
May 1998

INTERNATIONAL SPACE STATION

U.S. Life-Cycle Funding Requirements





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

**National Security and
International Affairs Division**

B-279653

May 22, 1998

The Honorable John McCain
Chairman, Committee on Commerce,
Science and Transportation
United States Senate

The Honorable William H. Frist
Chairman, Subcommittee on Science,
Technology and Space
Committee on Commerce, Science and Transportation
United States Senate

As requested, we reviewed issues associated with the National Aeronautics and Space Administration's (NASA) International Space Station program. As agreed with your office, this report (1) provides an estimate of the station's development, assembly, and operations costs and compares this estimate with the estimate in our June 1995 report;¹ (2) identifies program uncertainties that may affect those costs;² (3) discusses potential debris tracking costs; (4) discusses the status of program reserves; and (5) describes recent actions to measure prime contractor performance based on rebaselined information.

Background

NASA and its international partners—Japan, Canada, the European Space Agency, and Russia—are building the space station as a permanently orbiting laboratory to conduct materials and life sciences research, earth observation and commercial utilization, and related uses under nearly weightless conditions. Each partner is providing station hardware and crew members and is expected to share operating costs and use of the station. The NASA space station program manager is responsible for the cost, schedule, and technical performance of the total program. The Boeing Corporation, the prime contractor, is responsible for development, integration, and on-orbit performance of the station. By the end of 1997, the United States and its partners had produced well over 358,000 pounds of space flight hardware, of which the prime contractor was responsible for about 260,000 pounds. According to NASA, by the end of 1998, virtually

¹Space Station: Estimated Total U.S. Funding Requirements ([GAO/NSIAD-95-163](#), June 12, 1995).

²Space Station: Cost Control Problems Continue to Worsen ([GAO/T-NSIAD-97-177](#), June 18, 1997), Space Station: Cost Control Problems Are Worsening ([GAO/NSIAD-97-213](#), Sept. 16, 1997), Space Station: Deteriorating Cost and Schedule Performance Under the Prime Contract ([GAO/T-NSIAD-97-262](#), Sept. 18, 1997), and Space Station: Cost Control Problems ([GAO/T-NSIAD-98-54](#), Nov. 5, 1997).

all flight hardware for the first six flights will have been delivered to Russian or American launch sites.

In June 1995, we reported that the U.S. funds required to design, launch, and operate the space station would be about \$94 billion—over \$48 billion to complete assembly and almost \$46 billion to operate and conduct research. That total included \$17.4 billion for station development activities, \$13 billion for operations, and \$50.5 billion for shuttle launch support during assembly and operations. Our report also noted that the program’s funding reserves were limited and that the launch and assembly schedule would be difficult to achieve.

Results in Brief

Life-cycle cost is the sum total of direct, indirect, recurring, and nonrecurring cost of a system over its entire life through disposal. Overall, the estimated U.S. cost to develop, assemble, and operate the space station is about \$96 billion, an increase of almost \$2 billion over our last estimate made in 1995.³ Development costs represent the largest increase—more than 20 percent. The development increase is attributable to schedule slippages, prime contract growth, additional crew return vehicle costs, and the effects of delays in delivery of the Russian-made Service Module. Overall costs would have been significantly higher had there not been an offsetting reduction in shuttle support costs. The reduced shuttle costs have resulted from NASA’s estimation that the average cost per flight throughout the station era will be dramatically lower than was estimated in 1995.

A number of potential program changes could significantly increase the updated cost estimate. They include the potential for additional schedule slippage and the need for shuttle launches to test and deliver the crew return vehicle. A detailed analysis of cost and schedule projections by a third party cites many of the same program changes we identified and suggests that significant cost increases and schedule slippages are likely. At the current estimated spending rate, the program would incur additional costs of more than \$100 million for every month of schedule slippage.

In addition, NASA may have to incur costs related to protecting the station from space debris. In August 1997, the agency updated its overall space debris tracking requirement. The new requirement, as it relates to

³All dollar estimates in this report have been adjusted for inflation. The updated cost estimates are based on an assembly complete date of December 2003, followed by a 10-year operations period.

supporting the space station, includes the ability to track and catalog objects as small as 1 centimeter. Cost estimates for achieving the improved tracking capability range into the billions of dollars. Since ensuring the safety of all space missions is a NASA-wide, if not national, responsibility, those potential costs are institutional in nature and should not be reflected in the station program's life-cycle estimate.

The adequacy of the space station program's funding reserves has been a concern of ours and still is. The program has used, or identified potential uses for, a significant portion of its available reserves, with almost 6 years left before the last assembly flight is scheduled to be launched. The current reserve amount could be affected by additional schedule slips, contract disputes, manufacturing problems, or the possible need for additional testing.

In October 1997, NASA granted approval to Boeing to begin tracking cost and schedule performance using a new performance measurement baseline. The purpose of the change was to incorporate updated program schedules to reflect the most achievable recovery plans. For reporting purposes, the change had the effect of resetting cost and schedule variances to zero. The original baseline shows that the February 1998 cost variance would have been about \$50 million higher than the \$398 million Boeing reported prior to the change. While NASA approved the new baseline for reporting purposes, it continues to use Boeing's estimate of overrun at completion—\$600 million—as the basis for calculating the contractor's incentive award fee.

U.S. Funding Requirements for the Space Station

Since June 1995, total space station cost estimates have increased from \$93.9 billion to \$95.6 billion (see table 1). In particular, the development cost estimate has increased by more than 20 percent, in-house personnel requirements have increased dramatically, and eight shuttle flights have been added to the development program. However, the shuttle support cost, as of April 1998, is less than that of June 1995 because NASA is projecting a significant reduction in the average cost per flight.

Table 1: Estimated Space Station Costs

Current dollars in billions

Cost category	June 1995 estimate	April 1998 estimate
U.S. requirements through assembly complete^a		
Contract and in-house costs from 1985 through 1993	\$11.2	\$11.2
Development cost from 1994 to assembly complete	17.4	21.9 ^b
Station-related requirements		
In-house personnel	0.9	2.2 ^c
Principal investigators	0.3	0.2 ^d
Shuttle performance enhancements	0.3	0.2
Russian contract	0.4	n/a ^e
Shuttle launch support	17.8	17.7
Subtotal	48.2	53.4
U.S. requirements after assembly complete		
Operations/utilization	13.0	13.0
Principal investigators	Unavailable	0.7
In-house personnel	Unavailable	2.9 ^f
Shuttle launch support	32.7	25.6
Station decommissioning^g	Unavailable	Unavailable
Total	\$93.9	\$95.6

Note: Totals may not add due to rounding.

^aWe define assembly complete as December 2003, when the last assembly flight is currently scheduled.

^bIncludes station development, operations, and research activities through December 2003. Also includes funding reserves and costs associated with the crew return vehicle and U.S. missions to the Russian space station Mir. Costs associated with activities from October through December 2003 are prorated, based on the fiscal year 2004 budget planning estimate.

^cEstimate was derived by dividing total personnel cost by the number of full-time equivalents (FTE). We then multiplied that result by the number of space station program FTEs. Our current estimate includes an allocation of all research and program management costs to the station program.

^dNASA is continuously adjusting its plans for research as the availability of space station resources are better defined. NASA plans to increase its number of principal investigations consistent with resources available for space station utilization through assembly complete. For the operations period, the estimate assumes a flat or only slightly declining budget in the out-years.

^eU.S. costs associated with the Russian Space Agency contract are included in the development estimate.

^fOur estimate was derived by using the cost associated with station program FTEs in fiscal year 2003 and escalating that figure by 3 percent a year for 10 years.

^gNASA plans to attach a propulsion vehicle to the station and perform a controlled deorbit into the ocean. The U.S. share of the ultimate disposal cost will depend on the propulsion vehicle chosen.

The higher development costs—\$21.9 billion versus \$17.4 billion—are attributable to schedule delays, additional prime contractor effort not covered by funding reserves, additional crew return vehicle costs, and costs incurred as a result of delays in the Russian-made Service Module. In June 1995, NASA expected to complete assembly in June 2002. Partially due to delays in the Russian program, the last flight in the assembly sequence is now scheduled for December 2003, a delay of 18 months that has increased development costs by more than \$2 billion. Also, NASA has undertaken activities such as developing the Interim Control Module to mitigate delays in the delivery of the Service Module. These activities are estimated by NASA to cost more than \$200 million. It should be noted that our estimate includes the cost of the Russian Space Agency contract, which NASA does not include in its portrayal of station development funding needs.

The increased in-house personnel costs during development—\$2.2 billion versus \$0.9 billion—are attributable to a longer development program, higher estimated personnel levels, and a more inclusive estimating methodology. Our June 1995 estimate was based on a development program scheduled to end in June 2002 while our current estimate includes an additional 18 months of effort. In addition, our prior estimate was based on an average of 1,285 civil service staff annually. NASA's budget now estimates that about 2,000 staff per year will be needed during development. The increased staffing levels are attributable largely to the inclusion of science and crew return vehicle personnel into the station budget, which in most cases were previously covered under the Science, Aeronautics and Technology budgets. Finally, our current estimate is based on an allocation of all research and program management costs to the station program, while the previous estimate did not include all components of that budget line.

Regarding shuttle support, our 1995 estimate was based on 35 flights during development and 50 during operations. However, NASA now estimates 43 flights during development, including 2 additional flights to the Russian space station Mir, 1 flight to test the crew return vehicle, and flights required by changes to the assembly sequence. NASA continues to estimate that 50 flights will be needed during operations. However, NASA's estimate of average cost per flight is now lower, resulting in a shuttle launch support cost of \$17.7 billion during assembly, essentially the same cost as estimated in 1995, despite the increased number of flights. During operations, the estimated cost for shuttle support is now significantly less—\$25.6 billion versus \$32.7 billion—based on the same number of

flights. NASA's estimated reduction in the average cost per flight is based on its expectation that program efficiencies and other cost savings will be achieved and sustained throughout the operating life of the space station. If that expectation is not realized, the cost for shuttle support will increase.

Potential Added Program Costs

A number of potential program changes could significantly increase the current estimate. First, the development costs shown in table 1 would increase if the assembly complete milestone slips beyond December 2003. Second, it is likely that the program will ultimately require more shuttle flights than are included in our analysis. Finally, NASA is now considering modifying space shuttle Columbia to permit its use for some station missions. A recent independent assessment by NASA's Cost Assessment and Validation Task Force suggests that the program's schedule will likely experience further delays and require additional funding.⁴

Schedule Changes

We believe NASA and its partners face a formidable challenge in meeting the launch schedules necessary to complete assembly. Those schedules depend on the launch capacity in the United States and Russia and the program's ability to meet all manufacturing, testing, and software and hardware integration deadlines.

Through December 2003, over 90 launches by NASA and its international partners will be needed for assembly, science utilization, resupply, and crew return vehicle purposes. During this period, NASA's shuttles are currently scheduled to be flown up to 9 times a year for both station and nonstation needs, and Russia will have to average 9 to 10 launches a year to accommodate its station commitment. While these rates have been achieved in the past, a January 1998 NASA study of personnel reductions at Kennedy Space Center concluded that, without additional processing efficiencies, the required shuttle flight rate may not be supportable.⁵ If NASA is unable to maintain the planned flight rate, the station assembly schedule could experience further slippage. Also, recent Russian annual

⁴Our work and that of the independent assessment team was performed in the same time frame. Our work focused on aggregating the various components of space station life-cycle cost, based on NASA's current budget projections. The assessment team focused on evaluating the program in terms of potential cost and schedule growth primarily for the program's development portion. Report of the Cost Assessment and Validation Task Force on the International Space Station, April 21, 1998.

⁵Assessment of the Space Flight Operations Contract/United Space Alliance Risk Management Process for Determining Proposed Staff Reductions, January 16, 1998.

flight rates to support the Mir space station have been significantly lower than the required rate to support space station assembly.

The assembly schedule also assumes that further critical manufacturing delays will not occur. According to NASA's Aerospace Safety Advisory Panel's 1997 annual report, the program's schedule is at risk due to software, hardware, and testing issues.⁶ The report states, in part, that the ". . . software development schedule is almost impossibly tight. If something else does not cause a further delay in (station) deployment, software development may very well do so." Further, the report pointed out that the crew return vehicle development schedule is "extremely optimistic," noting that any delays in the availability of the vehicle could constrain station operations. In addition, the panel stated that, while integrated testing is a "very positive step for safety," there is no room in the current schedule for required changes that may be discovered during this testing.

Delays in the development program would increase costs because, at a minimum, fixed costs such as salaries, contractor overhead, and sustaining engineering would continue for a longer period than planned. Assuming NASA would continue to spend at the rate assumed in its current estimate for fiscal year 2003, the program would incur additional costs of more than \$100 million for every month of schedule slippage.

Additional Flights

The program could require more shuttle flights than are baselined in our estimate. For example, the baseline does not include additional flights that may be needed for crew return vehicle testing and launches and some resupply flights. While some of these possibilities are subject to program changes that have not been adopted, it appears that the costs associated with launching the crew return vehicle are not included. Depending on the ultimate life expectancy of that vehicle, two additional flights could be needed. On the basis of NASA's estimate of average cost per flight for the shuttle, this could add about \$1 billion to the total estimate. According to NASA, sustaining engineering costs associated with the crew return vehicle will have to be absorbed by the program's operations budget.

Also, NASA is reviewing alternatives for making Columbia capable of supporting the station. A modified Columbia could be used as a backup (in

⁶Annual Report for 1997, Aerospace Safety Advisory Panel, February 1998.

the event one of the other orbiters is out of service) or as a delivery vehicle for cargo.⁷

Additions Suggested by Independent Assessment

Between November 1997 and April 1998, an independent cost assessment and validation team examined the program's past and projected performance and made quantitative determinations regarding the potential for additional cost and schedule growth. Reflecting many of the same areas we identified, the team cited complex assembly requirements and potential schedule problems associated with remaining hardware and software development and concluded that the program could require an additional \$130 million to \$250 million in annual funding. The team also indicated that the program could experience 1 to 3 years of schedule growth beyond the currently anticipated completion date of December 2003.

Potential Debris Tracking Costs

The estimate we derived in 1995 and our latest estimate include those costs related to the space station's development, assembly, and operations. They do not include potential costs that may be incurred to satisfy NASA's space debris tracking requirement.

Due to its large size and long operational lifetime, the space station will face a risk of being struck by orbital debris. NASA plans to provide shielding against smaller objects and maneuver the station to avoid collisions with large objects.

The National Space Policy requires NASA to ensure the safety of all space flight missions involving the space station and shuttle, including protection against the threat of collisions from orbiting space debris. However, NASA has no surveillance capability and must rely on the Department of Defense (DOD) to perform this function.

As mentioned previously, NASA updated its overall requirement for space debris tracking as it relates to supporting the space station, to include the ability to track and catalog objects as small as 1 centimeter. NASA recognized that such a capability could require sensor facility upgrades and the addition of new sensors to DOD's surveillance network. However, DOD maintains that the upgrade is not feasible within current budget

⁷According to NASA, due to high structural weight the orbiter Columbia cannot be used for station assembly flights, but, as modified, it could be used for logistics flights.

constraints.⁸ A NASA study suggested that developing a system to satisfy NASA's needs could cost about \$1 billion. A DOD study suggested that the cost of a space-based system satisfying all DOD and NASA needs could exceed \$5 billion and noted that the cost to maintain a system that provides 24-hour a day tracking of 1-centimeter-sized space debris could be "prohibitively expensive."

More recently, the Senate Committee on Armed Services, in its report on the National Defense Authorization Act for Fiscal Year 1998, directed the Secretary of the Air Force to undertake a design study for a 1-centimeter debris tracking system. The study was to be coordinated with a number of national laboratories. The resulting report, which was transmitted to congressional committees on April 2, 1998, identified three possible designs that range in estimated cost from about \$400 million to \$2.5 billion.

The sources of funding for the system are undetermined at this time. Also, while the more stringent requirement is related to the space station, all other space activities would benefit from the ability to track 1-centimeter-sized debris. Since debris tracking is a NASA-wide requirement, and the agency relies on DOD to provide the service, the two agencies will have to work together to determine how to provide the capability.

Status of Funding Reserves

We have previously expressed our concern with the adequacy of space station financial reserves.⁹ We continue to be concerned. The program has used, or identified specific uses for a significant portion of its available reserves, with almost 6 years left before the last assembly flight is scheduled to be launched.

In January 1995, the space station program had more than \$3 billion in financial reserves to cover development contingencies. In March 1998, the financial reserves available to the program were down to about \$2.1 billion, and NASA had identified over \$1 billion in potential funding requirements against those reserves. In the past, reserves have been used to fund additional requirements, overruns, and other authorized changes. Some of the potential funding needs include those related to NASA's

⁸Space Surveillance: DOD and NASA Need Consolidated Requirements and a Coordinated Plan (GAO/NSIAD-98-42, Dec. 1, 1997).

⁹Financial reserves are used to fund unexpected contingencies, such as cost growth, schedule delays, or changes in project objectives or scope.

decision to add a third node to the station's design and unforeseen costs associated with the development of an Interim Control Module.

We recognize that NASA identifies adequacy of reserves as one of the highest current program risks. We also note that the current reserve status could be affected by additional schedule slips, contract disputes, manufacturing problems, or the need for additional testing.

Inadequate reserves hinder program managers' ability to cope with unanticipated problems. If a problem could not be covered by available reserves, program managers could be faced with deferring or rephasing other activities, thus possibly delaying the space station's development schedule or increasing future costs.

New Baseline to Measure Cost and Schedule Performance

In the summer of 1997, after many months of estimating that the total cost growth at the completion of the contract would not exceed \$278 million, Boeing more than doubled its estimate—to \$600 million. Through September 1997, \$398 million in cost growth had already accumulated.

On September 30, 1997, Boeing formally asked NASA to consider rebaselining the program using a more "meaningful program baseline against which performance measurements (could) be taken." In October 1997, NASA granted approval to Boeing to begin tracking cost and schedule performance using a new performance measurement baseline.

The revised baseline permitted Boeing to reset its budgeted cost of work scheduled and performed equal to the actual cost of work performed as of September 1997.¹⁰ According to Boeing, this change provides the program with the most accurate cost information and incorporates updated program schedules to reflect the most achievable recovery plans. For reporting purposes, the change had the effect of resetting cost and schedule variances to zero.

We asked the program officials to provide us with an analysis depicting a crosswalk back to the original baseline. That analysis shows that, as of February 1998, the total variance was \$448 million. Of that amount, about \$50 million was incurred in the first 5 months of fiscal year 1998. While NASA approved the new baseline for reporting purposes, it continues to use

¹⁰At the end of September 1997, prior to resetting the baseline, Boeing reported a cost variance of \$398 million and a schedule variance of \$139 million.

Boeing's estimate of overrun at completion—\$600 million—as the basis for calculating the contractor's incentive award fee.

NASA's estimate of total cost growth at completion, which had been in general accord with Boeing's \$600 million estimate, has been increased to \$817 million, and is the basis for its fiscal year 1999 budget request. This higher estimate is based on its assessment of trends and its belief that Boeing's cost control strategy will not be fully successful.

Conclusions

Since our last cost estimate was completed in June 1995, U.S. life-cycle funding requirements for building and operating the International Space Station have increased—from \$93.9 billion to \$95.6 billion. Many of the reasons for this increase were not foreseen by NASA in 1995. Reasons include schedule delays by Russia and prime contractor difficulties.

In light of our analysis and that by an independent team, additional costs could materialize. Potential program changes, such as additional schedule slippage and more shuttle flights, could increase our latest cost estimate. Also, NASA's updated requirement for tracking space debris may require DOD to upgrade its surveillance network. NASA's potential share of this cost has not yet been determined.

When the station is fully assembled, funding requirements for operational activities, such as shuttle launches, the crew return vehicle, principal investigator work, and in-house personnel support, will need to be fully defined. During the station's projected 10-year utilization period, U.S. funding requirements are estimated to total over \$42 billion, or about an average of \$4.2 billion per year. Therefore, station-related funding needs will continue to be a major portion of NASA's future budgets.

Agency Comments and Our Evaluation

In commenting on a draft of this report, NASA raised three major concerns: (1) our use of average cost per flight to estimate shuttle launch support costs, (2) the inclusion of certain program costs in the station development estimate, and (3) the inclusion of references to the requirement for improved orbital debris tracking capability. NASA also provided a number of technical and clarifying comments, which have been incorporated where appropriate.

NASA believes that marginal cost, rather than average cost per flight, is a more accurate estimate of shuttle launch support costs. NASA defines

marginal cost per flight as those costs incurred or avoided as a result of adding or deleting one flight to or from the shuttle manifest in a given fiscal year. Marginal cost does not include any fixed costs that NASA says are required to maintain the capability to launch the shuttle a specific number of times during a given year. Average cost per flight as defined by NASA is the total cost to operate the space shuttle on a recurring and sustained basis for a given fiscal year divided by the number of flights planned for that year. Its calculation of average cost per flight captures most costs in the shuttle operations budget line, as well as prorations of civil service personnel, space communications network costs, and recurring costs for shuttle improvements. We believe our use of average cost per flight is appropriate because more than 70 percent of shuttle flights during fiscal years 1999 through 2003 will be devoted to the space station.

NASA expressed concern with our inclusion of certain costs in the development estimate, particularly the Russian Space Agency contract cost. We chose to include all costs that we believe directly support station development and construction activities to more completely portray that portion of the life-cycle cost estimate. However, we revised the report to recognize the way NASA treats those costs.

NASA also expressed concern that our discussion of the costs associated with orbital debris tracking could be misunderstood. We believe our discussion is clear. We agree that debris tracking costs should not be considered part of the space station's life-cycle cost estimate, and benefits would accrue to programs other than the space station. However, it is a potential cost that is related to space station support because the requirement to track and catalog 1-centimeter-sized debris was established to support the station. As stated in the report, since debris tracking is a NASA-wide responsibility and the agency relies on DOD to provide the service, the two agencies will have to work together to achieve the improved capability.

We provide additional details on NASA's comments in appendix I.

Scope and Methodology

To estimate station costs, identify program uncertainties, examine program reserves, and assess the prime contractor's cost and schedule reporting system, we reviewed NASA's program planning and budgeting documents, internal cost reports, independent program assessments, and contracts relating to space station development. We interviewed NASA

officials in the Space Station Program Office, the Space Shuttle Program Office, the Office of Human Space Flight, the Office of Life and Microgravity Sciences and Applications, the Office of the Comptroller, and the X-38 development program. We also met with officials from NASA's space station Cost Assessment and Validation Task Force to discuss the scope and results of their work, and the National Research Council to discuss ongoing work related to station disposal. To examine potential impacts of satisfying NASA's debris tracking requirement, we discussed a recent Air Force study with cognizant officials and reviewed previous debris tracking studies.

We used NASA budget data to depict certain costs and to derive other costs. We used cost reports and independent assessments to test the reliability of NASA's estimates and to identify cost risks to the program. We did not, however, attempt to independently validate NASA's budget data.

We performed our work from December 1997 to April 1998 in accordance with generally accepted government auditing standards.

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 appropriate congressional committees, the NASA Administrator, and the Director of the Office of Management and Budget. We will also make copies available to others on request.

Please contact me at (202) 512-4841 if you or your staff have any questions about this report. Major contributors to this report are listed in appendix II.



Allen Li
Associate Director,
Defense Acquisitions Issues

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Abbreviations

DOD	Department of Defense
NASA	National Aeronautics and Space Administration

Comments From the National Aeronautics and Space Administration

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



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

APR 27 1998

Dear Mr. Li:

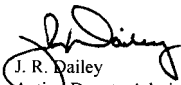
Thank you for the opportunity to review and comment on the recent draft report entitled, "International Space Station - U.S. Life Cycle Funding Requirements." This letter is to update a number of points made in the report, as well as, to provide a more indepth perspective on several of the problems discussed so that this information can be included in the final report.

We do have several important concerns to which we trust you will give serious consideration. A number of our concerns with this report are those same concerns that we voiced in our response to your 1995 report on this topic. Our key concerns with this year's report include:

- 1) The use by GAO of the average cost per flight algorithm for estimating the Shuttle launch support costs. NASA firmly recommends use of the marginal cost per flight.
- 2) Inclusion by GAO of unrelated program costs into the station development estimate such as the Russian Space Agency contract costs. NASA recommends that the development and assembly complete costs reflect the NASA's FY 1999 Budget to Congress.
- 3) Inclusion of references to a cost risk to station for an enhanced orbital debris tracking system. If developed, this activity would be a national asset and funded accordingly. We do not feel that it is reasonable to imply that the costs for developing this capability would be additive to the life cycle costs to the space station. NASA recommends deletion of all references to this activity in the GAO report.

Enclosed you will also find general observation comments for your consideration. Please contact Robert Soltess at 358-1895, if further assistance is required. The preparation and staffing of this response took 110 hours.

Sincerely,


J. R. Dailey
Acting Deputy Administrator

Enclosure

See comment 1.

See comment 6.

See comment 8.

**GENERAL OBSERVATIONS TO
GAO REPORT ON INTERNATIONAL SPACE STATION: U.S. LIFE CYCLE
FUNDING REQUIREMENTS**

See comment 1.

1. GENERAL COMMENT, Shuttle Cost per Flight

GAO Report

The GAO report uses average cost per flight to estimate Shuttle Launch Support costs for the Space Station.

Space Shuttle Comment

NASA disagrees, as it did in the January 1995 report, to GAO's use of average costs in preparing its estimate of Shuttle Launch Support costs for the Station. NASA believes it is more appropriate to use marginal cost per flight to calculate the Shuttle support costs to ISS (this data was supplied to the GAO in support of this audit). 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 the 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 flown. 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 calculation captures the total infrastructure (civil servants, labs, production facilities, TDRSS network, etc.) of the Shuttle program, assuming that no other payloads are flown besides ISS, which is not the case. Using marginal cost per flight, the Shuttle support costs for ISS development is estimated at \$3.1 billion and operations at \$5.5 billion. At a minimum, marginal cost information should be provided as an appendix and referenced in the report. Major concern

See comment 2.
See page 2.

2. GENERAL COMMENT, Timeframe Concern, Multiple Locations in Report

GAO Report

The GAO report does not include sufficient timeframe background for its cost estimates.

Space Station Comment

The absence of time frames for these estimates is a serious shortcoming. Without such context, it is difficult to understand the estimates in relation to the program schedule, and assess the annual funding requirements. Major concern.

See comment 3.
See page 4.

3. GENERAL COMMENT, Development and Assembly Complete Values

GAO Report

The GAO report has included a number of items under the category, "Development" that will create additional confusion in the system.

**Appendix I
Comments From the National Aeronautics
and Space Administration**

See comment 4.
Now on p. 1.

Space Station Comment

The GAO estimate should be revised to use the NASA FY 1999 Budget to Congress runout estimate of 19.6 billion for Development Complete (November 2002) and \$21.3 billion for Assembly Complete (December 2003) using the components included on Enclosure 1 and 2. If they decide to include anything else, those additional life cycle costs should go under a separate, standalone category. Major concern.

4. BACKGROUND, Page 3, First Paragraph

GAO Report

"...to conduct materials and life sciences research ..."

Space Station Comment

The sentence should be modified to reference earth observation, technology & commercial utilization and exploration-related uses. Minor concern.

5. BACKGROUND, Page 3, First Paragraph

GAO Report

The Boeing Corporation, the prime contractor, is responsible for integrating and assembling the Station.

Space Station Comment

NASA suggest modifying the statement to read, "The Boeing Corporation, the prime contractor, is responsible for the development, integration and on-orbit performance of the Station." Minor concern

See comment 5.
Now on p. 1.

See comment 6.

6. RESULTS IN BRIEF, Page 3, First Paragraph

GAO Report

"Development costs represent the largest increase - more than 20 percent."

Space Station Comment

NASA questions the derivation of the percent. Components of the calculation should be clearly identified. Major Concern.

See comment 7.

7. RESULTS IN BRIEF, Page 4, Second Paragraph

GAO Report

"A detailed analysis by a third party of Station cost and schedule projections, requested by Congress, cites many..."

**Appendix I
Comments From the National Aeronautics
and Space Administration**

Space Station Comment

The "analysis of a third party of Station cost and schedule projections" referred to on page 4, presumably the Chabrow analysis, was neither mandated nor requested by Congress. In fact, the NASA Administrator initiated the independent review in response to questions raised by Chairman John McCain concerning the feasibility of a "cost cap" on the ISS program. The Administrator announced this independent review, under the Chairmanship of Mr. Jay Chabrow, at a hearing before the Senate Subcommittee on Science, Technology, and Space on September 18, 1997, and Terms of Reference for the Cost Assessment and Validation (CAV) Task Force on the ISS were issued on October 14, 1997, to perform an independent review and assessment of costs, budgets, and partnership performance on the ISS program. Subsequently, on November 6, 1997, NASA issued a request to the CAV Task Force that, as a subset of its overall review, they perform an independent analysis of three discrete items called for in the Conference Report (House Report 105-297) accompanying the FY 1998 VA-HUD-Independent Agencies appropriations bill. Major concern.

See comment 8.

8. RESULTS IN BRIEF, Page 4, Third Paragraph

GAO Report

GAO includes a paragraph that discusses the orbital debris tracking issue and implies that the costs of an improved orbital debris tracking system should be included in the Life Cycle Cost for the Station.

Space Station Comment

NASA strongly recommends the deletion of this paragraph. Addressing the costs of an orbital debris tracking system as part of the International Space Station (ISS) Life Cycle Cost (LCC), even indirectly, inaccurately implies that the true LCC of the ISS should be an even larger number. Tracking orbital debris is a global problem and should not be a component of the Station life cycle cost assessment. Major concern.

See comment 9.

9. RESULTS IN BRIEF, Page 4, Fourth Paragraph

GAO Report

"The program has used, or identified specific uses for about \$2 billion, or about two-thirds of available reserves..."

Space Station Comment

NASA recommends deletion of the second sentence of this paragraph because it is inaccurate and somewhat misleading. NASA has "used," or allowed for use, approximately, a net of \$800 million in reserves through FY 2002 since the FY 1995 budget (\$1.6 vs \$2.4), and we do not have currently \$2 billion of specific uses, or even threats. Major concern.

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See comment 10.

10. RESULTS IN BRIEF, Page 5, Second Paragraph

GAO Report

“The original baseline shows that the February 1998 cost variance would have been about \$50 million higher than the \$398 million Boeing reported prior to the change.”

Space Station Comment

The wording of this sentence can be improved. NASA suggests modifying it to read, “The current variance incurred against the original baseline contract that was negotiated in January 1995 through February 1998 is \$448 million.” Minor concern.

See comment 11.
Now on p. 4.

11. U.S. FUNDING REQUIREMENTS FOR THE SPACE STATION, Page 6, Table 1

GAO Report

Table 1 uses the heading ‘Principal Investigator support.’

Space Station Comment

NASA suggests the heading Principal Investigator Support be changed to Principal Investigators. Minor concern.

See comment 12.
Now on pp. 4 and 5.

12. U.S. FUNDING REQUIREMENTS FOR THE SPACE STATION, Page 6, Table 1

GAO Report

GAO has included Russian Space Agency in their development estimate.

Space Station Comment

NASA strongly disagrees with the inclusion of Russian Space Agency (RSA) costs in the Station development category. GAO itself carried as a separate category in their January 1995 report. Inclusion of RSA costs in the development category is inappropriate. Major concern.

See comment 13.

13. U.S. FUNDING REQUIREMENTS FOR THE SPACE STATION, Page 6, Table 1

GAO Report

Shuttle Performance Enhancements are estimated to be \$0.2 billion in the report.

Space Station Comment

NASA questions the derivation of the estimate. Additionally, NASA recommended deletion of this category of activity from the Station Life Cycle Cost Assessment in 1995 and continues to believe the inclusion of such costs is inappropriate. Major concern.

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See comment 14.
Now on p. 4.

14. U.S. FUNDING REQUIREMENTS FOR THE SPACE STATION, Page 6, Table 1, Footnote b.

GAO Report

The footnote states "...and U.S. flights to the Russian Space Station Mir."

Space Station Comment

NASA suggests modifying the clause to read "and U.S. Missions to the Russian Space Station Mir." The costs for the U.S. flights to Mir included under the Shuttle Launch Support category.

Minor concern

See comment 15.
Now on p. 4.

15. U.S. FUNDING REQUIREMENTS FOR THE SPACE STATION, Page 6, Table 1, Footnote (e).

GAO Report

The footnote states "...with the Russian contract are included ..."

Space Station Comment

NASA suggests replacing the term "Russia contract" with the term "Russian Space Agency contract." **Minor concern**.

See comment 16.

16. U.S. FUNDING REQUIREMENTS FOR THE SPACE STATION, Page 7, First Paragraph

GAO Report

The higher development costs - \$21.9 billion versus \$17.4 billion - are attributable to schedule delays, additional prime contractor effort not covered by funding reserves, additional crew vehicle costs, and costs incurred as a result of Service Module delays.

"...a delay of 18 months that has increased development costs by more than \$2 billion."

Space Station Comment

NASA suggest reordering the reasons for growth in the following manner "... are attributable to and the effects of delays in delivery of the Russian-made Service Module -- including schedule slippage and related impacts to the assembly sequence, crew return vehicle costs , and prime contractor growth.." Additionally, the GAO estimate embeds the costs for the RSA contract (\$400 million) in its development estimate and does not explicitly state that it has done so. NASA strongly believes it is inappropriate to add those RSA contract dollars into the development total. **Major concerns**.

See comment 17.

17. U.S. FUNDING REQUIREMENTS FOR THE SPACE STATION, Page 7, Second Paragraph

GAO Report

"The increased in-house personnel costs during development - \$ 2.2 billion versus \$ 0.9 billion- are attributable"

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See comment 18.
Now on p. 5.

Space Station Comment

NASA's current estimate of Full-Time Equivalent civil service workforce costs in the ISS FY 1999 Budget to Congress is about \$1.6 billion from FY 1994-2003. Major concern.

18. U.S. FUNDING REQUIREMENTS FOR THE SPACE STATION, Page 7, Second Paragraph

GAO Report

"The increased staffing levels are attributable largely to the inclusion of science and crew return vehicle personnel into the Station budget."

Space Station Comment

NASA suggests an addition to the end of that sentence that would read, "which in most cases were covered under the Science, Aeronautics and Technology science accounts when the prior analysis was conducted." Minor concern.

19. U.S. FUNDING REQUIREMENTS FOR THE SPACE STATION, Page 7, Third Paragraph

GAO Report

GAO has included the costs for the crew return vehicle flight demonstration as a component of the Shuttle Launch Support for the ISS development period.

Space Station Comment

NASA disagrees with the inclusion of costs for the development and test demonstration flight of the X-38 as a component of the Station life cycle cost assessment. This project is clearly an advanced technology activity and has application potential for a wide range of programs, not just the Space Station. Therefore, NASA recommends that the GAO Life Cycle Cost assessment be modified to remove X-38 development and Shuttle Launch Support costs. This adjustment would change the total number of ISS development flights to 42 (versus 43 in the report) at a corresponding cost of \$17.3 billion instead of \$17.7 billion. Major concern.

20. POTENTIAL ADDED PROGRAM COSTS, Page 8, Second Paragraph

GAO Report

GAO states that the costs of modifying the Space Shuttle Columbia to permit its use for some Station missions needs to be added to the Life Cycle Cost assessment.

Space Station Comment

NASA disagrees with the GAO conclusion. NASA has recently made the decision to "scar" OV-102 Columbia for modifications so as to preserve maximum schedule flexibility. The cost of the scarring is estimated to be \$10-\$12 million. If the decision is required to modify OV-102 entirely (including external airlock with docking system), based on previous vehicle modification costs, the estimated cost would be a maximum of \$100 million. Current planning is to scar the Columbia so that the external airlock and docking system can be installed in the Columbia as needed. There are no plans to provide an additional set of docking equipment for the Columbia

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See comment 20.
Now on p. 7.

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since the equipment is transferable between orbiters. The costs for the Columbia scarring is not additional to the ISS LCC but will be covered within existing ISS reserve levels. Major concern.

21. POTENTIAL ADDED PROGRAM COSTS, Page 8, Fourth Paragraph

GAO Report

“... over 90 launches will be needed for assembly, science utilization, resupply, and crew return purposes. During this time, the Shuttle is scheduled...”

Space Station Comment

NASA suggests the first two sentences be modified to read, “Through December 2003, over 90 launches by NASA and RSA will be needed for assembly, science utilization, resupply, and crew return vehicle purposes. During this period, NASA’s Shuttles are scheduled...” Minor concern.

22. POTENTIAL ADDED PROGRAM COSTS, Page 9, Second Paragraph

GAO Report

“...delays in the availability of the vehicle (of crew return vehicle) could constrain Station operations.”

Space Station Comment

In 5th sentence, suggest modifying the term, “constrain Station operation,” to “delay 7 person operational capability.” Minor Concern.

23. POTENTIAL ADDED PROGRAM COSTS, Page 10, Second Paragraph

GAO Report

“...modifying Columbia could cost up to \$100 million.”

Space Station/Space Shuttle Comment

NASA has recently made the decision to “scar” OV-102 Columbia for modifications so as to preserve maximum schedule flexibility. The cost of the scar is estimated to be \$10-\$12M. If the decision is required to modify OV-102 entirely (including external airlock with docking system), based on previous vehicle modification costs the estimated cost could be a maximum of \$100M. Current planning is to scar the Columbia so that the external airlock and docking system can be installed in the Columbia as needed. There are no plans to provide an additional set of docking equipment for the Columbia since the equipment is transportable between Orbiters. The costs for the Columbia scarring is not additional to the LCC of the Station but will be covered within existing ISS reserve levels. Major concern.

See comment 21.
Now on p. 6.

See comment 22.

See comment 20.
Now on p. 7.

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See comment 24.
Now on p. 8.

24. POTENTIAL ADDED PROGRAM COSTS, Page 11, First Paragraph

GAO Report

GAO cites March 1998 for Cost Assessment and Validation (CAV) Team effort duration. The report also cites a CAV Team recommendation that, "the program could require an additional \$100 million to \$275 million in annual funding."

Space Station Comment

The Cost Assessment and Validation Team Report activity has continued into April 1998 and has just recently released its final report to NASA. The GAO final report should be updated to reflect the final CAV numbers. Minor concern.

See comment 8.

25. POTENTIAL DEBRIS TRACKING COSTS, Page 11, Second Paragraph

GAO Report

GAO has included an entire section of its report on Potential Debris Tracking Costs.

Space Station Comment

Adding the costs of an orbital debris tracking system to the ISS Life Cycle Cost, even by inference, inaccurately implies that the true LCC of the ISS is much larger. This reference should be deleted entirely from this analysis.

See comment 9.

26. STATUS OF FUNDING RESERVES , Page 13, Second Paragraph

GAO Report

"In January 1995, the Space Station program had more than \$3 billion in financial reserves to cover development contingencies. In March 1998, the financial reserves available to the program were down to about \$2.1 billion..."

Space Station Comment

As is typical in any developmental program, the Station has drawn down its reserves over the past three years to solve a number of very difficult and complex problems. The GAO report implies that NASA has somehow spent two-thirds of its Station reserves and now has only a small amount of reserves remaining to last the next six years. NASA suggests that the paragraph be rewritten as follows: "In January 1995, the Space Station program had more than \$3 billion in financial reserves to cover development contingencies. In January 1998, NASA's FY 1999 Budget to Congress included approximately \$2.4 billion in program flexibility and reserves for the Space Station program, including reserves for the Russian Program Assurance activities. NASA had identified nearly \$1 billion of potential funding requirements against those reserves. In the past, reserves have been used to fund additional requirements, overruns, and other authorized changes. Some of the recent reserve reductions are related to NASA's decision to add a third node to the Station's design and for costs incurred by the program that are associated with the schedule slip of the Service Module but not covered under the Russian Program Assurance budget. Major concern.

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See comment 27.

27. NEW BASELINE TO MEASURE COST AND SCHEDULE PERFORMANCE, Page 14,
Third Paragraph

GAO Report

The GAO report discusses Boeing's establishment of a new over target baseline for performance tracking and reporting.

Space Station Comment

NASA recommends that a sentence be added to end of paragraph, "The ISS program tracks Boeing performance against the original negotiated baseline contract as well as against the new over target baseline (OTB)." Major concern

See comment 28.
Now on p. 10.

28. NEW BASELINE TO MEASURE COST AND SCHEDULE PERFORMANCE Page 14,
Fourth Paragraph

GAO Report

The GAO report discusses the crosswalk back to the original baseline contract.

Space Station Comment

NASA recommends modifying the second sentence of paragraph to read, "That analysis shows that, as of February 1998, the total variance to date was \$448 million. About \$50 million was incurred in the first five months of FY 1998, and \$398 million was incurred in the first three years of the prime contract." Major concern.

See comment 29.
Now on p. 11.

29. NEW BASELINE TO MEASURE COST AND SCHEDULE PERFORMANCE, Page 15,
First Paragraph

GAO Report

The GAO report discusses the current NASA estimate of the Boeing Variance at Completion.

Space Station Comment

NASA suggest that a clause be added to the end of the paragraph, "...and is the basis for NASA's FY 1999 Budget to Congress." Minor concern.

See comment 30.
Now on p. 6.

30. CONCLUSIONS, Page 15, Third Paragraph

GAO Report

The GAO report cites "an independent team."

Space Station Comment

NASA suggest changing the reference from, "an independent team," to "the Cost Assessment and Validation Task Force." Minor concern.

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See comment 8.

31. CONCLUSIONS, Page 15, Third Paragraph

GAO Report


GAO discusses the space debris tracking issue yet again.

Space Station Comment

NASA recommends that GAO delete the all references to the Space debris tracking network in its report. It's not appropriate for a Life Cycle Cost analysis of Station. Major concern.



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	International Space Station Program Funding - Development Complete		Office of Space Flight
FY 1994 - 1997 Development, Operations, Research	\$8.5	billion	
Cost to Go (FY 1998 - Development November 2002)	\$10.8	billion	
	Development	\$4.5	billion
	Operations	\$4.1	billion
	Research	\$2.2	billion
Russian Program Assurance (FY 1997-1998)	\$0.3	billion	
NASA Estimate for Development Complete (FY 1994 - November 2002)	<u>\$19.6</u>	billion	

ENCLOSURE 1

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	International Space Station Program Funding - Assembly Complete	
ISS Development, Operations, Research (FY 1994 - June 2002)	17.4 billion	
Russian Program Assurance	0.3 billion	
July 2002 - December 2003	2.1 billion	
Crew Rescue Vehicle	0.6 billion	
Program Growth	<u>0.9 billion</u>	
Total ISS Program (FY 1994 - December 2003)*	21.3 billion	
*Excludes Freedom Uncosted (\$206M), Outyear Uncosted (-\$73M), X-38 (\$90M) and Russian Space Agency Contract (\$400M)		

Enclosure 2

The following are GAO's comments on the National Aeronautics and Space Administration's (NASA) letter dated April 27, 1998.

GAO Comments

1. According to NASA, shuttle support costs for the space station would be \$3.1 billion during development and \$5.5 billion during operations if marginal cost per flight is used to estimate those costs. However, we believe that it is more appropriate to use average cost per flight to estimate shuttle support.

NASA defines marginal cost per flight as those costs incurred or avoided as a result of adding or deleting one flight to or from the shuttle manifest in a given fiscal year. Marginal cost does not include any fixed costs that NASA says are required to maintain the capability to launch the shuttle a specific number of times during a given year. According to NASA officials, eliminating or adding a single flight in a given year has no effect on these fixed costs. Marginal cost per flight includes costs of personnel and any consumable hardware and materials, such as propellant, that can be added or removed with only temporary adjustment in the flight rate.

NASA defines average cost per flight as the total cost to operate the space shuttle on a recurring and sustained basis for a given fiscal year divided by the number of flights planned for that year. Its calculation of average cost per flight captures most costs in the shuttle operations budget line, as well as prorations of civil service personnel, space communications network costs, and recurring costs for shuttle improvements. The calculation does not include capital-type costs, such as those required to develop the system, and construct and modify government-owned facilities or nonrecurring costs associated with system improvements.

During its assembly, station elements will be almost the exclusive payload on the shuttle, and there is no alternative means of transportation for the station. Also, during the operations period, the station will be a major user of the shuttle. Since the station will be the predominant user of the shuttle for many years, we believe the use of average cost per flight is more appropriate than the use of marginal cost per flight to estimate shuttle launch support costs.

2. The time frames for the cost estimates were clearly portrayed in the life-cycle cost table. We added a footnote in the Results in Brief section to cite those dates earlier in the report.

3. We changed the heading in the table from “development budget” to “development cost”. We chose to aggregate all costs related directly to space station development and construction.
4. We revised the report to refer to earth observation and commercial utilization and related uses.
5. We revised the report to read “. . . development, integration, and on-orbit performance.”
6. We recognize that we have included some costs in our development total that were not included in 1995, such as the Russian Space Agency contract and crew return vehicle development costs. In calculating the percentage increase, we excluded those costs from our total in order to make a proper comparison. Using NASA’s own figures, the increase is more than 22 percent—\$17.4 billion vs. \$21.3 billion.
7. We recognize that the NASA Administrator initiated the idea of conducting an independent cost review. However, we note that the Congress specifically requested such an analysis in Conference Report 105-297. The report specified a number of preconditions to the release of some space station funding. One of those requirements was “a detailed analysis by a third party of (space station) cost and schedule projections . . .” For brevity, we have deleted references to this sequence of events.
8. We agree that debris tracking costs should not be considered part of the space station’s life-cycle cost estimate. We believe we have made that clear by (1) excluding any reference to debris tracking from the life-cycle cost table and (2) stating that debris tracking is a NASA-wide responsibility. However, we believe it is important to identify this potential cost because NASA established the requirement to catalog and track objects as small as 1 centimeter, in part, to support the International Space Station, and funding to achieve that capability is not yet available. As stated in the report, since debris tracking is a NASA-wide responsibility and the agency relies on the Department of Defense to provide the service, the two agencies will have to work together to determine how to move ahead on this challenge.
9. We do not imply that the program has spent \$2 billion of reserves. However, according to program documentation, the net unencumbered

reserve posture, as of March 1998, was about \$1.1 billion. This compared with a starting point of about \$3.1 billion in January 1995.

10. We believe the sentence, as written, accurately reflects the status of cost variance under the prime contract.

11. We revised our terminology.

12. We changed the life-cycle cost table category to read “development cost from 1994 to assembly complete” and added language in the report narrative to recognize NASA’s position. We note that in testimony on April 23, 1998, the NASA Administrator pointed out the relevance of the activities under the Russian contract to the development and construction of the space station.

13. The shuttle was incapable of supporting space station assembly without incorporating certain enhancements. We believe these nonrecurring costs are completely relevant to the discussion of space station life-cycle cost estimates.

14. We changed the footnote to read “U.S. missions to . . . Mir.”

15. We changed the footnote to read “Russian Space Agency contract.”

16. We did not change the order of reasons for contract growth. See comment 12 for discussion of Russian Space Agency contract.

17. Our estimate of civil service personnel costs includes an allocation of all elements of the research and program management budget—personnel and related costs, travel, and research operations support—to the station program. According to a NASA official, the agency’s estimate only allocates personnel and related costs to the station program. Since the station program benefits from all elements of the research and program management budget, we believe that it is appropriate to allocate all of those costs to the program.

18. We modified the report to incorporate this suggestion.

19. A crew return vehicle is required for space station operations. The X-38 program is focused on demonstrating a concept for station crew return. Therefore, we believe those costs are directly related to station development.

20. We changed the report to reflect NASA's current plans for modifying space shuttle Columbia.
21. We modified the report to read “. . . Over 90 launches by NASA and its international partners.”
22. We disagree. We believe a “delay” in the seven person operational capability is a constraint to the station program.
23. See comment 20.
24. We revised the report to reflect information in the final Cost Assessment and Validation Task Force report.
25. See comment 8.
26. See comment 9.
27. We believe report language accurately reflects the rebaselining of the prime contract performance measurement reporting system.
28. We modified the report to incorporate NASA's suggestion.
29. We modified the report to incorporate NASA's suggestion.
30. We identified the independent cost team as NASA's Cost Assessment and Validation Task Force earlier in the report.
31. See comment 8.

Major Contributors to This Report

National Security and
International Affairs
Division, Washington,
D.C.

Jerry Herley

Atlanta Field Office

John Gilchrist
James Beard
Fred Felder

Dallas Field Office

Vijay Barnabas

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