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Space Stations

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Space Stations

SUMMARY

Congress continues to debate NASA's International Space Station (ISS), a permanently occupied facility in Earth orbit where astronauts live and conduct research. Congress appropriated approximately $35 billion for the program from FY1985-2005. The FY2006 ISS request is $2.180 billion: $1.857 billion for construction and operations and $324 million for research.

The space station is being assembled in Earth orbit. Almost 90 launches of the U.S. space shuttle and Russian launch vehicles were originally planned 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 10" is now aboard. Cost growth and schedule delays have characterized the program since its inception. The grounding of the space shuttle fleet since the February 2003 *Columbia* tragedy is further affecting schedule, operations, and cost. Most of the remaining ISS segments are designed to be launched by the shuttle and construction therefore is suspended. A new exploration initiative announced by President Bush in January 2004 also is affecting the ISS program. He called for curtailing the shuttle program in 2010, and changing the focus of U.S. research aboard ISS to only that which supports his "Moon/Mars" human space exploration goals instead of the broadly-based scientific experiments that were planned.

Canada, Japan, and several European countries became partners with NASA in building the space station in 1988; Russia joined in 1993. 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.

In 1993, when the current space station design was adopted, NASA said it would cost $17.4 billion for construction (not including launch or other costs). That estimate grew to $24.1-$26.4 billion, leading Congress to legislate spending caps on part of the program in 2000. The estimate then grew by almost another $5 billion, leading NASA (at White House direction) to cancel or indefinitely defer some hardware to stay within the cap. NASA alerted Congress in its FY2006 budget request that it may exceed the cap, however.

Controversial since the program began in 1984, the space station has been repeatedly redesigned 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 the impact of the space shuttle *Columbia* tragedy, how and whether to ensure that U.S. astronauts can be part of long duration ISS crews, and the future of ISS in light of President Bush's new exploration initiative.

MOST RECENT DEVELOPMENTS

The "Expedition 10" crew (American Leroy Chiao and Russian Salizhan Sharipov) continues its work aboard the International Space Station (ISS). While the U.S. space shuttle fleet is grounded, Russian Soyuz spacecraft are being used to ferry crews to and from ISS, and Russian Progress spacecraft deliver cargo. NASA hopes to return the shuttle to flight between May 15 and June 3, 2005. If two test flights are successful, ISS construction can resume. NASA's ability to have its astronauts included in long duration "Expedition" crews, however, may end with a Soyuz launch scheduled for October 2005, which will return to Earth in April 2006. That is the last Soyuz Russia is obligated to use for crew rotation and return of U.S. crew members under a 1996 "balance agreement" between the two countries. NASA hopes to have the shuttle back in service by then, but the shuttle remains at ISS for only 1-2 weeks. In order to leave U.S. astronauts on the ISS after the shuttle departs, the astronauts must have access to a "lifeboat" (or "crew return" capability). The Bush Administration terminated plans to build a U.S. crew return vehicle, so Russian Soyuz spacecraft are the only option. NASA has not negotiated an agreement to buy Soyuz services from Russia after April 2006 because it is prohibited from paying Russia for ISS-related activities unless Russia complies with the Iran Nonproliferation Act (see CRS Report RS22072). NASA officials report that an interagency process is underway to develop an approach that would allow NASA to procure certain space goods and services from Russia.

The FY2006 request for the ISS is $2.180 billion: $1.857 billion for construction and operations and $324 million for research. NASA is still developing a new research agenda in the wake of last year's announcement of the Vision for Space Exploration (see CRS Report RS21720), under which the only U.S. research on the ISS will be that related to supporting human trips to the Moon and Mars. In its FY2006 budget justification (p. EC 2-4), NASA alerted Congress that, during FY2005, it may exceed the $25 billion cap for ISS development costs legislated in the FY2000-2002 NASA Authorization Act (P.L. 106-391).

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 join. 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. That "Moon/Mars" program, the Space Exploration Initiative, was not greeted with enthusiasm in Congress, primarily due to budget concerns, and ended in FY1993, although the space station program continued.

President Clinton dramatically changed the character of the space station program in 1993 by adding Russia as a partner to this already international endeavor. That decision 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 as it transitioned from the Soviet era. The Clinton Administration strongly supported the space station within certain budget limits.

President George W. Bush, prompted in part by the February 2003 space shuttle *Columbia* tragedy, made a major space policy address on January 14, 2004, directing NASA to focus its activities on returning humans to the Moon and someday sending them to Mars and "worlds beyond." Included in this "Vision for Space Exploration" is a plan to retire the space shuttle after construction of the space station is completed (now anticipated in 2010). The President said the United States would fulfill its commitments to its space station partners, but the details of how that will be accomplished without the space shuttle have not been announced. The shuttle was supposed to be available throughout the space station's operational years to transport crews, equipment, and scientific experiments.

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. (Some space station crews refer to the facility as "Space Station Alpha," but that is not its formal name). ISS is a laboratory in space for conducting experiments in near-zero gravity ("microgravity"). A broadly based research program had been planned for ISS, but President Bush's January 2004 "Vision for Space Exploration" would limit U.S. research on ISS to that which is needed to support the goal of returning human to the Moon and someday sending them to Mars and "worlds beyond." From FY1985 through FY2005, Congress appropriated approximately $35 billion for the space station program (see table later in this report).

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. They criticized the lack of firm plans for flying a centrifuge, considered essential to this research. NASA subsequently agreed to launch a centrifuge (although it reportedly is again reconsidering that now, see below).

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 three 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. A government-to-government Intergovernmental Agreement (IGA) was signed in September, and Memoranda of Understanding (MOUs) between NASA and its counterpart 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 one year earlier, have 25% more usable volume, 42.5 kilowatts more electrical power, and accommodate six instead of four 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 raised questions about whether NASA should leave more astronauts on *Mir*, but NASA decided *Mir* was sufficiently safe to continue the program. (As discussed below, *Mir* was deorbited in 2001.) 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. The 1988 Intergovernmental Agreement was renegotiated after Russia joined the program. The new version was signed in 1998. 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 its counterpart agencies. Brazil is not a partner in ISS, but agreed to participate 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 at least through 2012. The completion of assembly slipped to 2006, but President Bush restructured the space station program in 2001, and it was not clear when assembly would be "completed." NASA briefing charts in March 2003 showed space station operations possibly continuing until 2022. Under President Bush's January 2004 "Vision for Space Exploration," NASA is to redirect its human space flight program towards returning humans to the Moon and going to Mars. A NASA budget chart released in connection with the Vision shows NASA ending its space station activities in FY2017.

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/home/index.html]. Six major modules are now in orbit. The first two were launched in 1998: Zarya ("Sunrise," a Russian-built, U.S.-owned, module with guidance, navigation, and control systems) and Unity (a U.S. "node" connecting other modules). Next was Zvezda ("Star," a Russian module that serves as the crew's living quarters) in 2000. Destiny (a U.S. laboratory), Quest (a U.S. airlock), and Pirs ("Pier," a Russian docking compartment) arrived in 2001. Among the other modules that will be added are laboratory modules built by Russia, Europe, and Japan, and two more "nodes" built by Europe. (Zarya counts as a U.S. module because NASA paid Russia to build it. Some of the European- and Japanese-built hardware counts as U.S. because they are built under barter agreements where Europe and Japan produce hardware NASA needs instead of paying cash to NASA for launch and other ISS-related services.)

Ordinarily, the U.S. space shuttle takes crews and cargo back and forth to ISS. The shuttle system is currently grounded because of the February 2003 space shuttle *Columbia* tragedy (see CRS Report RS21408). Russian Soyuz spacecraft are also used to take crews to and from ISS, and Russian Progress spacecraft deliver cargo, but cannot return anything to Earth (Progress is not designed to survive reentry into the Earth's atmosphere). A Soyuz is always attached to the station as a lifeboat in case 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 was released after a January 2005 "Heads of Agency" meeting in Montreal, but it does not include launch dates, only the order in which the launches will go. It does list "Establishment of a Permanent Crew of Six (January 2009)," followed by nine shuttle launches to assembly complete. NASA has been instructed to complete ISS construction by 2010, so presumably that is target for assembly complete.

"Expedition" crews have occupied ISS on a 4-6 month rotating basis since November 2000. Originally the crews had three members (two Russians and one American, or two Americans and one Russian), with an expectation that crew size would grow to six or seven once assembly was completed. Crew size is temporarily reduced to two (one American, one Russian) while the U.S. shuttle is grounded in order to reduce resupply requirements. 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. Only Russian Soyuz spacecraft are available as lifeboats. Each Soyuz can hold three people, limiting crew size to three if only one Soyuz is attached. NASA planned to build a U.S. Crew Return Vehicle (CRV) to provide lifeboat capabilities for at least four more crew, but the Bush Administration canceled those plans due to cost growth in the ISS program (see **Key Issues for Congress** below).

Each Soyuz must be replaced every six 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, under normal conditions, the long duration Expedition crews are regularly visited by taxi crews, and by the space shuttle bringing up additional ISS segments or exchanging Expedition crews. During the current period of no shuttle flights, Expedition crews are taken back and forth on the "taxi" 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. The $17.4 billion estimate (called its "development cost," "construction cost," or "R&D cost") covered FY1994 through completion of assembly, then scheduled for June 2002. It 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. In 1998, GAO estimated the life-cycle cost at $95.6 billion (GAO/NSIAD-98-147). More recent, comparable, life-cycle estimates are not available from NASA or GAO.

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 research intended to be conducted aboard the space station. 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.)

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 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. Mr. Goldin initially refused to endorse the $24.7 billion estimate, but by 2000, NASA's own estimate had grown to $24.1-$26.4 billion.

Cost Caps. The $2.1 billion per year figure the Clinton 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 2004 that it could not verify whether NASA is complying with the caps because NASA cannot provide the data GAO requires, and NASA did not comply with the law's reporting requirements in its FY2005 budget request documentation (GAO-04-648R). In its FY2006 budget justification (p. EC 2-4), NASA alerted Congress that it may exceed the $25 billion cap for ISS development during FY2005, attributing the increased costs to delays resulting from the *Columbia* tragedy.

2001-Present: the George W. 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 announced 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 program managers had underestimated the complexity of building and operating the station. The Bush Administration signaled it supported the legislated cap, would not provide additional funds, and NASA would have to find what it needed from within its Human Space Flight account.

"Core Complete" Configuration. In February 2001, 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 Crew Return Vehicle (CRV). The decision truncates construction of the space station at a stage the Administration called "core complete." The Administration said that "enhancements" to the station might be possible if NASA demonstrated improved cost estimating and program management. In 2001, the space station program office at Johnson Space Center (JSC) estimated that it would cost $8.3 billion from FY2002-2006 to build the core complete configuration, described at that time 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 (then anticipated in 2008).

The non-U.S. partners, and U.S. scientists who planned to conduct research on ISS, expressed deep concern with the core complete configuration (see CRS Report RL31216). Concerns focused on the decision to indefinitely defer the CRV (which subsequently was canceled), which limits the space station to three permanent crew members, not seven as planned, reducing the number of crew available to conduct scientific research. For U.S. researchers, another issue was that NASA also reduced the space station research budget by 37.5% over the FY2002-2006 period, necessitating a reassessment of U.S. research priorities on ISS. A July 2002 report of the "Research Maximization and Prioritization" (ReMaP) task force, and a September 2002 National Research Council report, made recommendations on research priorities. (Both were superseded by the January 2004 "Vision for Space Exploration," which directs that U.S. research on ISS be restricted only to that which supports the Vision, discussed elsewhere in this report.) For Europe, Canada, and Japan, the lack of a U.S. crew return capability also poses problems because the additional crew member slots were to be allocated, in part, to their astronauts. Without those positions, their astronauts might be limited to working aboard ISS only for short durations as part of crews on the U.S. space shuttle or Russian Soyuz "taxi" missions. Europe is negotiating arrangements with Russia, however, for its astronauts to be part of Expedition crews. As discussed elsewhere in this report, there are questions as to whether U.S. astronauts will be able to continue to be part of Expedition crews (see **Key Issues for Congress** below).

Reviews of NASA's Cost Estimates and Adding Funds for ISS. NASA created the ISS Management and Cost Evaluation (IMCE) Task Force in July 2001 to review the space station program office's $8.3 billion cost estimate for finishing the core complete configuration. Chaired by former Lockheed Martin executive Tom Young, IMCE determined that the cost estimate was not credible, and NASA should make significant management and cost estimating changes (see CRS Report RL31216). NASA Headquarters directed the space station program office to reassess its estimate, and had two independent groups conduct their own estimates. A July 2002 GAO report (GAO-02-735) concluded that

NASA's focus on managing annual budgets resulted in NASA's failure to heed indicators of future program cost growth.

In November 2002, the Bush Administration submitted an amended FY2003 budget request that shifted $706 million into the ISS program for FY2004-2007: $660 million to boost program reserves, and $46 million in FY2004 for "long-lead" items to preserve the option of increasing crew size beyond three. (Congress cut $200 million from ISS in FY2004, however.) The latter included a proposal to build an Orbital Space Plane (OSP) to takes crews back and forth to ISS as a complement to the space shuttle.

At a December 2002 "Heads of Agency" meeting in Japan, the ISS partners agreed on a process for selecting a final ISS configuration by December 2003. The February 2003 space shuttle *Columbia* tragedy delayed the process, and President Bush's January 2004 announcement of the Vision for Space Exploration, changed NASA's own plans for construction and use of ISS. Included in the changes is cancellation of the Orbital Space Plane, and termination of the space shuttle program after ISS construction is completed. At a January 2005 Heads of Agency meeting, the partners endorsed a final configuration of ISS, but NASA is continuing to assess what modules it needs. For example, NASA officials indicate that the centrifuge and its accommodation module may not be needed now that the U.S. research program is limited to research in support of the Vision. A decision is expected in the spring of 2005.

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[A]
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 [B]
2004 [C]	2,285	2,085
2005	2,412	2,058 [D]
2006	2,180	

The numbers here reflect NASA's figures for "the space station program." Over the years, what is included in that definition has changed.
[A] NASA's FY1999 budget documents showed $2.501 billion in the expectation Congress would approve additional transfer requests, but it did not.
[B] Adjusted for 0.65% rescission.
[C] Reflects shift to full cost accounting.
[D] Congress did not specify an appropriations level. This figure is from FY2006 NASA budget charts.

Congressional Action

FY2005

The FY2005 request for the ISS program was $2.412 billion: $1.863 billion for construction and operations, including $140 million in a new "ISS Crew/Cargo Services" line

to pay for alternatives to the shuttle for taking crew and cargo to and from ISS; and $549 million for research. Congress did not specify a funding level for the ISS in the final version of the FY2005 VA-HUD-IA appropriations act, which was incorporated in the FY2005 Consolidated Appropriations Act (H.R. 4818, P.L. 108-447). Instead, it gave NASA "unrestrained transfer authority" to shift money between budget accounts. In its December 23, 2004 Initial Operating Plan, NASA showed that it plans to spend $1.676 billion on ISS construction and operations, including $98 million for ISS Crew/Cargo Services. A FY2006 NASA budget charts shows $382 million for space station research in FY2005.

FY2006

For FY2006, NASA is requesting $2.180 billion for the ISS program: $1.857 billion for construction and operations (including $160 million for ISS Crew/Cargo Services), and $324 million for ISS research.

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 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 at that time, now the Federal Space Agency), 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" or Canadarm 2) was launched in April 2001; development of another part, the Special Purpose Dextrous Manipulator (referred to as the Canada Hand), is complete and awaiting launch.

ESA is building a laboratory module called Columbus, and an Automated Transfer Vehicle (ATV) to take cargo to ISS. The ATV will be launched on Europe's Ariane launch vehicle. The first ATV launch is expected in 2005. The major contributors to Columbus 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 two of the

three "nodes" (Node 2 and Node 3) for NASA in exchange for NASA launches of Europe's module and other services. Node 2, Columbus, and the cupola are completed. NASA had canceled plans for Node 3, but now has revived them. NASA also has a bilateral agreement with Italy under which Italy built three "mini-pressurized logistics modules" (MPLMs). Already in use, they are launched via the shuttle, attached to ISS while cargo is transferred to the station, filled with refuse or other unwanted material, placed back into the shuttle's cargo bay, and returned to Earth.

Japan is building the Japanese Experiment Module, named Kibo (Hope). One part is pressurized and the other is not (called the "back porch," it will be exposed to space for experiments requiring those conditions). The pressurized section is completed and awaiting launch; the unpressurized section is in development. Japan also is building a centrifuge and a Centrifuge Accommodation Module ("CAM") for NASA in exchange for shuttle flights to launch Kibo. CAM was scheduled for launch in 2007, but is experiencing delays in its development. NASA now is reconsidering whether it needs the centrifuge, since NASA will be conducting only research related to accomplishing the Vision for Space Exploration.

CSA reported in February 2004 that Canada's total ISS spending is expected to be $1.4 billion (Canadian), of which $1.3 billion (Canadian) was spent by that time. ESA reported in March 2004 that its estimated funding for ISS is 5.1 billion Euros, of which 4.1 billion Euros were spent as of the end of 2003. (In March 2004, 1 Canadian dollar = 0.75 U.S. dollar and 1 Euro = 1.2 U.S. dollars.) In February 2004, the Japanese space agency reported that Japan expects to spend $4.8 billion on ISS, of which $4 billion was spent by the end of March 2003. (A 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. The level of its funding contribution is unclear.)

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.

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 six month) 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.

Risks and Benefits of Russian Participation

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) have provided 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 act, 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). Since the *Columbia* accident, access to ISS has been completely dependent on Russia, which ferries crews back and forth on the Soyuz spacecraft and takes cargo to ISS on Progress spacecraft. President Bush's exploration initiative would increase U.S. dependence on Russia vis a vis the space station (see **Key Issues for Congress** below).

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. Russian space agency officials have repeatedly expressed concern about whether they can provide the needed number of Soyuz and Progress spacecraft because of budget constraints.

Clinton Administration and NASA officials asserted repeatedly that Russian participation in the space station program would accelerate the schedule by two years and reduce U.S. costs by $4 billion. That 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. GAO concluded (GAO/NSIAD 94-248) 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 of the two former Cold War adversaries working together in space.

One benefit is that the space station can be serviced with Russian as well as American spacecraft, providing redundancy if either side must ground its fleet due to an accident, for example. This is an important advantage while the U.S. space shuttle is grounded. Russia is providing both crew and cargo flights to the space station, enabling it to continue operation without the shuttle.

ISS and U.S. Nonproliferation Objectives

The overall relationship between the United States and Russia is another factor in the ISS equation, including Russian adherence to U.S. nonproliferation objectives. Getting Russia to adhere to the Missile Technology Control Regime (MTCR), designed to stem proliferation of ballistic missile technology, 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 the Russian space agency nor any major Russian ISS contractors or subcontractors were among those sanctioned.

On March 14, 2000, President Clinton signed into law the Iran Nonproliferation Act (INA), P.L. 106-178. The law, *inter alia*, prohibits NASA from making payments related to ISS after January 1, 1999, in cash or in kind, to Russia unless Russia takes the necessary steps to prevent the transfer of weapons of mass destruction and missile systems to Iran, and the President makes a determination that neither the Russian space agency 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 hardware needed to dock the U.S. Interim Control Module (ICM, discussed earlier). Certain notifications are required if the exceptions are utilized. NASA was seeking permission to spend $35 million on Russia goods and services, of which $14 million was for the ICM docking hardware. President Clinton provided Congress with a required notification with regard to that $14 million on June 29, 2000. Ultimately, only $11 million was needed for the ICM hardware, leaving $24 million that NASA wanted to spend. No determination as required by the act was forthcoming from the President. NASA considered using the crew safety exception, but at a House International Relations Committee hearing on October 12, 2000, some committee Members sharply criticized NASA's legal interpretation of that exception, particularly NASA"s broad interpretation of the word "imminent." Thus, the INA has important ramifications for whether NASA can keep its astronauts on ISS for long duration missions after April 2006, or at all after 2010 when the shuttle is expected to be terminated. (see **Key Issues for Congress**, below). For more information on the INA and the ISS, see CRS Report RS22072.

Key Issues For Congress

Maintaining ISS Operations While the Shuttle is Grounded

The grounding of the space shuttle system following the *Columbia* accident has suspended assembly of ISS, temporarily reduced the size of Expedition crews from three to two, and complicated efforts to keep the crews supplied with consumables, scientific experiments, and spare parts for equipment that needs repair. Crews are being taken to and from ISS using Russian Soyuz spacecraft on the same six-month schedule already planned, and Russian Progress spacecraft are used to resupply the crew. Russia is obligated to provide crew return for three people throughout the lifetime of ISS. Currently, they accomplish that with two Soyuzes per year (each lasts only six months once docked to ISS). Russia also is obligated to provide a certain number of Progress spacecraft, but has cautioned that funding for Soyuz and Progress is not assured. Under the Iran Nonproliferation Act (INA), NASA is prohibited from paying Russia for ISS-related activities unless the President certifies that Russia is not proliferating certain technologies to Iran. The other ISS partners to date have not volunteered to pay for additional Soyuz or Progress spacecraft.

The Russians operated seven of their own space stations (see above) using only Soyuz and Progress spacecraft, so it is possible to keep ISS operating without the shuttle as long as Russia is willing to provide them. However, operation of ISS was premised on the availability of the cargo-carrying capacity of the space shuttle. Many observers point out that the longer the shuttle remains grounded, the more difficult it is to keep ISS operating. For example, the current crew (Expedition 10) was required to reduce its food intake because of shortages aboard the station in late 2004. Stocks were resupplied by a Progress that reached ISS late that December, but U.S. and Russian space station personnel made clear that if the Progress had failed to dock, the crew would have had to return home prematurely because of the food situation. ISS crews also need to repair faulty equipment, but replacement parts may not fit aboard Progress or Soyuz. NASA hopes to return the shuttle to flight status in May or June 2005. If that date slips, the ISS partners may need to reassess whether to keep a crew aboard ISS. In addition to questions about keeping the crews well supplied, with a two-person crew, less time may be available for scientific experiments. If little science can be accomplished, some may question 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.

Another issue is that, in the wake of *Columbia*, ISS has been designated as a "safe haven" for shuttle astronauts on the first two "Return to Flight" shuttle launches. If a problem is detected with the shuttle that would prevent its safe return to Earth, the shuttle crew would remain on ISS awaiting a rescue shuttle mission. Ensuring sufficient supplies of food, water, air and other consumables for the additional astronauts is problematic.

Ensuring U.S. Astronaut Participation in Long-Duration Missions

As noted, ISS crew size is limited in part by the number of occupants that can be accommodated in a lifeboat, or "crew return vehicle" (CRV), in an emergency. Without its own CRV, NASA is facing two deadlines in terms of assuring access to ISS for long duration missions by U.S. astronauts. First is spring 2006, when Russia will have fulfilled its commitment to provide lifeboat services for U.S. astronauts. Second is 2010, when the shuttle is expected to be retired in accordance with President Bush's Vision for Space Exploration. The 2010 deadline is discussed separately (see next issue).

Regarding the spring 2006 deadline, the international agreements that govern the ISS program obligate Russia to provide crew return services for three crew members throughout the lifetime of the ISS, and the United States to provide such services for at least four people beginning when assembly of ISS is completed. Prior to the *Columbia* tragedy, that milestone was expected to occur in 2006. By that time, a U.S. CRV, accommodating at least four people, was expected to be available. It would not only provide lifeboat capabilities for U.S. crew members, but allow the ISS crew size to grow to seven (three could return on a Soyuz, and four on the CRV), including representatives from the other partners. However, the Bush Administration terminated the CRV, and its successor, the Orbital Space Plane. Therefore, only Russian Soyuz spacecraft are available for lifeboat services.

Under a 1996 "balance agreement" between NASA and the Russian space agency, Russia is obligated to use 11 Soyuz spacecraft to provide crew return for U.S. crews. The first of the 11 was launched in November 2000. The last is scheduled for launch in October 2005, returning to Earth in April 2006. After that, Russia no longer must allocate any of the seats on its Soyuzes for U.S. astronauts. It can sell those flight opportunities to whomever it wishes, with no guarantee that Americans would be included. Russia is interested in selling flight opportunities to help finance its space program, so might choose to limit those opportunities to paying customers. As noted, the Iran Nonproliferation Act prevents NASA from paying Russia for ISS-related activities unless Russia does not proliferate certain technologies to Iran.

The impending situation where Russia's obligation will be fulfilled, and there is no U.S. CRV to ensure that American astronauts can be part of Expedition missions, has been recognized for several years. As that deadline approaches, attention to the issue is increasing. To date, the Bush Administration has not been willing to make the certification required by the INA to allow NASA to pay Russia. NASA officials have repeatedly stated that there is no intention to request a waiver from the INA. Without a presidential certification, a waiver, or a decision by Russia to continue providing such services without payment, the options appear somewhat limited. They include amending the law, concluding that one of the exceptions in the law applies in this instance, accepting the risk of allowing astronauts to remain on ISS without a lifeboat, or deciding that U.S. astronauts no longer need to be part of Expedition crews.

Impact of President Bush's Vision for Space Exploration, Including the "4-year Gap"

President Bush's January 2004 Vision for Space Exploration directs NASA to focus its activities on returning humans to the Moon by 2020, and someday sending them to Mars and "world beyond." If adopted, it would affect the ISS program in several ways. First, the President directed that the shuttle be retired in 2010 after construction of ISS is completed. A NASA budget chart that accompanied announcement of the Vision shows NASA completing its utilization of ISS by FY2017. By terminating the shuttle and NASA utilization of the ISS, that funding (approximately $6 billion per year) could be reallocated to achieving the Vision. (Then-NASA Administrator O'Keefe stated at a February 12, 2004, House Science Committee hearing, however, that NASA might continue using the station after that, and there is no plan to "turn out the lights." If that statement is correct, it is not clear how the Vision can be achieved on the announced schedule.) The President also directed that the U.S. research on ISS be restricted to the life sciences research needed to support the Vision, instead of the broadly-based research program that was planned.

The extent to which ISS can be utilized without the space shuttle is not clear. Soyuz spacecraft can take crews back and forth, but the shuttle's cargo capacity — both for taking cargo to ISS, and back to Earth (e.g. the results of scientific experiments, or hardware that needs repair) — could be expensive to replicate. No other partner has a spacecraft able to bring material back to Earth today. Europe reportedly is considering adding a return capsule to its Automated Transfer Vehicle (a robotic cargo spacecraft expected to make its first flight in 2005). NASA is exploring the possibility of U.S. commercial companies developing a return capability. None of those plans is firm, though, and the size and mass of what could be returned is likely to be less than what can be carried in the shuttle's cargo bay.

Another issue is how U.S. crews would be able to access ISS once the shuttle is retired in 2010. As already discussed, NASA is facing an April 2006 deadline regarding Russian support for U.S. astronauts. If those arrangements cannot be negotiated, U.S. astronauts will still be able to visit ISS using the shuttle, which typically docks for 1-2 weeks. That option obviously would not be available if the shuttle is retired. NASA would be completely dependent on Russia for access to ISS until NASA's new Crew Exploration Vehicle (CEV), which is being developed as part of the Vision, is available. Under the current schedule, CEV will be available to take astronauts to Earth orbit by 2014. The 2010-2014 period, when the United States would not be able to launch humans into space, is sometimes referred to as the "4-year gap."

Today, NASA is dependent on Russia for taking astronauts to and from the space station, and delivering cargo, because the space shuttle is grounded. While some view the 2010-2014 gap as similar to the situation today, it would, in fact, be quite different. Today, there is an agreement in place where Russia is launching U.S. crews and cargo to ISS at no cost to NASA. As noted above, that obligation will be fulfilled in April 2006. No agreement has been negotiated for 2010-2014. Russia could charge whatever price it wanted for those services. If the INA is still in effect, it is not clear if NASA could pay. Russia also would be able to make operational decisions with which NASA might disagree. Russia could decide, for example, to rotate crews at longer intervals. Russia proposed increasing Expedition durations to a year instead of six months, but NASA replied that it is not ready

to do so. If Russia is providing all the crew transport services, NASA's influence on decisions like that may be reduced.

There also is a difference between the emergency situation today, necessitated by the *Columbia* tragedy, and an intentional decision to terminate NASA's ability to launch astronauts into space and hope that the political relationship with Russia remains stable and a mutually beneficial agreement can be negotiated. To the extent the decision could create a situation where U.S. astronauts might not be able to work aboard ISS, a facility being built largely at U.S. taxpayer expense, Congress may choose to explore its implications.

If U.S. astronauts will not be part of Expedition missions, it might be useful to investigate whether ground-based alternatives are available for conducting the life sciences research needed to accomplish the Vision. If ground-based alternatives are available, though, some may question why the United States is continuing to spend such a large amount of money on ISS. Others may argue that fulfilling commitments to the other ISS partners is a sufficient justification for continued U.S. participation in the ISS program.

LEGISLATION

108th Congress, 2nd Session

P.L. 108-447, H.R. 4818. FY2005 Consolidated Appropriations Act. Incorporates VA-HUD-IA appropriations (including NASA) as Division I. H.R. 5051, FY2005 VA-HUD-IA appropriations, was reported from House Appropriations Committee September 9, 2004 (H.Rept. 108-674). No floor action. Companion bill, S. 2825, reported from Senate Appropriations Committee September 21, 2004 (S.Rept. 108-353). No floor action. Conference agreement on VA-HUD-IA included in conference report on H.R. 4818 (H.Rept. 108-792), which passed House and Senate November 20, 2004. Signed into law December 8, 2004.