Order Code IB93017

CRS Issue Brief for Congress
Received through the CRS Web

Space Stations

Updated June 17, 2003

Marcia S. Smith
Resources, Science, and Industry Division

CONTENTS

Space Stations

SUMMARY

Congress continues to debate NASA's International Space Station (ISS) 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 space station is being assembled in Earth orbit. Almost 90 launches are needed to take the various segments, crews, and cargo into orbit; more than two dozen have taken place already. ISS has been permanently occupied by successive "Expedition" crews rotating on 4-6 month shifts since November 2000. "Expedition 7" is now onboard. The original date to complete ISS assembly, June 2002, slipped to April 2006, with at least 10 years of operations expected to follow. Cost overruns in 2001 forced additional changes to the schedule. The grounding of the space shuttle fleet in the wake of the *Columbia* tragedy also will affect the schedule, and operations. Congress appropriated about $31.8 billion for the program from FY1985-2003. The FY2004 request is $2.285 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. A reliable figure for Russian expenditures is not available.

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 space station 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 is canceling or indefinitely deferring 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 space station debate focuses on the impact of the space shuttle *Columbia* tragedy on the ISS program; the possibility that portions of the space station may not be built for cost reasons; and whether Russia can fulfill its commitments to ISS.

MOST RECENT DEVELOPMENTS

The "Expedition 7" crew (Russian Yuri Malenchenko and American Edward Lu) continues its work aboard the International Space Station (ISS). While the U.S. space shuttle fleet is grounded due to the *Columbia* accident, Russian Soyuz and Progress spacecraft are being used ferry crews and some cargo to ISS. However, most of the additional segments needed to continue space station construction are designed to be launched on the shuttle and must await the space shuttle's return to flight. Because Russia's Progress spacecraft can deliver much less cargo than the shuttle, the size of the Expedition crews has been reduced from three to two to lessen resupply requirements. On June 1, President Bush and Russian President Putin issues a joint statement reasserting the commitment of the two countries to working together to continue the space station program.

The FY2004 request for ISS is $2.285 billion ($1.707 billion for construction and operation, plus $578 million for research), but these numbers reflect NASA's shift to full cost accounting (see CRS Report RS21430) and are not directly comparable to the FY2003 and prior funding levels. NASA is designing an Orbital Space Plane (OSP) to take crews to and from ISS, with a $550 million request for FY2004, and a projected 5-year (FY2003-2007) cost of $2.4 billion. NASA accounts for OSP under the Space Launch Initiative(SLI) in the Office of Aerospace Technology, rather than as part of the space station budget, even though its purpose is to support ISS.

BACKGROUND AND ANALYSIS

Introduction

NASA launched its first space station, Skylab, in 1973. Three crews were sent to live and work there in 1973-74. It remained in orbit, 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 NASA declared the shuttle "operational" in 1982, it 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 made statements that were generally supportive of the space station program following the February 1, 2003 space shuttle *Columbia* accident. On June 1, 2003, he and Russian President Putin issued a joint statement renewing the commitment of the two countries to work together to ensure the success of the space station program.

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 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 ISS or "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 FY2003, Congress appropriated approximately $31.8 billion for the space station program.

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, Congress appropriated $11.4 billion to NASA 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 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.

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 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, which grew to $473 million. (NASA transferred about $800 million to Russia for space station cooperation through this and other contracts.)

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 involve construction of the International Space Station itself, and blend into each other. Phase II began in 1998 and was completed in July 2001; Phase III is underway.

ISS Design, Cost, Schedule, and Lifetime

ISS is being built by a partnership among the United States, Russia, Europe, Japan, and Canada. Responsibilities are detailed in an Intergovernmental Agreement (IGA) among the respective governments. The IGA is a treaty in all the countries except the United States, where it is an Executive Agreement. The IGA is implemented through Memoranda of

Understanding (MOUs) between NASA and each of its counterpart agencies. Brazil is also a participant, through a bilateral agreement with NASA. Boeing is the U.S. prime contractor.

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, assembly would have been completed in 2002, with operations through 2012. By 2001, that schedule had slipped by four years, and with the new approach being taken by the Bush Administration, it is not clear when assembly will be "complete." Hence, while the operational period remains at 10 years, correlating that with a specific year is difficult. Each U.S. module was designed with a 15 year lifetime (5 years during the assembly period, plus 10 years thereafter). Spacecraft often exceed their design lifetimes, however, so that also may not serve as a reliable benchmark.

ISS segments are launched into space on U.S. or Russian launch vehicles and assembled in orbit. The space station is composed of a multitude of modules, solar arrays to generate electricity, 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. Among the other modules that will be added are laboratory modules built by Russia, Europe, and Japan, and at least one more "node" built by Europe. (Some of the European- and Japanese-built modules count as U.S. modules because they are built under barter agreements with NASA.) 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. At the end of the Clinton Administration, the assembly sequence showed completion of assembly ("assembly complete") in April 2006. The most recent assembly sequence is discussed below, but due to the *Columbia* tragedy, will need to be revised. Construction is suspended until the shuttle returns to flight.

Three-person "expedition" crews have occupied ISS on a 4-6 month rotating basis since November 2000 and the plan was to continue with three-person crews until a larger crew could be accommodated. The three-person crews 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. The replacement missions are called "taxi" flights since the crews bring a new Soyuz up to ISS and bring the old one back to Earth. Therefore the expedition crews are regularly visited by taxi crews, and by the space shuttle bringing up additional ISS segments. The shuttle also is used to exchange expedition crews.

NASA planned to build a U.S. Crew Return Vehicle (CRV) for at least four more crew members. 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 canceled or deferred these ISS elements.

In the wake of the *Columbia* accident, the ISS partners have decided to temporarily limit expedition crew sizes to two (one American, one Russian), to reduce resupply requirements. They will be taken to and from ISS on the Soyuz "taxi" missions, which will now become crew exchange flights.

September 1993-January 2001: the Clinton Administration.

Cost Growth. 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, comparable, 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 then-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, an independent task force 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 Mr. 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. GAO reported in April 2002 that it could not verify whether NASA is complying with the cap because NASA cannot provide the data GAO requires (GAO-02-504R).

2001-Present: the Bush Administration.

Cost Growth. As President Bush took office, NASA revealed substantial additional cost growth. In 2000, NASA's estimate of the remaining cost to build ISS was $8 billion (FY2002 to FY2006). In January 2001, however, 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 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 said it supported the legislated cap. A July 2002 GAO report (GAO-02-735) traces financial developments in the ISS program from May 2000-November 2001 and concludes that NASA's focus on managing annual budgets resulted in NASA's failure to heed indicators of future program cost growth.

"Core Complete" Configuration. In its February 2001 "Budget Blueprint," the Bush Administration announced 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." The Administration said that "enhancements" to the station might be possible if NASA demonstrates improved cost estimating and program management, but is only committed to build the core complete configuration. In 2001, NASA estimated that it would cost $8.3 billion from FY2002-2006 to build the core complete configuration, which was then described as all the U.S. hardware planned for launch through Node 2 plus the launch of laboratories being built by Europe and Japan. NASA subsequently began distinguishing between "U.S. Core Complete" (the launches through Node 2, which, prior to the *Columbia* tragedy, was scheduled for February 2004) and "International Partner (IP)Core Complete" which includes the addition of European and Japanese laboratory modules (through 2008).

The $8.3 billion estimate for FY2002-2006 was deemed "not credible" by the IMCE task force (see below). NASA Headquarters directed the space station program office to reassess its estimate, and had two independent groups conduct their own estimates. One was an internal NASA group and the other was the Department of Defense's Coast Analysis Improvement Group (CAIG). Following those reviews, in November 2002 the Administration submitted an amended FY2003 budget request that shifted $706 million into the ISS program from FY2004-2007: $660 million to boost program reserves to ensure sufficient funds to finish the core complete configuration, and $46 million in FY2004 for "long-lead" items to preserve the option of increasing crew size beyond three. The $46 million will e spent on Node 3 and an Environmental Control and Life Support System (ECLSS), which are enhancements that might be pursued. The amended request also proposed another potential enhancement, an Orbital Space Plane (see below), and increasing the annual shuttle flight rate to ISS to five per year beginning in FY2006. The Orbital Space Plane concept was approved in the FY2003 Consolidated Appropriations Act (P.L. 108-7). What annual shuttle flight rate can be accommodated following the loss of *Columbia* in February 2003 is yet to determined.

At a December 2002 "Heads of Agency" meeting in Japan, the international partners agreed on a process for selecting a final ISS configuration by December 2003. Despite press reports that the United States agreed to provide for crew size to increase in the 2006 time frame, the Bush Administration remains committed to building only the core complete (three person) configuration at this time.

Current Assembly Sequence. The most recently revised version of the "Rev F" (Revision F) assembly sequence was released in October 2002. Although it has been overtaken by suspension of shuttle flights due to the *Columbia* tragedy, it can be useful as an indication of how much work remains to complete ISS assembly. Unlike the many earlier versions, the October 2002 edition did not show a date for completion of assembly ("assembly complete"). The immediately prior version showed assembly complete in April 2006. The October 2002 version instead was based on the Bush Administration's "U.S. Core Complete" and "International Partner (IP) Core Complete" configuration. It showed IP Core Complete occurring in January 2008. More than two dozen launches needed to assemble and occupy ISS already have occurred. The October 2002 assembly sequence shows 26 more launches from November 2002 through January 2008, of which all but two are U.S. space shuttle launches. The assembly sequence does not list expected Russian launches of Soyuz "taxi" flights (2 per year) or Russian Progress cargo missions (3-6 per year). It shows only the first launch of Europe's Automated Transfer Vehicle (ATV) and Japan's H-II Transfer Vehicle (HTV), both of which are automated cargo missions (akin to the Russian Progress flights). Additional ATV and HTV flights are expected. Hence, the total number of launches is much higher than the 26 shown in the October 2002 assembly sequence.

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 evaluated 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) as "enhancements." See CRS Report RL31216 for more on IMCE. In December 2002, IMCE issued a status report concluding that NASA was making needed changes both in management and cost estimating. It declared the new program plan credible.

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 (see CRS Report RL31216). Concerns focus on the decision to indefinitely defer a 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 could work aboard ISS only for short durations as part of visiting crews on the U.S. space shuttle or Russian Soyuz "taxi" missions.

Crew Return Capability: CRV, CTV, and Orbital Space Plane (OSP). As noted, crew size aboard ISS is limited in part by the number of occupants that could be accommodated in a "lifeboat" in the event of an emergency such as a catastrophic hull depressurization or a fire. One Soyuz spacecraft, which can accommodate three people, is always docked at ISS today to provide this lifeboat function. Instead of building a U.S. 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. What price Russia would charge for additional Soyuzes is not known. Whether NASA could pay for them is complicated by the Iran Nonproliferation Act (see below)

NASA indefinitely deferred its plans to build a Crew *Return* Vehicle (CRV). A CRV would be able only to return crews to Earth from the space station (it would be taken into orbit, unoccupied, via the space shuttle). A Crew *Transfer* Vehicle (CTV), by contrast, could take people both to and from the space station. In November 2002, in its amended FY2003 budget request, NASA proposed building a CTV, which NASA calls an Orbital Space Plane (OSP). OSP is a spacecraft, not launch vehicle. It would be launched into space on a traditional "expendable" launch vehicle such as an Atlas 5 or Delta 4. NASA proposed shifting $882 million (in FY2003-2007) into OSP from funding it had planned to spend on building a replacement for the space shuttle (the Space Launch Initiative, or SLI, program). The FY2003 request was $296 million. Congress approved the OSP program in the FY2003

Consolidated Appropriations Resolution (P.L. 108-7), but neither approved nor disapproved the funding level, giving NASA flexibility in deciding that level.

NASA accounts for the OSP program not within the space station budget, but under the Space Launch Initiative in the Office of AeroSpace Technology. That decision could be controversial, since OSP's purpose is to take crews to and from the space station, and it replaces the CRV program, which was carried in the space station account. The $4.8 billion ISS cost growth included required funding for the CRV, and was ameliorated in part by the termination of CRV. Starting a replacement program, but putting it elsewhere in NASA's budget, might be considered misleading in terms of portraying space station costs.

NASA plans to conduct design studies for OSP through FY2004, after which it would decide whether to develop it or not. NASA included "placeholder" funding in the FY2003 amended budget request (for FY2003-2007) of $2.405 billion. The FY2004 request is $550 million. Until the design is firm, NASA says it cannot estimate the cost of building such a vehicle, but some suggest the cost is $9-13 billion. NASA says OSP would be available first in a CRV mode in 2010, and in 2012 (after the launch vehicle it will use is "human-rated") as a CTV.

That would mean that Soyuz spacecraft would be needed until 2010 as lifeboats for Expedition crews. In the existing international ISS agreements, Russia agreed to have one Soyuz (replaced every 6 months) docked to ISS through the lifetime of the station. A 1996 U.S.-Russia agreement stipulates that through "assembly complete" (then expected in 2006), Russia would provide crew return capability for three crew members. Eleven Soyuz spacecraft were specified for this purpose. According to NASA, that requirement ends in the spring of 2006. By 2006, the U.S. CRV was expected to be available, allowing crew size to increase. The U.S. CRV was required to support at least four more crew members. In the event the U.S. CRV is not yet available, the agreement simply calls on the parties to "discuss appropriate action." Since NASA's current plan is not to have such a capability until 2010, there is a four year gap (2006-2010) when Americans might be limited to residency aboard ISS only when the U.S. space shuttle is docked. (Russia presumably would continue to have one Soyuz docked at the station, but would control who could use it, with no guarantee that Americans would be included.) As noted, the Iran Nonproliferation Act prevents NASA from paying to use Soyuz unless Russia does not proliferate certain technologies to Iran. Some argue that NASA should focus on building a vehicle that could be ready by 2006, rather than 2010.

The ReMaP and NRC Reports on ISS Scientific Research. On July 10, 2002, the Research Maximization and Prioritization (ReMaP) task force reported to the NASA Advisory Council (NAC) on its efforts to reprioritize NASA's ISS scientific research program in light of the decision to scale back the space station's capabilities; the report is available at [ftp://ftp.hq.nasa.gov/pub/pao/reports/2002/REMAPrept.pdf]. ReMaP focused on research intended to be conducted on ISS through NASA's Office of Biological and Physical Research (OBPR). ReMaP recommended that OBPR's ISS research plan be reconfigured with an interdisciplinary approach, identified research priorities, reemphasized the need for a centrifuge, and stressed the need for a strategy for conducting research. It also recommended that if NASA does not build ISS beyond the core complete configuration, then the agency should cease characterizing ISS as a science-driven program. ReMaP noted that there may be other valid justifications for building ISS, however.

The National Research Council (NRC) released a study of how the ISS program restructuring would impact scientific research in September 2002. Its overall conclusions parallel those of ReMaP. Both NRC and ReMaP emphasized that the negative impact on science is due not only to inadequate crew time, but to limits on the amount of "upmass" (e.g., scientific equipment and experiments) that can taken to ISS because shuttle flights were reduced to four per year (see CRS Issue Brief IB93062).

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

For many years, controversy over the ISS program focused on Russia's participation in the program. Among the issues were the extent to which successful completion of ISS is dependent on Russia, Russia's financial ability to meet its commitments, and whether the United States should provide 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 other partners) provide funding to Russia. By 1998, the United States had paid approximately $800 million to Russia for space station cooperation. Although attention is currently focused on NASA's budgetary problems, the issues concerning Russia's role remain as important today as they were in the past.

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 is an ongoing issue. 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 is reassessing what other modules and hardware it will build at its own expense. At the end of 2002, Russian Aviation and Space Agency (RAKA, or Rosaviakosmos) director Yuri Koptev expressed concern as to whether his agency could provide Soyuz spacecraft in 2003 due to budget constraints. In the wake of the *Columbia* tragedy, ISS is now reliant on Soyuz and Progress spacecraft to keep ISS operating, and Mr. Koptev is expressing deep concern about from where the money will come. Mr. 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.

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 may only 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. H.R. 1001 (Lampson) would amend the INA to allow payments to Russia any time the space shuttle fleet is grounded.

Another benefit cited by the Clinton Administration also is in question—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, a NASA official 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, historic symbolism, and potential long term significance for future space cooperation, of the two former Cold War adversaries working together in space.

A further benefit, cited by NASA, is that the space station can be serviced with Russian as well as American spacecraft, providing redundancy in case either side must ground its fleet due to an accident, for example. This is an important advantage now that the space shuttle fleet is grounded.

Congressional Action

FY2003

For FY2003, NASA requested $1.839 billion for the space station program: $1.492 billion in the HSF account for ISS construction and operations, and $347 million in the SAT account for research. In the FY2003 Omnibus Continuing Appropriations resolution, P.L. 108-7, Congress approved that funding, plus $8 million for plant and animal habitats for ISS. According to NASA's initial operating plan, $1.810 billion is available for ISS in FY2003.

FY2004

For FY2004, NASA is requesting $2.285 billion for ISS: $1.707 billion for construction and operations, and $578 million for scientific research. In addition, it is requesting $550 million for the Orbital Space Plane. Note that NASA's FY2004 reflects full cost accounting, where personnel and facilities costs are now included in the program's budget, instead of accounted for separately, as had been done in the past. Hence FY2004 NASA funding figures are not directly comparable to previous NASA figures.

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	1,810**
2004	2,285***	

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 on the expectation Congress would approve additional transfer requests, but it did not.
**Adjusted for 0.65% rescission.
***Reflects shift to full cost accounting.

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 2005. 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. Node 3 is not included in NASA's core complete configuration. 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. Due to financial constraints, Kibo has been delayed until 2006. CAM is scheduled for launch in 2007. NASA also has a bilateral agreement with Italy 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. Brazil is restructuring its agreement in light of financial constraints, however.

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, *Mir*, was a modular space station built and operated between 1986 and 2001. Crews were ferried back and forth to *Mir* using Soyuz spacecraft 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 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 they remained for 5-6 months and then were replaced by a new crew. 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

Impact of the Loss of Space Shuttle *Columbia*

At a minimum, the *Columbia* tragedy will affect the schedule for assembly of ISS, and temporarily reduce the size of Expedition crews from three to two, as discussed earlier. The crews will be taken to and from ISS using Soyuz spacecraft on the same 6-month schedule already planned, and Russian Progress spacecraft will be used to resupply the crew. Progress cannot take space station segments into orbit, so construction of ISS remains suspended until the shuttle returns to flight. This agreement is dependent upon funding becoming available to accelerate the procurement of additional Progress spacecraft, however. Although Russia is obligated under existing agreements to provide two Soyuz and a certain number of Progress spacecraft each year, Russia has cautioned its partners for some time that is does not have the money to provide those spacecraft. Russia is looking to the other partners to pay some of the costs. Under the Iran Nonproliferation Act (INA), though, NASA is prohibited from paying Russia for such spacecraft unless the President certifies that Russia is not proliferating certain technologies to Iran. NASA Administrator O'Keefe told the House Science Committee on February 27, 2003 that he had not asked the White House to request a waiver from the INA requirements. H.R. 1001 would amend the INA to permit payments to Russia for ISS any time the space shuttle is grounded, but Mr. O'Keefe said no modifications to the INA are required now.

If the shuttle is grounded for an extended period. the decision to keep crews on ISS may need to be reassessed. The Russians operated all of their seven space stations using only Soyuz and Progress, so it is possible to keep ISS operating without the shuttle. In this case, however, not only would questions remain about how to fund the requisite Soyuz and Progress missions, but ISS was designed to take advantage of the crew- and cargo-carrying capacity of the U.S. space shuttle. For example, NASA earlier stated that 2 ½ crew members are needed to operate ISS. If only a two-person crew can be supported without the shuttle, even less time may be available for scientific experiments, and there also will be fewer experiments to conduct since many cannot be transported to the station without the shuttle. If little science can be accomplished, some may question the value of keeping a crew aboard, and the wisdom of asking astronauts and cosmonauts to accept the risks inherent in human spaceflight simply to maintain ISS systems. Conversely, how long ISS could continue to function with no one aboard is unknown. Progress spacecraft could dock with

ISS automatically to reboost it and keep it at the proper altitude, but a major system malfunction that could not be remedied by ground-based controllers could imperil the station. Assessing the likelihood of such a scenario is difficult.

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. Scientific research is often cited as a major reason for building the station. Many wondered whether *Freedom*'s fate awaited ISS, and now believe it has. 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 a larger crew to live aboard the station, meaning that the amount of research that can be conducted will be sharply reduced.

Operations and Commercialization Issues

Although construction of ISS is not yet completed, attention is being given to who should operate the facility and how to encourage commercial use of it. Congress declared economic development of Earth orbital space as a "priority goal" of ISS in the 1998 Commercial Space Act (P.L. 105-303). NASA supports space station commercialization, both in terms of getting the private sector to use research facilities on ISS, and assuming space station operations. According to its ISS commercialization Web site [http://commercial.hq.nasa.gov], NASA is committed to setting aside approximately 30% of the U.S. share of ISS's research capacity for economic development. In 1998, NASA proposed creation of a non-governmental organization (NGO) to oversee research on the space station that would be modeled after the Space Telescope Science Institute that operates the Hubble Space Telescope. 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. However, efforts to do so have not materialized as planned. The FY2003 Consolidated Appropriations Resolution (P.L. 108-7) gives NASA permission to proceed with Phase I of establishing an institute, but limits any contractual obligation to leadership and advocacy activities, not engineering and integration functions.

Another issue is the extent to which "tourists" should be allowed aboard ISS. The Russians launched American millionaire Dennis Tito to ISS in 2001 after months of strenuous objections from NASA and other ISS 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, on the condition that guidelines be developed on necessary training before other "spaceflight participants" visit ISS. The guidelines were released in January 2002, and another spaceflight participant (South African Mark Shuttleworth) flew to ISS that April. Following the *Columbia* accident, Russia suspended its "tourist" flights to free the Soyuz spacecraft for ISS crew exchange missions (discussed above).

Issues Related to Russia's Participation

The risks and benefits of Russia's participation in the program 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, too. 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). ISS will remain dependent on Russia for "lifeboat" spacecraft until another vehicle is available, currently expected no sooner than 2010. 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 of the INA. H.R. 1001 would amend the INA to make such payments possible any time the space shuttle is grounded.

LEGISLATION

P.L. 108-7, H.J.Res. 2 (Young)
FY2003 Omnibus Continuing Appropriations Act. Includes FY2003 funding for NASA as part of the VA-HUD-IA portion of the resolution. Passed House January 8, 2003; passed Senate January 23. Conference report (H.Rept. 108-10) passed House and Senate February 13, 2003. Signed into law February 20, 2003.

H.R. 1001 (Lampson)
Amends the Iran Nonproliferation Act to allow payments to Russia in connection with ISS for safety and maintenance purposes any time the space shuttle fleet is grounded. Introduced February 27; referred to House International Relations and House Science Committees.