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CRS Issue Brief for Congress

Space Stations

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SUMMARY

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

The space station is being assembled in Earth orbit. Almost 90 launches are needed to take the various segments, crews, and cargo into orbit. Several launches have taken place. The original date to complete assembly, June 2002, slipped to April 2006, with at least 10 years of operations expected to follow. Cost overruns in 2001 are forcing additional schedule changes, however, and the current schedule is uncertain. Crews rotate on 4-6 month shifts. Two crew rotations have taken place; another is now underway. Congress appropriated about $27.6 billion for the program from FY1985-2001. For FY2002, NASA requested $2.1 billion. Congress appropriated (P.L. 107-73) $2.24 billion, which actually is $75 million less because Congress included civil service salaries in the total while the request did not.

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 $9 billion of their own money.

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

In 1993, when the current design was adopted, NASA said the space station would cost $17.4 billion for construction; no more than $2.1 billion per year. The estimate did not include launch or other costs. NASA exceeded the $2.1 billion figure in FY1998, and the $17.4 billion estimate grew to $24.1-$26.4 billion. Congress legislated spending caps on part of the program in 2000. Costs have grown almost $5 billion since. NASA has proposed 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 debate focuses on the recently revealed cost growth in NASA's part of the program and the resulting possibility that portions of the space station may not be built; and whether Russia can fulfill its commitments to ISS.

MOST RECENT DEVELOPMENTS

The space shuttle Endeavor docked with the International Space Station (ISS) on December 7. The shuttle has delivered the "Expedition 4" crew (one Russian and two Americans) to replace the Expedition 3 crew (one American and two Russians). ISS is under construction in orbit.

On December 7, a Senate Commerce subcommittee held a hearing on the confirmation of Sean O'Keefe to become the next NASA Administrator. He currently is Deputy Director of the Office of Management and Budget (OMB). If confirmed, Mr. O'Keefe is expected to implement the recommendations of a task force that recently released its report on space station management and cost issues. At a November 7 House Science Committee hearing, Mr. O'Keefe endorsed the recommendations. The task force, chaired by retired Lockheed Martin executive Tom Young, concluded that NASA's $8.3 billion cost estimate for building and operating the station through a stage called "core complete" from FY2002-2006 is not credible and NASA's cost estimating techniques are insufficient to provide an accurate estimate. The task force recommended significant management and cost estimating changes to be implemented by June 2002. In general, the task force sees the next two years as a period for NASA to demonstrate credibility in effectively managing the program and developing cost estimates for the future. If it does, then NASA would be given permission to proceed with building the space station with the capabilities originally intended. Earlier in the year, NASA had revealed $4.8 billion in cost growth for FY2002-2006. Added to previous cost overruns, the development cost of the station would reach approximately $30 billion, well above the $25 billion cap that Congress legislated last year. NASA and OMB have proposed mitigating steps to reduce program costs to stay within the cap, but the changes would limit the capabilities of the station, particular in terms of research. The changes would affect all the partners in the program (U. S, Europe, Canada, Japan, and Russia). At a November 14-15 ministerial meeting, ESA confirmed that it will fulfill all its commitments to the program, and expects NASA to do the same.

The FY2002 VA-HUD-IA appropriations act (which includes NASA) was signed into law on November 26 (P.L. 107-73). The Act reduces the FY2002 space station budget by $75 million. The conferees on the bill did not adopt the House position of adding $275 million for a Crew Return Vehicle (CRV). However, they directed NASA to spend $40 million for the X-38 program, a precursor to a CRV.

BACKGROUND AND ANALYSIS

Introduction

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

of NASA's program in the 1970s and 1980s. Budget constraints forced NASA to choose to build the space shuttle first. When the shuttle was declared operational in 1982, NASA was ready to initiate the space station program.

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

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

President George W. Bush has not yet made a statement about his position on the space station program. However, Sean O'Keefe, deputy director of the Office of Management and Budget (OMB), told the House Appropriations VA-HUD-IA subcommittee on May 3, 2001, that the Bush Administration intends to bring costs under control. OMB has directed NASA to find whatever additional ISS funds it needs from within the Human Spaceflight account. Mr. O'Keefe also stated that the Administration "strongly supports" the $25 billion development cost cap imposed by Congress last year. Mr. O'Keefe has been nominated by President Bush to become the next NASA Administrator.

The International Space Station (ISS) Program

NASA began the current program to build a space station in 1984 (FY1985). In 1988, the space station was named *Freedom*. Following a major redesign in 1993, NASA announced that the *Freedom* program had ended and a new program begun, though NASA asserts that 75% of the design of the "new" station is from *Freedom*. The new program does not have a formal name and is simply referred to as the International Space Station (ISS). Individual ISS modules have various names, and the entire facility is informally referred to as "Space Station Alpha." ISS is a laboratory in space for conducting experiments in near-zero gravity ("microgravity"). Life sciences research on how humans adapt to long durations in space, biomedical research, and materials processing research on new materials or processes are underway or contemplated. From FY1985 through FY2001, Congress appropriated approximately $27.6 billion for the space station program (a year-by-year table is included under **Congressional Action** below).

Space Station *Freedom*: 1984-1993

When NASA began the space station program in 1984, it said the program would cost $8 billion (FY1984 dollars) for research and development (R&D—essentially the cost for building the station without launch costs) through completion of assembly. From FY1985-1993, NASA was appropriated $11.4 billion for the *Freedom* program. Most of the funding went for designing and redesigning the station over those years. Little hardware was built and

none was launched. Several major redesigns were made. A 1991 redesign evoked concerns about the amount of science that could be conducted on the scaled-down space station. Both the White House Office of Science and Technology Policy (OSTP) and the Space Studies Board (SSB) of the National Research Council concluded that materials science research could not justify building the space station, and questioned how much life sciences research could be supported, criticizing the lack of firm plans for flying a centrifuge, considered essential to this research. NASA subsequently agreed to launch a centrifuge.

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.

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.

1993 Redesign

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

In 1993, President Clinton pledged to request $10.5 billion ($2.1 billion a year) for FY1994-1998. NASA said the new station would cost $17.4 billion to build, not including money already expended on the *Freedom* program. That estimate was derived from the $19.4 billion estimate for the September 7 Alpha design minus $2 billion that NASA said would be saved by having Russia in the program. The $2.1 billion and $17.4 billion figures became known as "caps," though they were not set in law. By 2000, the program's cost had risen to $24.1-26.4 billion, and the $2.1 billion "cap" was exceeded in FY1998. Congress now has legislated caps on parts of the program (see **ISS Costs, Caps...**).

Current Program: The International Space Station (ISS)

The current International Space Station program began in 1993, with Russia added as a partner, joining the United States, Europe, Japan, and Canada. The 1993 and subsequent agreements with Russia established three phases of space station cooperation and the payment to Russia of $400 million ($100 million per year for FY1994-1997). In 1996, NASA increased that amount to $473 million, of which approximately $323 million was for Phase I and $150 million for Phase II. (Through the end of 2000, NASA had transferred a total of approximately $800 million to Russia for space station cooperation through this and other contracts. A request to transfer $24 million more is pending.)

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

Phases II and III: ISS Design, Schedule, and Lifetime. NASA identifies Phases II and III of space station cooperation separately, but they blend into each other. The result is the International Space Station (ISS), currently under construction by the United States, Russia, 10 or 11 European countries, Japan, Canada, and Brazil (which is not a partner on the program, but has a bilateral agreement with NASA to participate). Phase II was completed in July 2001. Phase III is underway, but the Office of Management and Budget (OMB) and NASA are proposing dramatic changes to the program in response to more than $4 billion of cost growth. Since the changes are still proposals only, the following paragraphs describe the program as it existed in January 2001. The proposed changes are discussed in the next section.

Boeing is the U.S. prime contractor for ISS. ISS segments are launched into space on American or Russian launch vehicles and assembled in orbit. Details on the various segments can be found at [http://spaceflight.nasa.gov]. Assembly is expected to take more than 7 years and be completed around April 2006 (originally it was to have been completed in June 2002). NASA originally stated that ISS would be operated for 10 years, with a possibility for 5 additional years if the research was considered worthwhile. Using the original completion date of 2002, that would have meant guaranteed operations through 2012. As the time frame for building the station slipped beyond 2002, NASA stated that it would operate the station until 2012 regardless of when construction is completed, with subsequent peer review determining whether continued operation was warranted. That would mean a shorter guaranteed lifetime. By 2000, NASA had returned to stating that it would operate the station for at least 10 years after assembly is completed. Whether NASA, a non-governmental organization, or the private sector will operate the space station is currently being discussed (see **Issues** below).

Six major modules are now in orbit: the first two, Zarya (Sunrise) and Unity, were launched in 1998; followed by Zvezda (Star) in 2000, and Destiny, Quest, and Pirs (Pier) in 2001. NASA paid for, built, and launched Unity, Destiny, and Quest. NASA paid for Zarya;

it was built and launched by Russia. Russia paid for, built, and launched Zvezda and Pirs. NASA continues to revise the schedule for launching the remaining segments (the "assembly sequence"). The most recent public edition, "Rev F" (August 2000), shows completion of assembly in April 2006.

There are 50 launches in the "Rev F" assembly sequence of which ten have been accomplished (Zarya, Unity, Zvezda, Destiny, Quest, and five other shuttle missions) and another is underway. Of the 50 launches, 40 are American, 9 are Russian, and one is listed as unassigned (of the European Automated Transfer Vehicle) although Europe plans to launch ATV on its Ariane launch vehicle. In addition, Russia is expected to provide each year about two flights of its Soyuz spacecraft to take crews to the station and three to six Progress spacecraft to "reboost" the station's orbit periodically. NASA is concerned that Russia may not provide all of the Progress reboost flights and modified the space shuttle orbiters so they can provide a limited amount of reboost in case sufficient Progresses are not available. NASA established two other contingency plans: an Interim Control Module (ICM) built by the U.S. Naval Research Lab (NRL), and a Propulsion Module NASA itself planned to build. Following the successful launch of Zvezda, NASA directed NRL to put the ICM in "cold storage" such that if it were needed in the future, it would take 24-30 months to get ready. Delays and cost estimate increases led NASA to reevaluate its Propulsion Module concept, and led Congress to request a GAO study of the program (GAO-01-633). NASA then announced a new plan to procure a Propulsion "System" using a "structural test article" constructed as part of building the Unity module. Because of the cost growth announced in February 2001 (see below), NASA canceled the Propulsion System. A May 21, 2001 NASA Inspector General audit concluded the program, as it existed at the time of the audit, had a life-cycle cost of $1.6 billion and was not cost effective.

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. NASA has been planning to build a U.S. Crew Return Vehicle (CRV), but its availability date slipped to 2005. Until then, only Russian Soyuz spacecraft will be 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 U.S. CRV is expected to accommodate six or seven people and would have a lifetime of 3 years, reducing operational costs. Because of the cost growth revealed in 2001, NASA is considering cancelling the CRV (see below).

ISS Costs, Caps, Overruns, and Additional Money to Russia. In 1993, NASA said it would cost $17.4 billion to build the space station (variously called its "development cost," "construction cost," or "R&D cost") from FY1994 through completion of assembly in June 2002 ($206 million was carried over from the *Freedom* program, for a total program cost of $17.6 billion). NASA estimated the life-cycle cost from FY1985-FY2012 (including construction costs, associated shuttle launch costs, civil service salaries, and 10 years of operations) at $72.3 billion. A more recent NASA life-cycle estimate is not available. In 1998, GAO said that the life-cycle cost would be $95.6 billion (GAO/NSIAD-98-147). As of early 2000, NASA's estimate for construction alone (FY1994 through completion of assembly, slipped to 2006) was $24.1-$26.4 billion.

Caps. In 1993, NASA agreed that it would spend no more than $2.1 billion per year on ISS. The $17.4 billion and $2.1 billion figures became known as "caps," although they

were not set in law. They did not include the cost of space shuttle launches needed to place ISS in orbit. Both were exceeded in 1997-1998. In 2000, Congress legislated 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, but the act also authorizes an additional $5 billion for development and $3.5 billion for associated shuttle launches in case of specified contingencies.

$4.8 Billion Cost Growth. In February 2001, NASA revealed significant cost growth in the program that would exceed the legislated cap. The February estimate was a $4.02 billion increase over the next 5 years (FY2002-2006), but that increased to $4.8 billion by June. That would raise the cost to approximately $30 billion, 72% above the 1993 estimate. NASA explains that the cost growth became evident as 2000 progressed and program managers realized that they had underestimated the complexity of building and operating the station. The agency thought it had sufficient funding in program reserve accounts to cover contingencies, but in late 2000 and early 2001 concluded that funding was insufficient. By late January, NASA says that it began to realize the cost growth was in the $4 billion range. The Bush Administration signaled that it would not provide additional funds and NASA would have to find what it needed from within its Human Spaceflight account. The Administration also indicated that it supported the legislated cap. Thus, NASA made dramatic proposals to reduce the cost of the program.

By the end of June, with the new cost growth estimate of $4.8 billion, more program changes were proposed, but they are not enough to compensate for it totally. NASA and OMB reported in June that the program would stay within President Bush's budget guidelines in FY2002 and FY2003 if their cost-cutting proposals were adopted, but $484 million more would be needed to cover shortfalls in FY2004-2006.

To compensate for the cost growth as it stood at the end of June 2001, NASA proposed the following steps. Space station construction would end after the "U.S. core" is completed in late 2003 and modules built by Europe and Japan are launched in 2004. NASA and OMB estimated it would cost $8.3 billion from FY2002-06 to build and operate the station to the "U.S. core complete" stage. The Habitation Module (the "Hab") and Crew Return Vehicle (CRV) would be "indefinitely deferred" and the Propulsion Module canceled. The fate of several other segments—the Centrifuge Accommodation Module (CAM), "Node 3," and a cupola—scheduled for launch after completion of the U. S. core remains unclear. They are being built for NASA in exchange for NASA launching Japanese and European hardware (Japan is building CAM; Europe is building Node 3 and the cupola). Thus the cost to NASA would be only to integrate those segments into the space station, not to build them. NASA hopes the integration costs are small enough to be accommodated within the new budget envelope, not only because it wants those capabilities, but because otherwise it would have to renegotiate the barter agreements. In February, NASA had included the station's fourth solar array (which generates electrical power) in the list of items that might be terminated, but the June agreement with OMB restores the solar array to the program. The June NASA/OMB agreement assumes that Node 3 will not be launched.

Regarding the Hab, CRV, and Propulsion Module, although NASA characterizes the above changes as *proposals*, the agency already has canceled the Propulsion Module. As discussed, plans to build that module developed because of concern that Russia could not fulfill its commitment to provide Progress spacecraft for reboost. NASA indicated in mid-

2000 that it wanted a U.S. propulsion capability to reduce reliance on Russia and to ensure that ISS was not dependent on *any* other country for reboost. Hence, it did not at that time consider Europe's ATV as an alternative. NASA now expresses optimism that Europe will proceed with its plans to build ATV and apparently feels comfortable relying on Europe for this capability. The first of nine planned ATV flights is scheduled for 2004, meaning that ISS will be dependent on Russian Progress spacecraft for reboost at least until then. Questions remain about Russia's financial ability to provide sufficient Progresses. In addition, ESA has recently revealed significant cost growth in the ATV program. Whether that will impact the program's schedule is unclear.

The Hab module and CRV are important for allowing crew size on ISS to grow from three to six or seven people. Additional life support equipment is needed to support a larger crew. Those systems were to be located in the Hab module, along with additional living quarters. Also, a larger crew requires additional lifeboat capabilities. Today, one Russian Soyuz spacecraft is used as a lifeboat. It can accommodate three people. The CRV was being designed for six or seven people. The additional crew members would conduct the scientific research that was foreseen as the major purpose of building a space station. If crew size is limited to three, research will be severely constrained because NASA estimates that "2 ½" people are required to operate ISS, leaving only half of one person's time for research. NASA also has proposed reducing the research budget by 37.5% over the FY2002-2006 period. Instead of building the Hab module, as a barter arrangement, NASA and Italy reached a "framework" agreement in April 2001 for Italy to provide a module that would offer many "Hab" capabilities. Details are pending. If NASA proceeded with construction after "Core Complete" and Italy provided "Hab" functions, the question would still remain as to how to return a larger crew in an emergency. One Soyuz can satisfy the lifeboat function for only three people. If CRV is not built, additional Soyuzes (which must be replaced every 6 months) would have to be provided by NASA or another partner buying them from Russia (it seems unlikely that Russia would provide them at no cost). Another partner might choose to develop a lifeboat capability, although this would take considerable time and money. NASA is discussing the possibility of a joint CRV development program with Europe and with Japan. ESA reportedly indicated in fall 2001 that it might be willing to provide more funding for CRV, but it likely will be dependent upon assurances that NASA also provide funding. An ESA ministerial meeting is scheduled for November to discuss this and other issues.

The IMCE ("Young") Task Force. NASA created the ISS Management and Cost Evaluation (IMCE) Task Force, headed by retired Lockheed Martin executive Tom Young, in July 2001. The task force released its report on November 2 [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 is not credible. The task force called on NASA to make significant management and cost estimating changes by June 2002. Overall the report saw the next two years as a period for NASA to demonstrate credibility, and if it does, then a decision would be made to proceed with space station construction to build the station as originally intended.

The White House had already made it clear that any additional funding for ISS would have to come from within NASA's funding for Human Spaceflight activities. The task force recommended that the number of shuttle flights per year be cut back to four per year in support of ISS, which it said would generate $668 million in savings over 5 years that it

assumed would be applied to ISS. This would mean that crew rotations aboard the space station would increase to 6 months (from the current 4-5 months). It also recommended increasing the crew size on the station temporarily by extending the length of shuttle visits to 14 days, and by increasing the length of Soyuz visits to ISS from a week to a month. The task force also made strong recommendations about what disciplines should be the focus of the ISS scientific research program, emphasizing the need to launch the centrifuge as soon as possible to conduct studies on how humans react to weightlessness. Japan is building the centrifuge and its accommodation module for NASA. Its original delivery date of 2006 recently slipped to 2008; the task force called that date "unacceptable."

The House Science Committee held a hearing on the Young task force report on November 7. Two letters from ESA, one to the State Department and one to Chairman Boehlert, and a Canadian Space Agency letter to the State Department, were submitted for the record. The letters express deep concern about the United States not meeting its commitments under the Intergovernmental Agreement (IGA), and the consequences to the international partners of resulting reductions in the availability of crew time to conduct research. The Canadian letter requests, as provided in the IGA, that the State Department convene a government-level multilateral consultation to discuss these matters as soon as practical. At an ESA ministerial meeting on November 14-15, 2001, ESA confirmed that it will fulfill its obligations under the IGA, and expects NASA to do the same. ESA approved full funding for its part of the space station, but will defer release of 60% of it pending confirmation from NASA that the IGA will be fulfilled.

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

One factor in the cost growth was concern that Russia would not launch its Zvezda module on time. As insurance against Zvezda delays or a launch or docking failure, NASA decided to build the ICM (discussed earlier). To cover cost growth associated with Zvezda's delay and the need to procure at least one 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 latter request was not approved, but the appropriations committees did approve transferring the $200 million in FY1997.

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 has remained; NASA estimates that overrun at $1.14 billion. Boeing's contract is currently valued at $9.6 billion and runs through December 31, 2003.

In March 1998, NASA announced that the construction cost estimate had grown from $17.4 billion to $21.3 billion. In April 1998, NASA released a review of space station costs conducted by an independent "cost assessment and validation" task force reporting to the NASA Advisory Council. Headed by Jay Chabrow, the report concluded that the space station's cost through assembly complete could be $24.7 billion and assembly could take 10-38 months longer. NASA agreed its schedule was optimistic and there would be about $1.4 billion in additional costs, but Administrator Goldin refused to endorse the $24.7 billion estimate. The current estimate is approximately $30 billion.

Additional Money to Russia. Meanwhile, NASA decided it needed to provide funding to Russia to ensure completion of Zvezda. This was in addition to more than $700 million NASA had transferred to Russia in exchange for goods and services since 1994. NASA formally notified Congress on September 29, 1998 of its plan to send another $60 million to Russia (from its FY1998 budget). The agency said the money would buy "up to" all the research time (4,000 hours) allocated to Russia during the assembly period, together with access to stowage space on Russian modules. The House and Senate appropriations subcommittees that oversee NASA (VA-HUD-IA) approved the transfer of the $60 million, but said they would view with "grave concern" a request for an additional $40 million NASA also had suggested it would need. NASA's authorizing committees (House Science and Senate Commerce) did not agree to the $60 million transfer.

NASA also said it expected to transfer $100 million of its FY1999 space station funds to Russia. Of that, $65 million was expected to be for a Russian Soyuz spacecraft and the remainder for other Russian hardware and services. However, NASA learned that Russia was selling one Soyuz, two Progresses, and 45 days of research time on the *Mir* space station to an American venture capitalist for $20 million. NASA thereupon withdrew its plans to spend $65 million for a Soyuz and proceeded, on February 14, 2000, to request permission to spend $35 million. Of that, $14 million was for a "pressure dome" needed for the U.S. ICM in case of problems with the Zvezda launch. The request was approved, but after Zvezda was launched, the pressure dome was no longer needed. NASA had spent $11 million at that point, leaving a total of $24 million for which permission is still pending. Whether NASA will obtain approval to spend that money in Russia, and what it would buy, is undecided and could be affected by the Iran Nonproliferation Act (see below). No funds are included in NASA's FY2000, FY2001, or FY2002 budgets for transfer to Russia.

Risks and Benefits of Russian Participation, Including Proliferation Issues. In the report to accompany the FY1994 VA-HUD-IA appropriations bill (P.L. 103-124), Congress stated that Russian participation "should enhance and not enable" the space station. The current design, however, can only be viewed as being "enabled" by Russian participation. Today 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.

The extent to which the program is dependent on Russia is important in terms of program risk because Russia's financial ability to meet its commitments has been a major issue for several years. Many Russian assurances have not been upheld, leading to skepticism on the part of U.S. officials as to Russia's financial ability and political resolve to meet its

commitments. Russian Aviation and Space Agency (RAKA, or Rosaviakosmos) director Yuri Koptev estimated in 1997 that Russia would spend $3.5 billion on its portion of the ISS (later he said $6.2 billion if launch costs were included), but it is not clear at this point how much money Russia will put into the program.

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

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

Russian adherence to MTCR was cited by the Clinton Administration as one of the benefits of involving Russia. That benefit is now in question along with another—financial savings. Clinton Administration and NASA officials asserted repeatedly in 1993 that a joint space station would accelerate the schedule by 2 years and reduce U.S. costs by $4 billion. This was later modified to one year and $2 billion, and an April 1, 1994 letter to Congress from NASA said 15 months and $1.5 billion. NASA officials continued to use the $2 billion figure thereafter, however. A July 1994 GAO report (GAO/NSIAD 94-248) concluded that Russian participation would cost NASA $1.8 billion, essentially negating the $2 billion in expected savings. In 1998, NASA's Associate Administrator for Human Spaceflight conceded that having Russia as a partner added $1 billion to the cost. Other benefits cited by the

Clinton Administration were providing U.S. financial assistance to Russia as it moves to a market economy, keeping Russian aerospace workers employed in non-threatening activities, and the emotional impact and historic symbolism of the two former Cold War adversaries working together in space.

Congressional Action

FY2002

The FY2002 VA-HUD-IA appropriations Act (P.L. 107-73), which includes NASA, reduces the FY2002 ISS budget by $75 million, although the budget figures are difficult to track.

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

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

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 (rev.)**	2,114	2,240***

The numbers here reflect NASA's figures for "the space station program." Over the years, what is included in that definition has changed.
* NASA's FY1999 budget documents show $2.501 billion for FY1998 based on the expectation that Congress would approve additional transfer requests, but it did not.
**$2.087 billion was initially requested; NASA later requested funding transfers that raised it to $2.114 billion.
***See text; Congress actually reduced the budget request by $75 million.

total of $2.114 billion. House and Senate appropriators adopted those revisions in their consideration of the request.

The House passed its version of the FY2002 VA-HUD-IA appropriations bill (H.R. 2620, H. Rept. 107-159) on July 30. A Roemer amendment was defeated (voice vote) that would have set a cap on space station funding and prohibited NASA from terminating or deferring certain space station elements; another, to terminate the program, was withdrawn. As passed, the bill fully funded the ISS request and conditionally added $275 million for a Crew Return Vehicle as recommended by the House Appropriations Committee. The Senate passed its version of the bill on August 2 (S. 1216, S. Rept. 107-43), reducing space station funding by $150 million as recommended by the Senate Appropriations Committee. The conference report was filed on November 6 (H. Rept. 107-272). The $283.6 million in the SAT account was approved. Conferees provided $1.96 billion in the HSF account, but that actually is a reduction of $75 million from the request because conferees included civil service salaries in the total whereas the budget request did not. The conferees stated that they were reducing the budget because they had "reached the conclusion that the only way management will actually manage the program, and thereby get its costs under control, is through being forced to live with less." The conferees did not adopt the House position of adding $275 million for a Crew Return Vehicle (CRV). However, they directed NASA to spend $40 million on the X-38 program, a precursor to CRV. They adopted a Senate provision requiring NASA to establish a special task group to develop and assess low cost options to enhance crew time for research aboard ISS. The conference report is sharply critical of NASA's management of the program. It calls for NASA and OMB to submit a report defining the "U.S. Core Complete" configuration and providing a 10-year funding profile; defining the content and scope of the research program; and providing cost and schedule estimates for CRV. If enhancements are proposed, OMB must make a number of certifications to Congress regarding their necessity, risk, and funding. NASA must place the highest priority on resolving the lack of an integrated financial management system. The conference report requires a report from NASA, OMB, and the State Department on how the United States is fulfilling its commitments to the partners.

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, the Canadian Space Agency, and the Russian space agency (Rosaviakosmos).

The IGA is a treaty in all the countries except the United States (where it is an Executive Agreement). NASA has a bilateral agreement under which Italy is providing three "mini-pressurized logistics modules" (MPLMs). They are attached to ISS while cargo is transferred to the station, then filled with refuse or other unwanted material and returned to Earth. Another bilateral agreement was signed with Brazil in October 1997 for Brazil to provide payload and logistics hardware. According to NASA data provided to CRS in June 2000, these countries jointly have spent $4.5 billion of their own funding on the space station so far and expect to spend a total of $8.6 billion.

Canada is contributing the Mobile Servicing System (MSS) for assembling and maintaining the space station. In February 1994, the new prime minister of Canada had decided to terminate Canada's role in the program, but later agreed to reformulate Canada's participation instead. The first part of the MSS (the "arm") was launched in April 2001; another part, the Special Purpose Dextrous Manipulator (the "fingers"), is scheduled for late 2003. ESA is building a laboratory module called Columbus and an Automated Transfer Vehicle (ATV). The major contributors are Germany, France, and Italy. Budgetary difficulties over the years led ESA to cancel other hardware it was planning. ESA also is building a cupola (a windowed dome) and paying for Italy to build two of the three "nodes" (Node 2 and Node 3), in exchange for free shuttle flights to launch its ISS hardware. 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. The fates of CAM, Node 3, and the cupola are in question as described earlier. Meanwhile, Japan has indicated that due to its own budget pressures, Kibo may be delayed 1-2 years. If CAM is built, design difficulties already had delayed its scheduled launch by two years; the earliest it is expected to be available is 2008.

Russia

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

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

Crews occupied *Mir* from 1986-2000. For almost ten of those years (1989-1999), *Mir* was continuously occupied by crews on a rotating basis. Although occasionally crews stayed for very long periods of time to study human reaction to long duration spaceflight, typically crews remained for 5-6 months and then were replaced by a new set of cosmonauts. The longest continuous amount of time spent by a single individual on *Mir* was 14 months. From

1995-1998, seven Americans participated in long duration (up to 6 months) missions aboard *Mir*, and nine space shuttle missions docked with the space station. Individuals from Japan, Britain, Austria, Germany, France, and the Slovak Republic also paid for visits to *Mir*. Russia deorbited *Mir* into the Pacific Ocean on March 23, 2001.

Issues For Congressional Consideration

Rationale

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

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

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

Cost and Cost Effectiveness

Cost effectiveness involves what can be accomplished with the facility that is ultimately built versus its cost. In 1993, NASA said it would cost $17.4 billion to build the U.S. portion of the space station. That rose to $24.1-$26.4 billion by early 2000, with $4 billion more in cost growth announced in 2001. Cost estimates for the earlier *Freedom* design had risen significantly as the years passed, and with each *Freedom* redesign, the amount of science diminished. Many wondered whether the same fate awaited ISS. In FY1996, FY1997, and FY1998 NASA transferred a total of $462 million from the space station science accounts into space station construction. In response to the $4 billion in cost growth, NASA has proposed reducing the research budget by 37.5% (FY2002-2006) and to indefinitely defer building hardware that would enable six or seven crew members to live aboard the station.

Without it, crew size could be limited to three. Since NASA states that 2 ½ crew members are needed to operate the station, only half of one person's time would be available for research. The fate of the centrifuge and its accommodation module is uncertain. Many worry that as costs rise further, other NASA activities may suffer, despite assurances that cost growth will have to be accommodated within NASA's human spaceflight budget.

Operations and Commercialization Issues, Including Transhab

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

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

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

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

and choose winners. The FY2000-2002 NASA authorization act (P.L. 106-391) limits the project to 3 years.

An issue that arose in 2001 was whether "tourists" should be allowed aboard ISS. The Russians launched American millionaire Dennis Tito to ISS in April 2001 after months of strenuous objections from NASA and other space station partners that he was insufficiently trained and the space station was not yet ready to accommodate nonprofessional astronauts. Days before the Russians were to launch Mr. Tito to ISS, NASA and the other partners agreed to the launch on the condition that the partners would develop guidelines on necessary training before other nonprofessional astronauts visit ISS. On August 10, NASA announced that agreement in principle had been reached among the partners, and a final document would be released later in the month or in September. A House Science subcommittee held a hearing on space tourism on June 26. On July 10, Representative Lampson introduced H. R. 2443, which seeks to facilitate the emergence of a space tourism industry by the private sector, but would prohibit the U.S. portion of ISS from being visited or occupied by anyone not engaged in supporting official business of the United States or the conduct of scientific or engineering R&D, and those authorized by relevant international agreements, except in emergency situations.

Russian Non-Performance and Proliferation Issues

The risks and benefits of Russia's participation in the program already have been discussed. Currently, the main 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. Assuming that U.S. policy remains to build the space station and include Russia, the keys are: how to limit the amount of money that is transferred to Russia and help ensure that it is used for the space station program and not for other purposes, and how to manage the construction of ISS amidst the uncertainty of when or if Russian hardware and services will be available. NASA's decision to put the ICM in "cold storage" and cancel the Propulsion System ensures ISS dependance on Russia for reboost (except for the very limited reboost capabilities of the U.S. space shuttle) at least through 2004. At that time, an alternative may be Europe's ATV. If the Crew Return Vehicle is canceled, ISS would remain dependent on Russia for "lifeboat" spacecraft indefinitely. As discussed earlier, the Iran Nonproliferation Act (INA) prohibits U.S. payments to Russia for ISS, with some exceptions, unless the government of Russia prevents Russian nuclear and missile technology from reaching Iran. NASA's interpretation of that law has stirred controversy and remains unresolved. The key question is what will happen if Russia insists it cannot fund reboost or lifeboat missions yet NASA is not permitted to transfer money to Russia for such missions because Russia is not in compliance with INA.

LEGISLATION

P.L. 106-73 (H.R. 2620)

FY2002 appropriations for VA-HUD-Independent Agencies (including NASA). H.R. 2620 reported from House Appropriations Committee July 25 (H. Rept. 107-159); passed House July 30. S. 1216 reported from Senate Appropriations Committee July 20 (S. Rept. 107-43). H.R. 2620 passed Senate, amended, August 2. Conference report (H. Rept. 107-272) passed House and Senate November 8. Signed into law November 26.