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Space Stations

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Marcia S. Smith
Resources, Science, and Industry Division

CONTENTS

For detailed information on the International Space Station Management and Cost Evaluation Task Force (the "Young Report"), see CRS Report RL31216.

Space Stations

Summary

Congress continues to debate NASA's program to build a permanently occupied space station in Earth orbit where astronauts live and conduct research. NASA expects that research performed in the near-zero gravity environment of the space station will result in new discoveries in life sciences, biomedicine, and materials sciences. The program is currently called the International Space Station (ISS); the facility itself is informally referred to as "Space Station Alpha."

The space station is being assembled in Earth orbit. Almost 90 launches are needed to take the various segments, crews, and cargo into orbit. Several launches have taken place. The original date to complete assembly, June 2002, slipped to April 2006, with at least 10 years of operations expected to follow. Cost overruns in 2001 are forcing additional schedule changes, however, and the current schedule is uncertain. Crews rotate on 4-6 month shifts. The fourth "expedition" crew is now onboard. Congress appropriated about $27.6 billion for the program from FY1985-2001. For FY2002, NASA requested $2.1 billion; Congress appropriated (P.L. 107-73) $2.09 billion. The FY2003 request is $1.84 billion.

Canada, Japan, and several European countries became partners with NASA in building the space station in 1988; Russia joined in 1993. Brazil also is participating, but not as a partner. Except for money paid to Russia, there is no exchange of funds among the partners. Europe, Canada, and Japan collectively expect to spend about $11 billion of their own money.

President Clinton's 1993 decision to bring Russia into the program was a dramatic change. Under the 1993 agreement, Phase I of U.S./Russian space station cooperation involved flights of Russians on the U.S. space shuttle and Americans on Russia's *Mir* space station. Phases II and III involve the construction of ISS as a multinational facility.

In 1993, when the current design was adopted, NASA said the space station would cost $17.4 billion for construction; no more than $2.1 billion per year. The estimate did not include launch or other costs. NASA exceeded the $2.1 billion figure in FY1998, and the $17.4 billion estimate grew to $24.1-$26.4 billion. Congress legislated spending caps on part of the program in 2000. Costs have grown almost $5 billion since. NASA plans to cancel or indefinitely defer some hardware to stay within the cap.

Controversial since the program began in 1984, the space station has been repeatedly designed and rescheduled, often for cost-growth reasons. Congress has been concerned about the space station for that and other reasons. Twenty-two attempts to terminate the program in NASA funding bills, however, were defeated (3 in the 106th Congress, 4 in the 105th Congress, 5 in the 104th, 5 in the 103rd, and 5 in the 102nd). Three other attempts in broader legislation in the 103rd Congress also failed.

Current congressional debate focuses on cost growth in NASA's part of the program and the resulting possibility that portions of the space station may not be built; and whether Russia can fulfill its commitments to ISS.

MOST RECENT DEVELOPMENTS

The "Expedition 4" crew (one Russian and two Americans) continues its work aboard the International Space Station (ISS), which is under construction in Earth orbit. That crew is scheduled to remain on ISS until June, when it will be replaced by the Expedition 5 crew. NASA launched the Space Shuttle Atlantis on April 8 to take additional segments of ISS into orbit to continue construction of the facility.

For FY2003, NASA is requesting a total of $1.839 billion for the space station program ($1.492 billion to build it, plus $347 million for space station research). This is $254 million less than the comparable figure for FY2002, reflecting the fact much of the hardware has been built and the Bush Administration has decided to truncate construction at a stage it calls "core complete." The FY2003 request is slightly higher than the $1.818 billion NASA projected it would need for FY2003 last year. The decision to truncate construction at "core complete" responds to the revelation last year of significant cost growth in the program. At a February 27, 2002 hearing, NASA Administrator O'Keefe told the House Science Committee that he remained uncertain about the ISS cost estimate, and would not know more until summer, when a refined NASA estimate is available. Th NASA estimate will be reviewed by an independent cost assessment group. The "core complete" configuration will permit only three crew members to live and work aboard ISS, instead of the seven planned. With a smaller crew, significantly less research can be conducted, which will affect all the partners in the program (U. S., Europe, Canada, Japan, and Russia). Europe, Canada, and Japan are planning to spend approximately $11 billion of their own money on building modules or other equipment for ISS, of which approximately $8.2 billion has been spent so far. (Russian spending figures for ISS are not available.) The international partners have expressed deep concern about the Bush Administration's decision.

BACKGROUND AND ANALYSIS

Introduction

NASA launched its first space station, Skylab, in 1973. Three successive crews were sent to live and work there in 1973-74. It then was unoccupied until it reentered Earth's atmosphere in July 1979, disintegrating over Australia and the Indian Ocean. Skylab was never intended to be permanently occupied. The goal of a permanently occupied space station with crews rotating on a regular basis was high on NASA's list for the post-Apollo years. In 1969, Vice President Agnew's Space Task Group recommended a permanent space station and a reusable space transportation system (the space shuttle) to service it as the core of NASA's program in the 1970s and 1980s. Budget constraints forced NASA to choose to build the space shuttle first. When the shuttle was declared operational in 1982, NASA was ready to initiate the space station program.

In his January 25, 1984 State of the Union address, President Reagan directed NASA to develop a permanently occupied space station within a decade and to invite other countries to participate in the project. On July 20, 1989, the 20th anniversary of the first Apollo landing on the Moon, President George H. W. Bush gave a major space policy address in which he voiced his support for the space station as the cornerstone of a long-range civilian space program eventually leading to bases on the Moon and Mars.

President Clinton was strongly supportive of the space station program, and dramatically changed its character in 1993 by adding Russia as a partner to this already international endeavor. Adding Russia made the space station part of the U.S. foreign policy agenda to encourage Russia to abide by agreements to stop the proliferation of ballistic missile technology, and to support Russia economically and politically.

President George W. Bush has not made a statement about his position on the space station program. However, Sean O'Keefe, while serving as deputy director of the Office of Management and Budget, told the House Appropriations VA-HUD-IA subcommittee on May 3, 2001, that the Bush Administration intends to bring costs under control. Mr. O'Keefe is now the Administrator of NASA.

The Space Station Program: 1984-1993

NASA began the current program to build a space station in 1984 (FY1985). In 1988, the space station was named *Freedom*. Following a major redesign in 1993, NASA announced that the *Freedom* program had ended and a new program begun, though NASA asserts that 75% of the design of the "new" station is from *Freedom*. The new program does not have a formal name and is simply referred to as the International Space Station (ISS). Individual ISS modules have various names, and the entire facility is informally referred to as "Space Station Alpha." ISS is a laboratory in space for conducting experiments in near-zero gravity ("microgravity"). Life sciences research on how humans adapt to long durations in space, biomedical research, and materials processing research on new materials or processes are underway or contemplated. From FY1985 through FY2002, Congress appropriated approximately $30 billion for the space station program (a year-by-year table is included under **Congressional Action** below).

Space Station *Freedom*

When NASA began the space station program in 1984, it said the program would cost $8 billion (FY1984 dollars) for research and development (R&D—essentially the cost for building the station without launch costs) through completion of assembly. From FY1985-1993, NASA was appropriated $11.4 billion for the *Freedom* program. Most of the funding went for designing and redesigning the station over those years. Little hardware was built and none was launched. Several major redesigns were made. A 1991 redesign evoked concerns about the amount of science that could be conducted on the scaled-down space station. Both the White House Office of Science and Technology Policy (OSTP) and the Space Studies Board (SSB) of the National Research Council concluded that materials science research could not justify building the space station, and questioned how much life sciences research could be supported, criticizing the lack of firm plans for flying a centrifuge, considered essential to this research. NASA subsequently agreed to launch a centrifuge.

Cost estimates for *Freedom* varied widely depending on when they were made and what was included. *Freedom* was designed to be operated for 30 years. As the program ended in 1993, NASA's estimate was $90 billion (current dollars): $30 billion through the end of construction, plus $60 billion to operate it for 30 years. The General Accounting Office (GAO) estimated the total cost at $118 billion, including 30 years of operations.

In 1988, after 3 years of negotiations, Japan, Canada and nine European countries under the aegis of the European Space Agency (ESA) agreed to be partners in the space station program (two more since have joined). An Intergovernmental Agreement (IGA) on a government-to-government level was signed in September, and Memoranda of Understanding (MOUs) between NASA and the other relevant space agencies were signed then or in 1989. The partners agreed to provide hardware for the space station at their own expense, a total of $8 billion at the time.

1993 Redesign—the Clinton Administration Restructuring

In early 1993, as President Clinton took office, NASA revealed $1 billion in cost growth on the *Freedom* program. The President gave NASA 90 days to develop a new, less costly, design with a reduced operational period of 10 years. A new design, *Alpha*, emerged on September 7, 1993, which NASA estimated would cost $19.4 billion. It would have used some hardware bought from Russia, but Russia was not envisioned as a partner. Five days earlier, however, the White House announced it had reached preliminary agreement with Russia to build a joint Russian/American space station. Now called the International Space Station (ISS), it superseded the September 7 *Alpha* design. NASA asserted it would be a more capable space station and be ready sooner at less cost to the United States. Compared with the September 7 *Alpha* design, ISS was to be completed 1 year earlier, have 25% more usable volume, 42.5 kilowatts more electrical power, and accommodate 6 instead of 4 crew members. ISS is being built in an orbit inclined at 51.6^{o}, the same as that used by Russian space stations, so Russian as well as U.S. launch vehicles can service the station.

In 1993, President Clinton pledged to request $10.5 billion ($2.1 billion a year) for FY1994-1998. NASA said the new station would cost $17.4 billion to build, not including money already expended on the *Freedom* program. That estimate was derived from the $19.4 billion estimate for the September 7 Alpha design minus $2 billion that NASA said would be saved by having Russia in the program. The $2.1 billion and $17.4 billion figures became known as "caps," though they were not set in law. (See **Cost Caps** below).

The International Space Station (ISS): 1993-Present

The International Space Station program thus began in 1993, with Russia added as a partner, joining the United States, Europe, Japan, and Canada. The 1993 and subsequent agreements with Russia established three phases of space station cooperation and the payment to Russia of $400 million ($100 million per year for FY1994-1997). In 1996, NASA increased that amount to $473 million, of which approximately $323 million was for Phase I and $150 million for Phase II. (NASA has transferred a total of approximately $800 million to Russia for space station cooperation through this and other contracts.)

Phase I: The Shuttle-*Mir* Program

During Phase I (1995-1998), seven U.S. astronauts remained on Russia's space station *Mir* for long duration (several month) missions with Russian cosmonauts, Russian cosmonauts flew on the U.S. space shuttle seven times, and nine space shuttle missions docked with *Mir* to exchange crews and deliver supplies. Repeated system failures and two life-threatening emergencies on *Mir* in 1997 (see CRS Report 97-685) raised questions about whether NASA should leave more astronauts on *Mir*, but NASA decided *Mir* was sufficiently safe to continue the program.

Phases II and III: ISS Design, Cost, Schedule, and Lifetime

NASA identifies Phases II and III of the ISS program separately, but they blend into each other. Phase II was completed in July 2001 and Phase III is underway. As noted, ISS is being built by the United States, Russia, 10 or 11 European countries, Japan, Canada, and Brazil (which is not a partner on the program, but has a bilateral agreement with NASA to participate). Boeing is the U.S. prime contractor for ISS. The original schedule called for construction to begin in 1997 and end in 2002. NASA originally stated that ISS would be operated for 10 years after assembly was completed, with a possibility for 5 additional years if the research was considered worthwhile. Using the original schedule, that would have meant guaranteed operations through 2012. As the schedule slipped (see below), NASA said it would operate the station until 2012 regardless of when construction was completed, with subsequent peer review determining whether continued operation was warranted. That would have meant a shorter guaranteed lifetime. By 2000, NASA had returned to stating that it would operate the station for at least 10 years after assembly was completed. With the new approach being taken by the Bush Administration (see below), it is not clear when assembly will be "completed," however. NASA does state that each U.S. module was designed with a 15 year lifetime (5 years during assembly, plus 10 years thereafter).

September 1993-January 2001—the Clinton Administration Plan. The following section describes ISS as it was envisioned in 1993 and how it evolved through 2001. This is the configuration detailed in the international agreements that govern the program (the Intergovernmental Agreement among the respective governments, and Memoranda of Understanding between NASA and each of its counterpart agencies.)

ISS segments are launched into space on U.S. or Russian launch vehicles and assembled in orbit. The space station is designed to be composed of a multitude of modules, solar arrays, remote manipulator systems, and other elements that are too numerous to describe here. Details can be found at [http://spaceflight.nasa.gov]. Six major modules are now in orbit. The first two were launched in 1998: Zarya ("Sunrise," with guidance, navigation, and control systems) and Unity (a "node" connecting other modules). Next was Zvezda ("Star," the crew's living quarters) in 2000. Destiny (a U.S. laboratory), Quest (an airlock), and Pirs ("Pier," a docking compartment) arrived in 2001. Other hardware, including solar arrays (for generating electricity) and remote manipulator systems, also have been attached. The U.S. space shuttle, and Russian Soyuz and Progress spacecraft, take crews and cargo to and from ISS. A Soyuz is always attached to the station as a lifeboat in the event of an emergency.

The schedule for launching segments and crews is called the "assembly sequence" and has been revised many times. The most recent formal assembly sequence, "Rev F," was released in August 2000, and showed a date for completion of assembly ("assembly complete") in April 2006. As discussed below, that assembly sequence is no longer valid, but a revised sequence has not been released. As an indication of the number of launches that were planned, there are 50 launches in the Rev F assembly sequence: 40 are American, 9 are

Russian, and one unassigned (of the European Automated Transfer Vehicle) although Europe plans to launch ATV on its Ariane launch vehicle. In addition, Russia is expected to provide about two flights of its Soyuz spacecraft, and three to six Progress spacecraft, each year. Although NASA is reviewing its plans for ISS (see below), construction of the station continues and is generally following the Rev. F assembly sequence today.

Three-person crews occupy ISS on a rotating basis. Called "expedition" crews, they remain for 4-6 months and are composed alternately of two Russians and one American, or two Americans and one Russian. The number of astronauts who can live on the space station is limited in part by how many can be returned to Earth in an emergency by lifeboats docked to the station. Currently, only Russian Soyuz spacecraft are available as lifeboats. Each Soyuz can hold three people, limiting the space station crew size to three if only one Soyuz is attached. Each Soyuz must be replaced every 6 months.

NASA planned to build a U.S. Crew Return Vehicle (CRV) for at least four more crew members, allowing crew size to increase to seven. NASA actually was designing a CRV capable of accommodating six to seven crew members in case Russia was not financially able to provide Soyuzes in the future. The CRV would have had a lifetime of 3 years, instead of 6 months like the Soyuz, reducing operational costs. NASA also planned to build a Habitation Module to accommodate the larger crew, and a Propulsion Module to provide fuel in case Russia was not able to provide all the Progress spacecraft it promised. Europe also was to provide Node 3, another connection point between modules. As discussed below, the Bush Administration has canceled or deferred these ISS elements.

Cost Growth During the Clinton Administration. From FY1994-FY2001, the cost estimate for building ISS grew from $17.4 billion to $24.1-26.4 billion, an increase of $6.7-$9 billion. The $17.4 billion (called its "development cost," "construction cost," or "R&D cost") covered FY1994 through completion of assembly, then scheduled for June 2002. That estimate did not include launch costs, operational costs after completion of assembly, civil service costs, or other costs. NASA estimated the program's life-cycle cost (all costs, including funding spent prior to 1993) from FY1985 through FY2012 at $72.3 billion. A more recent NASA life-cycle estimate is not available. In 1998, GAO estimated the life-cycle cost at $95.6 billion (GAO/NSIAD-98-147).

Cost growth first emerged publicly in March 1996 when NASA Administrator Daniel Goldin gave the space station program manager control of money allocated for (and previously overseen by) the science offices at NASA for space station research. Congress gave NASA approval to transfer $177 million from those science accounts to space station construction in the FY1997 VA-HUD-IA appropriations act (P.L. 104- 204). A similar transfer was approved for FY1996 ($50 million). NASA changed its accounting methods so future transfers would not require congressional action, and transferred $235 million from space station science into construction in FY1998. ("Space station science" funding is for scientific activities aboard the space station. It is separate from NASA's other "space science" funding, such as Mars exploration, astrophysics, or earth sciences.)

One factor in the cost growth was schedule slippage related to Russia's Zvezda module. As insurance against further Zvezda delays, or a launch or docking failure, NASA decided to build an "Interim Control Module" (ICM). To cover cost growth associated with the schedule delay and ICM, NASA requested permission to move $200 million in FY1997 from the space shuttle and payload utilization and operations accounts to the space station program, and to transfer $100 million in FY1998 from unidentified NASA programs to the space station program. The appropriations committees approved transferring the $200 million in FY1997, but not the FY1998 funding.

In September 1997, NASA and Boeing revealed that Boeing's prime contract would have at least a $600 million overrun at completion, and that NASA needed $430 million more than expected in FY1998. Boeing's estimate of its contract overrun grew to $986 million in 1999, where it remained. In 2001, NASA estimated that overrun at $1.14 billion. The contract runs through December 31, 2003.

In March 1998, NASA announced that the estimate for building the space station had grown from $17.4 billion to $21.3 billion. In April 1998, NASA released a review of space station costs conducted by an independent task force reporting to the NASA Advisory Council. Headed by Jay Chabrow, the report concluded that the space station's cost through assembly complete could be $24.7 billion and assembly could take 10-38 months longer. NASA agreed its schedule was optimistic and there would be about $1.4 billion in additional costs, but Administrator Goldin refused to endorse the $24.7 billion estimate. By 2000, the cost estimate had increased to $24.1-$26.4 billion.

Cost Caps. The $2.1 billion per year figure the White House and Congress agreed to spend on the space station, and NASA's $17.4 billion estimate to build the station, became known as "caps," although they were not set in law. Both were exceeded in 1997-1998. As costs continued to rise, Congress voted to legislate caps on certain parts of the ISS program in the FY2000-2002 NASA authorization act (P.L. 106-391). The caps are $25 billion for development, plus $17.7 billion for associated shuttle launches. The act also authorizes an additional $5 billion for development and $3.5 billion for associated shuttle launches in case of specified contingencies. The caps do not apply to operations, research, or crew return activities after the space station is "substantially" complete, defined as when development costs consume 5% or less of the annual space station budget.

2001-Present—the Bush Administration Restructuring. NASA is continuing with construction of the space station, and expedition crews sequentially live and work aboard the facility. However, the program has encountered significant additional cost growth, leading to another restructuring.

Cost Growth. As President Bush took office in January 2001, NASA revealed substantial additional cost growth. In 2000, NASA's estimate of the remaining cost to build ISS was $8 billion (FY2002 to FY2006). Now it revealed that an additional $4.02 billion was needed. That figure grew to $4.8 billion by June, and the IMCE task force (discussed below) said another $366 million in growth was discovered between August and October. Those increases would have raised the cost to over $30 billion, 72% above the 1993 estimate, and $5 billion above the legislated cap. NASA explained that the cost growth became evident as 2000 progressed and program managers realized that they had underestimated the complexity of building and operating the station. The agency thought it had sufficient funding in program reserve accounts to cover contingencies, but in late 2000 and early 2001 concluded that funding was insufficient. The Bush Administration signaled it would not provide additional funds, and NASA would have to find what it needed from within its Human Space Flight account. The Administration also supported the legislated cap.

"Core Complete" Configuration. In its February 2001 "Budget Blueprint," the Administration announced that it would cancel or defer some ISS hardware to stay within the cap and control space station costs. It canceled the Propulsion Module, and indefinitely deferred the Habitation Module, Node 3, and the CRV. The decision truncates construction of the space station at a stage the Administration calls "core complete," which includes the planned launches of U.S. hardware through Node 2, plus launch of the European and Japanese laboratory modules. These launches would be completed in the 2004-2005 time frame. The Centrifuge Accommodation Module is also included in the "core complete" definition even though it is not expected to be launched until 2007. A detailed assembly sequence for this configuration has not been released yet, partially because the Administration also decided to reduce the number of shuttle flights to four per year (from six or seven), which affects the construction schedule. NASA's FY2003 budget estimates show that the cost to finish "core complete" through FY2005 will be $24.879 billion, just under the legislated cap. NASA will continue to need at least $1.3 billion per year for operations. NASA's FY2003 budget charts show, however, that the current budget includes a shortfall for FY2003-2006 of over $600 million (see **Projected Funding Shortfall**).

The IMCE ("Young") Task Force. At the urging of the Office of Management and Budget (OMB), NASA created the ISS Management and Cost Evaluation (IMCE) Task Force in July 2001. Headed by retired Lockheed Martin executive Tom Young, the task force was chartered to evaluate ISS program management and cost estimates. IMCE was a subunit of the NASA Advisory Council (NAC). The task force released its report on November 2, 2001 [http://www.hq.nasa.gov/office/pao/History/youngrep.pdf], concluding that NASA's estimate for FY2002-2006 of $8.3 billion to finish the "U.S. core complete" stage was not credible. The task force called on NASA to make significant management and cost estimating changes by June 2002. IMCE viewed the next two years as a period for NASA to demonstrate credibility. If it does, a decision could be made to restore the CRV and Habitation Module (or something similar, perhaps contributed by another partner under a barter agreement) as "enhancements." See CRS Report RL31216 for more on IMCE.

NASA has not released a formal response to the IMCE report yet, although it is implementing some of its recommendations. In one area, the result is not exactly what IMCE had in mind. IMCE recommended that the number of shuttle flights per year in support of ISS be cut to four. IMCE estimated that would generate $668 million in savings over 5 years that could be applied to ISS. NASA followed the recommendation to reduce the shuttle flight rate to ISS to four per year, but allocated all of the savings to the shuttle program itself. Additional shuttle flights can be purchased by other NASA program offices at $70 million per launch (the marginal shuttle launch cost). If the ISS program needs more than four flights per year, therefore, it could pay for additional flights. In essence, instead of adding money to the ISS budget, the flight rate change could increase ISS costs is more than four flights per year are necessary.

Concerns of the Non-U.S. Partners and U.S. Researchers. The non-U.S. partners, and U.S. scientists who plan to conduct research on ISS, have expressed deep concern with the "core complete" configuration. The concerns focus on the decision to indefinitely defer the Crew Return Vehicle (CRV). Without CRV, the space station can accommodate only three permanent crew members, not seven as planned. Since 2 ½ crew members are needed to operate and maintain the station, this leaves only one-half of one person's time to conduct research. Research is ostensibly one of the major reasons for building the space station. For U.S. researchers, another issue is that NASA also has reduced the space station research budget by 37.5% over the FY2002-2006 period, necessitating a reassessment of U.S. research priorities on ISS. For Europe, Canada, and Japan, the "core complete" configuration also poses problems because the additional four permanent crew member slots were to be allocated, in part, to their astronauts. Without those positions, European, Japanese, and Canadian astronauts would be able to work aboard ISS only for short durations as part of visiting crews on the U.S. space shuttle or Russian Soyuz "taxi" missions, which bring a new Soyuz spacecraft to ISS every six months (Soyuzes must be replaced at that interval).

Instead of building a CRV, one option is to procure additional Soyuzes, so two could be docked at the station at a time. That would allow crew size to expand to six (in an emergency, three could be returned in each Soyuz). What price Russia would charge for additional Soyuzes is not yet known. Another partner might choose to develop a lifeboat capability, although this would take considerable time and money. NASA had been discussing the possibility of a joint CRV development program with Europe and with Japan, but with NASA's budget uncertainty, those discussions reportedly have been put on hold.

Europe, Canada, and Japan have all expressed deep concern about the new plan (see CRS Report RL31216). At an ESA ministerial meeting on November 14-15, 2001, ESA confirmed it will fulfill its obligations under the IGA, and expects NASA to do the same. ESA approved full funding for its part of the space station, but will defer release of 60% of it pending confirmation from NASA that the IGA will be fulfilled.

Projected Funding Shortfall FY2003-2006. NASA's FY2003 budget charts show a shortfall of $603 million for FY2003-2006 to build and operate the "core complete" version of the space station. NASA asserts that it hopes to achieve $628 million in savings to compensate for the shortfall, but describes the potential savings in terms that make them seem uncertain: $330 million to be saved from program re-engineering is labeled "shows most promise"; $110 million from prime rates/task reductions is labeled "threats may offset a portion"; and $188 million from flight integration/processing is labeled "much may not [be] achieved." NASA states that if the savings cannot be achieved, it will use funding in its ISS reserve account ($674 million through FY2006). Others note that reserves are usually needed to pay for "unknown unknowns" that cannot be anticipated, and should not be assumed to be available to cover shortfalls in known work. At a February 27, 2002 hearing, NASA Administrator O'Keefe told the House Science Committee that he remained uncertain about the ISS cost estimate, and would not know more until summer when an independent cost review is expected to be completed.

Risks and Benefits of Russian Participation, and the Iran Nonproliferation Act (INA)

Russia's participation in the ISS program has not been without controversy. Among the issues that have been raised are the extent to which the successful completion of ISS is dependent on Russia, Russia's financial ability to meet its commitments, and whether the United States should be providing funding to Russia if it proliferates missile technology to certain countries. While there is no exchange of funds among the other ISS partners, the United States (and others) do provide funding to Russia. By 1998, the United States had paid approximately $800 million to Russia for space station cooperation.

Following the Clinton Administration's decision to bring Russia into the program, Congress stated that Russian participation "should enhance and not enable" the space station (H. Rept. 103-273, to accompany H.R. 2491, the FY1994 VA-HUD-IA appropriations bill—P.L. 103-124). The current design, however, can only be viewed as being "enabled" by Russian participation. It is dependent on Russian Progress vehicles for reboost (to keep the station from reentering Earth's atmosphere), on Russian Soyuz spacecraft for emergency crew return, and on Russia's Zvezda module for crew quarters (which allows ISS to be permanently occupied).

Russia's financial ability to meet its commitments has been a major issue for several years. The launch of Zvezda, the first module Russia had to pay for itself, was more than two years late. (Zarya was built by Russia, but NASA paid for it.) Since Zvezda's launch in 2000, Russia has met its commitments to launch Soyuz and Progress spacecraft, but it is reassessing what other modules and hardware it will build at its own expense. Russian Aviation and Space Agency (RAKA, or Rosaviakosmos) director Yuri Koptev estimated in 1997 that Russia would spend $3.5 billion on its portion of the ISS (later he said $6.2 billion if launch costs were included), but it is not clear at this point how much money Russia will put into the program. Russia is interested in commercial arrangements, such as space tourism, and the Enterprise module it hopes to build with the U.S. company Spacehab (see **Operations and Commercialization Issues**, below). While these activities may be laudable in the context of space commercialization, they also underscore Russia's continuing financial challenges in meeting its commitments as an ISS partner.

Political issues also are crucial. The overall relationship between the United States and Russia is one major factor. Another is the linkage between the space station and Russian adherence to the Missile Technology Control Regime (MTCR) designed to stem proliferation of ballistic missile technology. Getting Russia to adhere to the MTCR appears to have been a primary motivation behind the Clinton Administration's decision to add Russia as a partner. The United States wanted Russia to restructure a contract with India that would have given India advanced rocket engines and associated technology and know-how. The United States did not object to giving India the engines, but to the technology and know-how. Russia claimed that restructuring the contract would cost $400 million. The 1993 agreement to bring Russia into the space station program included the United States paying Russia $400 million for space station cooperation. At the same time, Russia agreed to adhere to the MTCR. The question is what the United States will do if Russia violates the MTCR. Some Members of Congress believe Russia already has done so. The Clinton Administration sanctioned 10 Russian entities for providing technology to Iran. Neither Rosaviakosmos nor any major Russian ISS contractors or subcontractors were among those sanctioned.

On March 14, 2000, President Clinton signed into law (P.L. 106-178) the Iran Nonproliferation Act (INA). The law, *inter alia*, prohibits NASA from making payments after January 1, 1999 in cash or in kind to Russia for ISS unless Russia takes the necessary steps to prevent the transfer of weapons of mass destruction and missile systems to Iran and the President certifies that neither Rosaviakosmos nor any entity reporting to it has made such transfers for at least one year prior to such determination. Exceptions are made for payments needed to prevent imminent loss of life by or grievous injury to individuals aboard ISS (the "crew safety" exception); for payments to construct, test, prepare, deliver, launch, or maintain Zvezda as long as the funds do not go to an entity that may have proliferated to Iran and the United States receives goods or services of commensurate value; and the $14 million for hardware needed to dock the U.S. ICM (see above). President Clinton provided Congress with the required certification with regard to the $14 million on June 29, 2000, but no certification was forthcoming for the remaining $24 million. Without such a certification, NASA would only be able to spend more money in Russia for ISS by meeting one of the remaining exceptions— maintenance of Zvezda (further defined in the law) and crew safety. At a House International Relations Committee hearing on October 12, 2000, Members sharply criticized NASA's legal interpretation of the crew safety exception.

Russian adherence to MTCR was cited by the Clinton Administration as one of the benefits of involving Russia. That benefit is now in question along with another—financial savings. Clinton Administration and NASA officials asserted repeatedly that a joint space station would accelerate the schedule by 2 years and reduce U.S. costs by $4 billion. This was later modified to one year and $2 billion, and an April 1, 1994 letter to Congress from NASA said 15 months and $1.5 billion. NASA officials continued to use the $2 billion figure thereafter, however. A July 1994 GAO report (GAO/NSIAD 94-248) concluded that Russian participation would cost NASA $1.8 billion, essentially negating the $2 billion in expected savings. In 1998, NASA's Associate Administrator for Human Spaceflight conceded that having Russia as a partner added $1 billion to the cost. Other benefits cited by the Clinton Administration were providing U.S. financial assistance to Russia as it moves to a market economy, keeping Russian aerospace workers employed in non-threatening activities, and the emotional impact and historic symbolism of the two former Cold War adversaries working together in space.

Congressional Action

FY2002

The FY2002 VA-HUD-IA appropriations Act (P.L. 107-73) approved $2.093 billion for ISS— reducing funding for ISS construction by $75 million, while increasing funding for space station science by $55 million. The budget figures are difficult to track, however.

NASA's original request for ISS was $2.087 billion, all within the Human Space Flight (HSF) account. That amount was $229 million over what NASA had said the previous year would be needed for FY2002. In total, the 5-year budget runout shown in the FY2002 budget request included about $1 billion more for FY2002-2006 than had been planned last year. The increase was offset by redirecting the funding that had been planned for the Crew Return Vehicle, previously carried in a different part of NASA's budget.

Subsequently, NASA made revisions to the request. Funding for space station research ($283.6 million) that had been identified in the HSF account was shifted to the Office of Biological and Physical Sciences (OBPR) in the Science, Aeronautics, and Technology (SAT) account. NASA also took funds from two HSF subaccounts and added them to ISS: $8.5 million from the space shuttle for a flight test of the X-38 vehicle, and $19 million from Investments and Support that would have been used for the HEDS Technology/Commercialization Initiative. Thus, the revised request for ISS in the HSF account was $1.83 billion, plus $283.6 million in the SAT account—a total of $2.114 billion. House and Senate appropriators adopted those revisions in their consideration of the request.

The House passed its version of the FY2002 VA-HUD-IA appropriations bill (H.R. 2620, H. Rept. 107-159) on July 30. A Roemer amendment was defeated (voice vote) that would have set a cap on space station funding and prohibited NASA from terminating or deferring certain space station elements; another amendment, to terminate the program, was withdrawn. As passed, the bill fully funded the ISS request and conditionally added $275 million for a Crew Return Vehicle as recommended by the House Appropriations Committee. The Senate passed its version of the bill on August 2 (S. 1216, S. Rept. 107-43), reducing space station funding by $150 million as recommended by the Senate Appropriations Committee.

Table 1. U.S. Space Station Funding
(in $ millions)

Fiscal Year	Request	Appropriated
1985	150	150
1986	230	205
1987	410	410
1988	767	425
1989	967	900
1990	2,050	1,750
1991	2,430	1,900
1992	2,029	2,029
1993	2,250	2,100
1994	2,106	2,106
1995	2,113	2,113
1996	2,115	2,144
1997	2,149	2,149
1998	2,121	2,441*
1999	2,270	2,270
2000	2,483	2,323
2001	2,115	2, 115
2002**	2,114	2,093
2003	1,839	

The numbers here reflect NASA's figures for "the space station program." Over the years, what is included in that definition has changed.
* NASA's FY1999 budget documents show $2.501 billion for FY1998 based on the expectation that Congress would approve additional transfer requests, but it did not.
**See text for explanation of NASA's derivation of this figure.

The conference report was filed on November 6 (H. Rept. 107-272). Congress added $55 million to the $283.6 million in the SAT account for space station science; a total of $338.6 million. The conferees provided $1,960 million in the HSF account for ISS construction, but that actually was a reduction of $75 million from the request because they included civil service salaries while NASA does not. The conferees did not adopt the House position of adding $275 million for a Crew Return Vehicle (CRV), but directed NASA to spend $40 million on the X-38 program, a precursor to CRV. According to NASA's FY2003 budget estimate, ISS funding for FY2002 is 2,093 million: $1,722 million for construction (the $1,960 million that was appropriated, minus civil service costs), $338.6 million for space station science appropriated by Congress, and another $33 million for space station science that NASA reallocated in its operating plan.

FY2003

For FY2003, the request for the space station program is $1.839 billion: $1,492 billion in the HSF account for ISS construction, and $347 million in the SAT account for space station research. This is $254 million less than the comparable figure for FY2002, reflecting the fact that much of the hardware has been built, but is $21.5 million higher than what NASA had projected last year that it would need in FY2003.

International Partners

The Original Partners: Europe, Canada, and Japan

Canada, Japan, and most of the 15 members of the European Space Agency (ESA) have been participating in the space station program since it began. Formal agreements were signed in 1988, but had to be revised following Russia's entry into the program, and two more European countries also joined in the interim. The revised agreements were signed on January 29, 1998, among the partners in the ISS program: United States, Russia, Japan, Canada, and 11 European countries—Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom. Representatives of the various governments signed the government-to-government level Intergovernmental Agreement (IGA) that governs the program. (The United Kingdom signed the IGA, but is not financially participating in the program so the number of European countries participating in the program is variously listed as 10 or 11.) NASA also signed Memoranda of Understanding for implementing the program with its counterpart agencies: the European Space Agency (ESA), the Canadian Space Agency (CSA), the Russian space agency (Rosaviakosmos), and the Japanese Science and Technology Agency. The IGA is a treaty in all the countries except the United States (where it is an Executive Agreement).

Canada is contributing the Mobile Servicing System (MSS) for assembling and maintaining the space station. In February 1994, the new prime minister of Canada had decided to terminate Canada's role in the program, but later agreed to reformulate Canada's participation instead. The first part of the MSS (the "arm") was launched in April 2001; another part, the Special Purpose Dextrous Manipulator (the "fingers"), is scheduled for late 2003. ESA is building a laboratory module called Columbus and an Automated Transfer Vehicle (ATV). The major contributors are Germany, France, and Italy. Budgetary difficulties over the years led ESA to cancel other hardware it was planning. ESA also is building a cupola (a windowed dome) and paying for Italy to build two of the three "nodes" (Node 2 and Node 3), in exchange for free shuttle flights to launch its ISS hardware. The cupola and Node 3 are not included in NASA's core complete configuration, however. Japan is building a laboratory module, Kibo (Hope). One part will be pressurized and another part will be exposed to space for experiments requiring those conditions. Japan also is building a large centrifuge and a module ("CAM") to accommodate it for NASA in exchange for free shuttle flights to launch Kibo. Technical challenges delayed CAM from an anticipated 2006 launch to 2008, but NASA and Japan reached agreement on modifications that will accelerate its availability to 2007. NASA has a bilateral agreement under which Italy is providing three "mini-pressurized logistics modules" (MPLMs). They are attached to ISS while cargo is transferred to the station, then filled with refuse or other unwanted material and returned to

Earth. Another bilateral agreement was signed with Brazil in October 1997 for Brazil to provide payload and logistics hardware.

According to Japan's space agency, NASDA, Japan's total spending on ISS is expected to be $4.8 billion, of which $3.48 billion had been spent by the end of March 2001. CSA reports that Canada's total ISS funding is expected to be $1.3 billion (U.S.), of which $1.04 billion (U.S.) had been spent by October 2001. NASA reported in January 2002 that, as of October 2001, ESA had spent $3.7 billion of an estimated total of $4.8 billion on its ISS contributions. Russian figures are not available.

Russia

Issues associated with Russia's participation in ISS are discussed elsewhere. This section explains Russian space station activities from 1971 to the present. The Soviet Union launched the world's first space station, Salyut 1, in 1971 followed by five more *Salyuts* and then *Mir*. At least two other *Salyuts* failed before they could be occupied. The Soviets accumulated a great deal of data from the many missions flown to these stations on human adaptation to weightlessness. The data were often shared with NASA. They also performed microgravity materials processing research, and astronomical and Earth remote sensing observations. Importantly, they gained considerable experience in operating space stations.

Russia's most recent space station was *Mir,* a modular space station that was built and operated between 1986 and 2001. Crews were ferried back and forth to *Mir* using Soyuz spacecraft (reminiscent of Apollo capsules). A Soyuz spacecraft was always attached to *Mir* when a crew was aboard in case of an emergency, and Soyuz capsules now are used as Crew Return Vehicles, or lifeboats, for ISS.

Crews occupied *Mir* from 1986-2000. For almost ten of those years (1989-1999), *Mir* was continuously occupied by crews on a rotating basis. Although occasionally crews stayed for very long periods of time to study human reaction to long duration spaceflight, typically crews remained for 5-6 months and then were replaced by a new set of cosmonauts. The longest continuous amount of time spent by a single individual on *Mir* was 14 months. From 1995-1998, seven Americans participated in long duration (up to 6 months) missions aboard *Mir*, and nine space shuttle missions docked with the space station. Individuals from Japan, Britain, Austria, Germany, France, and the Slovak Republic also paid for visits to *Mir*. Russia deorbited *Mir* into the Pacific Ocean on March 23, 2001.

Issues For Congressional Consideration

Rationale

When NASA, the Reagan Administration, and Congress considered the rationale for building a space station in the early 1980s, NASA summed it up by calling a space station "the next logical step" in the space program. In many respects, that is the fundamental rationale for the space station program. Human exploration of space appeals to what many believe is an innate desire to push the frontiers of human experience. They view the space station as the next step in America's—and humanity's—inexorable desire to explore new worlds. Life sciences research on the effects of long durations in weightlessness on human physiology is considered by some as a prerequisite to sending people to Mars, research for which a space station is required. Other supporters believe materials research conducted on a space station will lead to new profitable industries, although this rationale was dismissed by the White House science office and the National Academy of Sciences in 1991.

Human spaceflight is felt by many in the space community to be the heart and soul of the space program. For them, the debate over the space station is a debate over America's future in space and NASA's purpose. A rejection of the program would be viewed as an abandonment of the vision they perceive as inherent in a strong national program of civilian space activities. As a visible symbol of America's technological prowess, human spaceflight is often perceived as a centerpiece of an image of American preeminence.

This somewhat romantic view is in stark contrast to those who view human exploration of space as, at best, a waste of money, and at worst, an unnecessary exposure of humans to the hazards of space travel. These observers argue that there is much yet to explore here on Earth, and robotic spacecraft should be used to explore the heavens for safety and cost-effectiveness reasons. They see the Apollo, space shuttle, and space station programs as successive drains on resources that could be better used for robotic space activities, or non-space related activities.

Cost and Cost Effectiveness

Cost effectiveness involves what can be accomplished with the facility that is ultimately built versus its cost. In 1993, NASA said it would cost $17.4 billion to build the U.S. portion of the space station. That rose to $24.1-$26.4 billion by early 2000, with $5 billion more in cost growth announced in 2001. Cost estimates for the earlier *Freedom* design had risen significantly as the years passed, and with each *Freedom* redesign, the amount of science diminished. Many wondered whether the same fate awaited ISS. In FY1996, FY1997, and FY1998 NASA transferred a total of $462 million from the space station science accounts into space station construction. In response to the cost growth revealed in 2001, NASA reduced the ISS research budget by 37.5% (FY2002-2006) and indefinitely deferred building hardware that would enable six or seven crew members to live aboard the station. As discussed, the smaller crew size will reduce the amount of research that can be conducted, since 2 ½ crew are needed to operate and maintain the station, leaving only ½ of one person's time available for research.

Operations and Commercialization Issues, Including Transhab

As NASA continues to struggle with building ISS, attention is also turning to who should operate the facility and how to encourage commercial use of it. NASA supports the concept of space station commercialization, both in terms of station operations and getting the private sector to use research facilities on ISS on a commercial basis. In 1998, NASA proposed creation of a non-governmental organization (NGO) to oversee research on the space station, similar to the Space Telescope Science Institute at Johns Hopkins University that operates the Hubble Space Telescope. Conferees on the FY2002 VA-HUD-IA appropriations bill (H.R. 2620, H. Rept. 107-272) prohibited NASA from finalizing any such NGO agreement prior to December 1, 2002.

The NGO would report to NASA. Others want the private sector, not the government, to manage and operate the space station. Still others think there is a role for the private sector in building, not just operating the space station. In December 1999, the U.S. company Spacehab announced agreement with the Russian company Energia to build a commercial module to be attached to the Russian part of ISS. The companies planned to provide space-originated news, information, education, entertainment, and business advertising and promotion, broadcasting from the module for viewing on television and the Internet. In March 2001, however, they announced that they no longer expected substantial revenue from those activities, and would wait until one of the space station partners other than Russia committed to leasing the module before they construct it. On June 2, 2000, NASA announced a deal with DREAMTiME, a company that said it would, among other things, broadcast multimedia images from ISS and make documentaries about its construction. Media reports indicate, however, that DREAMTiME is not meeting its commitments and NASA plans to terminate the contract.

NASA also explored whether the private sector would build a module called "Transhab" to replace the Habitation Module as the long term crew quarters. Transhab would be an inflatable module that its supporters argue could be a prototype for a craft to take crews to Mars. Inflatable modules are an innovative concept, making reliable cost estimating difficult. Congressional concern that it might add costs to the already overrun ISS program led to language in the conference report on the FY2000-2002 NASA authorization bill (P.L. 106-391) prohibiting NASA from spending funds on Transhab, but allowing NASA to lease such a module if the private sector builds it, with conditions.

More broadly, language in the FY2000 VA-HUD-IA appropriations act (P.L.106-74) permits NASA to conduct a demonstration commercialization program for 5 years. Receipts collected from commercial use of ISS would be used first to offset costs incurred by NASA in support of commercialization with any remainder retained by NASA for promoting further ISS commercialization activities. NASA was directed to establish a pricing policy for use of ISS by commercial entities; it was released in February 2000. The chairs of the House and Senate Committees that authorize NASA activities (House Science and Senate Commerce) both objected to including the language because of concern that it would allow NASA to pick and choose winners. The FY2000-2002 NASA authorization act (P.L. 106-391) limits the project to 3 years.

Another issue, that now seems to be resolved among the partners, is whether "tourists" should be allowed aboard ISS. The Russians launched American millionaire Dennis Tito to ISS in April 2001 after months of strenuous objections from NASA and other space station partners. They argued that he was insufficiently trained and the space station was not yet ready to accommodate nonprofessional astronauts. Days before the Russians were to launch Mr. Tito to ISS, NASA and the other partners agreed to the launch on the condition that the partners develop guidelines on necessary training before other nonprofessional astronauts (or "spaceflight participants") visit ISS. The guidelines were released in January 2002 and another spaceflight participant (South African Mark Shuttleworth) is scheduled to visit ISS in April 2002. On July 10, 2001, Representative Lampson introduced H. R. 2443, which seeks to facilitate the emergence of a space tourism industry by the private sector, but would prohibit the U.S. portion of ISS from being visited or occupied by anyone not engaged in supporting official business of the United States or the conduct of scientific or engineering

R&D, and those authorized by relevant international agreements, except in emergency situations.

Issues Related to Russia's Participation

The risks and benefits of Russia's participation in the program already have been discussed. A continuing issue is how to cope with the fact that the Russian government may not provide the funding needed to fulfill its commitments to the program. Although U.S. funding uncertainty is the focus of attention today, Russia's financial circumstances remain a challenge as well. NASA's decision to cancel the Propulsion Module ensures ISS dependance on Russia for reboost (except for the very limited reboost capabilities of the U.S. space shuttle) until Europe's ATV is available (scheduled for 2004). With the indefinite deferral of the Crew Return Vehicle, ISS will remain dependent on Russia for "lifeboat" spacecraft indefinitely. As discussed earlier, the Iran Nonproliferation Act (INA) prohibits U.S. payments to Russia for ISS, with some exceptions, unless the government of Russia prevents Russian nuclear and missile technology from reaching Iran. The key question is what will happen if Russia insists it cannot fund reboost or lifeboat missions yet NASA is not permitted to transfer money to Russia for such missions because Russia is not in compliance with INA.

LEGISLATION

H.R. 2443 (Lampson)

To promote the development of a U.S. space tourism industry. Introduced July 10, 2001; referred to the Committee on Science, the Committee on Ways and Means.