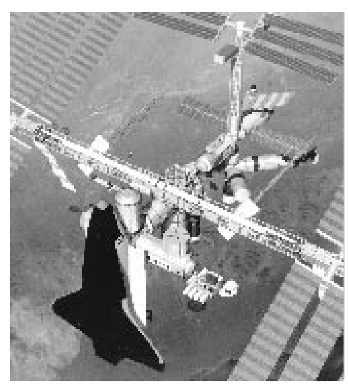
Introduction and Findings 1

INTRODUCTION

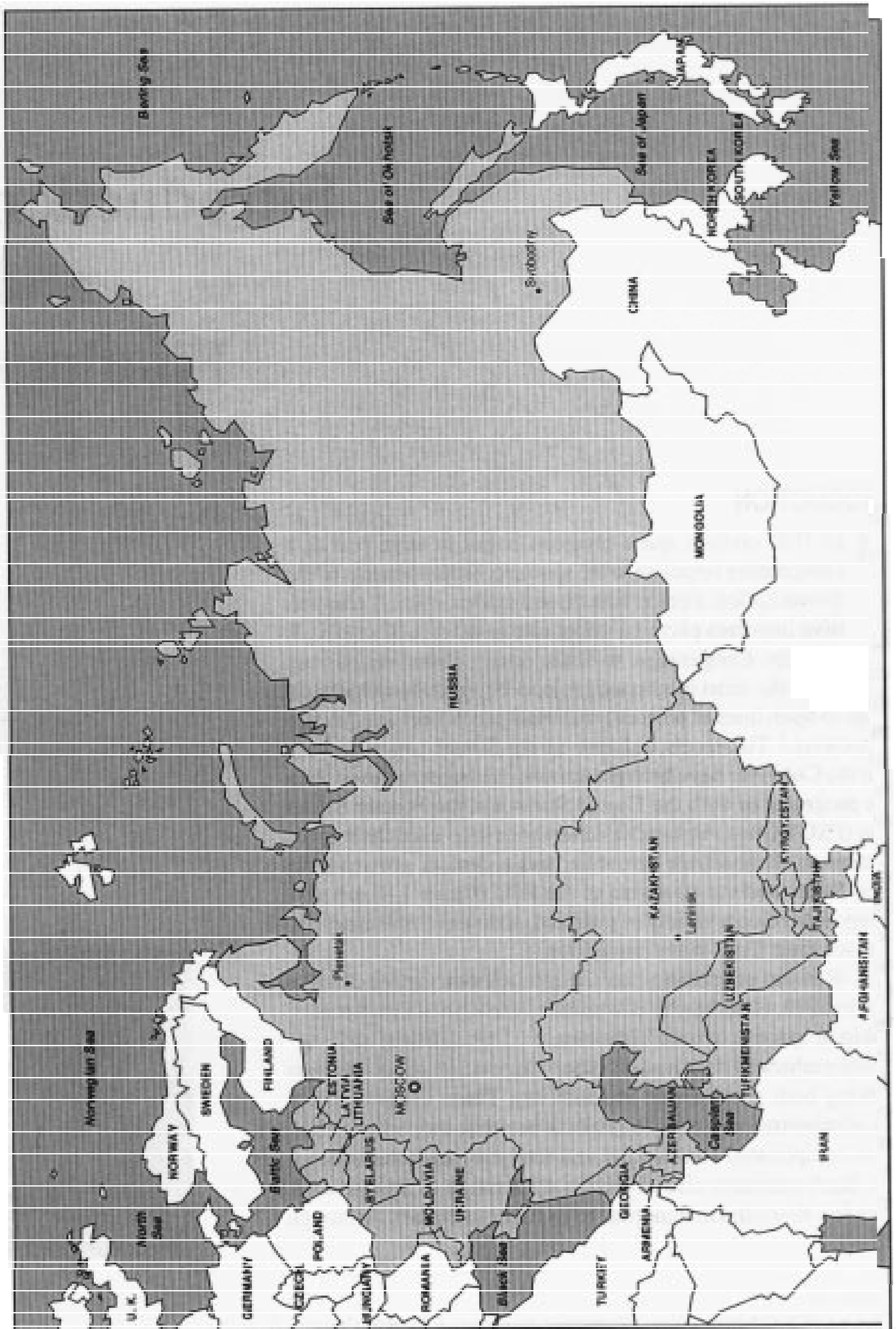
The U.S. civilian space program began in large part as a competitive response to the space accomplishments of the Soviet Union. For the first three decades, at least, competitive impulses played a major role in the direction of U.S. space activities. Cooperation with the Soviet Union was highly limited, with the most important projects being undertaken in an attempt to open lines of political communication between the two superpowers.[1] The recent collapse of the Soviet Union and the end of the Cold War have brought dramatic changes to the civilian space programs of both the United States and the Former Soviet Union (FSU). Once implacable adversaries who used their space programs to demonstrate scientific and technical prowess, the United States and the countries of the FSU (figure 1-1) are now seeking to develop a variety of political, economic, and other ties to replace their Cold War competition.

U.S.-Russian cooperation on the International Space Station, begun in 1993, is the largest and most visible sign of the new relationship in space activities. However, the United States and Russia have embarked on a host of other cooperative space projects involving both government and industry. These ventures range from administratively simple projects between individual scientists to complicated commercial and intergovernmental transactions. Such activities also involve a wide range of investments, from a few thousand to hundreds of millions of dollars. Although



[1] See, e.g., U.S. Congress, Office of Technology Assessment, *U.S.-Soviet Cooperation in Space*, OTA-TM-STI-27 (Washington, DC: U.S. Government Printing Office, July 1985).

FIGURE 1-1: Newly Independent States of the Former Soviet Union



the United States' most extensive partnerships with FSU countries are with the Russian government and Russian commercial entities, the United States and U.S. companies are exploring additional cooperative ventures with other FSU countries.

This rapid expansion of cooperative activity is taking place in the context of serious economic decline, political instability, and social disruption in Russia and the other countries of the FSU. As a result, both the potential benefits and the risks involved are considerably greater than they are in U.S. space cooperation with Europe, Japan, and other partners. This is particularly the case for the International Space Station program. By engaging the Russians as partners and purchasing related Russian space hardware and services, the United States hopes to benefit not merely from Russian technical capabilities, but from improved Russian political and economic stability and continued adherence to nonproliferation goals. At the same time, Russian failure to deliver as promised, for whatever reason, could risk the future of the program itself.

This report surveys issues related to U.S.-Russian efforts—governmental and commercial-to cooperate in civil space activities.[2] It was requested by the House Committee on Science, which asked the Office of Technology Assessment (OTA) to "undertake an initial survey of issues related to U.S.-Russian cooperation in space activities."[3] The committee also asked OTA to extend its analysis to other republics of the FSU, where applicable.

To gather data for this report, OTA convened a workshop of experts with experience in U.S.-Russian cooperative efforts in space science, space applications, space-launch services, and human spaceflight.[4] The workshop gave OTA the opportunity to explore the lessons learned in previous or ongoing U.S.-Russian cooperative programs and to discuss the implications for future cooperative efforts.

Chapter 1 presents OTA's major findings regarding U.S.-Russian cooperation. Chapter 2 summarizes the status and organization of the Russian space program and shows how it relates to programs of other FSU countries. The history and current state of U.S.-Russian cooperation are explored in chapter 3. Chapter 4 summarizes lessons learned from others who have developed major space ties with Russia and its predecessor, as well as past and potential interactions among Russia's partners and the United States. Chapter 5 examines risk management, the role of governments, and opportunities for and impediments to establishing or expanding cooperative relationships. Finally, chapter 6 examines the impacts of closer cooperation on U.S. industrial and national security concerns.

FINDINGS

FINDING 1: *The dramatic expansion of U. S.-Russian cooperation in space since 1991 has begun to return scientific, technological, political, and economic benefits to the United States. Further cooperative gains will depend on:*

- successful management of extraordinarily complex, large-scale bilateral and multilateral cooperative projects;
- progress in stabilizing Russia's political and economic institutions;
- preservation of the viability of Russian space enterprises;
- successful management of cultural and institutional differences;
- continued Russian adherence to missile-technology-proliferation controls; and

[2] This report deals only with civil space cooperation and does not address cooperative activities of the military or of the Department of Defense.

3 George E. Brown, Jr., and Robert S. Walker, House Committee on Science, Space, and Technology, letter to Roger Herdman, Director of OTA, Aug. 29, 1994.

[4] Held Nov. 9, 1994, in Washington, DC.

BOX 1-1: General Benefits of Cooperation in Space

- ***Reducing costs and sharing burdens.*** Many of the agencies involved in space share common goals and have developed overlapping programs. Facing budget constraints, these agencies are looking for ways to coordinate their programs to eliminate unnecessary duplication and to share the cost burden of projects they might otherwise do on their own.
- ***Broadening sources of know-how and expertise.*** Scientists and engineers from other countries may possess technology or know-how that would improve the chance of project success.
- ***Increasing effectiveness.*** The elimination of unnecessary duplication can also free up resources and allow individual agencies to match their resources more effectively with their plans This reallocation of resources can eliminate gaps that would occur if agency programs were not coordinated. International discussions can be valuable even if they merely help to identify such gaps, but they can be particularly useful if they lead to a division of labor that reduces those gaps.
- ***Aggregating resources for large projects.*** International cooperation can also provide the means to pay for new programs and projects that individual agencies cannot afford on their own. This has been the case in Europe, where the formation of the European Space Agency has allowed European countries to pursue much more ambitious and coherent programs than any of them could have accomplished alone.
- ***Promoting foreign policy objectives.*** Cooperation in space also serves important foreign policy objectives, as exemplified by the International Space Station program. The agreements on space cooperation reached in 1993 and 1994 by Vice President Al Gore and Russian Prime Minister Viktor Chernomyrdin have also led to significant cooperate activities in space science and Earth observations

SOURCE Off Ice of Technology Assessment, 1995

- additional progress in liberalizing U.S. and Russian laws and regulations in such areas as export control, customs, and finance.

Most knowledgeable observers conclude that international cooperation will be essential to the success of future major space plans.[5] Most large programs are too ambitious to be undertaken as unilateral efforts.[6] Multilateral projects and extensive coordination among all potential partners in a particular field are becoming increasingly common as all major space-faring nations encounter significant budget pressures yet desire to accomplish more in space (box 1-1). The emergence of Russia as a major cooperative partner for the United States and other space-faring nations offers the potential for a significant increase in the world's collective space capabilities.

U.S.-Russian cooperation in space is taking a wide variety of forms, ranging from relatively straightforward company-to-company arrangements to high-profile government-to-government cooperative agreements. Most large U.S. aerospace companies are pursuing some form of joint venture or partnership with Russian concerns. The

[5] Kenneth Pedersen, "Thoughts on International Cooperation and Interests in the Post-Cold War World," *Space Policy* 8(3): *205-220,* August 1992; George van Reeth and Kevin Madders, "Reflections on the Quest for International Cooperation," *Space Policy* 8(3): 221-232, August 1992; American Institute of Aeronautics and Astronautics (AIAA), *Conference on International Cooperation* (Kona, HI: AIAA, 1993); U.S.-CREST, *Partners in Space* (Arlington, VA: U.S.-CREST, May 1993); John M. Logsdon, "Charting a Course for Cooperation in Space," *Issues in Science and Technology,* 10(1): *65-72,* fall 1993.

[6] U.S. Congress, Office of Technology Assessment, *International Collaboration in Large Science Projects* (Washington, DC: U.S. Government Printing Office), forthcoming, Spring 1995.

National Aeronautics and Space Administration (NASA) is exploring cooperative space research and development (R&D) in virtually every area that interests its scientists and engineers. Intensified cooperation with Russia, either bilaterally or in a multilateral framework, could yield great benefit for both countries.

Cooperation between the two countries raises economic, financial, scientific, foreign policy, and national security issues. U.S. efforts to include Russian scientists and engineers in cooperative efforts derive in large part from a desire to help Russia make a successful, stable transition to democracy, develop a market economy, and reduce military production in favor of civilian manufacturing. By involving some portion of Russia's technical elite in high-technology space projects, the United States hopes to encourage highly educated professionals to stay in Russia and help develop its economy, rather than move to countries potentially hostile to the United States and its allies.[7] U.S. purchases of space-related goods and services from Russia also provide much-needed hard currency for the Russian economy. Cooperation on Earth-observation projects stems in part from a desire to involve Russia more deeply in regional and global environmental matters.

The recent broad political rapprochement between the United States and Russia has transformed the environment for cooperation on space projects. Previously, both governments limited what could be done, for political reasons and because of the desire to prevent the transfer of strategically useful technical information; conversely, efforts to ease political tensions occasionally stimulated the pursuit of cooperative activities that might not otherwise have been considered of high scientific or engineering value, such as the Apollo-Soyuz Test Project (see photo on page 10).[8] NASA program managers constantly faced the reality that the political linkage—that is, the linkage between politics and support for certain projects—could work to disrupt cooperative undertakings, as events in the Soviet Union, Afghanistan, and Poland did at the end of the 1970s and early 1980s.[9] Today, the desire to support economic and political stability in Russia and to provide tangible incentives for positive Russian behavior in areas such as nonproliferation of weapons of mass destruction and their delivery systems encourages cooperation.[10] As a result, the United States has made unprecedented commitments of resources to cooperative projects, including purchases of Russian goods and services, and has been willing to make Russian hardware and launch services major components of keystone NASA projects, particularly the International Space Station.

Technologically, Russian hardware and other capabilities have much to offer the space station and other projects. To learn more about working together and to gain early long-duration-flight experience, NASA has embarked on a two-year series of engineering and scientific experiments involving the Mir Space Station and the U.S. Space Shuttle.[11] Nevertheless, more intense cooperation entails some significant risks and liabilities. Political and economic instabilities with-

[7] 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).

[8] The Apollo-Soyuz Test Project involved an orbital rendezvous between a U.S. Apollo capsule and a Soviet Soyuz capsule. The project was planned and carried out during the early 1970s (see ch. 3 for greater detail).

[9] Human rights abuses in the Soviet Union, the Soviet invasion of Afghanistan in 1979, and the institution of martial law in Poland in 1981 occasioned a sharp cooling in the cooperative relationship.

[10] U.S. Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction*, OTA-BP-ISC-115 (Washington, DC: U.S. Government Printing Office, December 1993).

[11] This arrangement gives the United States access to long-duration-flight opportunities for the first time since the mid-1970s, when the United States launched and occupied Skylab.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Apollo-Soyuz Test Project.

in Russia constitute the greatest risks to the pursuit of cooperative activities. After investing both time and money in cooperative programs, if Russia failed for any reason to follow through, the United States could be faced with having to complete such programs on its own, cancel them, or find new partners. Companies face the risk of losing their investment of time and money if commercial agreements fail. In time, companies also risk the loss of entire programs or product lines.

Russia has undergone enormous political changes, having gone from a centralized regime under the Soviet flag to an emerging democracy in just a few years. Its newly formed democratic institutions are still quite fragile.[12] Russia is also attempting to move from a centrally planned economy to one in which market forces predominate. Such changes have imposed considerable hardship on Russia's people. Rapid political and economic improvements are impeded by the very human impulse to resist change. To solidify changes in its political and economic order, Russia must, therefore, build the legal and commercial infrastructure to support and enhance the changes. Because the political, economic, and administrative nature of Russian private and governmental institutions is changing rapidly, each cooperative agreement generally requires charting new institutional ground, adding to the uncertainties of cooperating with Russia.

Russians and Americans have strong cultural differences. Over the nearly 40 years of mutual isolation in technical matters, the two countries have also acquired different technical and managerial approaches to the development and application of space technology. Such differences can be beneficial to both sides because they add new perspectives, but they can also be barriers to increased cooperation. By contrast, the European, Japanese, and Canadian space communities have had a close relationship with their U.S. counterpart, making communication and collaboration much easier than they are between the United States and Russia. Although cooperation with Canada, Europe, and Japan has its own set of risks, cooperation with Russia is currently more difficult. Workshop participants pointed out the importance of maintaining open minds and learning more about Russian practices in order to reduce misunderstandings resulting from cultural differences. The uncertainties of cooperating with Russia (box 1-2) suggest that the U.S. government and

[12] The debate within Russia over the Russian military's recent attempts to prevent the Russian Republic of Chechnya from seceding from Russia underscores the vulnerability of these new institutions.

BOX 1-2: Uncertainties of Cooperating with Russia

- ***Technical risks.*** Despite Russia's prowess in developing and maintaining a large and capable space program, it has certain weaknesses, such as difficulty maintaining schedules on new spacecraft and components, which were evident even before the end of the Cold War. Russia will have to complete several new systems to fulfill its upcoming cooperative and contractual commitments.
- ***Unstable political institutions.*** Russian democratic institutions are in a very early stage of development, and successful maturation is far from certain. Legal and political instability is great and appears likely to remain so for some time to come.
- ***Russian military actions.*** The Russian military has undergone substantial change in the past few years and is much less stable than it was under the U.S.S.R. government. Instability in the Russian military could make the Western world much more wary about investing in Russia and could even undermine economic and political stability. For example, the war in Chechnya has drained important resources from the civilian economy and has raised concerns about human rights abuses.
- ***Economic uncertainty*** The near collapse of the Russian economy and its impact on the many enterprises essential to Russian space activity could affect Russia's ability to deliver on international commitments. Russia lacks a common, settled business and procedural framework within which to organize and regulate its new marketplace.
- ***Crime and corruption.*** The political and legal changes in Russia and lax enforcement have increased the incidence of serious crime and open corruption, thus impeding the development of normal business relationships.
- ***Cultural barriers.*** U.S. and Russian partners face a high risk of misunderstanding each other's intentions and of inadvertently creating discord in their relationships.

SOURCE. Office of Technology Assessment, 1995

U.S. companies should proceed cautiously and develop clearly defined objectives for cooperative ventures.

FINDING 2: *Intergovernmental cooperation with Russia in space science, Earth observations, and space applications is developing well for the most part, although severe Russian budgetary constraints have put some projects in jeopardy The political, technical, and administrative risks involved are somewhat higher than they are in* NASA's *traditional cooperative relationships, but U.S. program managers understand them and have planned accordingly*

Although cooperation with Russia in space has varied widely in intensity, it has a three-decade history. The United States and the Soviet Union began sharing data from weather satellites in 1966.[13] U.S. and Russian space scientists have cooperated at some level of interaction since the late 1960s.

Over the years, the United States has made some useful gains in space science and Earth observations by cooperating with Russia. For example, data acquired during the Soviet Union's Venera Venus landings of the 1970s provided U.S.

[13] The first experimantal Soviet weather observation sensors were flown in 1964. The sharing of weather-satellite data began two years later, after the launch of the Soviet Kosmos 122 satellite. (N.L. Johnson, Kaman Sciences Corporation, Colorado Springs, CO, personal communication, Feb. 6, 1995.)

BOX 1-3: Current and Future Intergovernmental Scientific and Technical Cooperation Between the United States and Russia

- ***Solar system exploration:*** proposed coordinated or joint missions to Mars, Pluto, and the neighborhood of the Sun; flight of instruments on each other's spacecraft, including Russia's Mars 96.
- ***Space physics:*** coordinated observing campaigns to study cosmic rays and the Earth's solar magnetic environment, using U.S., European, Japanese, and Russian spacecraft and ground facilities,
- ***Space biomedicine, life support, and microgravity:*** flight experiments on Mir, Spacelab, the Space Shuttle, and Russian biosatellites to support increased understanding of microgravity phenomena and factors affecting humans in space,
- ***Earth sciences and environmental modeling;*** flight of U.S. Earth Observing System instruments on Russian meteorological satellites; ground-based, aircraft, satellite, and spacecraft measurements of crustal and atmospheric phenomena and other aspects of the Earth as a system
- ***Astronomy and astrophysics:*** flight of x-ray and gamma-ray instruments on each other's spacecraft; data exchanges and coordinated research,

SOURCE: Office of Technology Assessment, 1995

planetary scientists with unique insights into chemical and physical processes in the Venusian atmosphere and on its surface. 14

As noted above, throughout the Cold War, the overall state of the relationship between the United States and the Soviet Union placed general limits on the extent of cooperation in space activities. In addition, the risk that U.S. technology might be used to further Soviet military capabilities also limited the scope and depth of such cooperation from the U.S. side. Furthermore, Soviet authorities were loath to open their facilities to westerners or to allow their scientists and engineers to travel outside the Soviet Union. Nevertheless, during the Cold War, U.S. officials viewed scientific cooperation between the United States and the Soviet Union as helping to provide important insights into the workings of the closed Soviet society. Cooperation also exposed Soviet scientists to Western economic prosperity and political ideals. Since 1991, the pace of cooperative intergovernmental science and technology programs with Russia has increased significantly (box 1-3).

Russia operates a fleet of reliable, relatively inexpensive launch vehicles. However, Russian space and earth sciences instrumentation and science spacecraft are generally not up to U.S. standards of sophistication and long-term reliability.[15] Russian strengths lie in theoretical science, materials, software development, space propulsion, and mechanical engineering. To counter their technical weaknesses, the Russians have actively sought foreign instruments for their spacecraft. Flying U.S. instruments on some Russian spacecraft continues to be an attractive way for the United States to gain additional flight opportunities at minimum cost. For example, from August 1991 until February 1995, a NASA Total Ozone Mapping Spectrometer (TOMS) delivered important data from aboard a Russian Meteor-3 polar-orbiting weather spacecraft. NASA has recently concluded an agreement with the Russian Space

[14] James W. Head III, "Scientific Interaction with the Soviet Union: The Brown Geology Experience," *Geological Sciences Newsletter,* May 1988, pp. 1-3.

[15] Russian engineers have compensated for less reliable spacecraft design by building operational spacecraft, such as their Meteor weather-monitoring satellites, in series and by launching new ones as needed. Russia's efficiency in launching payloads to Earth orbit makes this approach feasible.

Agency (RSA) to fly a Stratospheric Aerosol and Gas Experiment (SAGE) instrument and a TOMS instrument on Meteor-3M spacecraft in 1998 and 2000, respectively. At the same time, the U.S. participants in these cooperative efforts must be keenly aware of the risk that Russian agencies or enterprises may be late or unable to perform because of technical, economic, and/or political difficulties.[16] Well-developed contingency plans are, therefore, a necessity.

In the past, NASA has almost always arranged its cooperative projects so that there is no exchange of funds with the other countries or agencies involved. OTA's workshop participants believed that under normal circumstances, this practice was sound because it helps ensure balanced projects and avoids the political difficulties that could arise from sending funds abroad. Moreover, they agreed that foreign agencies that find a place in their budgets for their part of cooperative projects tend to be more fully engaged and committed partners.

Consistent with this approach, the use of Russian launch vehicles for U.S. space science and applications spacecraft is an attractive cooperative option that may permit some projects that would not be undertaken otherwise. Normally, such cooperative agreements should be made on the basis that Russia would supply the launch vehicle in return for participating in the activity and receiving access to the data returned. Nevertheless, as a short-term measure, U.S. support of some portion of the launch costs for an experiment may be appropriate—for example, to ensure the project's completion.[17]

Cooperation in space science and applications has a lower profile, and a less immediate connection to political matters, than does cooperation in human spaceflight and thus would be much more likely to survive a cooling in the political relationships between the United States and Russia. Nevertheless, the emergence of sharp policy differences between the two countries, particularly in geographical areas of intense conflict, might make all cooperative projects harder to carry out.

FINDING 3: *Because of the high cost, complexity and public visibility of projects involving human spaceflight, cooperation on such projects promises the potential for both greater benefits and higher risks than it does in space science and applications. Although Russian technical contributions to the International Space Station will result in a substantial increase in the station's planned capabilities, the potential benefit for the United States in this and other human-space flight projects lies at least as much in foreign policy as in space activities.*

Russia has more operational experience with long-duration human spaceflight than does the United States. During the 1970s and early 1980s, the Soviet space program orbited and operated six Salyut space stations. In February 1986, the U.S.S.R. launched the core module for the larger and more capable Mir Space Station, which is still

[16] For example, Russian budgetary constraints have forced the near abandonment of the "Mars Together" concept for linking the Us. and Russian programs for the exploration of Mars in a series of joint missions.

[17] To obtain much-needed technical information about the Russian Meteor-3M spacecraft for determining the feasibility of Joint missions, the United States has paid Russia about $100,000 for a set of spacecraft-interface design-and-control documents. These arrangements will help defray Russia's costs for its part of the Meteor-3 M/SAGE and Meteor-3 M/TOMS projects. The United States will also reportedly pay integration costs for the 1998 and 2000 flights, which will total around $5 million for both missions.

BOX 1-4: Technical and Operational Advantages of Cooperating with Russia on the International Space Station

- The use of Russian launch vehicles for construction and logistics, in addition to Space Shuttle and other Western vehicles, significantly improves transportation availability.
- The space station "Alpha" redesign with Russian participation will be completed 15 months earlier than the "Alpha" redesign without Russian participation (but two years later than Space Station Freedom's scheduled completion).
- The space station will have 25 percent more usable volume (if the European Columbus module is reauthorized in October 1995),
- When assembly is completed, the station will have 42,5 kilowatts more electrical power than did the "Alpha" design,
- Crew size can be Increased from four to SIX, providing additional crew time for scientific experiments and maintenance
- Portions of all international laboratory facilities will be within the zone of best microgravity conditions for research,
- An orbital inclination of 51.6° means that the space station will overfly a large portion of the Earth's surface, thus increasing opportunities for Earth observations.

SOURCES "Addendum to Program Implementation Plan, " NASA, Nov. 1, 1993, Marcia S. Smith, "Space Stations, " Congressional Research Service Issue Brief 93017, Washington, DC, October 1994 (updated periodically), Off Ice of Technology Assessment, 1995

m operation under Russian control.[18] Throughout the program, cosmonauts have extended Russia's experience in long-duration spaceflight, up to the current record of 473 days.

In December 1993, U.S. Vice President Al Gore and Russian Premier Viktor Chernomyrdin announced their governments' agreement to cooperate on the International Space Station.[19] This agreement was a highly visible sign that the United States was willing to work more closely with Russia on important science and technology programs. It was undertaken in large part to underscore the new political relationship between the two countries, in which the United States and Russia are attempting to work together on technical and political problems of mutual interest. Also in December 1993, NASA Administrator Dan Goldin and RSA Director General Yuri Koptev signed a cooperative agreement for joint Space Shuttle-Mir experiments and a letter contract committing the United States to a total of $400 million ($100 million per year for four years) for Russian goods and services related to the Shuttle-Mir program. The joint activities planned under this agreement should yield critical life sciences data and important insights into working with the Russians. Russia will make a substantial addition to the International Space Station by contributing several major components; the United States is purchasing other components (box 1-4). The United States will spend nearly $650 million in Russia over four years for the Shuttle-Mir program and other Russian space goods and services.

As noted earlier, by including the Russians in high-profile projects in space, U.S. officials hope to reduce possible proliferation of Russian military technology and assist the stabilization of Russian economic and political institutions. Successful execution of the space station agreement would also be an important symbol of the chang-

[18] Indeed, the two cosmonauts aboard Mir during the 1991 attempted coup were launched as citizens of the U.S.S.R. and returned to Earth as citizens of Russia.

[19] Al Gore and Viktor Chernomyrdin, Joint Statement, Dec. 16, 1993.

ing world order—a demonstration both of the ability of two former superpower adversaries to substitute cooperation for competition and of Russian integration into a major Western cooperative venture.

The Clinton Administration's policy of involving Russia in the International Space Station and other space projects also stems from a growing U.S. appreciation of Russian technical capabilities in developing and maintaining the support structure for humans in low Earth orbit (LEO). The series of engineering experiments beginning in 1995 involving Mir and the Space Shuttle will serve as important precursors to space station construction.

Involving the Russians in the International Space Station promises to increase program flexibility and capability. It also reduces the potential for space station failure resulting from the loss of a shuttle orbiter.[20] Russia has highly capable launch systems that can assist in building the space station and in supporting its operations and that can reduce the probability of interruptions in these activities. For example, Russia will contribute SoyUZ-TM spacecraft for crew rotation and rescue (if needed) during the 1997-2002 period (box 1-5). However, including the Russians in the space station also increases the managerial complexity of space station planning, construction, and operations.

How the United States manages the relationship with its other space station partners and Russia will also affect space station success. The 1993 U.S. decision to invite Russia to participate in the International Space Station was the latest episode in a series of trials that have strained the partnership since the signing of the initial agreements in 1988. U.S. officials angered other partners by the unilateral manner in which they invited the Russians to join the project.[21] Since then, NASA has endeavored to repair the damage its actions might have done to an effective partnership and has taken care to involve fully *all* partners in space station decisions. Although working-level cooperative activities appear to be proceeding well in the new framework, other events may place added pressure on the space station partnership. In 1994, Canada decided to reduce its space station participation significantly, and the scale and shape of the European Space Agency's (ESA's) commitment remains uncertain, pending a ministerial meeting scheduled for October 1995.

FINDING 4: *Including Russia in the International Space Station program provides technical and political benefits to the space station partners, but placing the Russian contribution in the critical path to completion also poses unprecedented programmatic and political risks.*

Russian contributions to the space station involve the development and construction of several critical elements (box 1-6). To keep space station construction on schedule and costs down, these space station elements must be delivered on time and within budget. Because successful completion of the space station is so important to NASA's future, difficulties in meeting space station cost or schedule goals will especially stress NASA's relations with Congress and the other partners. Some analysts, for example, worry that although Russian supplies of space hardware seem adequate

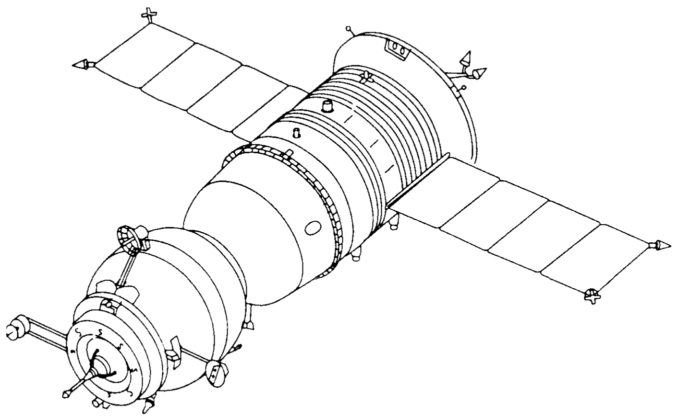
[20] As noted in an earlier OTA report, the risk of losing a shuttle orbiter during or after space station construction is Sufficiently high to raise concerns about the wisdom of using only the Space Shuttle to support the space station. The availability of Russian space-transportation systems greatly reduces the risk of a failure to complete space station construction. See U.S. Congress, Office of Technology Assessment, *Access to Space: The Future of U.S. Space Transportation Systems, OTA-ISC-415* (Washington, DC: U.S. Government Printing Office, May 1990), p. 7.

[21] According to news reports, U.S. officials initially failed to consult adequately with Canada, the European Space Agency, and Japan concerning the inclusion of Russia in the joint project. See, e.g., "Clinton Orders New Design for Space Station, ''Aviation *Week and Space Technology,* Feb. 22, 1993, pp. 20-2 1; James R. Asker, "NASA's Space Station Takes Friendly Fire," *Aviation Week and Space Technology,* Mar. 22, 1993, p. 25; and "Station Partners Blast U.S. Design, " *Aviation Week and Space Technology,* May *3, 1993,* p. *20.*

BOX 1-5: The SOYUZ-TM

The Soyuz series of crew ferries began with the Soyuz (1967-81), moved to the Soyuz-T (1979-86), and is represented today by the Soyuz-TM (1986-present). Designed and manufactured by NPO Energia (now RSC Energia), the Soyuz-TM carries a crew of two to three in its 10-cubic-meter habitable volume, Two 10.6-meter solar arrays provide electrical power during the two- to three-day trip from Earth to the Mir Space Station and connect to the space station's electrical system to provide it with an additional 1.3 kilowatts of electrical power, The Soyuz-TM is just over 7 meters long, has a gross weight of 7.07 metric tons, and is rated for flight times of up to 180 days while docked with Mir The 20 successful launches of the Soyuz-TM, in addition to the 51 launches of the Soyuz and Soyuz-T, have given the Russians unparalleled experience in automated and manual docking procedures.[1]

The SOYUZ-TM Spacecraft



SOURCE. David F. Portree, *Mir Hardware Heritage,* 1994,

Part of the Russian contribution to the International Space Station will be Soyuz-TMs to serve for crew return and crew rotation during Phase Two of the space station. The Progress-M, a vehicle designed like the Soyuz-TM but made to carry cargo only, will be used throughout all phases to bring fuel and supplies to the space station,

[1] U.S. astronaut Norman Thagard and two Russian cosmonauts, Vladimir Dezhurov and Gennadiy Strekalov, were launched toward Mir aboard a Soyuz-TM on Mar, 15, 1995, On Mar, 16, they docked automatically with Mir. Astronaut Thagard will return to Earth on the Space Shuttle, which is scheduled to dock with Mir in June 1995.

SOURCE: N.L. Johnson and D.M. Rodvold, *Europe and Asia in Space, 1991-1992,* DC-TR-219/103-1 (Colorado Springs, CO Kaman Sciences Corporation, 1993).

today, Russian enterprises might not be able to maintain an appropriate pace and quality of pro duction.[22] On the other hand, for certain items, such as launch vehicles and many launch subsystems, Russian enterprises have excess capacity, and given sufficient funding, may be able to increase their production to meet market needs.

At least one OTA workshop participant observed that Russian space enterprises have functioned extremely well in building a production series of spacecraft but have had difficulties meeting schedules with new, untried, and one-of-a-kind designs. Others expressed concern about the state of second- and third-tier equipment suppliers

[22] Judyth L. Twigg, "The Russian Space Program: What Lies Ahead?" *Space Policy* 10(1):19-31,1994.

BOX 1-6: Key Russian Elements in the Critical Path of the International Space Station

- Guidance, navigation, and control of the Phase Two station depends on the Functional Cargo Block (FGB) module, purchased from Khrunichev Enterprise by Lockheed.
- Rebooting the space station, to prevent premature reentry caused by atmospheric drag, will depend on a series of Russian Progress-M and Progress-X cargo spacecraft (the latter is an enlarged version that does not yet exist).
- Russia will be responsible for crew-return ("lifeboat") capability in the period before planned space station completion (1997-2002).
- Fuel resupply is also a Russian-only function, under current plans.

SOURCE Marcia S Smith, "Space Stations, " Congressional Research Service Issue Brief 93017, Washington, DC, October 1994 (updated periodically)

to the large enterprises and about whether those suppliers could continue to meet planned production schedules.

Other concerns relate to Russia's space infrastructure. For example, the Baikonur Cosmodrome, or launch facility, in the nation of Kazakhstan is a crucial part of Russia's contribution to the space station program; the Proton, Soyuz, and Zenit launch vehicles are launched from Baikonur. Visitors to the facility in 1994 expressed concern about its condition and about low morale among key personnel at the site.[23] Further, news reports about Leninsk, the city created to support the launch complex, have painted a grim picture of living conditions.[24] However, prospects for the long-term viability of the Baikonur Cosmodrome have improved as a result of: 1) the ratification of the Russia-Kazakhstan agreement on its use and 2) the apparent resolution of internal Russian government differences over funding its operation and maintenance. Recent visitors from NASA and Anser Corporation report that the Baikonur facilities are in good repair. In addition, LKE International's decision to invest in the modification of a payload processing facility at Baikonur demonstrate that at least one major American-Russian partnership has confidence in the long-term operation of the Cosmodrome. Finally, in 1994, Russia launched 13 Proton vehicles from Baikonur, which tied the all-time high for the number of Proton launches in a given year.

Of perhaps greatest importance to the relationship between Russia and the United States in the International Space Station effort is whether political and/or military events within Russia or between Russia and other countries will cause either the United States or Russia to amend or even cancel their space station agreement. Although few believe that a resumption of the level of hostility present during the Cold War is likely in this restructured world, a sharp cooling of the U.S.-Russian political relationship could slow or even cancel space station activity. On the other hand, the space station's high visibility in the overall political relationship and the Clinton Administration's strong commitment to the project could help insulate it from transitory political strains.

FINDING 5: *Although the emerging commercial partnerships between the United States and Russia exhibit promise in some space sectors, it is too ear/y to tell how successful these partnerships will be. Because of the higher economic and political uncertainties, commercial ventures with Russian companies carry much higher risk than those with firms in Western Europe or Japan.*

[23] *Oversight Visit: Baikonur Cosmodrome,* Chairman's Report of the Committee on Science, Space, and Technology, House of Representatives, 103d Congress, 2d Session (Washington, DC: U.S. Government Printing Office, February 1994).

[24] "Baykonur-Leninsk Difficulties Evaluated," Foreign Broadcast Information Service, FBIS-USR-94-074, July 5, 1995.

BOX 1-7: Areas of Commercial Cooperative Activities

- ***Propulsion technology*** Using Russian engines to enhance the performance of existing U.S. launch vehicles, or for potential use in future systems, such as reusable demonstration vehicles,
- ***Launch services,*** Using Russian space-launch vehicles for Western satellites,
- ***Launch-vehicle components.*** Taking advantage of Russian expertise in materials and fabrication to achieve cost and weight savings and increased reliability.
- ***Telecommunications services.*** Using Russian communication satellites to provide International services.
- ***Others.*** Remotely sensed data; underlying technologies and materials; software and analytical services.

SOURCE: Office of Technology Assessment 1995

Russian companies have much to offer U.S. companies, especially in liquid-fuel propulsion, launch vehicles, and launch services. Incorporation of Russian technologies into U.S. launch vehicles and launch operations could make U.S. launch services more competitive in the international marketplace than they are today. Russian launchers such as Proton and Soyuz are highly capable and have a strong record of launch success. Russia also has significant skills in satellite remote sensing and now markets, through several Western companies, the highest-resolution remotely sensed data[25] that are commercially available.[26] However, Russian skills in the global marketplace are just developing. The combination of Russian know-how and U.S. marketing skills can improve the international competitiveness of U.S. companies and also help Russian companies earn much-needed hard currency.

Continued progress in developing these partnerships (box 1-7) will depend in part on the speed with which Russia converts its large state enterprises into firms driven by market forces. It will also depend on the development of stable Russian laws and institutions aimed at reducing the institutional uncertainties and economic risks of such ventures. Commercial progress will also depend on developing and maintaining stable and supportive U.S. and Russian governmental policies toward these industrial partnerships.

As noted above, the Clinton Administration, with cautious encouragement from Congress, has pursued policies of greater openness with the FSU. U.S. agencies could play a significant role in easing the path of private sector cooperative agreements with Russia, but interagency conflicts and continued distrust of Russian motives impede greater progress. Despite the end of the Cold War, the dismantlement of the Coordinating Committee on Export Controls (COCOM), and the realignment of the State Department and Commerce Department's export-control responsibilities (during which many space items were removed from the State Department's U.S. Munitions List), U.S. export-control restrictions continue to increase the time and cost involved in cooperating with Russian entities in both the public and private sectors.

Although business relationships among U.S. and Russian firms have generally developed without unduly affecting either side's relations with third parties, competition in launch services may

[25] However, the highest-resolution Russian remotely sensed data are in photographic form and cannot be provided in a timely manner after acquisition, which inhibits their use in applications where timeliness or well-calibrated radiances are necessary.

[26] WorldMap International, Ltd., markets data from the Russian Resurs-F satellites that have been digitized from photographic originals; several other companies market photographic images or digital data from second-generation images obtained through Soyuzcarta, a Russian data-marketing firm.

prove an exception. The U.S. government faces growing pressure from some U.S. firms and Russia either to liberalize its launch-services agreement with Russia or abandon it altogether.[27] The latter, in particular, seems likely to provoke a strong protest from Europe, which favors an upper limit on launches for Russia.

The political and economic uncertainties in Russia should prompt U.S. companies to be cautious in pursuing partnerships with newly created Russian private companies. In addition, the changing institutional relationships within the Russian government make navigating Russian regulatory requirements a challenge to U.S. companies. Russian officials worry about the loss of economically or militarily significant technologies to the West. For most space technologies, the Russian military plays an important role in the establishment of fruitful business relationships with Russian companies. Despite the increasing power of Russian aerospace corporations to chart their own destiny, many U.S.-Russian agreements require the consent and/or the active participation of the Russian Ministry of Defense and the Military Space Forces. These parties, which may possess veto power over projects, are often not included in negotiations at the early stages.

FINDING 6: *The Russian government has made important strides in reorganizing its civilian space program to allow smoother cooperation with Western governments and commercial enterprises. Nevertheless, Russian space program faces many challenges in achieving long-term stability*

To change the way space policy is made within Russia, to separate the civilian space effort from the military, and to make cooperation with other governments and with non-Russian corporations easier, the Russian government created the Russian Space Agency in February 1992. Made up of a relatively tiny cadre of about 200 people who were part of the old Ministry of General Machine Building that once controlled all aspects of the space program, RSA reports directly to the government of Russia. It is responsible for drafting space policy and for implementing the policy once it has been ratified by the government. Funding for RSA comes through several ministries, including the Ministry of Science. RSA is responsible for space program management, budgeting, and international negotiations. The agency lacks the personnel to engage in R&D activities or detailed program oversight, and it must depend on Russian industry to carry out many of the functions that NASA's field centers perform in the United States.

Whatever the prognosis for the commercial space industry, Russian space science will likely suffer during the next few years. The Institute of Space Research (IKI) is the official body that orchestrates Russia's efforts in space science, and although IKI is a part of the Russian Academy of Sciences (RAS), it depends on the RSA for its funding. Funding for science will almost certainly take aback seat to funding for projects that are either necessary to the state or that promise to bring in Western currency. Two other organizations are involved in determining Russia's space science efforts: 1) the Interdepartmental Scientific and Technical Council on Space Research (MNTS KI), which provides peer review of proposed projects and is chaired by the head of RAS, and 2) the Interdepartmental Expert Commission, which is made up of chief designers from industry and members of other ministries and which tries to coordinate the needs of industry with those of the scientific community.

FINDING 7: *The Russian space program is suffering from the current political and economic climate in the FSU. The budget for space activities is decreasing sharply The survival of some parts of Russia's space program will depend on cooperation with other countries.*

27 The agreement, which was signed in September 1993, limits Russian commercial launches to eight between 1993 and 2000. See chapter 5, "Governments as Regulators."

The Russian space-related work force has decreased 30 to 35 percent over the past three years. A total of 200,000 workers have left the industry for more lucrative aerospace jobs elsewhere, both inside and outside Russia. Many of these workers are young people who are leaving for more promising futures in the emerging private sector. One of the largest aerospace firms, RSC Energia, used to hire 2,000 young people each year; now it hires 200. From December 1994 through February 1995, RSA argued forcefully in the Russian media and before the Duma that unless its 1995 funding request was met, the space program could collapse. Although the Duma was publicly sympathetic, there is no reason to expect that RSA will fare better in 1995 than it did in 1994, when it reportedly received approximately one-quarter of the funding it requested, and one-half of what had been allocated by the government. On the other hand, the space program has already survived what may be the worst times. Efforts at restructuring the space program and moving to a market-oriented way of doing business have ameliorated the situation and are continuing. Systems required by the government (such as reconnaissance satellites) will continue to be funded, but funds for basic research, new designs, and many commercial projects will almost certainly have to come from external sources. Despite many economic hardships, the Russian civil and military space programs continue to lead the world in annual numbers of launches and active satellites.

FINDING 8: NASA's *purchase of goods and services from Russia serves important foreign policy goals and improves the chances that Russia will be able to meet its obligations to the International Space Station. The scale of NASA funding that this requires, however, further increases the political risk faced by the International Space Station program.*

The planned payment of nearly $650 million from the NASA budget during FY 1994-97 (directly and through contractors) for Russian space goods and services represents by far the largest transfer of funds from the U.S. budget to Russian government and private organizations in that period.[28]

Symbolically, these payments are an important international signal of U.S. support for Russia's transition to a market economy. Given Russia's pride in its aerospace accomplishments, U.S. support for that sector takes on added political and psychological significance. U.S. purchases of Russian space goods and services should also help to sustain Russian adherence to the Missile Technology Control Regime, both because of the political linkage that was established when the $400 million NASA/RSA contract was announced[29] and because the funding will help preserve employment for Russian engineers and technicians in at least some major Russian space-industrial centers. By funding a significant portion of the total RSA budget and making payments to Russian enterprises that play pivotal roles in the Russian contribution to the International Space Station program (such as RSC Energia and the Khrunichev Enterprise), NASA improves the chances that Russia will be able to meet its obligations to the space station project.

On the other hand, the size of the funding requirement virtually guarantees that it will be controversial when considered by Congress, particularly in the context of efforts to reduce the U.S. budget deficit. Moreover, some observers have questioned the wisdom of supporting the Russian aerospace industry, which provided much of the technological underpinnings for the Soviet threat to the United States. However, most, if not all, of these funds would be spent in industrial subsec-

28 See chapter 3, "The Financial Dimension," for a detailed discussion of these payments.

29 The White House, "Joint Statement on Space Cooperation," from the first meeting of the U.S. Russian Joint Commission on Economic and Technological Cooperation, Washington, DC, Sept. 2, 1993.

tors that support spaceflight rather than ballistic-missile production.

FINDING 9: *The French experience in cooperating with the Soviet Union and Russia since 1966 largely parallels and confirms that of the United States.*

France and the European Space Agency have the two most significant programs of space cooperation with Russia other than the United States. The long French relationship with the FSU demonstrated an early understanding and acceptance of the importance of political motives for space cooperation.[30] French president DeGaulle's 1966 decision to begin cooperating with the Soviet Union on space projects was principally intended as an assertion of French independence within the Western alliance, but it quickly acquired significant substantive content, particularly in the space sciences. In 1982, France and the Soviet Union began a series of cooperative human-spaceflight activities, despite strains in the political relationships with Western nations caused by Soviet actions in Poland. These actions precipitated a U.S. decision, in the same year, to allow formal space ties to lapse. In contrast, the French opted to maintain cooperative ties, adjusting the scale of cooperation in response to the state of the political environment.

ESA, which is a relatively new participant in cooperating with Russia, is now spending significant amounts on several major projects. In all, ESA committed about $81 million to Russia to pay for Mir flights and other activities between November 1992 and the end of 1994. ESA has budgeted approximately $240 million to provide European-built hardware for use on Russian elements of the space station.

FINDING 10: *Although the Russian government and Russian enterprises have preserved most of the technical and managerial capabilities of the former Soviet Union, Ukraine also retains significant space assets and capabilities. Kazakhstan owns the Baikonur launch facility and several tracking and data stations. The United States may find it beneficial to form partnerships with firms and governmental entities in these countries.*

- *Kazakhstan.* Russia and Kazakhstan have concluded a long-term agreement on the support and use of the Baikonur Cosmodrome, which is a critical component in Russia's launch infrastructure. The importance of this launch complex to the launch of space station components and supplies guarantees U.S. interest in the continuation of good political relations between Russia and Kazakhstan. NASA is exploring cooperation in environmental research, space science, and telemedicine with Kazakhstan and is maintaining its own lines of communication with Kazakhstani space authorities in order to follow space developments there closely.
- *Ukraine.* Russia itself uses launch vehicles with significant Ukrainian content[31] and Ukrainian-built components extensively.[32] The United States will have to determine the appropriate balance between working directly with Ukrainian partners and developing ties through Russia. So far, the U.S. approach has been to rely on Russia to represent Ukraine in matters in-

30 See **appendix** D and U.S. Congress, Office of Technology Assessment, *U.S.-Soviet Cooperation in Space,* OTA-TM-STI-27 (Washington, DC: U.S. Government Printing Office, July 1985), ch. 4.

31 An example is the Zenit booster, for which NPO Yuzhnoye, Ukraine, is the prime contractor and for which the Russian firm NPO Energomash provides the main engines.

32 However, some Russim enterprises are cutting back their dependence on Ukranian suppliers of space goods in a government-wide effort to make the Russian space program independent of Ukraine. See Peter B. deSelding, "Russia Distances Space Program from Ukraine," Space News, Feb. 20-26, 1995, p. 3.

volving the space station partnership, while awaiting confirmation of Ukrainian adherence to the Missile Technology Control Regime (MTCR).[33] Meanwhile, NASA is seeking to advance cooperation with Ukraine in areas such as environmental research and telemedicine.

FINDING 11: *Despite the economic and political uncertainties, most early participants in cooperative ventures have found the potential gains worth the problems of pursuing cooperative projects. Participants suggest that any organization planning cooperation with Russian (or other former Soviet) organizations take several precautions to enhance the success and minimize the risks of such projects.*

- *Plan for the possibility of nonperformance.* Given the significance of the Russian contribution to the space station, the U.S. ability to make up for delays or for failure to deliver is severely limited by available U.S. resources.[34] In robotic space exploration, program managers emphasize the importance of such planning from the outset.
- *Seek a better understanding of the larger political and economic forces that could affect Russia's ability to deliver on commitments.* Some increased confidence might be obtained through further systematic analysis of Russian adaptation of their defense industry to post-Soviet conditions.
- *Maximize open and frank communication.* Minimizing technical and managerial surprises means seeking (and allowing) a high degree of communication and interpenetration between U.S. programs and their Russian counterparts, both for the space station partnership and in robotic space cooperation.
- *Be prepared for delays and reverses, and seek good advice.* Businesspeople interviewed by OTA believe that the best protection against the immaturity of Russia's legal and business systems is to obtain sound advice from Russian experts, to expect delays and reverses, and to be patient.
- *Be aware of and manage cultural differences effectively.* As noted in finding 1, cultural differences can also increase the level of project risk. To minimize these risks, U.S. entities should:
  - Sensitize all personnel who will be in contact with Russian personnel to be aware of cultural differences, learn ways to avoid affront, and build personal rapport with their Russian counterparts.
  - Resist the temptation to assume that U.S. and Russian personnel share common assumptions about the meaning of business or contractual terms and concepts; when in doubt, such terms should be spelled out. Find out who has the authority to make the needed decisions.
  - Avoid postures or assumptions of superiority, particularly in technical areas; a good rapport and mutual respect for each other's technical achievements and capabilities are critically important.
  - Make use of the best available expertise in Russian nonaerospace business law and practices, both to structure relationships properly and to avoid surprises as much as possible when political or financial circumstances change.

FINDING 12: *Experts disagree over the extent to which cooperation with the Russian government and industry on space projects would affect the retention of U.S. jobs.*

Some industry officials have expressed concern that U.S. jobs could be lost as a result of using Russian technology in the U.S. space program. Others have argued that skillful incorporation of

33 Ukraine has agreed to abide by the restrictions of the MTCR, but before being admitted to the regime, it must demonstrate its adherence to the terms of the regime.

34 The United States cannot afford to maintain Parallel developments for the Russian FGB module or the Soyuz-TM crew-return vehicle.

Russian technologies in U.S. projects could save taxpayer dollars in publicly funded programs such as the space station and could boost U.S. international competitiveness in commercial programs. Although the use of Russian technologies and know-how may cause some job shifts, and even the loss of certain technical skills, if U.S.-Russian cooperative activities are properly structured, they could improve the scope of the U.S. space program and, possibly, enhance U.S. competitiveness.

Russian launch vehicles and related systems (particularly propulsion systems) have the most obvious potential for commercial use. Russian launch experience is unmatched, and both existing hardware and underlying technological developments can fill important gaps in U.S. capabilities. On the other hand, U.S. national security interests demand that the United States maintain its national launch capability and technology base. The simple purchase of vehicles or launch services appears to be less attractive than joint ventures, co-production of vehicles and/or systems, and analogous business arrangements as ways of accommodating these differing interests.