United States General Accounting Office

GAO

Report to Congressional Requesters

August 1999

SPACE STATION

Cost to Operate After Assembly Is Uncertain

G A O

Accountability * Integrity * Reliability

GAO/NSIAD-99-177

GAO
Accountability * Integrity * Reliability

United States General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-280736

August 6, 1999

The Honorable F. James Sensenbrenner, Jr.
Chairman
Ranking Minority Member
Committee on Science
House of Representatives

When completed around 2004, the goal of the International Space Station (ISS) is to provide the United States and its international partners with an Earth orbiting facility that supports human habitation and scientific research in a microgravity environment. Because of Russia's ongoing problems in funding its share of the space station's construction costs, the National Aeronautics and Space Administration (NASA) is concerned that Russia may also not be able to fulfill its commitments to fund ISS operations costs. NASA estimated that the annual cost to operate the completed space station will average $1.3 billion, or $13 billion over a 10-year mission life. NASA anticipates sharing these costs with its international partners, and it hopes to further reduce funding requirements through sharing with commercial users or through more efficient commercial operations.

As requested by you and the late Representative George E. Brown, Jr., we reviewed NASA's estimate for the cost to operate the space station after assembly is completed. Specifically, we were asked to determine (1) if any space station-related costs are not included in NASA's estimate; (2) the level of uncertainty in the cost estimate for operations, especially with regard to the potential impact of changes in Russian participation; and (3) how NASA funding requirements will be reduced by sharing costs with international partners or through commercial use and operations. We reported on NASA's efforts to promote commercial activity on the space station in a separate report to you.[1]

Results in Brief

NASA's $1.3 billion estimate does not include all funding requirements related to space station operations. NASA does not prepare budget

[1] Space Station: Status of Efforts to Determine Commercial Potential (GAO/NSIAD-99-153R, June 30, 1999).

estimates on a full-cost basis because it has not completed implementation of its full cost accounting system. Additional items that will have to be funded in the future within the space station budget include costs for upgrading obsolete systems and operating an alternative propulsion module. NASA has not developed detailed estimates for potential upgrades to combat component obsolescence and improve performance, but space station officials believe that a robust enhancement program could cost $100 million or more per year. NASA has not estimated the cost of operating an alternative propulsion module being procured to provide reboost if Russia is unable to provide that function. Items that we determined to be space station-related that are funded in other NASA budget lines include space shuttle flights, civil service personnel, principal investigators, and space communications; these are estimated to cost a total of $2.5 billion in fiscal year 2004.[2] When NASA implements full cost accounting in 2001, some costs currently in other NASA budget lines will be included in the space station budget. In commenting on our draft report, NASA stated that shuttle flights should be allocated to the overall cost of operating the space station using a marginal cost of $84 million per flight rather than an average cost of $435 million. We believe the average cost per flight more accurately represents NASA resources related to operating the space station.

There is a high degree of uncertainty in NASA's estimate for the cost to operate the space station from 2005 to 2014. NASA's original estimate of $13 billion for operating the space station was developed to aid in evaluating life-cycle costs of redesign options rather than to accurately forecast budget needs. This estimate did not consider end-of-mission costs for either extending the life of the space station beyond 10 years or decommissioning it. The estimate was also developed for an earlier space station configuration that has since been modified. NASA does not prepare detailed budget estimates for the space station and other programs beyond fiscal year 2004, the last year of its current 5-year budget-planning period. NASA recently began an effort to review its operations cost estimate and develop a long-range funding profile that would better reflect annual requirements over the 10-year operations period. Adding to the uncertainty of future costs, the full impact on operations if Russia is unable to fulfill its obligations is not known at this time. NASA would incur costs to operate an alternative propulsion module, but does not yet know whether there will

[2] This amount does not include the cost of space communications.

be a shortfall in Russian logistics flights or how such a shortfall would be spread among the shuttle and international partner resupply vehicles.

There is insufficient information at this time to determine the amount that NASA funding requirements could be reduced by international partners' contributions toward common operating costs. In sharing operating responsibilities for the space station, NASA and Russia have agreed to exchange services rather than funds. However, NASA and Russia may not be able to achieve a balance in the services provided to each other if Russia cannot fulfill its obligations. NASA's share of common operating costs has increased and could change again if international partners revise their participation in the space station program. It is likely that the partners will provide services for the space station rather than transfer funding to NASA to pay for their shares of operating costs. Allowing partners to pay common costs with services may not reduce NASA funding requirements. For example, if partners pay for their common costs by launching space station payloads for NASA that could have been launched on the space shuttle, it likely will not offset NASA's budget. At this time, it is not possible to accurately determine what the partners may owe for reimbursable costs for shuttle launch services and communications, or how the partners would pay for these services.

Because NASA has already initiated actions to review its ISS operations cost estimate and to develop a 10-year funding profile for the period after assembly is complete, we are not making recommendations in this report. We will monitor NASA's progress in developing the 10-year funding profile.

Background

In 1984, President Ronald Reagan directed NASA to develop a permanently manned space station and invited other countries to participate. NASA's original partners included Canada, Europe, and Japan.[3] In 1993, the space station was redesigned to incorporate significant contributions from Russia.[4] In 1997, Brazil became a participant in the program. Appendix I describes the partners' contributions to the space station.

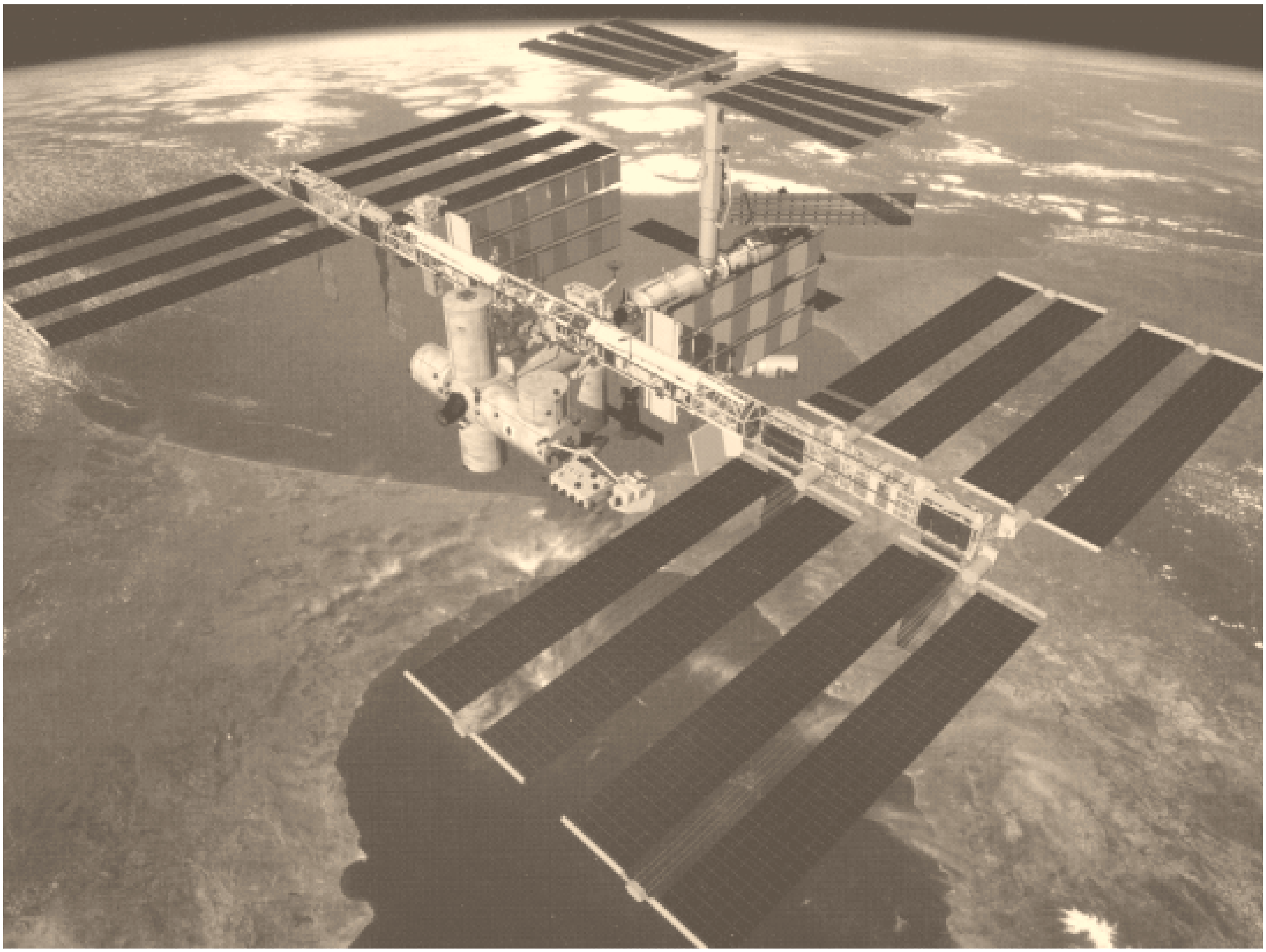
[3] Members of the European Space Agency participating in the ISS program include Belgium, Denmark, France, Italy, Germany, the Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom.

[4] Space Station: Update on the Impact of the Expanded Russian Role (GAO/NSIAD-94-248, July 29, 1994).

The ISS will be a large and complex space vehicle, weighing more than four times Russia's existing Mir space station. It will take more than 80 launches and 1,900 hours of spacewalks over a 6-year period to complete assembly. The first two elements of the space station were launched in 1998, with the completion of assembly currently planned for 2004. When assembly is complete, ISS will measure 356 feet and weigh nearly one million pounds. In 1998, we estimated that U.S. funding for the space station development and assembly would total $53 billion.[5] Figure 1 depicts the fully assembled space station.

[5] International Space Station: U.S. Life-Cycle Funding Requirements (GAO/NSIAD-98-147, May 22, 1998).

Figure 1: Artist's Conception of Fully Assembled ISS on Orbit.



Source: NASA.

Estimating the cost to operate a facility as complex as the space station so far into the future is a challenging task. After assembly is complete, ISS will begin a long-term mission that will run from 2005 to 2014. During this 10-year period, NASA estimates that annual space station operating costs will average $1.3 billion, for a total of $13 billion. After this initial period of operations, NASA and its partners will decide whether to continue to operate the space station and for how long.

Space Station Budget Does Not Contain All Related Items

NASA's space station budget line does not contain all funding requirements related to space station operations. NASA has not completed implementation of a full-cost accounting system. Consequently, estimates presented in this report were not prepared on a full-cost basis. Additional costs to replace or upgrade aging components and to operate a propulsion module will need to be funded within the space station budget. NASA's annual estimate of $1.3 billion for operations does not include costs totaling more than $2.5 billion for items such as space shuttle flights, civil service personnel, principal investigators, and space communications.

Full-cost Accounting

NASA initiated a plan to implement full-cost accounting practices in 1995 to respond to new federal financial accounting standards and to direction from an internal NASA review team. In 1995, the federal government approved new managerial cost-accounting standards, including a specific standard on full-cost accounting. In addition, during 1995, NASA completed a Zero Base Review that involved a comprehensive analysis related to streamlining NASA activities. The Zero Base Review team indicated that NASA should improve cost information and pursue full-cost management.

NASA's full-cost concept integrates several fundamental accounting, budgeting, and management improvements. NASA officials told us that implementation of full-cost accounting was originally scheduled for fiscal year 1999, but has been delayed to fiscal year 2001. When it is implemented, the space station budget will include several additional items that are currently funded in other budgets. For example, the civil service and space communications costs related to the space station will be funded in the space station budget. In addition, the space station budget will include other costs, such as a share of the general and administrative costs and institutional capabilities providing direct support to the program.

Additional Costs That Will Need to Be Funded in Space Station Budget Line

In estimating the cost to operate the space station, NASA considers only those elements that are funded in the space station budget.[6] Table 1 shows the funding requirements for these elements for fiscal year 2004 as estimated in NASA's fiscal year 2000 budget submission.[7] Appendix II provides brief descriptions of each of the budget elements that are related to space station operations.

[6] The NASA budget is divided into five main budget lines: International Space Station; Launch Vehicles and Payloads; Science, Aeronautics and Technology; Mission Support; and Inspector General.

[7] NASA's fiscal year 2004 budget estimate for the space station includes $1,361 million for operations and $212 million for development, for a total of $1,573 million.

Table 1: Elements of Operations Cost to Be Funded in Space Station Budget

Current dollars in millions

Elements	FY 2004[a]
Operations planning & cargo integration	$21
Sustaining engineering	224
Logistics & maintenance	128
Station operations support	202
Launch site processing	65
Institutional support	62
Utilization Support	108
Research Projects	360
Crew Return Vehicle Operations	23[b]
Unallocated program reserves	169
Total	**$1,361**[c]

[a] According to NASA officials, the operations portion of the projected budget for fiscal year 2004—the year the space station should be completed—should approximate the budget for the operations period after assembly is completed.

[b]Operations costs are included in the crew return vehicle (CRV) development budget in fiscal year 2004.

[c]Total does not add due to rounding.

The current estimate does not reflect the cost of likely additions to the program. Specifically, NASA has begun planning for the replacement or upgrade of obsolete components as the space station ages. In addition, NASA will procure an alternative propulsion module to reduce dependence on Russia for critical guidance, navigation, control, and reboost functions.

Replacing Obsolete Components

NASA recognizes that obsolescence will be an issue for the space station and that additional funding will likely be needed to fully address it. An April 1998 report by the NASA Advisory Council also raised the obsolescence issue.[8] The report stated that based on the current speed of technological advancement, the normal rate of obsolescence in space systems and computer technology would cause major cost growth for the space station in later years. In its response to the report, NASA acknowledged that the space station program did not have any funds specifically for obsolescence upgrades. While the program had funds

[8] Report of the Cost Assessment and Validation Task Force on the International Space Station, NASA Advisory Council, April 21, 1998.

budgeted for sustaining engineering and logistics and maintenance, NASA stated that those monies would be inadequate to support a meaningful upgrade program for major systems. The logistics and maintenance budget, for instance, funds the replacement of components that fail as a result of normal wear and tear. These funds could also be used to upgrade minor systems or discrete components. However, additional funding would be needed to upgrade major systems whose replacement is not included in the budget.

NASA has begun planning for the replacement of obsolete components as a part of its pre-planned program improvements. The objectives of this program include: increasing reliability, maintainability, and sustainability; enhancing research productivity and capability; and improving operational capability and reducing costs. Funding for the program is currently limited to $28.9 million for studying high priority enhancements. The studies have identified several candidates for replacement or upgrade. For example, NASA is studying how to upgrade the space station's current computer system from 386-based processors, which are considered third-generation, to at least fifth-generation processors that are currently available. NASA is concerned that the 386 processors will not be able to handle growth in processing requirements and that parts for these processors may not be available 5 to 10 years from now. NASA has not yet developed detailed cost estimates for implementing the enhancements identified in the studies. Space station officials said that a robust enhancement program could potentially cost $100 million or more per year. Upgrading and enhancing the components could become more critical if the space station will operate for more than 10 years.

Operating a Propulsion Module

NASA will also need to fund the costs of operating a propulsion module within the space station budget. Russia is responsible for providing the propulsion capability for the space station as well as guidance, navigation, and control functions. Because of Russia's ongoing financial problems, NASA is studying an alternative propulsion and guidance and navigation capability. Space station officials have not yet developed an estimate for the cost of operating a propulsion module. Most of the operating costs would be incurred for spares and sustaining engineering.

Some Costs of Space Station Operations Are Funded in Other NASA Budget Lines

Several items related to the space station are not included in its operations estimate because they are funded in other NASA budget lines. These items--which include the annual cost of space shuttle support, civil servants, principal investigators, and space communications--total more than $2.5 billion in fiscal year 2004.[9] When NASA implements full cost accounting in 2001, some of these costs will be reflected in the space station budget.

Space Shuttle Support

NASA estimates that five to six shuttle flights a year will be needed to support the space station after assembly is completed: Five flights will be launched each year to resupply the space station and rotate crew, and a sixth shuttle flight will be launched every 3 years to exchange the CRV. Based on an average cost of $435 million per flight in fiscal year 2004, about $2.2 billion to $2.6 billion of the annual space shuttle budget should be considered space station-related costs.[10]

Space station-related shuttle costs would increase commensurately if the number of flights to the space station increases because the international partners cannot fulfill their launch commitments or because the shuttle has to rotate two crew return vehicles instead of one. An increase in the number of shuttle flights dedicated to supporting the space station may also increase the shuttle budget if the overall flight rate increases. In developing the shuttle budget, NASA plans to support seven flights per year. If an additional space station-related flight can be accommodated within those seven planned flights, the shuttle budget would remain the same and another $435 million of that total budget would be considered a space station-related cost. If an additional space station-related flight would increase the flight rate from seven to eight, the shuttle budget would have to be increased by the marginal costs for processing another flight. The marginal cost includes the costs of personnel, hardware, and consumables such as propellant that can be added or removed from the program when there is a temporary adjustment in the flight rate. NASA estimates that the marginal cost for adding one shuttle flight to the overall manifest is about $84 million.

Civil Servants, Principal Investigators, and Space Communications

The cost for salaries and benefits associated with the approximately 2,300 civil servants supporting space station operations in fiscal year 2004 is around $260 million. Civil servant costs are funded in the Research and Program Management portion of NASA's Mission Support budget. Funding

[9] This amount does not include the cost of space communications.

[10] Average cost per flight is defined as the total cost to operate the shuttle on a recurring and sustained basis for a given year divided by the number of flights planned for that year. NASA plans to fly seven flights annually during the operations period. The average and marginal costs per flight are based on fiscal year 2004 estimates projected in NASA's fiscal year 2000 budget submission to Congress.

for principal investigators who will be flying experiments on the space station is estimated at $49 million in fiscal year 2004. These costs are funded in the Office of Life and Microgravity Sciences and Applications line in NASA's Science, Aeronautics, and Technology budget. Finally, communications costs for the space station are currently funded in the Space Communications portion of NASA's Mission Support appropriation. NASA is in the process of determining the extent of these costs as it combines its space operations activities (communications, data transport, and space vehicle command and control) under the Consolidated Space Operations Contract.

High Degree of Uncertainty in NASA's Estimate of Cost to Operate the Space Station

There is a high degree of uncertainty in the estimated cost to operate the space station from fiscal year 2005 to 2014. NASA has not prepared a detailed budget estimate for the space station beyond fiscal year 2004, the last year of its 5-year budget planning period. NASA recently began developing a 10-year funding profile for the operations period and expects to have a preliminary estimate in the fall of 1999. Adding to the uncertainty of future costs is the question of Russia's ability to fulfill its commitments and whether NASA may have to compensate for a shortfall in Russian support for the space station.

Detailed Budget Estimates for the Operations Period Have Not Yet Been Developed

NASA's initial $1.3 billion estimate for annual operations costs discussed previously did not provide a basis for developing reliable budget estimates for the period after assembly is complete. During a major redesign of the space station in 1993, NASA developed an estimate for operations to aid in evaluating the life-cycle cost of various design alternatives. According to NASA officials, this estimate was not meant to be a rigorous assessment of funding requirements during the operations period. As part of the redesign process, a NASA review team estimated the funding requirements for the second full year of operations after the space station is completely assembled. The team believed that the second year represented a typical year of operations.[11] This team arrived at an estimate of $1.3 billion for a typical year of operation, and it extrapolated that figure over the 10-year life of the space station for a total of $13 billion. This estimate did not consider end-of-mission costs for either extending the life of the space station beyond 10 years or decommissioning it. The estimate was also

[11] The first year after completing assembly the space station would involve on-orbit verification of hardware and systems and would likely have a higher than normal number of anomalies or problems.

developed for a space station configuration that has since been modified to include significant Russian participation and added elements such as a propulsion module, CRVs, a third connecting node, and a centrifuge accommodation module.

NASA program managers responsible for each of the various program cost elements have not yet projected funding requirements for the operations period (2005 to 2014) because it is outside the current budget-planning horizon. NASA's current budget-planning horizon is 5 years, extending only through fiscal year 2004. Moreover, NASA officials told us that with all the changes and replanning that have occurred in the ISS program in recent years, they have had to focus budget activities on the development and assembly period.

Some NASA managers told us that it would be difficult to project the funding needed for some budget components until they knew how well the space station would function. For example, they would need to know actual failure rates for space station components before they can accurately project the funding needed for spares and maintenance. Similarly, the actual number of anomalies and engineering problems the space station experiences will drive the funding requirements for the sustaining engineering function. In the interim, NASA officials told us that they will rely on computer modeling and analyses to project funding requirements for these items.

Even when NASA has historical data on which to make projections for elements, the total cost for these elements can depend to a large degree on unpredictable factors. For example, NASA has sufficient information to accurately estimate the launch site processing costs for a shuttle flight to support the space station. However, these costs could vary depending on the number of shuttle flights in a given year. NASA plans to provide five or six shuttle flights annually to support the space station, but it could be responsible for additional flights if any international partner is unable to meet its launch and resupply commitments. There are uncertainties in partner resupply commitments because (1) the payload capacity of the European and Japanese cargo vehicles may be different than their design specifications when the vehicles are actually built, (2) there is concern about the number of Progress vehicles Russia may launch, and (3) technical problems or launch failures could also temporarily ground some of the resupply vehicles.

As part of its fiscal year 2001 budget review cycle, NASA recently began an effort to review its operations cost estimate and to develop a 10-year funding profile that would more accurately reflect the year-to-year costs of the program after assembly is complete. NASA officials expect to complete a preliminary estimate of operations costs in the fall of 1999. This estimate will be refined over the next program year. Many of the key people who need to be involved in developing the long-term estimate are currently working on near-term assembly operations. As part of the review, NASA officials plan to identify factors or scenarios that could significantly alter the profile.

Russia's Ability to Fulfill Obligations Is Uncertain

When Russia joined the program in 1993, it agreed to provide critical hardware and services for space station operations. Russia is responsible for providing crew living quarters, life support systems, guidance, navigation, and attitude control for the space station through its Service Module. In addition, Russia is responsible for supplying fuel and dry cargo (food, water, clothes, spares, air, and nitrogen) and reboosting the space station to maintain its proper orbit. The reboost and dry cargo resupply will be accomplished by unmanned Russian Progress vehicles. Finally, Russia will launch and return crews for the space station on Soyuz vehicles. The Soyuz also will serve as the only emergency crew return vehicles until the U.S.-developed crew return vehicle is available in 2004.

Beginning in late 1995, NASA became increasingly concerned about Russia's ability to adequately fund its space station commitments. Since then, shortfalls in Russian funding have led to delays in the delivery of the Service Module. NASA continues to be concerned about Russia's funding problems. For the 10 years of operations after assembly is complete, NASA's primary concern is Russia's ability to produce and launch enough Progress vehicles to reboost and resupply the space station. Current plans call for Russia to launch three to four Progress vehicles annually to the space station after assembly is completed.

NASA officials believe that Russia will be able to meet this Progress launch rate, but NASA has developed contingency plans to protect against a shortfall.[12] NASA is studying development of an alternative propulsion module that could provide guidance, navigation, attitude control, and

[12] Space Station: Status of Russian Involvement and Cost Control Efforts (GAO/T-NSIAD-99-117, Apr. 29, 1999).

reboost if Russia is unable to perform those functions. According to space station program officials, propellant used by this module would be scavenged from excess fuel on the shuttle while it is docked to ISS during resupply missions. As discussed earlier, NASA has not yet estimated the cost of operating this module. NASA is also reviewing options for launching additional propellant and cargo on the shuttle and on the planned European and Japanese resupply vehicles in the event Russia reduces the number of Progress flights. NASA has not determined how the increased resupply requirements would be spread among the vehicles or if additional shuttle flights would be needed.

Unclear if NASA Funding Requirements Will Be Reduced by Cost Sharing Arrangements With Partners

In sharing operating responsibilities for the space station, NASA and Russia have agreed to exchange services rather than funds. However, NASA and Russia may not be able achieve a balance in the services provided to each other. The cost of operating the space station is also supposed to be shared with NASA's other international partners. NASA's share of common operating costs has increased slightly as partners have reduced their participation. Allowing the other partners to provide services to reimburse NASA for their shares of common costs may not offset NASA funding requirements. The partners may also reimburse NASA for shuttle and communication services, but the amount and form of reimbursement cannot be accurately estimated at this time.

NASA and Russia May Not Achieve Balance in Services Provided

For purposes of assigning operations responsibilities and costs, the space station is divided into the United States On-orbit Segment (USOS), which includes hardware provided by NASA, Canada, Europe, and Japan and the Russian Orbital Segment. Interaction between the two segments is governed by agreements between NASA, representing USOS interests, and the Russian Space Agency (RSA). The underlying basis for the agreements is that the partners in each segment "keep what they bring"; that is, NASA and the USOS partners will retain utilization rights in their segment and operate and maintain elements they provide. Russia will retain utilization rights to its facilities, and it will operate and maintain Russian elements. The NASA-RSA agreements recognize that it may be more efficient for certain services to be provided by a particular partner. A goal of the agreements is to achieve a balance in services provided by partners in each segment to the other over the assembly and operations period so as not to require an exchange of funds between partners.

The balance in services that was agreed to may not be achieved if Russia reduces the number of Progress vehicles it launches to supply the space station. In 1996, NASA and RSA signed the "Balance Protocol" listing the services that each side would provide to the other during the assembly and operation periods.[13] As part of the balance in services, Russia agreed to deliver half of the USOS propellant requirements during the 10 years of operations after assembly is completed.[14] However, if the Russians only launch three to four Progress vehicles per year, NASA's analysis of propellant resupply indicates that Russia will not be able to deliver the full amount of propellant as agreed. The shortfall would be delivered by a European cargo vehicle that will also transport propellant for the USOS. According to a space station program official, the 1996 protocol would have to be amended to maintain balance if the Russians are unable to provide all of the agreed to hardware and services. The Balance Protocol provides that if it is necessary in the future to adjust NASA and RSA contributions and obligations, the parties will attempt to resolve any issues through the use of barter.

Common Operating Costs Are to Be Shared by USOS Partners

International agreements governing the space station partnership specify that each USOS partner is responsible for funding the operation and maintenance of the elements that it contributes, the research activities it conducts, and a share of common operating costs. Under current planning, NASA will fund the entire cost of USOS common supplies and ground operations costs and then be reimbursed by the other partners for their shares. Eventually, partners may provide some common items, such as crew supplies or propellant, directly rather than reimburse NASA for those costs. The partners' shares of USOS common costs are as follows: NASA, 76.6 percent; Canada, 2.3 percent; Europe, 8.3 percent; and Japan, 12.8 percent. These percentages are linked to the partners' rights to research utilization resources on the space station. For example, NASA is entitled to 76.6 percent of crew time, power, and data processing available for research and is therefore responsible for 76.6 percent of the common costs. Utilization rights are determined by each partner's contributions to

[13] Protocol Including Terms, Conditions, and Assumptions, Summary Balance of Contributions and Obligations to International Space Station (ISS) and Resulting Rights of NASA and RSA to ISS Utilization Accommodations and Resources, and Flight Opportunities, June 11, 1996.

[14] Partners in both segments are responsible for providing propellant to the space station proportion to the mass of hardware each provides. Therefore, USOS partners are responsible for providing 71 percent of the total propellant required during 10 years of operations after assembly is completed and Russia is responsible for providing the remaining 29 percent.

the development and assembly of the space station. Under bilateral agreements with NASA, Italy and Brazil are also providing hardware in exchange for small shares of NASA's utilization rights.

Each partner will be responsible for a percentage of two types of common operating costs: common ground operations and transportation of common supplies. NASA, in consultation with the other USOS partners, determined the categories and amounts of ground operating costs that will be shared. Common ground operations costs were estimated to be $305.3 million in fiscal year 2004, or 33 percent of the total funding for the common categories in NASA's budget. Table 2 shows the categories of ground operations costs and the amount that will be shared as common costs.

Table 2: Common Ground Operating Costs for Fiscal Year 2004

Current dollars in million

Common ground operations categories	Common cost
Integrated tactical planning	$52.7
Space systems operations	106.5
POIC[a] operations and logistics	46.6
Integrated logistics systems operations	28.8
Pre-launch/post-landing operations	70.7
Total	**$305.3**

[a]Payload Operations and Integration Center.

Common supplies to be transported to the space station include propellant, crew, crew supplies such as food and clothing, life support gases, and water. Common transportation requirements were estimated to average about 66,000 kilograms per year over the 10-year period after assembly is completed. A partner may reimburse NASA for launching its share of supplies on the shuttle, fund the launch of the common supplies on its own resupply vehicle, or purchase or barter for launch services from another partner. Table 3 shows the allocations of common ground operations costs and common supply transportation requirements for each USOS partner.

Table 3: USOS Partner Shares of Annual Common Operations Costs

Current dollars in millions

USOS partner	Percent of common costs	Common ground operating costs[a]	Common transportation kilograms[b]
United States	76.6	$233.9	50,556
Canada	2.3	7.0	1518
Europe	8.3	25.3	5,478
Japan	12.8	39.1	8,448
Total	**100.0**	**$305.3**	**66,000**

[a]Estimated common ground operating costs for fiscal year 2004.

[b]Approximate average annual common cargo requirement.

As stipulated in the international agreements, NASA's partners do not pay common operating costs until they begin utilizing the space station. Partner utilization is expected to begin when their research modules are launched and outfitted near the end of the assembly sequence. The Japanese laboratory module should be ready for utilization in fiscal year 2003; the European laboratory module in fiscal year 2004. Canada does not have its own laboratory but has rights to research facilities in other partner modules. Canada can begin conducting research in 2000 after its major hardware contribution, the space station's robotic arm, is attached to the space station and verified. Canada plans to begin utilization in 2001, but has flexibility to delay starting its research. NASA will be solely responsible for funding USOS space station operations for most of the assembly period, and it will also be the only partner with utilization privileges during most of that period. Russia also has utilization rights in its segment during assembly. To conduct research before their laboratories are available, partners can purchase or barter for early utilization rights from NASA or RSA.

NASA's Share of Costs Has Changed Over Time

NASA's share of common costs has increased from 71.4 percent in 1988 to 76.6 percent at present, and its share could change again if the partners reassess their level of participation in the space station program. If the shared costs were $305 million and common transportation requirements were 66,000 kilograms, the total 5.2 percent increase in NASA's annual share of common ground operations costs would be about $16 million and of transportation requirements would be about 3400 kilograms. If, over the life of the space station, partners reduce their participation in the program, NASA could become responsible for a larger share of operating costs and transportation requirements. A space station program official said that changes in partner allocations have to be agreed to by all the parties concerned. The official also pointed out that a reduction in a partner's utilization share presents an opportunity for NASA to increase its share of utilization without contributing additional hardware. NASA would only have to fund an increased share of common operations.

Allocations have already been renegotiated and adjusted in two cases: the Canadian share has been reduced from 3.0 percent to 2.3 percent and the European share reduced from 12.8 percent to 8.3 percent. In both cases, NASA acquired the partners' shares of costs along with a commensurate share of utilization rights. Because of funding shortages in 1994, the Canadian government proposed revising its contribution to the space station, and NASA agreed to provide the goods and services that Canada no longer planned to contribute. In 1998, NASA and Canada agreed that Canada could provide some of its hardware as payment for common costs rather than as a contribution of infrastructure. Because the 1994 and 1998 agreements resulted in Canada providing less hardware and fewer services as a contribution, Canada's share of utilization rights dropped from 3.0 to 2.3 percent, which also had the effect of reducing its share of common costs by the same amount. Consequently, NASA's share of utilization rights and common costs increased by 0.7 percent. In 1995, Europe downsized its research module--its main hardware contribution--and believed that both its share of utilization resources and common costs should be reduced accordingly. After reviewing revised European and NASA contributions, it was agreed that Europe's share of utilization and common costs would be reduced from 12.8 to 8.3 percent, and NASA's would increase by 4.5 percent.

Allowing Partners to Pay Common Costs With Services May Not Reduce NASA Funding Requirements

The international agreements stress that the partners should seek to minimize the exchange of funds through the performance of specific space station operations activities or, if the concerned partners agree, through the use of barter. NASA and its partners have agreed that rather than transferring funds to NASA for common operating costs the partners can propose performing common system operations or other services to offset payments. NASA will consider and agree to offsets on a case-by-case basis. NASA and the partners will attempt to find offsets within the space station program. If offsets within the space station program are not feasible, NASA is also willing to consider offsets unrelated to the space station. For example, rather than transferring funds to NASA for common space station costs, a partner could propose launching a NASA space science satellite.

Europe and Japan plan to develop and launch space station resupply vehicles that could carry their shares of common transportation requirements along with partner research payloads and logistics and maintenance items for their modules. Europe is developing the Automated Transfer Vehicle (ATV) and Japan is developing the H-II Transfer Vehicle (HTV). Europe and Japan would also like to launch additional payloads for NASA to offset their shares of common ground costs and thereby minimize transfer of funds to NASA. For purposes of calculating the value of common cargo launched, NASA determined that it would offset a partner's common ground operations costs by about $22,000 for each kilogram of cargo launched for NASA. For example, if NASA agrees, Europe could launch 1,149 kilograms of payload on the ATV for NASA in lieu of paying NASA $25.3 million for Europe's 8.3 percent share of common ground operations costs. Table 4 shows the allocation of the estimated $305.3 million common ground operating costs to the partners and the conversion of those common costs to kilograms of payload that could be launched as an offset.

Table 4: Partner Shares of Common Ground Operating Costs Expressed in Kilograms

Current dollars in millions

USOS partner	Partner common ground cost[a]	Partner cost in kilograms[b]
United States	$233.9	10,608
Canada	7.0	319
Europe	25.3	1149
Japan	39.1	1773
Total	**$305.3**	**13,848**

[a]Estimated common ground operating costs for fiscal year 2004.

[b]Kilograms not exact due to rounding during conversion.

European and Japanese vehicles will make an important contribution to resupplying the space station, but they may not carry enough cargo to fully offset those partners' common costs. NASA periodically prepares a transportation traffic model for the operations period that identifies which resupply vehicles could carry which payloads (the actual payloads to be flown on specific vehicles will not be determined until it is closer to launch time). The models indicate that European and Japanese cargo vehicles would not carry enough common cargo to fully offset their shares of common transportation and ground costs. The partners will have to provide additional launches, other services, or funding to NASA to fully reimburse NASA for common operating costs.

Allowing Europe and Japan to reimburse NASA with launch services as payment toward annual common ground operating costs would not necessarily produce a corresponding reduction in NASA's funding requirements. If Europe and Japan launch approximately 2,900 kilograms of NASA cargo that could have been carried on the shuttle, it would not offset NASA annual appropriations by the $64 million value assigned to that amount of cargo. Whether the cargo could be loaded on the shuttle cannot be determined until about 2 years prior to a scheduled launch, when actual payloads are selected for a particular flight. Space station officials pointed out that even if shifting some cargo from the shuttle to a partner vehicle does not change the shuttle flight rate, it could benefit the program by increasing opportunities to fly other items, such as research or commercial payloads on the shuttle.

Canada has also sought to pay common costs through services. Since Canada does not have its own launch capability to offer as an offset to common costs, it proposed providing the Special Purpose Dexterous Manipulator (SPDM) that it was developing for the space station and other services as payment for common costs rather than as a contribution for utilization rights.[15] In return for providing the SPDM, Canada's common costs will be offset by 2 percent for up to 4 years, equivalent to a $24-million reduction in its share of ground operations costs and around 5,300 kilograms in common transportation requirements. The agreement between Canada and NASA includes an option for an additional offset to common operating costs. If Canada agrees to assume responsibility for the repair and overhaul of the Canadian robotic arm, which shifted to NASA in 1994, NASA would further reduce Canada's payments for common ground operations and transportation requirements.

Allowing Canada to pay its share of common costs with the SPDM does not reduce NASA funding requirements for space station operations. NASA and Canada are simply reclassifying hardware that Canada is planning to provide from a contribution to a payment for common costs. There will be no reduction to NASA's budget for the value of the SPDM offset. NASA officials believed that allowing Canada to pay its common costs with the

[15] The SPDM can be thought of as the “hand' attached to the space station's robotic arm that Canada is providing as its main contribution. The SPDM can be used to manipulate delicate objects.

SPDM was preferable to Canada further scaling back its contribution to the space station and NASA possibly having to spend substantially more to develop the SPDM or similar capability. Space station program officials said that there would be a reduction in NASA's budget for the cost of maintaining the arm if Canada exercises the optional offset.

Not Yet Possible to Accurately Estimate the Amount of Potential Funding From Partners for Reimbursable Services

During the space station's operational phase after assembly is complete, NASA may provide launch and return transportation services on the space shuttle and communication services on its data relay satellite system to other partners on a reimbursable basis. To support their utilization plans, partners have a right to obtain an allocation of the total transportation and communication services available for utilization commensurate with their shares of utilization resources. A partner may satisfy its allocation by providing its own transportation and communication systems or purchasing from any other partner providing such services. NASA, Europe, Japan, and Russia plan to provide transportation services, and NASA, Japan, and Russia plan to provide communication services.

It is too early in the planning process to accurately project partner use of reimbursable NASA services. Although integrated transportation models make assumptions about the amount of utilization payloads that could be loaded on each resupply flight, specific partner payloads will not be assigned to a particular vehicle until about 2 years prior to a scheduled launch. Europe and Japan are developing their own resupply vehicles, but will likely still use the shuttle for payloads because the shuttle provides the best conditions for some experiments during launch and is the only vehicle that can return cargo. Russia's Soyuz capsule also returns to Earth, but is primarily used to return crew and has very little capacity to bring back other payloads. After delivering supplies to the space station, the European and Japanese vehicles will be loaded with trash, and after leaving the space station they will be destroyed during reentry. To communicate with the space station, the other partners may also purchase available capacity on NASA's Tracking and Data Relay Satellite System (TDRSS), but NASA officials believe that it is too early to tell how much demand the partners will have for TDRSS services.

If partners do use available space shuttle and TDRSS capacity, they are likely to barter for these reimbursable services rather than exchange funds with NASA. For example, Europe agreed to build two space station cupolas for NASA in exchange for launch and return of five external payloads. As with the barters for common operating costs, it is too early to tell what services the partners may provide or whether those services will reduce NASA funding requirements. In considering future offsets or pricing shuttle services, NASA has assumed that shuttle cargo will be valued at about $22,000 per kilogram for launch or return services. NASA has not yet priced potential TDRSS services to partners.

Conclusions

The complexity, long life, and international nature of the space station program make it extremely challenging to accurately forecast future operating costs. Since NASA originally estimated the cost to operate the space station, the configuration has changed and new partners are participating. Significant uncertainties exist with respect to the funding that may be required to upgrade obsolete components and to mitigate shortfalls in Russian performance. Adding to this uncertainty is the fact that the start of full operations in late 2004 is outside the current 5-year window for detailed NASA budgets. Also unknown at this time is the degree that agreements with international partners for sharing costs and for reimbursable services will offset NASA funding requirements.

NASA's recent initiative to prepare a 10-year funding profile should produce a more accurate estimate of future costs. In preparing this profile, NASA will have an opportunity to incorporate significant changes in the program since the original $1.3 billion estimate and to reduce significant uncertainties surrounding operations. In particular, NASA should have more information on requirements for combating obsolescence and Russia's ability to fulfill its commitments. The cost estimate for operating the space station should also improve over the next several years as NASA gains operational experience. Also, when NASA implements full-cost accounting, NASA will be better able to estimate the overall agency resources required to operate the space station. Until NASA revises its estimate and identifies the potential effects of significant uncertainties, decisionmakers in Congress, the administration, and NASA should recognize the uncertainties associated with the current estimate for the cost to operate the space station after assembly is completed.

Agency Comments

NASA agreed with the contents of the draft report with the exception of our use of the average cost per flight in preparing an estimate of shuttle costs related to the space station. NASA believes that it is more appropriate to use the marginal cost per flight to calculate shuttle support costs for the space station. NASA describes the average cost per flight as a calculation to capture the fixed-base investment of the agency that must be borne by the program whether 1 or 10 flights are required. According to NASA, the average cost per flight can be used to gauge the overall agency resources committed to the space station, but should not be used to determine the direct budget impact of the ISS program. Using the marginal cost per flight of $84 million in fiscal year 2004, NASA believes that the shuttle support costs for space station for five to six flights per year would range from $420 million to $504 million. NASA's comments on the draft report are presented in their entirety in appendix III.

We believe the use of average cost per flight is more appropriate in determining the amount of NASA's budget that can be attributed to operating the space station. As noted in NASA's comments, the average cost per flight can be used to gauge the overall agency resources committed to the space station. This is precisely why we use the average cost per flight. Because 75 percent of planned shuttle flights after 2004 will be for space station support, we believe that 75 percent of the fixed base for the shuttle should be allocated as a cost of the space station program. As discussed in our report, we believe it is appropriate to use the marginal cost per flight in budgetary decisions about whether to increase or decrease the overall shuttle flight rate.

Scope and Methodology

We reviewed space station-related costs in NASA's budget for the 10-year period of operations following the space station's assembly. To determine which space station-related costs were not included in NASA's estimate for ISS operations, we reviewed prior GAO reports on space station life-cycle costs and Space Station Program Office (SSPO) budget documents. We interviewed NASA officials in the SSPO, Space Shuttle Program Office, Microgravity Research Program Office, Office of Human Space Flight, Office of Life and Microgravity Sciences and Applications, and Office of the Comptroller. We also discussed obsolescence issues with a member of NASA's space station Cost Assessment and Validation Task Force and the National Research Council's Committee on Engineering Challenges to the Long-Term Operation of the International Space Station.

To determine the level of uncertainty in NASA's operations cost estimate, we reviewed NASA Operations Phase Analysis Team reports and interviewed NASA officials involved in preparing the initial operations cost estimate as well as SSPO officials responsible for estimating current operations cost elements. We also interviewed officials from the Space Shuttle Program Office, Microgravity Research Program Office, Office of

Human Space Flight, Office of Life and Microgravity Sciences and Applications, and Office of the Comptroller. To determine the potential impact of Russian performance problems, we reviewed NASA's contingency plans and ISS integrated traffic models, and interviewed officials from the SSPO's Mission Integration Office.

To determine if cost-sharing arrangements with international partners would reduce NASA's funding requirements, we reviewed the intergovernmental agreement on space station between the United States and partner governments, memoranda of understanding and implementing agreements between NASA and partner space agencies, and ISS integrated traffic models. We interviewed officials from the SSPO's International Partners Office and Mission Integration Office.

We performed our work between July 1998 and May 1999 in accordance with generally accepted government auditing standards at NASA headquarters in Washington, D.C.; the Johnson Space Center in Houston, Texas; and the Marshall Space Flight Center in Huntsville, Alabama.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 15 days from its issue date. At that time, we will send copies to Representative Dana Rohrabacher, Chairman, andRepresentative Bart Gordon, Ranking Minority Member, House Subcommittee on Space and Aeronautics; the Honorable Daniel Goldin, NASA Administrator; the Honorable Jacob Lew, Director, Office of Management and Budget; and other interested parties. We will also make copies available to others on request.

If you have any questions regarding this report, please contact me at (202) 512-4841. Other key contacts are listed in appendix IV.

Allen Li
Associate Director,
Defense Acquisitions Issues

Contents

Figures

Abbreviations

ATV	Automated Transfer Vehicle
CRV	Crew Return Vehicle
HTV	H-II Transfer Vehicle
IGA	Intergovernmental Agreement
ISS	International Space Station
JEM	Japanese Experiment Module
NASA	National Aeronautics and Space Administration
POIC	Payload Operations and Integration Center
RSA	Russian Space Agency
SPDM	Special Purpose Dexterous Manipulator
SSPO	Space Station Program Office
TDRSS	Tracking and Data Relay Satellite System
ULC	Unpressurized Logistics Carrier
USOS	United States On-Orbit Segment

International Partner Contributions

International Space Station Partners

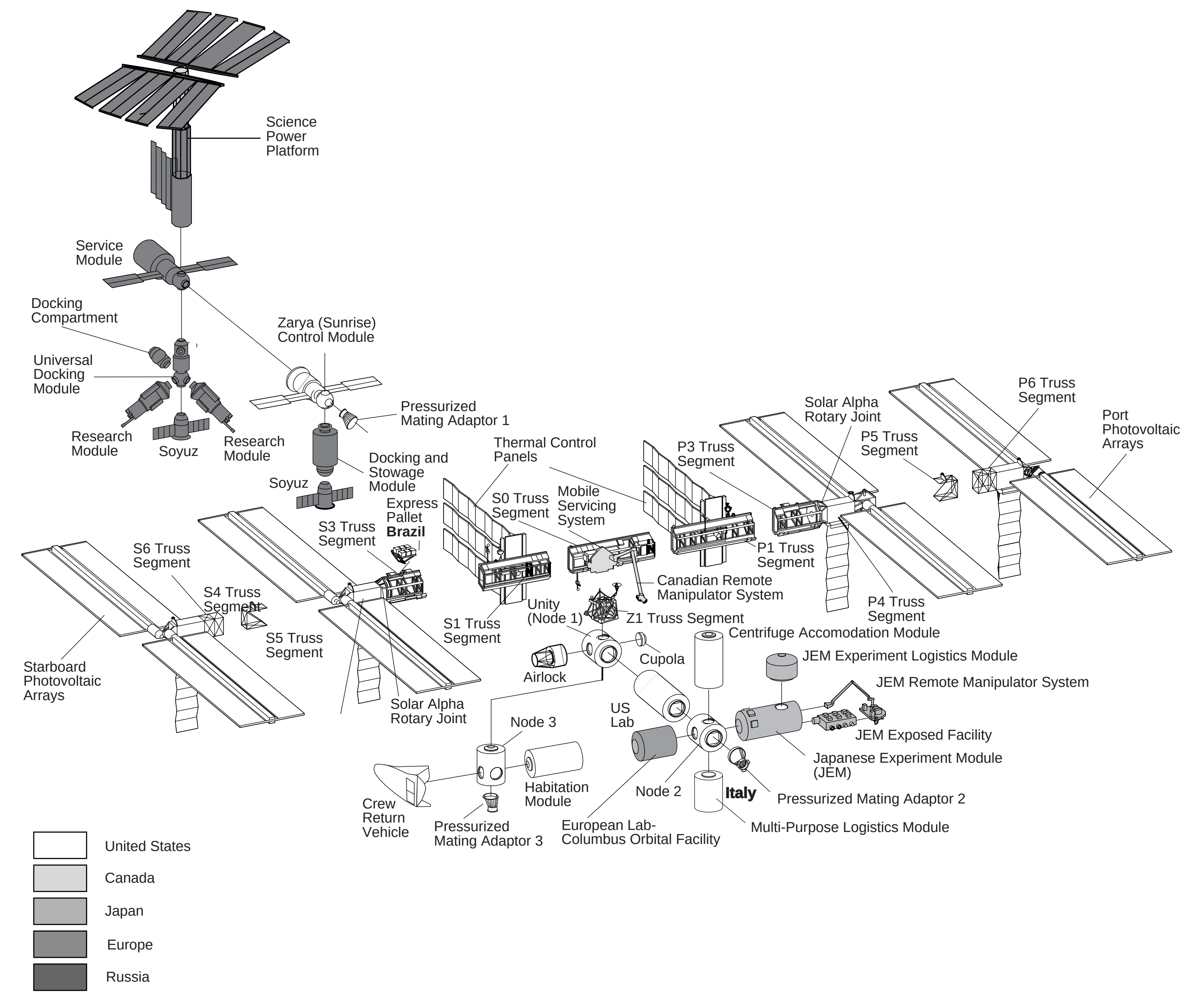
The major partners in the International Space Station (ISS) program include the United States; Canada; Europe (Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, and the United Kingdom); Japan; and Russia. Brazil is also participating in the space station program. The overall framework for international cooperation is contained in an intergovernmental agreement (IGA), originally signed by the partners in 1988 and updated in 1998 to add Russia to the partnership.[1] Brazil is not a signatory to the IGA, but instead participates in the ISS program through an arrangement with National Aeronautics and Space Administration (NASA). Cooperation on the space station is further defined in memoranda of understanding between NASA and each of the major partners. NASA also has a series of bilateral agreements with individual partners for barter of goods and services.

Hardware Contributions by Partners

Each of the partners has agreed to provide components to the space station. For purposes of determining partner utilization rights and common operations obligations, the space station is viewed as two segments, the United States On-orbit Segment (USOS) and the Russian Obital Segment. The USOS includes contributions from the United States, Canada, Europe, Japan, and Brazil. The Russian Orbital Segment consists entirely of Russian hardware. Figure I.1 illustrates the space station components each partner plans to provide.

[1] Agreement Among the Government of Canada, Governments of Member States of the European Space Agency, the Government of Japan, the Government of the Russian Federation, and the Government of the United States of America Concerning Cooperation on the Civil International Space Station, January 29, 1998.

Figure I.1: Components of ISS



Source: NASA.

Infrastructure and Accommodation Elements

There are two basic types of contributions to the space station: infrastructure and accommodations elements. Infrastructure elements and systems enable the use and operation of the station by all partners. Examples include power systems; life support systems; the station robotic arm; guidance, navigation, and control systems; crew habitation modules; airlocks; truss segments; and connecting nodes. Accommodation elements are research facilities that include pressurized laboratories and external payload sites. NASA, Canada, and Russia are contributing infrastructure elements. NASA, Europe, Japan, and Russia are contributing accommodation elements. Table I.1 shows the approximate hardware mass to be provided by each partner.

Table I.1: Approximate Hardware Mass Provided by Partners

Partner	Hardware mass (lbs.)	Percent of ISS mass
United States	592,000	60
Canada	10,000	1
Europe	27,000	3
Japan	74,000	7
Total USOS[a]	**703,000**	**71**
Russia	287,000	29
Total ISS	**990,000**	**100**

[a]USOS includes hardware from the United States, Canada, Europe, and Japan.

U.S. Components Are Being Built by Other Partners.

Several components that are considered U.S. contributions to the space station are being built by other countries. The first space station element that was launched, the Zarya module, was built by a Russian company under a contract with Boeing, the prime contractor for the U.S. space station hardware. Because funding for the Zarya module originated from NASA, the module is a U.S. contribution to the space station. Other U.S. contributions are being built by international partners as offsets to services NASA is providing to those partners.

- NASA will launch the Japanese Experiment Module (JEM) on three shuttle flights. One flight will be dedicated to Japan's pressurized laboratory, and two flights will carry both Japanese and NASA components. In return, Japan is providing to NASA the centrifuge accommodation module and centrifuge rotor, life sciences glovebox, eight payload interface units for integrating NASA experiments on the

JEM exposed facility, and launch services for a NASA payload on Japan's H-IIA launch vehicle. Candidate payloads include space and earth science satellites.

- NASA will also launch Europe's laboratory module, the Columbus Orbital Facility. One shuttle flight will be required to launch the European laboratory. In return, Europe is providing NASA with two connecting nodes, cryogenic freezer racks, crew refrigerator/freezer racks, sustaining engineering and spares for a laboratory freezer and microgravity science glovebox, and hardware and support for NASA's Software Development Integration Laboratory.
- Europe is also providing NASA with a microgravity sciences glovebox, freezers to transport thermally controlled items to the station, a hexapod pointing system for NASA's external payloads, and mission database software for use in NASA's Mission Build Facility. In return, Europe will receive a share of utilization rights to NASA research facilities prior to the launch of Europe's laboratory. Europe will also get two flight opportunities for astronauts on the space shuttle.
- In another barter agreement, Europe is providing two cupolas to NASA in exchange for shuttle launch services for external European payloads. The cupolas are multiwindowed elements that will attach to modules and will allow station crew members greater visibility during external operations. In return, NASA will launch five external payloads on the shuttle. Three of the payloads will be launched during the early utilization period defined in the agreement above. Two of the payloads will be cooperative payloads between Europe and NASA.
- In addition to contributing space station components as a member of the European Space Agency, Italy is providing hardware to NASA through a bilateral agreement between NASA and the Italian Space Agency. Italy is providing three Mini Pressurized Logistics Modules that will be carried by the shuttle and used to transport supplies and experiments to and from the space station. In return, Italy will be provided a small percentage of NASA's pressurized and external utilization accommodations and utilization resources, shuttle launch and return services for Italian payloads, and data communications services. Italy will also be entitled to flight opportunities out of NASA's allocation for three ISS or shuttle crew members.
- Brazil has agreed to provide the Technology Experiment Facility, Block 2 of the Window Observational Research Facility, EXPRESS Pallet, Unpressurized Logistics Carrier (ULC), Cargo Handling Interface Assembly, and a ULC Attach System for mounting the ULC on the ISS truss. In return, NASA, from its ISS allocation, will provide Brazil access to a small portion of pressurized and external experiment space, shuttle

launch and return services for Brazilian experiments, and data communication services. To carry out its experiments, NASA will provide a small percentage of its utilization resources to Brazil. Finally, NASA will provide Brazil with the opportunity to fly one astronaut on ISS for one crew rotation period.

- NASA and Europe are also negotiating a role for Europe in the development of the X-38 experimental space vehicle. The X-38 is being developed as a predecessor to an operational crew return vehicle for the space station. In this case, NASA and the European Space Agency are cooperating on the development without offsets. Europe is participating with the expectation that it will enhance the potential for future European involvement in the development and production of future operational Crew Return Vehicles (CRV). If Europe provides components for operational CRVs, NASA and Europe may negotiate an offset to Europe's share of common operations costs.

Allocation of Research Facilities and Resources

As compensation for providing elements and resources that benefit all the partners, the partners agreed that those providing infrastructure elements would be entitled to an allocation of research facilities provided by the other partners. For example, as compensation for providing the space station's robotic arm, Canada is entitled to use 2.3 percent of the user facilities in each of the other partners' laboratory modules. Based on contributions to the station and allocations of utilization accommodations, the partners also agreed on a division of utilization resources. These resources include power, user-servicing capability, heat rejection, data handling, crew time, and extra-vehicular activity capacity. NASA received an additional allocation of accommodation elements and resources to recognize NASA's lead role in the management and integration of the space station program. Partners are free to barter or sell their accommodations and resources to other partners or other acceptable entities. For example, during the assembly period, NASA purchased 4,000 hours of Russian crew time and stowage space on Russian modules for $60 million. Table I.2 shows the percentage of user accommodations and utilization resources allocated to each partner on the USOS.

Table I.2: Allocation of Research Facilities and Resources

	Percentage of USOS partner allocations			
USOS research facilities	U.S.	Canada	Europe	Japan
U.S. laboratory, external sites	97.7	2.3		
European Columbus Orbital Facility	46.7	2.3	51.0	
Japanese Experiment Module	46.7	2.3		51.0
Utilization resources	76.6	2.3	8.3	12.8

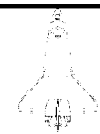
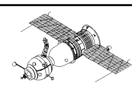
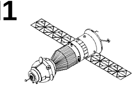
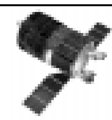
Russia is also providing both infrastructure elements and research facilities. However, to minimize the impact on existing relationships and allocations between the partners, it was agreed that Russia would be treated separately. Russia will retain the use of 100 percent of the user accommodations on its laboratory modules and external payload sites and will not share in utilization accommodations and resources provided by USOS partners.

ISS Transportation Services

Several partners are also planning to provide transportation services to the space station to carry crew, propellant, supplies, and experiments. NASA's space shuttle can dock to pressurized mating adapters on Node 2 or Node 3 of the U.S. segment. Europe's Automated Transfer Vehicle (ATV) will be launched by the Ariane V expendable rocket and most likely will dock to Russia's Service Module. Japan's H-II Transfer Vehicle (HTV) will be launched on Japan's H-II rocket and will be berthed to Node 2. Russian Progress and Soyuz vehicles will be launched on Soyuz rockets, and they can dock to several locations on the Russian segment. The U.S.-built CRV will be attached to Node 3.

During a typical year of operations after assembly complete, NASA plans to fly five to six shuttles a year to the station; Russia, three to four Progress and two Soyuz; Europe, one ATV; and Japan one to two HTVs. The CRV will be attached to the station for 3 years before being rotated. The shuttle, Soyuz, and CRV are the only vehicles capable of transporting crew and returning to Earth. After unloading their cargo onto the station, the Progress, ATV, and HTV vehicles will be loaded with non-recoverable items and after separating from the station, will be destroyed during reentry into the Earth's atmosphere. Figure I.2 shows the vehicles that plan to service the space station after assembly is completed.

Figure I.2: ISS Transportation Capabilities

Vehicle	Payload[a]	Cargo Types	Available Date
Shuttle 	16,420 kg	• Crew Rotation • Pressurized • Unpressurized • Gas, Water	• Available
Soyuz-TM 	480 kg	• Crew Rotation • Pressurized	• Available
Progress-M1 	2,230 kg	• Pressurized • Unpressurized • Propellant • Gas, Water	• 1999
ATV 	7,500 kg	• Pressurized • Gas, Water • Propellant	• 2003
HTV 	6,000 kg	• Pressurized • Water • Unpressurized	• 2002
CRV 	TBD kg	• Crew Return	• 2003

[a]Payload capability to an altitude of 407 kilometers at an orbital inclination of 51.6 degrees.

Source: The Boeing Company.

Description of Operation Costs Budget Elements

The elements that comprise the operations costs funded in the space station budget are described briefly below.

Operations Planning and Cargo Integration

Operations planning includes the costs related to defining the resources, allocations, research objectives, priorities, and manifests for each mission. It includes cargo planning and analysis, cargo engineering, and external program integration. Cargo integration covers the costs associated with identifying the items to be transported and returned on each mission and their location on the shuttle or other vehicle.

Sustaining Engineering

Sustaining engineering provides the basic engineering capability needed to keep the station operating. This includes resolving anomalies and developing enhancements. Sustaining engineering includes the following functions: station performance, trend, and anomaly analysis; maintenance of station analytical models; development of hardware and software modifications; and configuration management of flight hardware and software.

Logistics and Maintenance

The purpose of logistics and maintenance is to keep all space station systems in working order, maintain all necessary life support functions, provide continuous station operations, support crew activities, and provide the necessary resources for conducting scientific experiments. This involves preventive maintenance, the planned replacement of life-limited hardware, and replacement of failed units.

Station Operations Support

Station operations support funds the development and implementation activities necessary to train and certify flight controllers, crew members, and training instructors for the station. Among other things, it also funds planning and analysis tools for pre-mission and real-time operations support, trajectory and flight design, timelines, resource utilization, onboard systems, and performance analysis.

Launch Site Processing

The Launch Site Processing Office is responsible for the processing and integration of space station flight hardware at Kennedy Space Center. It is also responsible for the design, development, operations, and maintenance of space station launch site facilities and ground support equipment.

Institutional Support

The institutional support budget element includes the cost for facilities that are used by multiple research and development programs. The institutional charges help to fund the basic operating cost of such facilities.

Utilization Support

The utilization budget element includes the cost of customizing hardware to accommodate payloads for scientific research and the cost of payload integration and operations. Payload integration and operations includes the Payload Data Library (a database system used to collect payload user requirements), Payload Planning System (a software system used to create ground and on-board planning products), Payload Operations and Integration Center (the facility from which the mission is executed), and Payload Operations and Integration Function (engineers who staff the Payload Operations and Integration Center).

Research Projects

This budget element includes the costs of facilities for research that NASA expects to perform on the space station. The core of the space station research program will be its eight major research facilities: Gravitational Biology Facility, Centrifuge Facility, Human Research Facility, Materials Science Facility, Biotechnology Facility, Fluids and Combustion Facility, Window Observational Research Facility, and Low Temperature Microgravity Physics Facility.

Crew Return Vehicle Operations

CRV operations costs are incurred for items such as logistics and maintenance planning, procuring spares, training, ground support, and sustaining engineering. This estimate does not include the additional costs that would be incurred if the CRV had to be used in an emergency.

Reserves

Reserves reflect the amount of uncommitted funds and provide program managers with the ability to cover unanticipated contingencies.

Comments From the National Aeronautics and Space Administration

National Aeronautics and
Space Administration
Office of the Administrator
Washington, DC 20546-0001

JUL 23 1999

Mr. Allen Li
Associate Director
Defense Acquisition Issues
General Accounting Office
Washington, DC 20548

Dear Mr. Li:

Thank you for the opportunity to review and comment on the recent draft report entitled, "Space Station – Cost to Operate After Assembly is Uncertain (GAO code 707355)." Based upon the results of the July 6, 1999, telephone conference between Mr. Richard Eiserman of your staff, and Mr. Robert Soltess of the NASA Headquarters Office of Space Flight, we are in agreement with the content and data shown in the draft report, with the exception of GAO's use of average costs in preparing its estimate of Shuttle launch support costs for the Space Station.

NASA believes it is more appropriate to use marginal cost per flight to calculate the shuttle support costs to the International Space Station (ISS). Consistent with previous NASA estimates to determine the direct budget impact of the ISS program (i.e., additional effort such as more overtime or materials), allocation of the marginal cost of Shuttle launches should be used in determining ISS life-cycle costs. Full-average cost is a calculation to capture the "fixed base" investment of the Agency that must be borne by the program whether one or ten flights are required. It can be used to gauge the overall Agency resources committed to the Station, but should not be used to determine the direct budget impact of the ISS program. This is because the average cost per flight captures the total infrastructure (civil servants, labs, production facilities, networks, etc.) of the Shuttle program, assuming that no other payloads are flown in addition to the ISS, which is not the case. Using marginal cost per flight, the shuttle support costs for ISS for fiscal year 2004 would range from $420 to $504 million, instead of the $2.2 to $2.6 billion shown on page 8 of the draft report. At a minimum, marginal cost information should be included as an appendix and referenced in the body of the report.

Please contact Mr. Robert Soltess at 358-1895, if further assistance is required. The preparation and staffing of this response consumed 12 work hours.

Sincerely,

J. R. Dailey
Associate Deputy Administrator

GAO Staff Acknowledgments

Acknowledgments

Vijay Barnabas, Steven Boyles, Richard Eiserman, and Jerry Herley also made key contributions to this report.

Ordering Information

The first copy of each GAO report and testimony is free. Additional copies are $2 each. Orders should be sent to the following address, accompanied by a check or money order made out to the Superintendent of Documents, when necessary, VISA and MasterCard credit cards are accepted, also.

Orders for 100 or more copies to be mailed to a single address are discounted 25 percent.

Orders by mail:

U.S. General Accounting Office
P.O. Box 37050
Washington, DC 20013

or visit:

Room 1100
700 4th St. NW (corner of 4th and G Sts. NW)
U.S. General Accounting Office
Washington, DC

Orders may also be placed by calling (202) 512-6000
or by using fax number (202) 512-6061, or TDD (202) 512-2537.

Each day, GAO issues a list of newly available reports and testimony. To receive facsimile copies of the daily list or any list from the past 30 days, please call (202) 512-6000 using a touchtone phone. A recorded menu will provide information on how to obtain these lists.

For information on how to access GAO reports on the INTERNET, send an e-mail message with “info” in the body to:

info@www.gao.gov

or visit GAO’s World Wide Web Home Page at:

http://www.gao.gov

PRINTED ON RECYCLED PAPER

United States
General Accounting Office
Washington, D.C. 20548-0001

Official Business
Penalty for Private Use $300

Address Correction Requested

Bulk Rate
Postage & Fees Paid
GAO
Permit No. GI00

[redacted]