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U.S. and Russia link manned space programs

The docking of the Space Shuttle to the Russian Mir space station marked a milestone in scientific, economic, and diplomatic relations between the two space superpowers. Marsha Freeman reports.

On June 29, as Space Shuttle Commander Robert "Hoot" Gibson and his crew maneuvered the orbiter Atlantis toward the Mir station, a page in the history of manned spaceflight was turned. Although there was a link-up between an Apollo spacecraft and a Soviet Soyuz almost exactly 20 years earlier, that singular event never developed into long-lived space collaboration. But it was an important accomplishment in the temporary era of détente between the United States and Soviet Union, and a pathfinder that laid the basis for today's success.

Throughout the 1970s and 1980s Cold War, each manned space program went its separate way. The United States concentrated on reusable space transportation by developing the Shuttle, and the Soviets, on long-duration space flights, deploying a series of Earth-orbiting space stations. The hope that following Apollo/Soyuz, joint docking flights would continue, at least to provide a rescue capability should either nation's astronauts need assistance in space, was dashed with the Soviet invasion of Afghanistan in 1979, and imposition of martial law in Poland in 1981. As a result, however, the unique capabilities developed by each manned space program are complementary to the other, and can now be combined into a more robust international effort.

For the United States, near-term cooperation with Russia on Shuttle/Mir missions will enhance NASA programs by providing access to Russia's long-duration space stations, unique technologies, and 38 years of space experience. For Russia, the infusion of more than $150 million per year from the United States, which now represents more than a third of the Russian government's funding for the Russian Space Agency, is literally keeping its space programs alive.

Longer-term cooperation with Russian participation in the U.S.-led International Space Station Alpha (ISSA) is a *political* commitment to the Russian government by the Clinton administration. While the cooperation does garner some additional U.S. congressional support for the space station, by those who, for foreign policy purposes, see the need to support these capabilities in Russia, this support is not decisive, and certainly has not stopped the budget-slashing Congress from trying to emasculate the space agency's budget.

Only false arguments have been made to justify the cooperative space program by stating that Russian participation will "save" the United States money; international programs never do. The so-called "savings" of buying Russian hardware at a cheaper cost than producing it in the United States are offset by the increased expenditures to NASA for redesigning and building new hardware, including for the Space Shuttle, to make its systems compatible with those of the Russians. But as the U.S. administration, from President Clinton on down, is well aware, without the Russian participation in ISSA, there would be no manned Russian space program once the Mir station reaches the end of its useful life over the next two years.

The recent Shuttle/Mir mission is the first in a series of seven such joint flights, and a rehearsal for the construction of International Space Station Alpha, the first element of which is scheduled to be launched by the Russians in November 1997. The commitment to this endeavor to combine two separate manned space programs is strongly supported at the highest levels in both nations, and withstood its first test of political will when the Clinton administration refused to hold the space agreements hostage to the events in Chechnya.

This in no way implies that there are not substantial risks in this joint manned space program. The risks are both techni-

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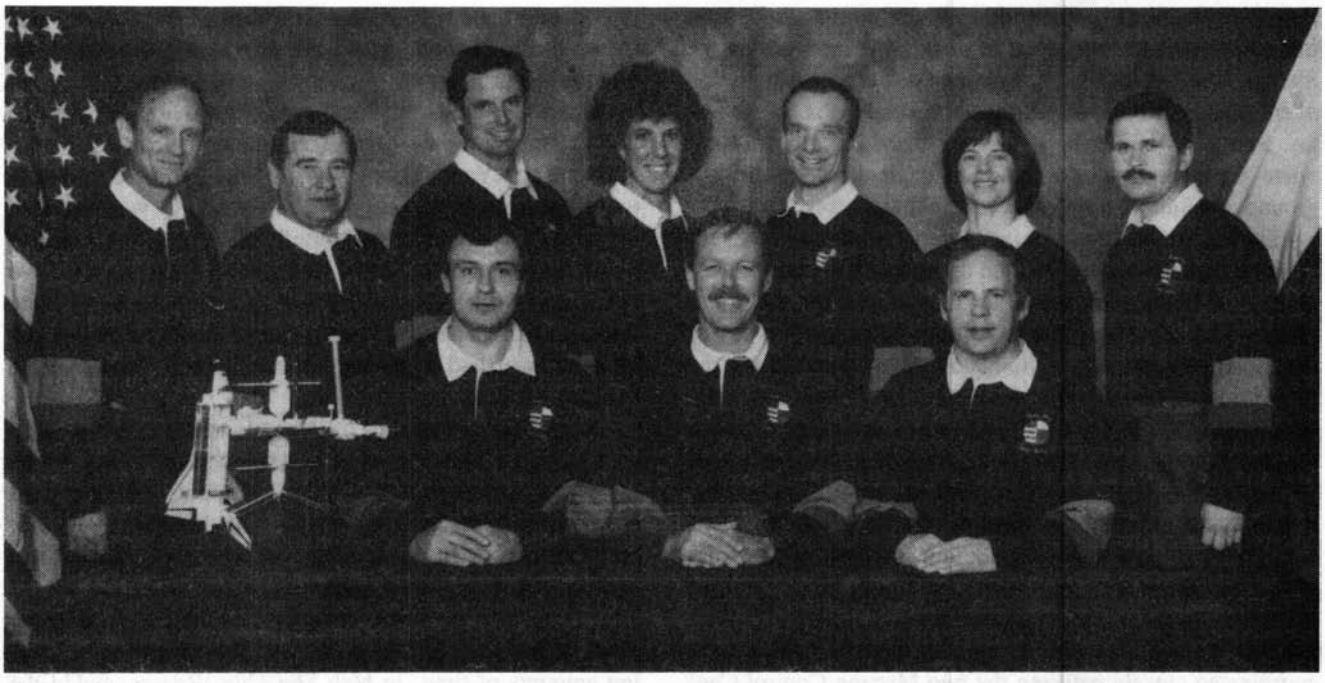


The ten astronauts and cosmonauts on the Mir 18, STS-71 Shuttle, and Mir 19 missions. For the first time in history, there were ten astronauts and cosmonauts, from three missions and two countries, in space at the same time. In the front row are the commanders, Vladimir Dezhurov (Mir 18), Robert Gibson (STS-71), and Anatoliy Solovyev (Mir 19). The back row of crew members are Norm Thagard and Gennady Strekalov (Mir 18), Gregory Harbaugh, Ellen Baker, Charles Precourt, and Bonnie Dunbar (STS-71), and Nikolai Budarin (Mir 19).

cal and political. But the alternative would be to watch the Russian space program continue its rapid decline, greatly diminishing the possibility of ever restoring technology-driven economic growth to that nation.

There are only two nations in the world that have ever put men into space. With the recent Shuttle/Mir mission, for the first time, they did that together.

A groundbreaking technological accomplishment

Bringing together two spacecraft as massive as the Shuttle orbiter and the Mir required the most delicate piloting skills. As soon as the Space Shuttle Atlantis lifted off at 3:32 p.m. on June 27, it started on its approach to the Mir station. While the Mir 18 crew on board the station reported that they were "tidying up" for the visit of the Shuttle, Commander Hoot Gibson was bringing the Atlantis within range of the Mir.

Unlike the chase by the Shuttle to catch up with the Hubble Space Telescope or other satellites with which astronauts have made rendezvous, the Shuttle took advantage of orbital mechanics to slow itself down in order to minimize firing its thrusters in proximity to the station. As a spacecraft's altitude increases, its speed decreases. At a low-Earth orbit of a couple hundred miles, it takes about 90 minutes to complete an orbit. At the 23,500 mile altitude of geosynchronous orbit, the same trip takes 24 hours. Atlantis approached the Mir from underneath, in order to avoid thruster firings in the direction of the station, which could have damaged the latter's delicate solar arrays.

The docking of these two massive vehicles was described by Shuttle pilot Charles Precourt during a pre-flight press conference as an "eight dimensional problem." The crew had to control the orbiter's own axes of rotation to keep its attitude steady, in the pitch, roll, and yaw directions. The second set of three dimensions concerned the Shuttle's position relative to the Mir—up/down, left/right, and forward/aft. In order to "soft dock" the two vehicles, the Space Shuttle had to make the final approach to Mir at a "glacial" speed of between 0.07 and 0.13 feet per second.

And the eighth constraint was time. The Russian Mission Control Center in Kaliningrad had to be able to communicate with the cosmonauts aboard the Mir station during the docking sequence to allow real-time "back-up commands" if needed, and to be able to coordinate the docking with Mission Control in Houston. The Russians can only communicate with their cosmonauts when the Mir is over one of the Russian ground stations, which, for security reasons, had only been built in the Soviet Union.

During the Shuttle/Mir mission, Russian Mission Control was able to communicate with the crew for 40 minutes out of each approximately 90-minute orbit, for the first 9 hours of their day, and hardly at all for the next 9 hours. This translated

into a 2-3 minute envelope within which Commander Gibson had to perform the sequence of docking maneuvers on the Shuttle. The United States, by contrast, uses a constellation of six geosynchronous satellites—the Tracking and Data Relay Satellites—which provide the capability to transmit voice, data, tracking information, and telemetry between the ground and Shuttle for 85% of the Shuttle's orbit.

During the five days that the two spacecraft were docked, engineers on the ground had the opportunity to compare the predictions from their computer models of how the entire stack would behave, to the real thing. After the first day of docked operations, NASA flight controllers reported that the propulsion fuel the Shuttle was expending to hold the entire stack in the attitude needed to point Mir's solar arrays toward the Sun to produce electricity, was 70% higher than projected.

Before the flight, engineers had determined the energy requirements for attitude control using models based on estimates of total mass, mass distribution, stiffness of the structure, and other variables which could only be determined accurately once the spacecraft were docked. Relatively minor adjustments, on both the Shuttle and the Mir, which were coordinated closely between the two Mission Control Centers, reduced the fuel use.

There were many firsts on this joint mission. One of the most beautiful was the sight of three bodies flying separately, but in close proximity, as the undocking sequence unfolded. Commander Gibson had said that during the training for this in the simulator, "the words 'cosmic ballet' came to mind."

Early on July 4, the Mir 19 crew, Commander Anatoly Solovyev and Flight Engineer Nikolai Budarin, left the Mir station and entered their Soyuz capsule. At 7 a.m. on July 4, the small Soyuz—which brings the cosmonauts up to the Mir, stays attached to it during their mission, and then usually returns them back to Earth—undocked from the top of the Mir. The Shuttle, still attached to the bottom of the Mir at the Kristall module, took photographs as the Soyuz slowly "floated" away from the huge complex.

At a distance of about 300 feet from the Mir, the Soyuz stopped and photographed the Atlantis as it undocked from the station. When Atlantis was about 700 feet away from Mir, it held that position. After the Soyuz had redocked to the Mir, the Shuttle began a 360° fly-around of the station, to provide the Russians with photographic documentation of the overall state of Mir after nine years in orbit.

In important ways, the flawless docking mission followed in the footsteps that had been set by Apollo/Soyuz. Many of the engineers on both sides who worked on the 1975 mission, worked on this one. The docking mechanism that was used for the Shuttle and Mir was modeled upon the one that first joined the U.S. and Soviet space programs two decades ago. And 20 years ago, when the entire Soviet space program was highly classified, Apollo/Soyuz gave American engineers their first-ever glimpse into Soviet space technology. Most important, a lasting trust and friendship developed, especially between the two commanders, Gen. Tom Stafford and Gen. Alexei Leonov, who have provided guidance to the Shuttle/Mir project.

But while preparing for the Apollo/Soyuz mission, the U.S. astronaut crew—Gen. Tom Stafford, Donald "Deke" Slayton, and Vance Brand—visited the Soviet Union only twice during more than two years. Each crew was launched on its own spacecraft, met briefly in space, and returned home. In comparison, during the Atlantis/Mir mission, two cosmonauts (the Mir 19 crew) and three astronauts were flown up on Atlantis, and two different cosmonauts (the Mir 18 crew), who had been launched on a Soyuz in March, came back on Atlantis.

Norm Thagard became the first American astronaut to fly on a foreign vehicle, when he was launched on a Soyuz with his Mir 18 colleagues in March. Therefore, a total of four cosmonauts and one astronaut (or half the 10-person combined Atlantis, Mir 18, and Mir 19 crews) will have flown on both American and Russian spacecraft when the Mir 19 crew lands in September. This required the closest working relations between the crews, who trained together, for varying amounts of time, in both Star City, Russia, and at the Johnson Space Center, in Houston.

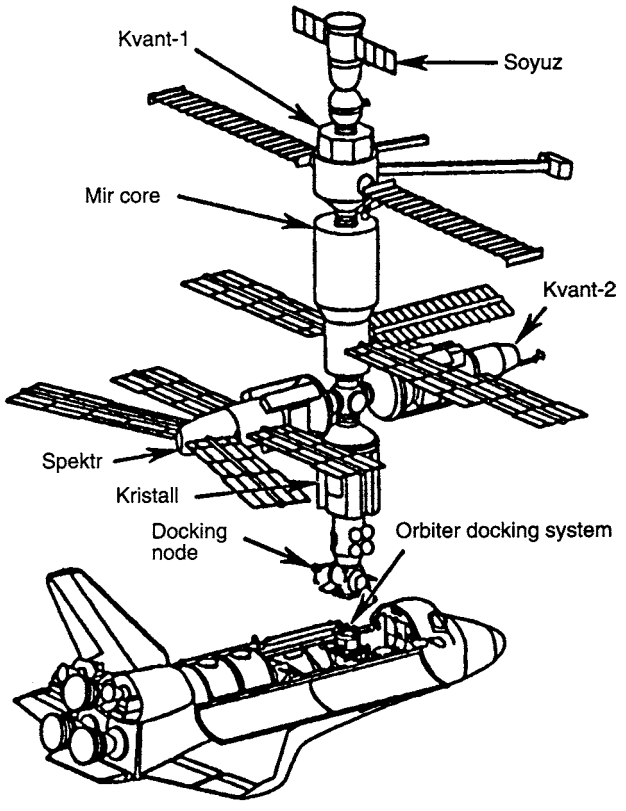
The close working relationships and camaraderie that developed among the 10 space travelers was evident during the mission. Dr. Bonnie Dunbar, who was a Mission Specialist on the Atlantis crew, had trained in Star City for a year as a back-up to Norm Thagard. The affection with which she was greeted by Mir 18 cosmonauts Vladimir Dezhurov and Gennady Strekalov, who had last seen her in Star City before their launch in March, was evident from the television coverage. After the Shuttle Atlantis landed in Florida on July 7, Commander Gibson made clear that he will not consider the mission over until all 10 astronauts and cosmonauts meet when the Mir 19 crew lands in Kazakhstan, on Sept. 9.

It 'runs like a railroad'

There would be little justifiable reason, considering the added risk and cost to the Shuttle program, to execute seven Shuttle/Mir missions unless such experience could be applied to future projects. The Shuttle/Mir program is only the first in a three-phase U.S./Russian space program, that includes building and operating International Space Station Alpha (ISSA). Although the United States has docked vehicles in space, notably during the Earth-orbit rendezvous of the Apollo missions to the Moon, there is no question that the Russians have become the experts at docking and undocking different kinds of spacecraft in orbit.

It was necessary for the Russians to develop this capability for their manned program because they do not have any vehicle near the size of the Shuttle for transporting crews and supplies to orbit. Therefore, if a crew is to stay on Mir for months at a time, supplies have to be delivered periodically. It is also useful to have an unmanned Progress cargo vehicle

FIGURE 1
The Space Shuttle Atlantis mated to the Mir space station



"visit" the Mir during long-duration flights to bring additional scientific equipment, not to mention letters from home and treats for the cosmonauts. The Progress arrives at the station, docks there automatically, and is jettisoned to be burned up in the atmosphere after it has been unloaded.

The Mir itself is currently made up of four major science modules each weighing about 20 tons (see **Figure 1**), plus the Mir core module. A Soyuz crew-return vehicle is always docked there. The confidence which the Russians have developed in their ability to move modules around to reconfigure the station when necessary, was demonstrated in the hectic activity accomplished to prepare for the Atlantis docking, to make sure the orbiter would not damage the Mir.

In the space of six weeks, the Russian cosmonauts of the Mir 18 crew performed five EVAs (Extra-Vehicular Activities, or space walks outside the station), moved the Kvant-1, Kristall, and Spektr laboratory modules to different ports, which required the repositioning of the one docking cone they have each time, moved solar arrays between modules, and tried to make repairs on bulky solar arrays. As Norm Thagard said during a press conference aboard Mir on April 12: "The Progress comes up on time, the Soyuz comes up on time. It runs like a railroad, and when you look at the budget it's operated on, that's pretty impressive."

A decade ago, when Mir was designed, it was expected to be in operation for about eight years, but economic problems prevented the Soviets from ever building Mir 2 to replace it. Over the past few years, Mir's condition has seriously deteriorated, and astronaut Norm Thagard, who spent more than 100 days aboard Mir, commented during an in-flight press conference July 3 that it "takes the considerable effort of two folks to keep Mir operating."

Nonetheless, the Russians are committed to doing just that until 1997, when International Space Station Alpha will begin construction. Just to do repairs and prepare for the next Shuttle docking mission, scheduled for October, the present Mir 19 crew will undertake a dizzying schedule of activity. There will be one EVA to try to release a solar array on the Kvant 2 module that is not properly articulating and therefore not producing its rated electrical power. The cosmonauts will also inspect a leaking side docking port. A few days later, the Kristall module will be moved to the side port. The crew will undertake an EVA to try to free a stuck solar array on the Spektr module, using tools that were fabricated at the Johnson Space Center and in Russia and brought up on the recent Atlantis flight.

On July 20, a Progress supply ship was launched and docked on the bottom port (where Kristall had been) two days later. During a third EVA in mid-August, the cosmonauts will mount scientific hardware on the outside of the Spektr and remove radiation monitoring detectors from the outside of Mir. On Sept. 1, a trio of cosmonauts including a European researcher—the Mir 20 crew—will launch, and dock their Soyuz with the Mir on Sept. 3, after the Progress ship has been jettisoned the day before. On Sept. 9 the Mir 19 crew, which traveled to the Mir on the Shuttle in June, will return to Kazakhstan.

Each national space program has its own strengths, and confidence in its own systems and technology. The Russians have accumulated a great deal of experience with orbital structures, which was evident as soon as there was a problem during the mission. At the time that the Shuttle undocked from the Mir, the space station lost attitude control and started to rotate out of position. Mission Control in Kaliningrad ordered the crew in the Soyuz spacecraft back to redock with the empty Mir five minutes earlier than planned, before its misalignment would make redocking the Soyuz a problem. When nervous engineers in Mission Control in Houston expressed their concern, Russian flight controllers assured the Americans that this had happened before on the Mir, and they knew how to fix it (which they did do).

The shoe was on the other foot during the STS-63 Shuttle mission in February, when a leaky thruster on Discovery threatened to ruin a planned close rendezvous between the orbiter and the Mir. NASA analyzed the problem and was convinced that the leak would not damage the Mir, and that

Like Norm Thagard, who spent more than three months on the Mir, Dr. Bonnie Dunbar (right) trained in Star City with the cosmonauts, as Thagard's back-up. Gennady Strekalov (hugging Dunbar) was the flight engineer on Mir 18 and was making his fifth space flight.

Commander James Wetherbee could maneuver the Shuttle even if one thruster were shut off. The nervous Russians said they would give the go-ahead for a rendezvous, but only to a distance of 400 feet. Throughout the night, engineers halfway around the world conferred, and on Feb. 6, Wetherbee got the go-ahead and brought Discovery within the planned 37 feet of the space station.

More than technical expertise or diplomatese, this joint manned space program is based on mutual respect and trust based on real accomplishment. It is in that way that the complementary capabilities in the two programs can be combined to produce the best results.

The 'meat' of the program is the science

The purpose of mastering on-orbit rendezvous and docking, EVAs, and space construction is to be able to build a world-class research laboratory, as a stepping-stone to further exploration in space. Here, the United States makes a unique contribution.

Although the Russians have operated manned space stations since the early 1970s—and on the Mir have consistently broken new ground, setting a new record of a 14-month mission earlier this year—the data they have collected on the effects of this microgravity environment on the cosmonauts have been poor, or nonexistent. There are a number of reasons for this, all of which can be eliminated by making use of U.S. capabilities.

The Russians have not developed the kind of highly sophisticated biomedical equipment that is used in the Space Shuttle program. Due to a lack of both the physical space on the station for more hardware, and of the availability of compact, high-quality equipment, the Russians have done almost no in-flight analysis of physiological changes; just pre- and post-flight analyses.

On this joint mission, the European Spacelab module was housed in the orbiter's payload bay, and outfitted for a full set of life sciences experiments. The Mir 18 crew underwent extensive testing of body functions that are known to change in microgravity, in the cardiovascular system, the skeletal and muscle systems, and the immune system. Spacelab carried, for example, a portable blood analyzer to check the astronauts' blood chemistry while still in orbit, without waiting for samples to be returned to Earth.

Space Shuttle Mission Specialists Ellen Baker (a medical doctor) and Bonnie Dunbar (a biomedical engineer) carried out invasive experiments, such as injecting the crew with pneumococcis to perturb their immune systems and see how they would respond. The long-duration Mir 18 crew members underwent tests to study how much calcium was deposited in their bones using chemical tracers, since one of the earliest and most debilitating effects of microgravity is the loss of bone calcium, which is similar to osteoporosis.

Although the crammed schedule of tests and experiments in Spacelab, especially during the five days during which the Shuttle and Mir were docked, sometimes tested the patience of the astronauts, after the Shuttle landed, mission scientist Tom Sullivan reported that they had accomplished 10% more scientific work than had been planned. A week later NASA life sciences director Dr. Arnauld Nicogossian reported that there did not seem to be any "show stoppers" for long-dura-

tion space flight.

As part of the U.S./Russian space agreements, American equipment and medical technology will be used not only when the Shuttle is visiting the station, but will be provided to upgrade the continuous scientific productivity of the Mir. The United States agreed to provide more than 1,500 pounds of equipment for the Spektr module that the Russians had built, which was scheduled to be attached to the Mir in early May. The medical equipment on Spektr was to be used by Dr. Thagard during his three-month stay on Mir and remain as a permanent addition to the station. Processing problems in readying Spektr for launch in Russia and problems in delivering the U.S. equipment, led to launch delays, which threatened the schedule for the manned flights. The Russians allocated about 30 days to launch, dock, and unload the Spektr and then to reconfigure the Mir for Atlantis. If the Spektr launch had been delayed, either Thagard's Mir 18 launch would have had to be delayed, or they would have launched the crew to Mir first, and Thagard would have had to make do without the medical equipment for most of his stay aboard Mir.

The Mir 18 launch was delayed for two weeks, but Spektr did not arrive until two months later. In the meantime, the United States included hundreds of pounds of medical and other equipment on Progress supply ships sent to Mir before Thagard arrived there on March 16. On May 20, Spektr was finally launched to the Mir, carrying over 1,000 pounds of equipment, and it docked on June 1. One of the most important items that it brought to Mir was a refrigerator to store biological samples to be returned to Earth. The Russians did not draw blood samples in the past, because they did not have refrigerators on board to store them. The Priroda science module, carrying an additional 2,000 pounds of medical equipment, is scheduled to arrive at Mir by the end of this year.

One of the most severe constraints on the Mir/Soyuz system for scientific research is the lack of room to bring back material to Earth. Unlike the Shuttle, which has a maximal 60,000 pound payload capability, the small Soyuz capsule can only bring home a few hundred pounds of payload with two cosmonauts on board. This has severely limited the biological samples—of urine, blood, and saliva, for example—that the crew can transport to Earth for analysis in laboratories. For the joint missions, the Shuttle will carry hardware up to the Mir, and return biological and other materials.

One of the complementary aspects of the two systems, concerns the most important commodity for the health of the crew—water. The Space Shuttle produces water in the process of making electricity in its fuel cells. Usually, this water is simply dumped overboard before the orbiter returns. However, on the Shuttle/Mir mission, over 1,000 pounds of water were transferred to the Mir, along with some oxygen and nitrogen in the atmosphere, which will save the Russians the need to bring it from Earth.

During the five days that the Shuttle and Mir were docked, the astronauts and cosmonauts who were not involved in the medical studies, worked tirelessly to transfer the treasure trove of over 400 pounds of biological samples and recorded data from Mir to Atlantis, which had been collected over the 110-day Mir 18 mission. The Shuttle also carried back Russian station equipment that needed repair or replacement.

Dr. Helen Lane, the principal scientific investigator for metabolic studies, explained at a briefing on July 1 that another advantage that the United States has is that the landing sites for the Shuttle (either California or Florida) are not as remote as the Russian landing site (Kazakhstan), allowing the biological samples to be gotten to laboratories in only a matter of hours.

There are rough edges that still have to be smoothed out, such as integrating the hardware from two very different space programs (the Russians use the metric system, for example, and the Americans do not), as well as integrating the crews. In addition to the most severe problem of coordination—that is, the difference in language—the differences in operational style and approach that result from the differences between long- and short-duration flights caused some irritation for the crews.

Space Shuttle astronauts, who are going to be in space for less than two weeks and have a lot to accomplish in that short time, train intensively for the mission, and practice virtually everything they will have to do. By contrast, when you are going to be aboard a space station, as the Russians have been, for six or more months, not only is it not possible to practice everything ahead of time, you would likely forget half of it before you had to do it.

The cosmonauts on Mir are accustomed to discussing their upcoming schedule with Mission Control in advance, and being briefed on any changes the night before. Mission Control in Houston generally spends the night (when the astronauts are sleeping) evaluating that day's activities, and confers with the crew first thing in the morning. The cosmonauts on the Shuttle found this procedure disorienting. In general, the cosmonauts found the schedule of activities on the Shuttle frenetic, while Thagard found the more leisurely pace of work on Mir frustrating.

These kinds of adjustments will be made throughout the remaining six Shuttle/Mir missions. One lesson learned from Thagard's stay on Mir was that it is emotionally and intellectually difficult to spend three months in close and isolated quarters with two people who do not speak one's native language, if there is not frequent contact with one's family and colleagues back home.

The first of seven Shuttle/Mir missions was a stunning success. For the United States, the purpose was to gain access to a space station five years before the American-led international one will be fully available. These missions, therefore, reduce the risks involved in assembling structures in space,

and exposing human crews to long months in microgravity, by learning more about such problems and solving them. Because the Russians will be full partners in the international station, it is important to develop the procedures, language skills, trust, and compatibility to work together in space.

The joint manned program augments the Shuttle/space station program which the United States has been pursuing with its European, Canadian, and Japanese partners. For the Russians, it has been the lifeline that has kept a portion of their advanced aerospace capabilities intact and can give them a prominent place in the space program of the future.

Preserving Russian space capabilities

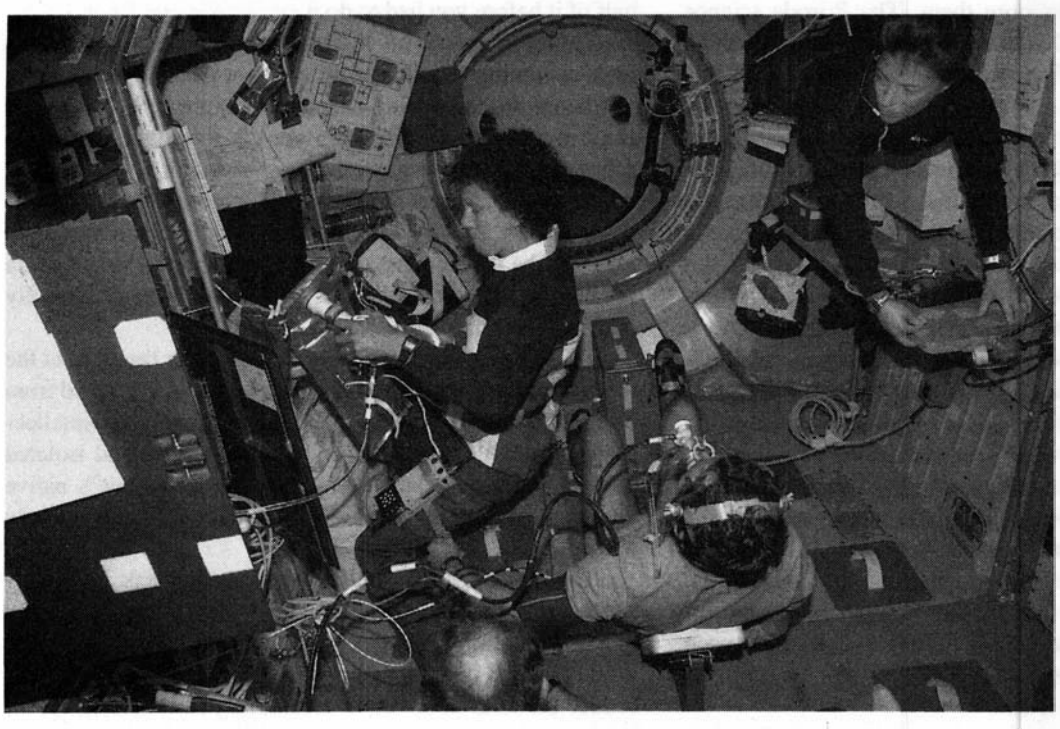
The aerospace/defense sector of the former Soviet Union has been collapsing at a breathtaking speed over the past six years. In November 1991, James Oberg, an American specializing in Soviet/Russian space analysis, reported in *Omni* magazine that this decline began as early as 1987, when President Mikhail Gorbachov started reducing the space budget, cutting it 10% for each of three years. The series of political crises, and fantastic inflation during the transition from the Soviet Union to independent republics accelerated the process, with President Boris Yeltsin pledging to continue the downward trend in the space program when he became President.

The pride of the Soviet space program had been its seemingly effortless ability to launch more than 100 spacecraft per year, at its peak. By 1991, the number of launches had fallen to a 25-year low of 59 launches, compared to 66 missions in 1967. Last year there were 48 launches, and in 1995, only 45 are planned. While it is true that there have been some improvements in technology, allowing unmanned satellites to remain operational for longer periods of time, requiring less frequent replacement, this in no way accounts for a 50% decline.

The withdrawal of government funding for the civilian space program, under the rubric, enforced by the International Monetary Fund, that assets should be "privatized," is mindboggling. *Aviation Week* reported on March 15, 1993 that the budget for that year was expected to be 51 billion rubles. Factoring in inflation, this was equivalent to ***half*** the amount of the 1980s. In July, according to *Space News,* the 1993 budget still had not been approved by the Parliament. Alexei Krasnov, deputy director of Russian Space Agency's international department, finally stated at that time what no one had wanted to admit in public—that no hardware had been built yet for the Mir 2 space station to replace the one now in orbit, and there was little chance any would be.

By August 1993, Russian Space Agency director Yuri Koptev reported that the space industry had lost 30% of its trained specialists and 34% of its top space scientists. Employment in the Russian space industry stood at 790,000 in 1990 and fell to 560,000 by 1992. In 1993 it was reported to be at 295,000 people.

The Russian Space Agency has had political problems, in addition to its economic ones, in keeping its space program up and running. More than half of the launches of the program since the 1950s, and all of the manned launches, have taken place from the Baikonur Cosmodrome. It is the oldest launch facility in the world, and since 1957 has launched more than



Astronaut/doctor Ellen Baker (left) and astronaut biomedical engineer Bonnie Dunbar (right) were principally responsible for the experiments and tests on the long-duration Mir 18 crew in the European Spacelab. This was the first time that such extensive measurements on the health of the crew were taken in space.

900 orbital missions. But it is not in Russia; it is in Kazakhstan. With the dissolution of the Soviet Union and independence of the republics, the government of Kazakhstan tried to assert its claim on the vast facility.

In September 1991, Kazakhstan President Nursultan Nazarbayev declared all enterprises in his republic under his authority and created a Kazakhstan Space Agency. Unfortunately, there was no possibility that his government would be able to run, or take care of, this precious resource. On Feb. 24-25, 1992 about 2,000 military construction troops at Baikonur rioted over inadequate food supplies and the generally poor state of living conditions. Several buildings were burned down, and three soldiers died in a fire. Three weeks earlier, technicians had staged a brief strike over lack of pay.

A few months later, on July 25, Yuri Semenov, director of the major design and manufacturing bureau NPO Energia, told a press conference in the town of Leninsk, which houses the military and civilians who work at the Cosmodrome, that the Russian government had invested 2 billion rubles from the end of 1992 to early 1993, "to keep the Baikonur Cosmodrome from completely falling apart overnight." A Feb. 9 article in the Russian newspaper *Nezavisimaya Gazeta* reported that workers at the Cosmodrome had been stealing equipment from the mothballed Buran launch complex. In June, 500 Kazakh military construction troops took part in riots at Baikonur and caused 100 billion rubles in damage during an arson and looting rampage.

Finally, on Dec. 29, 1993, Yuri Koptev announced that an agreement had been signed with Kazakhstan to rent Baikonur for 20 years for $115 million/year. But a nervous U.S. congressional delegation from the House Science and Technology Committee that visited Baikonur on Dec. 2, 1993 filed a report concluding that the infrastructure surrounding the launch facilities and in Leninsk is "in need of major upgrade and investment in order to guarantee the ongoing viability of Baikonur, especially if the U.S. chooses to commit to a dependent relationship to the Russian space program." Periodic electricity blackouts, water that is undrinkable, and lack of most other services deeply concerned the congressional delegation.

More recently, on March 2, 1995, there was a meeting of the Russian cabinet specifically to address the crisis in the aerospace industry. At a press conference to report on the meeting, Koptev said that the situation was so critical that a shortage of funds "made it impossible to finance the federal space program in January and February." In addition to its ongoing operating costs, Koptev explained, the Russian Space Agency owes 230 billion rubles to various entities for work done in 1994, because it only received 78% of the budget appropriations last year, and only half of what it had requested. "It is impossible to live on the basis of month-by-month financing. The more so when even this has to be pleaded for. . . . So far, there is no sense that space activities should be a national priority, and there have been no practical steps to back it up financially," he said.

At the cabinet meeting, the budget for this year, which had been set at 1.5 trillion rubles (at today's exchange rate, less than $400 million), was increased by 300 billion rubles by the finance minister. Responding to a question from a CNN reporter regarding help from the United States, Koptev defensively replied, "Russia's experience in this area of space exploration is invaluable." "This is not humanitarian assistance to Russia," Koptev asserted, since the United States is simply buying services and hardware from Russia. "This is an objective need."

Maybe so. But Koptev fought long and hard for a long-term commitment by the United States to put dollars into the Russian space program because, while the 1.5 trillion rubles is not in any way really equivalent to $400 million in terms of what each can buy (a Russian engineer earns about $170 per month), it is the case that the $150 million or so per year that NASA is putting into the Russian effort is now close to 40% of the amount of money that the Russian Space Agency receives from the Russian government.

It was clear by the summer of 1993 that the Russians would never build their Mir 2 space station. Without participation in the U.S.-led international station, within two years, Russia, which was the pioneer in space exploration, would be out of the manned space business.

Koptev expressed his recognition of this unfortunate circumstance, stating that his program "can only be realized if this activity is supported by the Russian government with substantial investments much larger than what we are getting from the Americans." The same month, Koptev announced that the Buran, the Russian space shuttle, would never be used.

The inability of the Russian government to adequately support space exploration, or other science and technology programs, is a result of the economic shock therapy policies imposed by institutions such as the International Monetary Fund, the "Conservative Revolution" privateers, and the criminal mafias that reap fortunes from the sell-off of Russia's national technological patrimony. That there may be a recommitment on the part of the Russian government to its space sector is a great source of concern for such vultures.

In a vicious March 13, 1995 commentary in the *Washington Times* on the March 2 cabinet meeting which discussed how to improve the state of the Russian space industry, Hoover Institute fellow Arnold Beichman asked, "What will foreign investors think?" The IMF is deciding on a $6.3 billion loan. If the Russian government decides to put more money into state industry, "isn't this a pullback from the market economy?"

There is little doubt that only if the Russian government throws out the "market economy" and its fanatics, and the IMF and its loans, will it have the possibility to save its country.