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Fact Sheet for the Chairman, Committee on Science, Space, and Technology, House of Representatives

July 1987

SPACE STATION

National Aeronautics and Space Administration's 1987 Cost Estimate

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National Security and
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July 21, 1987

The Honorable Robert A. Roe, Chairman
Committee on Science, Space, and Technology
House of Representatives

Dear Mr. Chairman:

On January 21, 1987, you asked us to examine the coverage and methodology of the National Aeronautics and Space Administration's (NASA's) space station cost review to explain how NASA had compiled and analyzed the data to support the cost estimate and to identify the categories of included costs. We presented the results of our work in a briefing on April 15, 1987. This fact sheet summarizes and updates the information contained in that briefing.

In late 1986 the NASA Administrator directed NASA's Space Station and Comptroller's offices to revalidate or modify the 1984 space station cost estimate of $8 billion. NASA presented the results in 1984 dollars to maintain comparability with the 1984 estimate. (Unless otherwise indicated, all dollar figures presented in this fact sheet are in 1984 dollars.)

According to NASA officials, the estimates were to be calculated using what NASA referred to as "grass-roots" cost estimating methodology wherever possible. This method estimates the cost of each detailed work element of a known design. Because detailed space station designs were not usually available, analogous and parametric cost estimating methods were also employed. (See appendix I for an explanation of these methodologies.)

The NASA cost review focused primarily on the Space Station Office's costs to design and develop space station hardware and to deliver that hardware to the Kennedy Space Center for launch. It did not include the costs already incurred by NASA for space station concept definition, nor did it include the future NASA costs to launch, assemble, and conduct experiments on the space station. The cost review examined costs incurred by NASA's Research and Development appropriation and did not include space station-related costs which would be funded by other NASA appropriation

accounts, such as Research and Program Management; Space Flight, Control and Data Communications; and Construction of Facilities.

NASA formulated an estimate of $14.5 billion for space station development costs based on the Space Station Office's and Comptroller's estimates and presented it to the Office of Management and Budget (OMB) in February 1987. As part of its cost review effort, the Space Station Office estimated space station operations costs at $5.3 billion for fiscal years 1987 to 1998, with subsequent annual operations costs of about $1 billion per year. Based on the above figures, space station development and operations costs through 1998 would be $19.8 billion.

However, the excluded costs could add billions of dollars to the initial cost of the station and, according to one Space Station Office estimate, more than $650 million to the annual operating costs. For example, NASA provided a range of costs for the 31 shuttle missions needed to launch, assemble, and initially supply the station at $1.1 billion to $5.3 billion. Another NASA estimate shows the cost of a crew emergency return vehicle--which was not included in the space station base program at the time of the cost review--to be in the range of $750 million to $1.5 billion. Also, the cost of modifying the space shuttle fleet with devices for berthing with the space station could cost $60 million, according to NASA officials.

We developed the information in this fact sheet through an examination of NASA documents and discussions with NASA officials. We did not assess or verify the reliability of cost review data, assumptions, or estimates.

We have discussed the information in this fact sheet with knowledgeable NASA officials. They generally agreed with the information presented and made some clarifying comments. We considered these comments in finalizing this document.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this fact sheet until 5 days after its issue date. At that time, we will send copies of this fact sheet to the Chairmen, House and Senate Committees on Appropriations and Senate Committee on Commerce, Science, and Transportation; the Administrator, National Aeronautics and Space Administration; the Director, Office of Management and Budget; and other interested parties upon request.

Should you have any additional questions, please feel free to contact me at 275-4268.

Sincerely yours,

Harry R. Finley

Harry R. Finley
Senior Associate Director

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ABBREVIATIONS

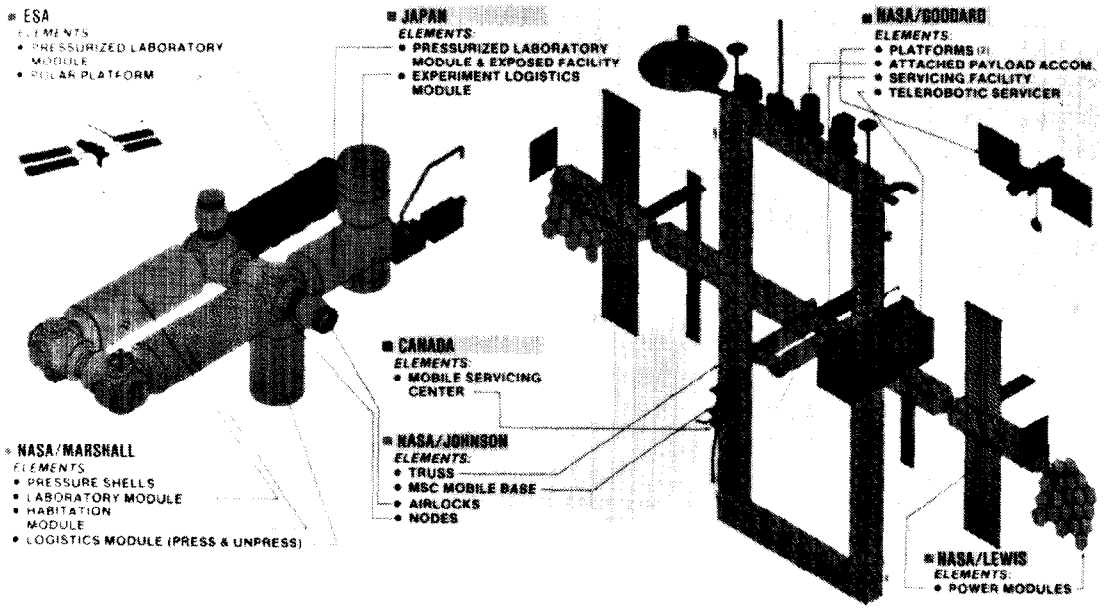
ESA	European Space Agency
NASA	National Aeronautics and Space Administration
OMB	Office of Management and Budget

SPACE STATION COST REVIEW

On January 25, 1984, President Reagan announced in his State of the Union Address that he was directing the National Aeronautics and Space Administration (NASA) "to develop a permanently manned space station . . . within a decade." In February of that year, NASA's Administrator told a congressional committee that "the space station can be in place within a decade and for approximately 8 billion dollars."[1]

By mid-1986, NASA had established a space station configuration (illustrated in fig. I.1) incorporating major components to be developed by NASA field centers and by international partners.[2] In April 1986, NASA estimated that such a station would cost $7.8 billion to develop.

Figure I.1: NASA Space Station Configuration (1986)



Source: NASA

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[1]Unless otherwise indicated, all figures in this fact sheet are in 1984 dollars. They may be converted to 1988 dollars by multiplying them by NASA's conversion factor of 1.193.

[2]NASA's Johnson Space Center, Kennedy Space Center, Marshall Space Flight Center, Lewis Research Center, and Goddard Space Flight Center are responsible for major aspects of the program. Canada, Japan, and the European Space Agency (ESA) are developing additional modules and components.

APPENDIX I

In August 1986, the newly appointed NASA Administrator directed the Space Station Office to revalidate or modify the $8 billion cost estimate by January 31, 1987. In October 1986, he directed the Comptroller's Office to perform an independent assessment of the space station's cost. Personnel from the Comptroller and Space Station offices worked together on cost review teams that collected and analyzed the data. The two offices then separately prepared estimates based on that data.

COST REVIEW GUIDELINES

The Space Station Office distributed cost review guidelines to program participants at headquarters and field centers in October 1986. The Space Station Office had previously indicated that space station costs were to be addressed in terms of prime and non-prime costs. Prime costs were defined in the guidelines as prime contractor costs for detailed design, development, and operations. Non-prime costs were defined as costs for such things as NASA systems engineering and integration, overall verification (including major test articles), operations and user operations capability development, launch site facility outfitting, simulator and training development, and NASA program management and support.

The Space Station Office assumed that detailed design and development would begin in mid-1987 and specified that prime development costs would end with the delivery of flight hardware to the Kennedy Space Center for launch package integration. Included were costs associated with developing operations capabilities, such as outfitting operations support facilities and developing tools needed for operations. The Space Station Office also instructed the centers to assume prime contractor fees of 8 percent, to identify reserve funds in their estimates, and to include the cost to the United States of integrating the international partners' components into the station.

The guidelines assumed the following space station construction schedule:

-- launch of first element in January 1993,
-- permanent crew on station in August 1994, and
-- space station complete in October 1996.

The Space Station Office guidelines indicated that cost estimates should be based on the assumption that hardware used for integration testing and subsystem qualification would later be refurbished and used as flight hardware. NASA officials informed us that this "protoflight" concept was selected to reduce station development costs. The guidelines also specified that no new thermal vacuum testing facilities were to be included in the cost estimates because station elements (including its inhabited modules, airlocks, and nodes) would not be subjected to full scale thermal vacuum testing.

The guidelines instructed the centers to account for any cost savings realized by commonality in design elements. For example, not all NASA centers were to include development costs of the same battery in their individual cost estimates; only the center responsible for initially developing the battery would include the development cost, thereby eliminating duplicative accounting and realizing the savings of commonality.

In addition to instructing the centers how to estimate design and development costs, the guidelines directed participants to estimate space station operations costs for fiscal years 1988 to 1998 and for fiscal year 2000 (assumed to be a year of "steady state" operations). These costs were defined as costs associated with preparations to support orbital operations and recurring operational costs.[3] This definition included the costs of initial crew and ground personnel training, initial spares and replenishment, operations support, facility maintenance and operations, training and trajectory planning for specific flights, launch site sustaining engineering, launch package integration, and the overhaul and repair of the space station. Estimates were not to include the cost of structural spares except under "very unique" circumstances involving safety, operations, or efficiency.

To illustrate the difference between development costs and annual operations costs, one NASA official told us that the cost of outfitting an operations facility with a computer was a development cost. The cost of using the computer's software and data bases to support space station missions was an annual operations expense.

The cost review guidelines for space station operations included assumptions concerning the distribution of operations functions, an operations scenario, pre-launch and post-landing processing, requirements for the operations process, an integrated logistics system, and support for user operations. For example, the guidelines assumed that U.S. logistics would require about 72 tons of material, which would have to be lifted to the space station annually. About 58 tons would have to be returned to earth each year. Crew rotations, assumed to occur every 45 days initially, would take place every 90 days after the space station was permanently occupied.

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[3]The recurring operational costs of such policy-making activities as user pricing, market research, and public information were not included.

COST REVIEW METHODOLOGY AND IMPLEMENTATION

The NASA centers participating in the cost review were directed to estimate costs using a grass-roots methodology[4] wherever possible. We were told that NASA engineers and cost analysts had estimated non-prime development costs through a combination of grass-roots and analogous[5] techniques because in some areas the existing level of design understanding needed for a true grass-roots approach did not exist.

We were informed by NASA officials that the Lewis Research Center had been able to apply a grass-roots approach in estimating prime costs because it had a sufficiently detailed design approach. NASA estimators at the other centers used in-house parametric[6] and analogous cost models as points of comparison with the estimates that had been prepared by the prime contractors. The NASA estimators then selected the estimates they judged most realistic. Each center was responsible for ensuring that its prime contractor's work could be fully integrated with all other affected prime and non-prime work.

Cost review team efforts

The NASA centers submitted their cost estimates to the Space Station Office and Comptroller cost review teams in early December. These teams reviewed the development cost submissions for consistency in integration and commonality assumptions to guard against overlaps and gaps among the centers' information and to capture savings due to shared equipment designs. The teams also removed the centers' estimates for reserves from the submissions to allow the application of a consistent, program-wide reserves estimate. According to participating NASA officials, the review teams conferred with the centers throughout the process.

The operations cost data was assembled and cross-checked against a new operations costs parametric model and was also reviewed by a separate group NASA had established to review plans for operating

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[4]Grass-roots (also known as bottoms-up or engineering) cost estimating techniques are used for very specific designs. Cost experts consider a grass-roots approach to be one of the most accurate cost methodologies.

[5]Analogous cost estimating techniques are used when the system involved is similar to an existing system and the estimator can therefore draw upon past experience to prepare the cost estimate.

[6]Parametric cost models are based on a set of general parameters such as weight and thrust. Cost data are gathered for past systems as a function of the same parameters and then used to predict what the new system will cost.

the space station--the Space Station Operations Task Force. Although Space Station Office officials informed us that the operations cost estimates were not as rigorously analyzed as the development cost submissions, the centers' operations cost submissions were found to contain some overlapping, incomplete, or inconsistent information.

The centers submitted their cost estimates in 1987 dollars. To maintain comparability with the 1984 estimate, the cost review teams deflated the final cost estimates to 1984 dollars, using an inflation rate of 13.5 percent for the entire 1984 to 1987 period.

COST REVIEW RESULTS

In mid-December, the Space Station Office and Comptroller teams began to independently analyze the data submitted by the centers. On January 22, 1987, the Space Station Office briefed the NASA Administrator on its findings. The Comptroller's Office briefed the Deputy Administrator on the following day.

Development cost estimates

The Space Station Office estimated the space station's development cost at $13.2 billion. The Comptroller's estimate for such costs was $16.6 billion. Following the briefings, NASA formulated a single development cost estimate of $14.5 billion (see table I.1).

Table I.1: Cost Review Estimates of Development Costs

Estimates	Space Station Office	Comptroller	NASA
	(billions)		
Prime/non-prime	$10.7	$13.5	$10.7
Reserves	2.5	3.1	3.8
Total	$13.2	$16.6	$14.5

NASA's $14.5 billion estimate coupled the Space Station Office's prime/non-prime development cost estimate with a higher reserve level than had been suggested by either the Comptroller or the Space Station Office. On February 5, 1987, NASA presented the $14.5 billion development cost estimate to the Office of Management and Budget (OMB).

Estimated operations costs

The Space Station Office team estimated operations costs at $5.3 billion for fiscal years 1987 to 1998 and $800 million to $1.1 billion for fiscal year 2000. The Comptroller team's estimate did not address operations costs.

APPENDIX I

In briefing OMB, NASA did not present estimated operations costs for either fiscal years 1987 to 1998 or fiscal year 2000. Instead, it estimated that operations costs for fiscal years 1988 to 1992 would total $908 million in then-year dollars.

COSTS NOT INCLUDED IN THE COST ESTIMATE

The cost estimates for space station development and operations did not reflect all space station-related costs, some of which had been estimated by NASA cost reviewers. Examples of excluded costs include an additional $655.5 million in fiscal year 2000 operations costs that would be borne by other NASA elements. Similarly, fiscal year 1986 to 1992 costs for a flight telerobotic servicer ($212 million) and transition definition work ($150 million)[7] were not included in the development cost estimate. The cost of developing an emergency return vehicle, which was not included in the space station design configuration, was not included in the final cost review results and is estimated to cost $750 million to $1.5 billion.

Some other costs were not only excluded from the cost review results but were not estimated anywhere in the cost review. For example, launch costs for the 31 shuttle missions needed to assemble and initially supply the station and some tracking and data support costs[8] were excluded from the review's scope. NASA officials informed us that NASA's standard practice is to exclude launch costs from a program's budget and to include them in the Space Flight appropriation.

NASA officials later provided us with low, middle, and high launch cost estimates of $1.1 billion, $2.4 billion, and $5.3 billion. The lowest cost was based on a marginal flight cost[9] of $36.5 million. The middle cost was based on NASA's current charge to the Department of Defense of $78.0 million per shuttle flight. The high cost was based on the full average cost per flight in 1993 of $170 million.

The space station cost review focused primarily on those costs borne by the Space Station Office in NASA's Research and Development appropriation. However, other related research and development costs were not addressed, such as the cost of the

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[7]These figures are in total then-year dollars.

[8]Some tracking costs were included in the excluded annual operational cost estimate of $655.5 million.

[9]A NASA official told us that the "marginal cost" represents the additional cost for launching a mission. The official cited propellants, an external tank, and expendable hardware as examples.

Orbital Maneuvering Vehicle (estimated at $467 million)[10] and of developing the space station berthing capability for the shuttle fleet (estimated at $60 million). Research costs[11] incurred by the space station users will be charged to the users. Users include commercial and government customers--both foreign and domestic. The U.S. government customers also include elements within NASA.

Costs incurred in parts of NASA's budget other than the Research and Development appropriation--the Construction of Facilities and the Research and Program Management appropriations--were also omitted. The Space Station Office guidelines had directed the field centers to submit anticipated construction needs but to separate them from the cost review data.[12] Similarly, civil service salaries/benefits and travel costs were not included. The Space Station Office asked the centers to estimate the number of civil service employees who would be required to support the program. NASA later estimated that annual civil service costs should not exceed $125 million to $130 million.

The cost review addressed only the program's design, development, and operations phases; it did not encompass the funding already appropriated for the concept and definition phases. NASA estimated that these earlier "sunk" costs total about $600 million.

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[10]The Space Station Office has stated that it plans to use the space shuttle's Orbital Maneuvering Vehicle estimated to cost the shuttle program $467 million (then-year) dollars. The marginal cost of procuring a second Orbital Maneuvering Vehicle for the exclusive use of the space station is estimated at $80 million to $100 million.

[11]Such costs include payload definition, design and development, data operations systems, and logistical goods and services.

[12]NASA has estimated that the cost of constructing space station facilities will be about $200 million.