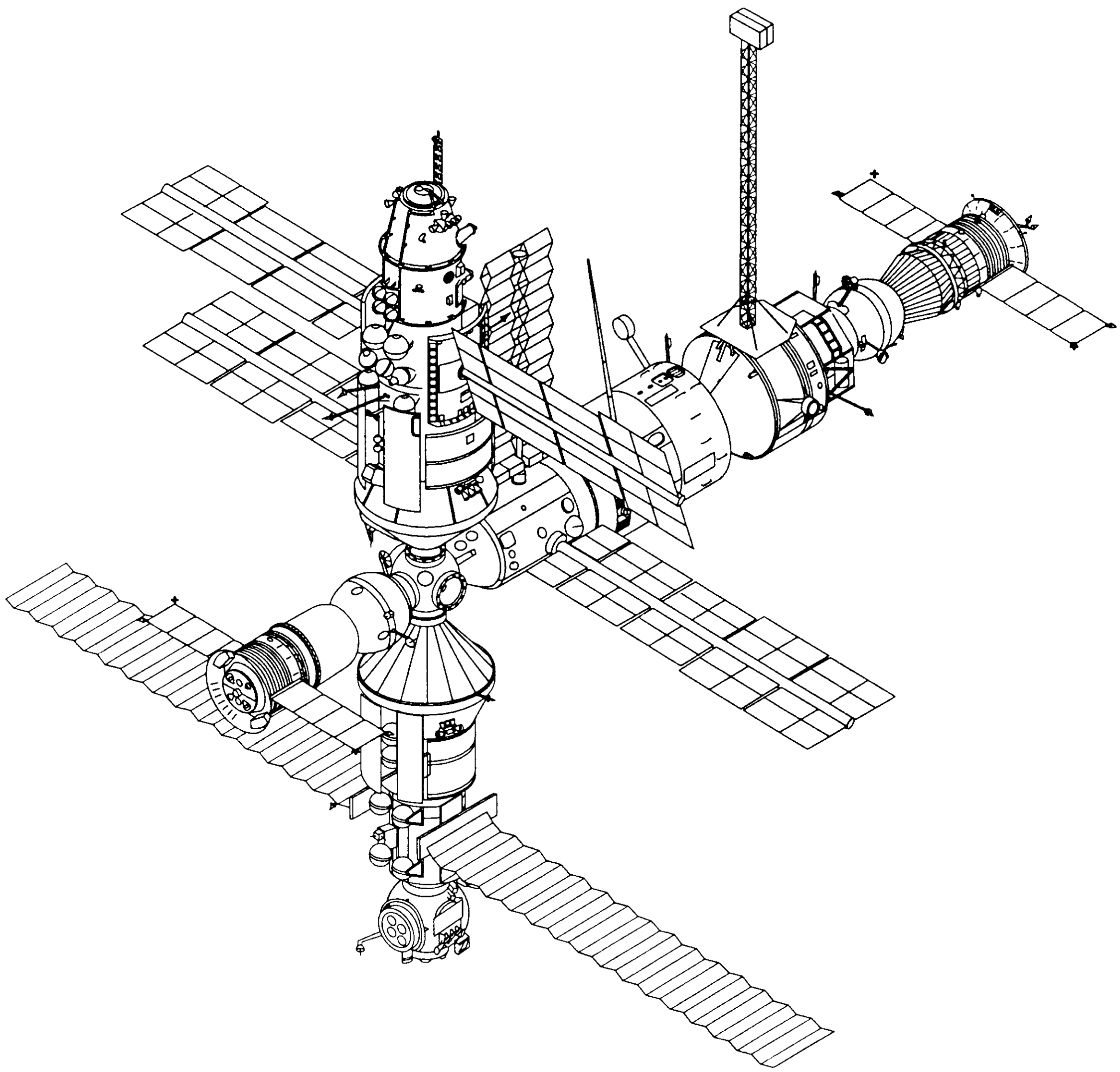
[14] For a detailed discussion of the evolution of the current design and Russian participation, see Marcia S. Smith, "Space Stations," Congressional Research Service Issue Briefs, Washington, DC, October 1994 (updated regularly).

[15] Formally, the two governments agreed only on the joint development of a program plan that would be the basis of a U.S. government decision and consultations with the other space station partners.

[16] Shuttle flight STS-60 in February 1994, involving the flight of cosmonaut Sergei Krikalev on a Space Shuttle mission, is formally also considered part of the Phase One program.

[17] The latest published manifest, dated Nov. 30, 1994, shows a total of 44 flights in the four-year construction period, of which 27 are to be Space Shuttle flights. Those totals do not include flights to rotate crews at the station or to resupply fuel and other consumables.

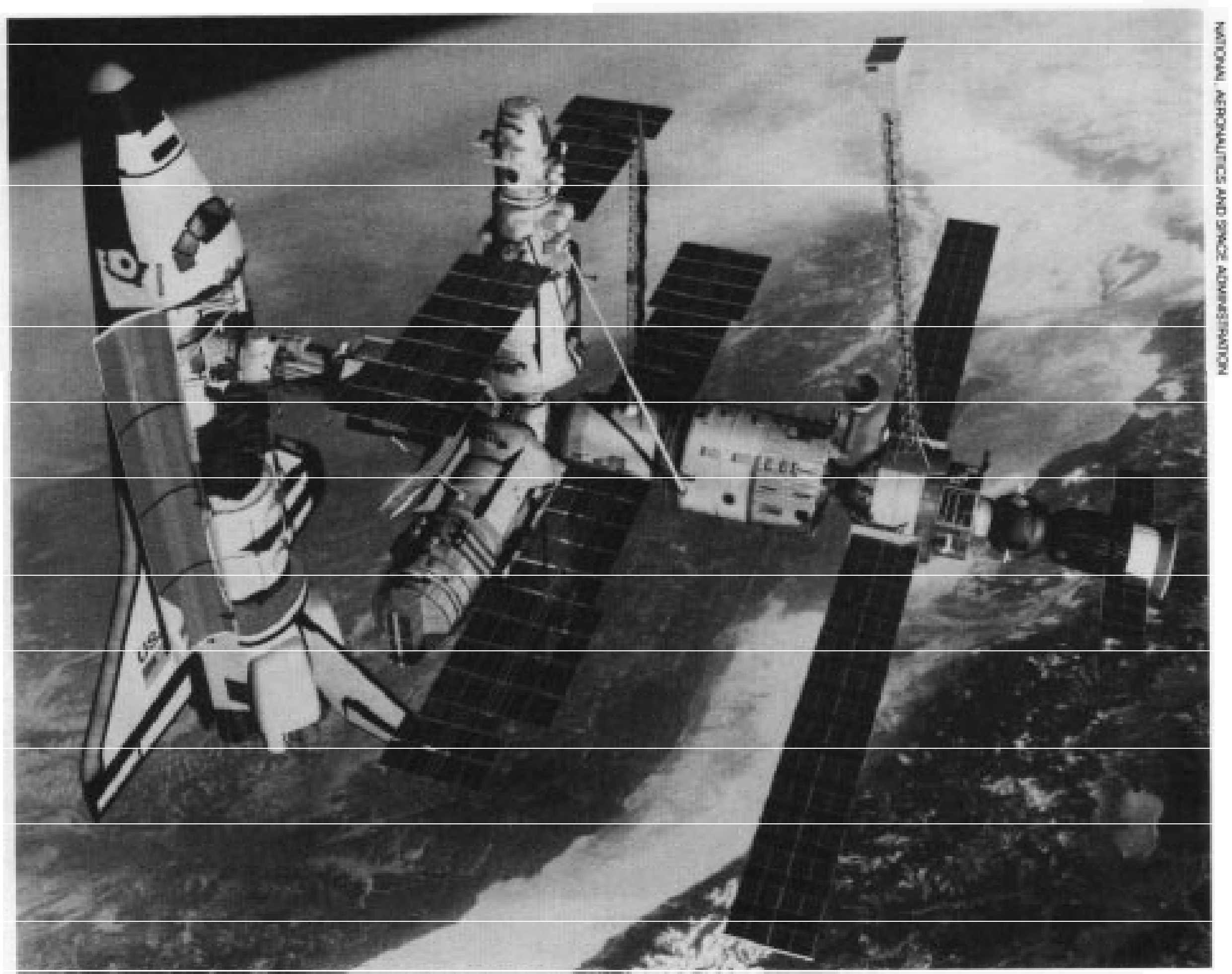
FIGURE 3-3: Mir Complex with Docked Progress-M and Soyuz-TM Spacecraft



SOURCE: David S.F. Portree, *Mir Hardware Heritage,* Houston, TX, 1994

Goldin and RSA Director General Koptev signed an Interim Agreement covering initial Russian participation in the space station. The actual $400 million, fixed-price contract was also signed at that meeting. Negotiations are under way on a Memorandum of Understanding with Russia, on amending the existing Memoranda of Understanding with the other partners, and, in parallel, on amending the multilateral Intergovernmental Agreement to include the Russians and to bring it into conformity with the underlying bilateral agreements.

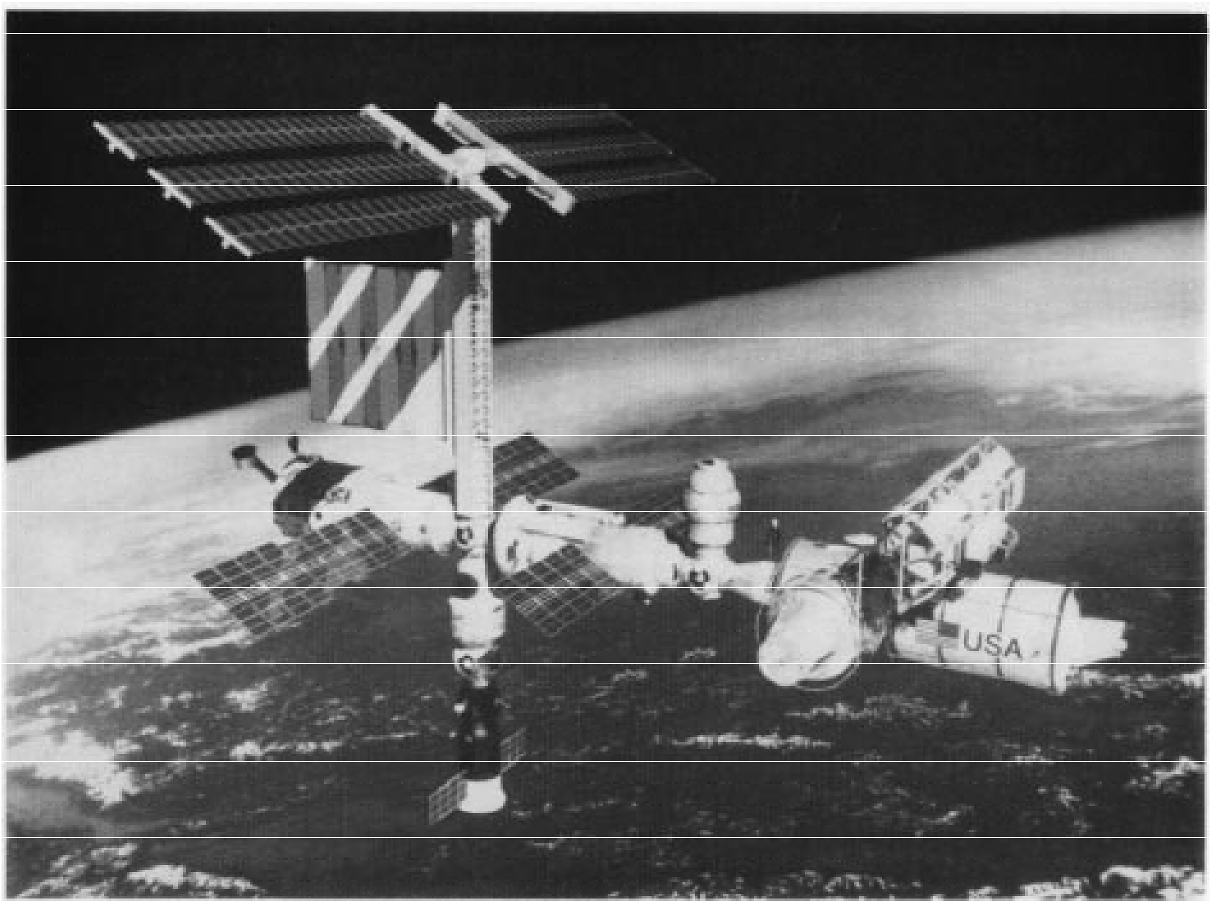
The original agreement structure stated that each partner would receive rights to use the space station proportionate to its contributions to the station, that each would pay the costs of its own assembly and logistics flights, and that the common operations costs would be shared among the



Artist's conception of U.S. Space Shuttle docked with Mir.

partners in proportion to each partner's contribution. The agreements envisioned that there would be a significant net flow of resources to the United States during the utilization and operations phase, which might be accomplished either through cash transfers or (preferably for the partners) through provision of goods or services. However, the very large Russian role in the station now includes elements formerly reserved for the United States (notably, provision of core systems and of transportation services during the assembly phase). ESA and Japan may become transportation providers as well. Negotiating allocations of space station resources and contributions to common operations costs is a challenging task; NASA hopes to complete the necessary negotiations and renegotiations during 1995.

Meanwhile, a series of milestones has been reached successfully in the development of the revised program. In particular, NASA and RSA reached technical and management agreements during August-September 1994, including a joint management protocol and an agreed specification document for the Russian segment of the space station. The first major shipments of equipment for use by U.S. astronauts on Mir were made in the September-December period, and the first top-level Joint Program Review was carried out in Moscow during November, confirming program milestones for 1995 and beyond. Rockwell In-

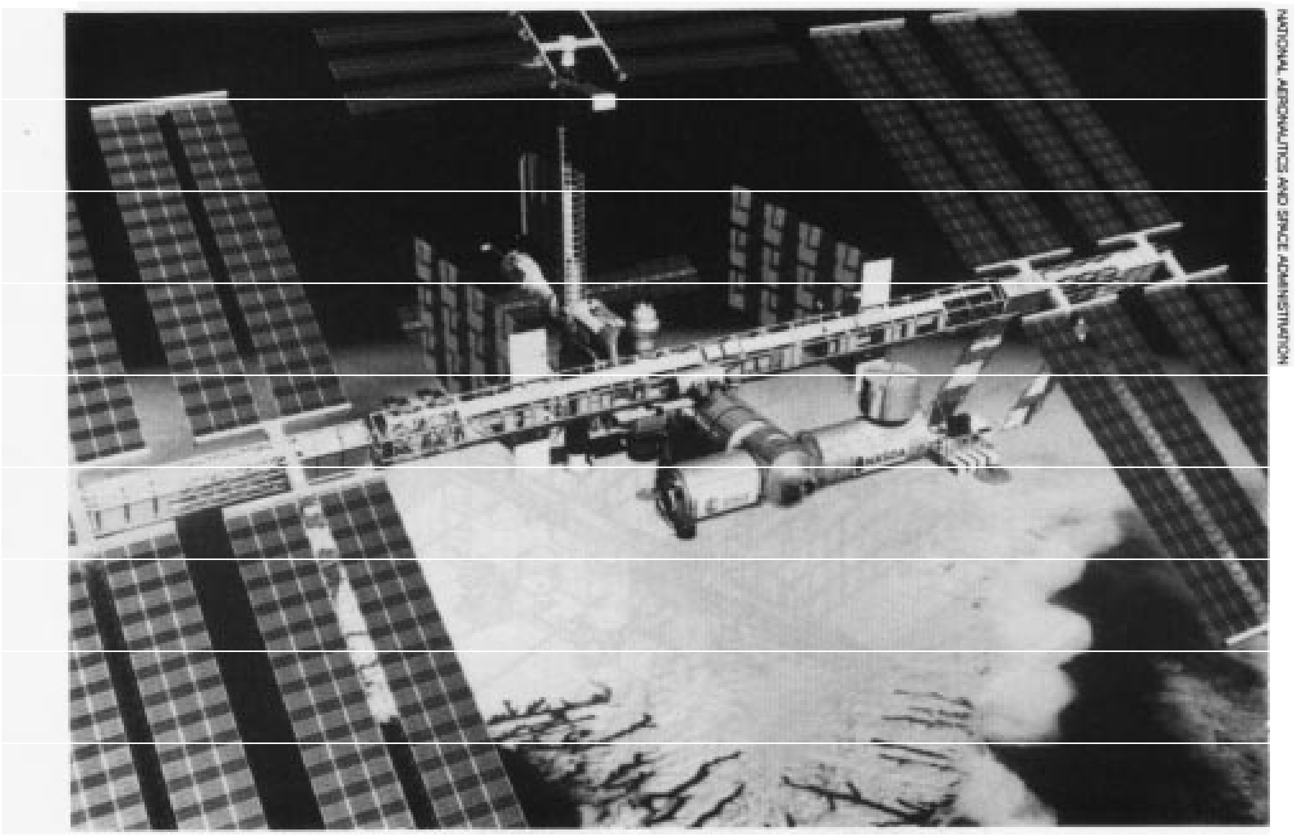


Artist's conception of Phase Two of the Intemational Space Station,

ternational delivered the Space-Shuttle-to-Mir docking mechanism, incorporating key components from RSC Energia, to the Kennedy Space Center in Cape Canaveral, Florida, in November 1994. The Shuttle-Mir rendezvous and close-approach mission was successfully completed in February 1995, a key dress rehearsal for the docking missions to come. Finally, in mid-February, Lockheed, Khrunichev, NASA, and RSA successfully concluded separate, interlocking negotiations on purchase of the Functional Cargo Block (FGB) module, which provides guidance, navigation, and control capabilities for the Phase TWO space station.

Progress has not been entirely smooth, however. Technical and organizational difficulties on the Russian side have been largely responsible for causing the scheduled date of the Spektr module's launch to Mir to slip from March until May 11, 1995. As a result, the frost U.S. astronaut on Mir will have use of the equipment aboard for only about two weeks, rather than two months, as first anticipated; the next long-duration U.S. flight on Mir will not occur until March 1996.[18] In addition, severe problems with Russian customs clearance for the U.S. equipment involved in the flight have required the intervention of Vice President

[18] Part of the equipment is being launched to Mir on Progress cargo spacecraft instead.



Artist's conception of Phase Three of the International Space Station.

Gore and premier Chernomyrdin; a customs agreement was signed at the December 1994 Gore-Chernomyrdin meeting.

The Financial Dimension

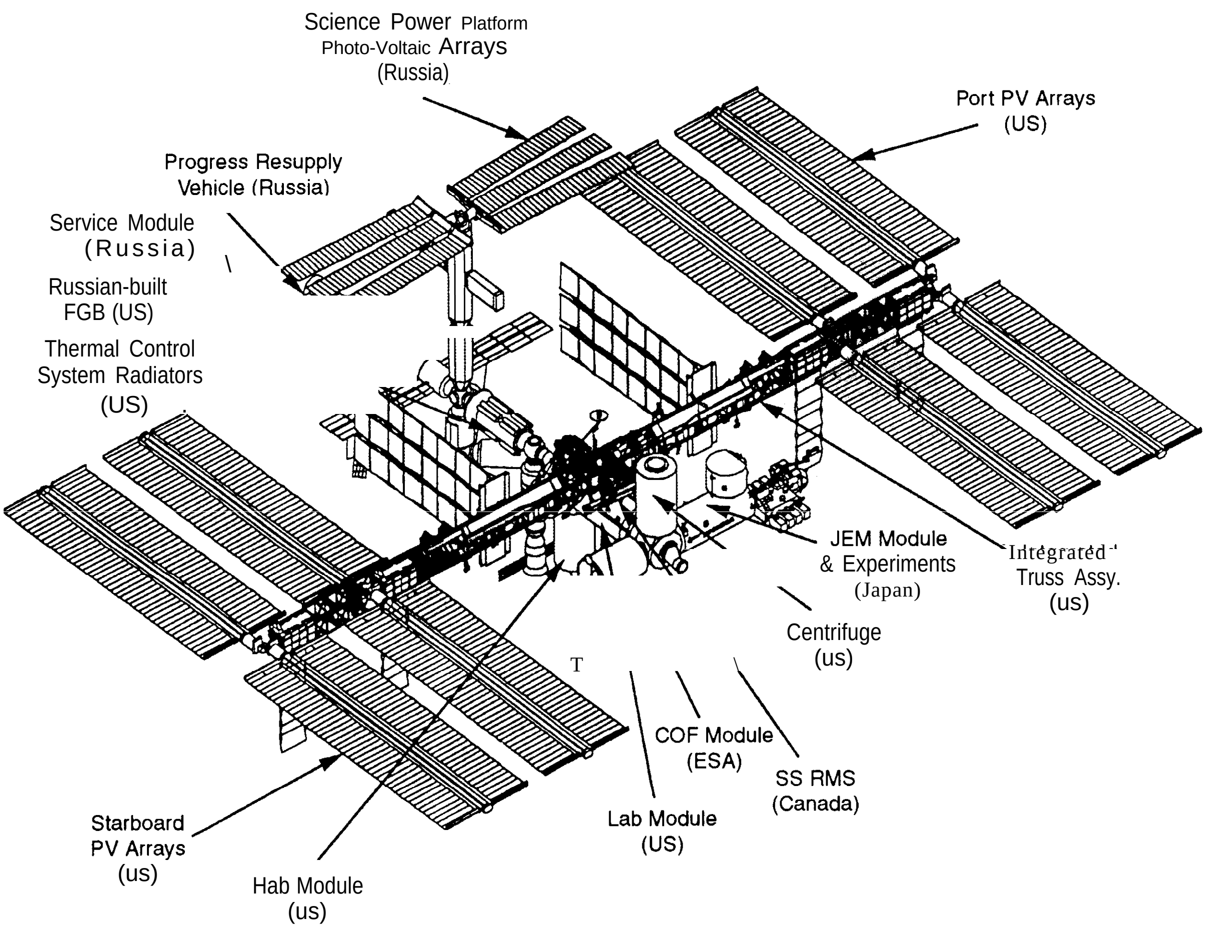
NASA has historically conducted international cooperation on a no-exchange-of-funds basis. Since 1992, however, foreign policy and national security interests have led to a significant departure from this precedent in NASA activities with Russia. The effects of this change on NASA and on the place U, S.-Russian space cooperation occupies in the overall U.S.-Russian relationship are discussed in this section.

NASA payments to Russian entities, combined with directed procurements from Russian sources under NASA contracts with U.S. industry, will likely total nearly $650 million over the FY 1993-97 period:

- $400 million for space-station-related goods and services,[19]
- at least $210 million for the initial docking-mechanism purchase and the FGB procurements,
- $16 million for two Bion biosatellite flights, and
- at least $10 million in smaller procurements of goods and services.

[19] This comprises $335 million for Phase One Shuttle-Mir activities and $65 million for Phase Two, plus procurement of all Russian-provided docking mechanisms after the first one. As of March 1, 1995, only $62.5 million had been disbursed from the $100 million available in FY 1994; disbursements are made as deliveries of goods or services are received.

FIGURE 3-4: Schematic Drawing of the International Space Station



SOURCE National Aeronautics and Space Administration, 1994

These payments do not constitute **assistance** from NASA to RSA or to Russian space enterprises. The $400 million NASA-RSA contract covers at least seven Shuttle-Mir rendezvous and docking missions and up to 21 months of U.S. astronaut presence on Mir. NASA expects to gain fundamental experience in joint operations, including risk reduction, command and control, docking the shuttle with large structures in space, performing technology experiments, and executing a joint research program. The contract amount includes $20 million in support for jointly peer-reviewed Russian scientists' proposals in all space-related disciplines and $25 million toward the cost of the FGB module being purchased by Lockheed from the Khrunichev Enterprise for use in the International Space Station. The FGB procurement by Lockheed, at a cost of $190 million, includes one unit and related services; NASA and RSA have agreed that RSA will contribute to NASA, at no cost, the FGB launch and all services not covered by the Lockheed contract, with the possible exception of some command-and-control software that may be needed.[20] The procurements of the docking mechanism, the Bion flights, and other, minor goods and services all involve the use of unique Russian capabilities by NASA at a low cost compared with the cost of developing them indigenously.

Nevertheless, no other executive branch agency is transferring funds to Russia at anything approaching this rate. U.S. government funds obligated for **assistance** to Russia through September 30, 1994, total something over $3 billion,[21] but over a third of that total is for in-kind goods (food shipments, principally in FY 1993), and significant funds that were obligated have been lost because of failure to spend them in time. Of the remainder, almost all have been paid to U.S. consultants and other entities to conduct assistance activities in Russia. Meanwhile, other non-NASA executive branch spending in Russia has been relatively minor.[22]

At the September 1993 Gore-Chernomyrdin Commission meeting, the United States committed $400 million of the NASA total payments to Russia when it agreed to involve Russia in the space station and to conclude an agreement on Russian access to the commercial space-launch market, in exchange for Russia's agreement to terminate its transfer of cryogenic-rocket-engine technology to India.

NASA funding is very important to the Russian space program. Inflation, the dramatic depreciation of the ruble, and conflicting data make it difficult to quantify this impact, but one senior RSA official said that RSA actually received R450 billion from the state treasury during 1994, about half its appropriation. Arguing for more state funding, he asserted that the total of all foreign agreements and contracts "represents just a fourth of our requirements."[23] However, at an average exchange rate of R3,000 = U.S.$1.00, the NASA/RSA contract alone yielded nearly R200 billion over that period.[24]

Aside from direct and indirect payments to Russian entities, NASA is committing significant budget resources to expenditures in the United States that are directly related to Russian cooperation. The totals stated by NASA in its FY 1996 budget submission are listed in table 3-1. Each item identified in the table is contained within broader program or project line items in the NASA budget, and some of the amounts in the table, such as the $100 million per year for "Russian Space Agency Contract," are included in the discussion of transfers to Russia above. In addition, the space station expenditures shown are

[20] Interview with Lynn F. H. Cline, Director, Human Space Flight Division, Office of External Relations, NASA Headquarters, Feb. 14, 1995.

[21] Office of the Coordinator for U.S. Assistance to the Newly Independent States, Department of State, "Cumulative Obligations of Major NIS Assistance Programs by Country to 9/30/94." See also U.S. Congress, Office of Technology Assessment, *Proliferation and the Former Soviet Union*, OTA-ISS-605 (Washington, DC: U.S. Government Printing Office, September 1994) for a discussion of nonproliferation-related U.S. spending programs involving Russia. This discussion includes Department of Defense funding under the Cooperative Threat Reduction Program.

[22] U.S. Congress, Office of Technology Assessment, op. cit., footnote 21, p. 28. Department of Energy (DOE) joint research programs with the Russian weapons laboratories are funded at $35 million in the FY 1994 Foreign Operations Appropriations Act, while the International Science and Technology Center (established to help fund Russian military scientists and engineers in civilian work related to their former fields) is funded at $25 million total, of which very little has been disbursed.

[23] Boris Ostroumov, Deputy General Director of the Russian Space Agency, quoted in "Manned Space Program in Imminent Jeopardy," Moscow *Trud*, in Russian, Dec. 10, 1994 (translated by Foreign Broadcast Information Service).

[24] If anything, this probably understates the impact because by the end of 1994, the exchange rate was approaching R4,000 = U.S.$1.00.

TABLE 3-1: NASA Russian-Related Activities
Summary of Agency Programs and Costs with the Russian Republic
($ in millions—provided to Congress March 1995)

	FY 1995	FY 1996	FY 1997	FY 1998	FY 1999
Russian Space Agency contract	100.0	100.0	100.0		
Mir missions[a]	141.7	102.7	54.3	16.3	0.6
Space station-related developments	**20.0**	**20.0**	10.0	0.0	0.0
Space science	14.4	10.1	9.2	12.3	6.2
Earth science	3.7	3.1	3.3	3.0	3.0
Space access	2.7				
Aeronautics	11.7	3.0			
Tracking and data	2.3	1.9	2.0	2.1	2.1
TOTAL	**296.5**	**240.8**	**178.8**	**33.7**	**11.9**

[a] Includes payloads and Shuttle/Spacelab support related to Mir and Shuttle-Mir missions

[b] Does not include pending Lockheed contract costs.

SOURCE. NASA Headquarters.

subsumed within the $2.1 billion/year cap for space station spending.

PRIVATE SECTOR

U.S. private companies, for the most part, did not pursue potential business relationships in Russia or Ukraine until the demise of the Soviet Union. Since 1991, this situation has been changing, and cooperative efforts are beginning to bear fruit. In general, progress has been slow because of differences in business and technical cultures, as well as residual suspicions and restrictions left over from the Cold War.

Early Entrepreneurs and Glavkosmos: Before 1991

During the 1980s, a few small-scale entrepreneurial companies and individuals sought to open the U.S. market to Soviet launch services and remote-sensing imagery, with little success. Meanwhile, the Soviets formed Glavkosmos in 1985 as a marketing arm of their then-invisible Ministry of General Machine Building. Even earlier, there had been an abortive Soviet effort to commercialize the Proton launch vehicle, including requests that INTELSAT and INMARSAT, two international communications satellite operators, consider it as a candidate launch vehicle for their upcoming satellites. In this and subsequent efforts to qualify as a launch supplier for INTELSAT, however, Glavkosmos was unsuccessful.[25] Otherwise, little of consequence occurred during the late 1980s; one American firm successfully arranged for the flight of a small microgravity payload on the Mir Space Station in 1989, precipitating a brief but heated U.S. interagency dispute over whether the export of the experiment hardware had been properly approved.[26]

Several factors acted to limit the potential for private sector space business with the Soviet Union. First, Soviet secrecy about space-industry facilities and capabilities discouraged most companies from pursuing business ties; Glavkosmos

[25] After the collapse of the Soviet Union, Glavkosmos was reconstituted as a “private” company marketing space and other high-technology products and services. Although it continues to operate, the firm is not known to be involved in any of the major cooperative ventures currently under way.

[26] Another small payload was flown in 1992 without controversy.

was too obviously a front organization, and its officials were too abrasive and inexperienced in business. More important, all exports of space hardware and related technical data were controlled by the U.S. State Department under the International Traffic in Arms Regulations (ITAR). These regulations identified the Soviet Union and other Warsaw Pact countries as proscribed destinations, meaning that requests to export ITAR-controlled items to them were automatically denied unless a waiver of the proscription was approved at a high level in the Department of State, with the concurrence of other concerned agencies, most notably the Department of Defense (DOD).[27] Finally, most U.S. firms in a position to do business in Soviet space goods and services were heavily dependent on contracts with NASA and DOD; in the absence of clear, positive signals from these important clients, most firms chose not to pursue business ties in the Soviet Union.

Learning to Work Together: U.S. and Russian Industry

In the period following the breakup of the Soviet Union, the changed policy environment and the opening of Russian and Ukrainian enterprises to business contacts with the West resulted in a flood of Western aerospace business people to those countries. Initially, at least, some had hopes of acquiring space technology at "fire-sale" prices. Many went with authority only to visit, assess, and report back. The visitors found the Russian and Ukrainian aerospace sectors beginning slowly and painfully to abandon generations of secrecy and to learn Western business methods, while also confronting the devastating economic effects of dramatically reduced state contracts, hyperinflation, and a widespread breakdown of supplier and customer networks.

The Strategic Defense Initiative Organization (SDIO) actually initiated the first major "private sector" imports of Russian space technology beginning in late 1990, when it sought to import Topaz 2 space nuclear-reactor hardware and "Hall Effect" spacecraft thrusters (used for attitude control and station-keeping, or keeping the satellite in its proper orbit). SDIO used private firms as its purchasing agents for these procurements. Approval of these proposals by the U.S. government in March 1991, together with the decision to permit INMARSAT to negotiate with Russia for the Proton launch of a single INMARSAT satellite, signaled a significant shift in the U.S. government's attitude toward space trade with Russia.

Progress in developing business relationships has been slow, in most instances, and the Office of Technology Assessment (OTA) has not found any U.S. space enterprise that has yet shown a profit from its Russian activities. According to press reports and interviews conducted by OTA staff, the slow pace is attributable to factors on both sides. After the initial wave of U.S. "tire-kicking" visits, many Russian organizations felt that further contacts without tangible return were useless and began to reject further discussions unless the visitors could demonstrate, in advance, that they were prepared to invest substantial hard currency in the relationship. For their part, the Americans (and other Western businesspeople, as well) found the Russians often unwilling to provide financial and technical information that would have been a routine part of such exploratory exchanges in the West.[28] Even when business interest has been established and negotiations have begun, there have been serious conceptual and communications problems. Regulatory, legal, and bureaucratic obstacles on both sides disrupted schedules and strained relationships. Cultural differences, false

[27] Russia and the newly independent states continue to be proscribed destinations on the ITAR today.

[28] In part, this apparently reflected simple Russian inexperience; there also appear to have been significant residual security concerns and, in some instances, personal resistance to being asked to prove technical or managerial capabilities.

preconceptions, differing negotiating styles, and simple inexperience were all further complications. And always, there was the underlying political and economic uncertainty.

Nevertheless, U.S. firms are persevering and, in several areas, are increasingly optimistic about their prospects for the future.[29] The most promising prospects appear to be:

- *Marketing Russian and Ukrainian launch services, either from Russia or through innovative arrangements for launch elsewhere.* Lockheed is the firm most deeply involved, through the LKE International (Lockheed-Khrunichev-Energia) joint venture, but several others, including Boeing, are attempting to develop prospects involving Ukrainian launch vehicles and a variety of converted Russian missiles.[30]
- *Introducing Russian launch-vehicle and propulsion technology into U.S. systems through purchase and/or co-production arrangements.* Aerojet and Pratt and Whitney have each announced activities aimed at replacing the engines of existing U.S. launch vehicles; in addition it was announced at the Gore-Chernomyrdin Commission meeting in June 1994 that Pratt and Whitney would be working with NASA to explore the possible application of tri-propellant-rocket-engine technology developed by NPO Energomash, which might have application in future single-stage-to-orbit launch vehicles.
- *Marketing Russian remote-sensing-data products and services.* Firms including EOSAT, Worldmap International, and Core Technologies have announced the availability of Russian optical imagery with spatial resolution as good as 2 meters, as well as radar data from the Almaz satellites.
- *Using joint-venture efforts to apply Russian materials science and other underlying technologies to U.S. aerospace products.* Kaiser Aerospace and Electronics and McDonnell Douglas are among the firms pursuing these possibilities.
- *Using in situ Russian human resources in fields where their capabilities are well-known*. McDonnell Douglas, for example, has established joint research centers in Moscow and Huntington Beach, California, with the Mechanical Engineering Research Institute of the Russian Academy of Sciences, and it is pursuing a variety of technology and software development efforts.

Lessons

Cooperation to date in both the public and private sectors (including the experience of the Soviet period, although much more has been possible since 1991) has yielded a rich mix of lessons for the U.S. participants. OTA sought to collect and evaluate these lessons both through its November 9, 1994, workshop and through many interviews with people participating in cooperative activities. The following are the most broadly applicable principles that were identified by public and private sector managers:

1. *Although the payoffs can be great, and in some instances can only be gained through cooperation with Russia, cooperative activities with Russia are more difficult, take longer, and are, at this stage, riskier than is governmental cooperation with NASA's traditional partners or cooperation between U.S. companies and aerospace firms in Europe, Japan, and Canada.* In some respects, the situation is comparable to the early stages of those established

[29] A table listing representative private sector undertakings that have been reported in the press is in appendix C. Of course, important contacts are probably under way that have not been publicized.

[30] Daimler-Benz Aerospace of Germany and the Khrunichev Enterprise have recently announced a joint venture to market the Rockot space-launch vehicle, which is derived from the SS-19 intercontinental ballistic missile (ICBM) and can deliver small to medium-sized payloads to low Earth orbit (see Peter B. deSelding, "Rockot Launcher to Go Commercial," *Space News*, pp. 3, 6, Feb. 20-26, 1995).

relationships, but with a difference: the United States largely inculcated its space standards and practices in Western countries by virtue of its unchallenged leadership position during the 1960s and 1970s, but the Russian space infrastructure is already well-established and likely to resist changing its practices to conform to U.S. norms.

2. *There are wide linguistic, cultural, and societal differences between Russians and Americans, differences that are reinforced by the history of the past 75 years and the enforced separation of the U.S. and Russian space communities since the beginning of the Space Age. At the same time, technical people of the two sides tend to share an approach to the solution of problems in space technology and have a substantial body of common interest and mutual respect in space science.* Several consensus lessons follow from these basic observations:

   - Whenever possible, understandings should be documented in detail, in writing, to avoid ambiguity. To remove as many misunderstandings as possible at the outset, it is very worthwhile to develop texts of important documents in both languages and to compare them formally and recognize both as equally authoritative.
   - As one OTA workshop participant observed, Russia lacks settled legal frameworks for most business relationships, which are taken for granted in the West. As a result, it is important explicitly to define terms and establish agreement on the substance of contractual relationships, and not merely acceptance of language. Several workshop participants emphasized that Russian negotiators are quite willing to undo understandings reached earlier in order to exploit political and time pressures to achieve their objectives.
   - It is important to establish direct, open relationships and mutual respect based on technical competence. Russian society places great weight on personal relationships in business, particularly in the absence of established institutional structures for these new cooperative ventures. In addition, some U.S. participants believe that U.S. cooperation with Russia in space science has been more successful than ESA's or France's because, they say, Russian space officials recognize the United States as an approximate equal, while they regard other countries' space programs as inferior.
   - Russian officials are extremely sensitive to any implication of condescension from the West, regardless of their currently weak economic position.[31]

3. *Even during the Soviet period, with plentiful resources and relative political stability, delays were frequently encountered in first-time scientific missions and original technological developments.* Conservatism in schedules is indicated; as one participant observed, schedules with no margin for slipping deadlines increase the risk of failure.
4. *Several workshop participants believe that internal bureaucratic conflict and disorganization are an important source of delay and disappointment to both sides.* They noted that proposed projects may well involve several Russian organizations, even if only the lead agency is represented in negotiations, and that these interagency relationships are in constant flux. Reliance on the principal Russian organization to deliver the others whose cooperation is needed can be risky because so little is

[31] One participant in OTA's workshop believes that the legacy of the 1980s has adversely affected current cooperative efforts by feeding a Russian perception that the United States is not serious about cooperation and seeks to take unfair advantage of Russia's current, disadvantageous position.

known about relationships among these organizations or their leaders.[32] Workshop participants and others also complained that officials and organizations on both sides continue to apply anachronistic controls on the transfer of space hardware and technical data, rather than acting to encourage the development of normal business relationships.

TOWARD NORMALIZATION

U.S. government program managers at the OTA workshop generally agreed that the large transfers of U.S. public funds to Russia currently being undertaken by NASA should not be continued longer than necessary (for either political or economic reasons). Several emphasized the desirability of developing a cooperative relationship with Russia that is comparable to those with the other major spacefaring nations.[33] Such a relationship would restore the principle of government-to-government cooperation with no exchange of funds (including an end to directed procurements across national boundaries). The cooperative element would be balanced by a vigorous commercial relationship involving an industry-determined mix of free and open commercial competition, on a reasonably level playing field, and teaming between U.S. and Russian firms where this makes business sense to the companies involved.

[32] Of course, such problems may be exacerbated when, for example, a project with Russia involves launches from Kazakhstan; the newly signed Russian-Kazakhstani agreement on the status of Baykonur may alleviate many of these concerns, but its implementation remains to be tested.

[33] One workshop participant believes that the United States should not seek to return to the general principles that govern its other cooperative relationships but should be willing to pursue a pragmatic, case-by-case approach (including fund transfers, as needed) for as long as necessary. This participant also believes that space science cooperation with Russia is dominated by unduly rigid adherence to such principles, and he praised the space station program's approach.