

REINVENTING NASA

**The Congress of the United States
Congressional Budget Office**

NOTES

Unless otherwise indicated, all years are fiscal years.

Cover photo of the Hubble Space Telescope is courtesy of the National Aeronautics and Space Administration.

Preface

The National Aeronautics and Space Administration (NASA) is confronting the difficult task of squeezing a program that it anticipated would cost about \$95 billion for five years into a budget plan allowing just over \$70 billion. This study, which was prepared for the House Committee on Science, Space, and Technology, evaluates NASA's strategy for coping with the expectation of lower funding in the future and develops a set of illustrative alternatives that would reduce the scope of NASA's mission. In keeping with the mandate of the Congressional Budget Office (CBO) to provide objective analysis, the study makes no recommendation.

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Summary

The National Aeronautics and Space Administration (NASA) is confronting the difficult task of reinventing its program within the confines of a dramatically lower five-year budget plan. The agency has chosen a two-pronged strategy: maintaining the broad structure of its program while marginally adjusting its content by stretching out, scaling down, and canceling some of its projects; and buying more program with its appropriation by doing business more efficiently. This study examines that strategy and a set of alternatives that would focus NASA's program more tightly on one or another of its three major traditional objectives--piloted exploration of space, the generation of new scientific knowledge, or the development of space and aeronautical technology--under an annual budget of no more than \$14.3 billion.

The analysis concludes that improving the way NASA conducts its business--buying more for less--is unlikely to produce significant budgetary savings in the next five years. A disproportionate share of the burden of living with lower budgets is likely to involve adjustments to the content of NASA's program--buying less for less. If so, the distinguishing characteristics of that program (high fixed costs for projects with long operational lives), coupled with the agency's tendency to underestimate the cost of its projects, increase the risk that NASA's strategy will lead to greatly reduced productivity in the form of deferred, diminished, or even lost benefits.

An alternative to the current course would be to focus the agency's efforts on narrower objectives. Projects in the emphasized areas would then have adequate budgets, and the chances would be greater that NASA would deliver a productive program--one that produces benefits as promised in a timely way. This strategic alternative would explicitly forgo other benefits that NASA's program might

deliver, but it would save the costs of pursuing them in cases in which the risk of failure was high.

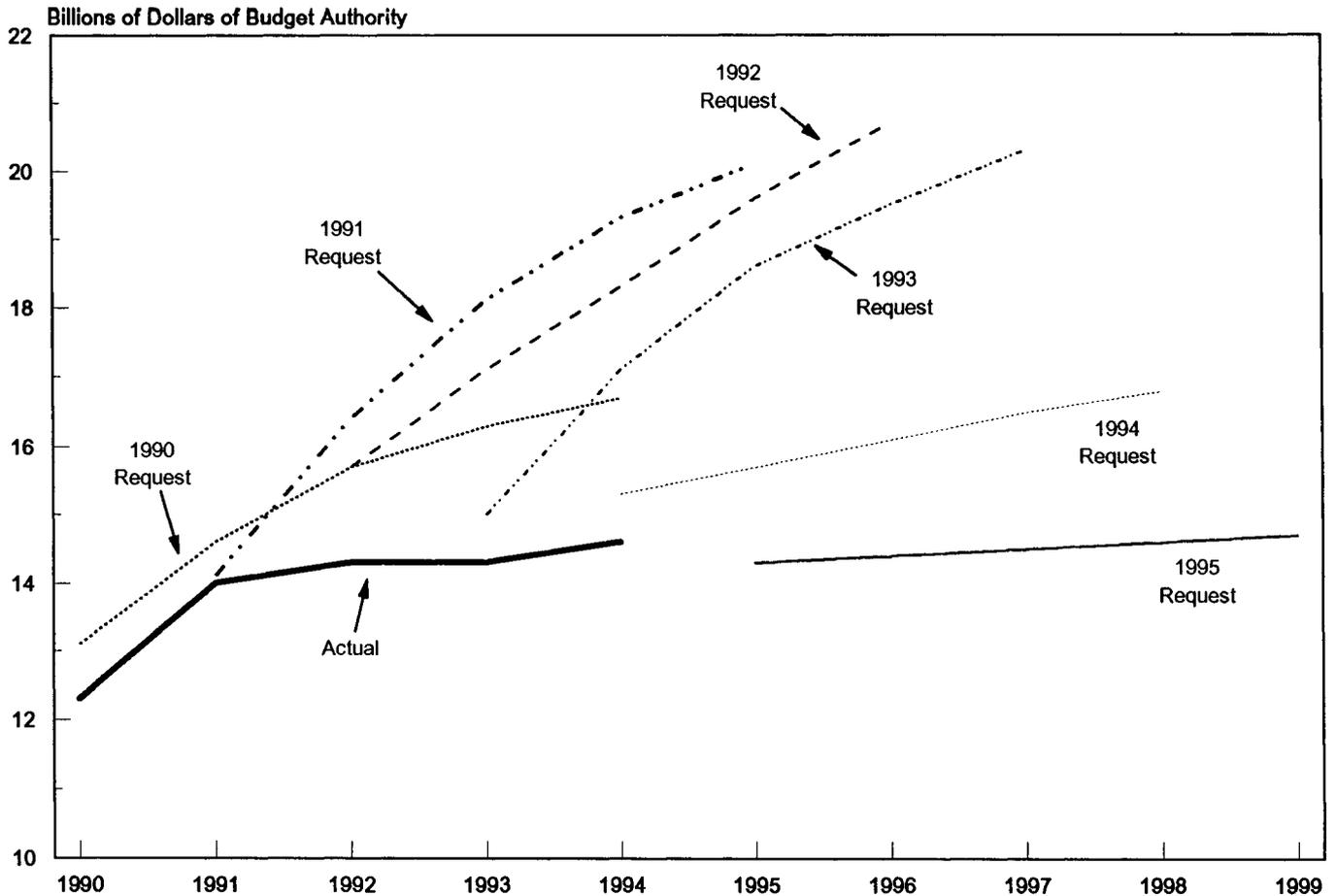
NASA's Program and Budget

Since the mid-1980s, NASA's program has required consistent growth in its out-year budgets, even after adjusting for inflation. By itself, a program plan that requires real increases in funding need not evoke criticism. But in today's environment of fiscal restraint, NASA's plan has generated criticism because of the agency's recurring problems in estimating the costs of its program and because of shortfalls in the performance of some of its major projects.

Concerns about the cost of the NASA program increased after 1990, when the Budget Enforcement Act (BEA) required a tightening of all domestic discretionary spending. As the BEA's caps on spending began to bind, the Congress significantly lowered NASA's budget from the level requested by President Bush for 1992 and 1993. In 1992, the budget request for NASA was \$15.8 billion, but the Congress appropriated only \$14.3 billion. In 1993, the agency's appropriation was again \$14.3 billion, \$700 million below the Administration's request of \$15 billion.

In this context, the Clinton Administration's proposal to slow the growth in NASA's budget by \$16 billion over the 1994-1998 period represented a significant change (see Summary Figure 1). Nevertheless, the Congress voted a smaller appropriation than the Administration's request for 1994: it reduced the Administration's figure of \$15.2 billion by \$700 million to \$14.6 billion. The second Clinton budget proposal for 1995 through 1999

Summary Figure 1.
Five-Year Budget Requests of the National Aeronautics and Space Administration, 1990-1995
 (In billions of dollars of budget authority)



SOURCE: Congressional Budget Office based on *Budget of the United States Government* (various years) and 1993 projections from the NASA Comptroller's Office.

flattens NASA's funding even more and for the first time in 21 years requests less for NASA in the coming budget year (\$14.3 billion for 1995) than was provided in the current year (\$14.6 billion).

To adapt to the new budgetary realities, NASA has chosen to adjust the content of its program marginally and improve its efficiency. If successful, this strategy would permit the agency to pursue simultaneously objectives in piloted spaceflight, space science (using robotic spacecraft), and aeronautics and space technology useful to both the

public sector and private aerospace industries. At stake are the benefits of NASA's projects in these areas--for example, new knowledge about the universe or progress toward the piloted exploration of Mars. Such benefits are directly observable but difficult to measure and value. Most research on the effects of past NASA spending and the benefits of its program does not substantiate the claim that the choices among program objectives or funding levels for NASA will have significant implications for the U.S. economy.

The Risks of Marginal Adjustment

A part of NASA's strategy to adapt to new budget realities is to delay, scale back, and cancel some projects but maintain the overall structure of the program that the agency has sought to establish since the early 1980s. That structure includes developing and operating piloted spacecraft (the space shuttle and the space station), developing and operating robotic spacecraft (for example, the Earth Observation System and the Hubble Space Telescope), and making continued advances in rocket and satellite, aeronautical, and other systems and technologies necessary to support the nation's public and private aerospace activities. Essential characteristics of NASA's current program heighten the risks of the strategy of marginal adjustment. Moreover, long-standing concerns about the productivity of NASA's overall program will intensify as a strategy of marginal adjustment is pursued.

High fixed costs and support for long-term mission operations and data analysis in order to realize benefits are two characteristics of many of NASA's projects that complicate a strategy of marginal adjustment. High fixed costs imply that relatively large cuts in the activities of a program produce only small budgetary savings. For example, cutting the space shuttle's annual rate of flights by 25 percent (two flights of the normally scheduled eight) reduces the operating costs of the shuttle system by less than 5 percent. Similarly, reducing the funding necessary to operate space science missions and analyze the data they produce can inflict a disproportionately high cost in lost benefits, which lowers the return on NASA's substantial past investment in spacecraft and facilities.

NASA's strong tendency to underestimate the cost of its projects is a third characteristic that compounds the risk of the agency's marginal adjustment strategy. Extensive documentation compiled by the General Accounting Office (GAO) and the Institute for Defense Analysis attests to NASA's poor record in this regard. The prospect that large numbers of projects in NASA's program will cost more than anticipated complicates decisions about which programs to downgrade, delay, or cancel, and further

increases the possibility that the benefits of NASA's work will be deferred, decreased, or lost.

Concerns about the content and worth of NASA's program might well arise even if cost and budgetary problems were not evident, but those concerns are strengthened by the adjustments that NASA is making in the content of its program to reduce its budgetary requirements. First is the question of people in space. On the one hand, supporters of piloted spaceflight and human exploration are unhappy with the slow pace of these activities. On the other hand, critics argue that NASA's decision to spend more than 50 percent of its budget on piloted spaceflight crowds out more worthy science and technology projects.

A second content issue is that NASA's science program is dominated by projects that critics label as too big, too expensive, and too long-lived. For example, the Hubble Space Telescope cost billions of dollars to build and operate; the life span of the project, from the beginning of development to the end of operations, is expected to be at least 20 years. Critics contend that "cheaper, better, quicker" missions are preferable: although such missions are less ambitious than recent large projects, more of them can be supported, and they inflict a lower cost in lost scientific benefits if they fail.

Third, the content of NASA's program has been criticized as unresponsive to the economic challenges facing the nation. This viewpoint calls for more emphasis on projects to increase private productivity--for example, research and development supporting U.S. aircraft, rocket, and satellite manufacturers.

Changing the Way NASA Does Business and Reducing Program Costs

Changing the way NASA does business, the second part of the agency's strategy to adapt to lower budgets, may offer improvements in program management and technical performance and some reduc-

tions in costs. But the associated budgetary savings are uncertain and unlikely to be realized in the near term. Accordingly, the first element of NASA's strategy to adapt to lower budgets in the future--making adjustments in the content of its program--will have to bear more of the burden of lowering costs. The Congressional Budget Office (CBO) has reviewed six types of proposals for improving the way NASA conducts its business.

Ongoing Management Reforms

Proposals for reforming NASA's management emphasize better planning, uniform and more centralized review of projects, improved cost estimating independent of program advocates, and development of measures of contractor and program performance. If successful, the proposals could allow the agency to control its costs better, but the effects of the proposals are more likely to be felt in the future because improved management and planning will influence new programs more than current ones. Making a success of these efforts will require a steadfastness among NASA's leaders not always evident in the past. For example, funds for planning projects carefully early in their life cycle have been cut in difficult budgetary times, despite the acknowledgment by senior management that such funds are necessary to avoid future problems.

Ongoing Procurement Reform

NASA proposes three major changes in its procurement process: modifying the agency's procedures for incentive contracting, placing more weight on a contractor's past performance when awarding new contracts, and streamlining midrange procurement (purchases between \$25,000 and \$500,000).

Formal evaluations of the Department of Defense's (DoD's) use of incentive contracting suggest that incentives helped to hold down growth in the costs of developing strategic missile systems and satellites. Because NASA has long practiced incentive contracting, the changes currently being considered are unlikely to lower costs significantly. But NASA may be able to improve its technical

results by basing a contractor's incentive fees more on the performance of finished systems than on meeting interim schedules and cost goals, and emphasizing a contractor's past performance when awarding new business.

NASA spent only 13 percent of its 1992 funding for procurement under contracts covered by its Mid-Range Procurement Initiative. Thus, even an extremely successful reform effort that reduced costs by 5 percent would save only about \$85 million annually. The initiative might yield additional savings by decreasing the number of NASA employees needed in the procurement area. However, increased productivity in procurement activities is more likely to allow the agency to make do with a smaller increase in personnel for that area than was recently recommended by examiners for both the executive branch and the Congress.

A New Relationship with the Private Sector

The possible relationships between NASA and the private sector span a wide range. At one extreme is NASA's traditional mode of acquisition, which is characterized by extensive and direct involvement of the government in all phases of activity. At the other extreme is purchasing data and services provided by private firms that are wholly responsible for the design, production, launch, and operation of the spacecraft necessary to provide those products. Among the candidates for purchases on commercial terms are NASA's communications satellites or the services they provide, data needed for research on the global climate, and launch services for small scientific payloads.

The vision that underlies suggestions to buy more on commercial terms emphasizes two points. First, the aerospace industry can produce the technically sophisticated products that NASA needs more cheaply without government supervision than with that oversight. Second, NASA has a self-defeating tendency to drive up the cost of the hardware it buys in the traditional manner through excessive oversight, overly detailed design specifications, and too many contract changes.

Similar concerns have been raised about the defense acquisition process. A 1993 study by the Defense Science Board, for example, argues that DoD's acquisition costs could be reduced by as much as 20 percent, largely by applying commercial practices. That conclusion should be treated as tentative, however, because it is based on a small number of cases and expert judgment. The board used those factors to develop rules of thumb that it then extrapolated to the entire defense budget. In addition, the study concluded that the savings it projected were likely to accrue only after five years of determined reform, a point as applicable to NASA as to DoD.

Purchasing on commercial terms has drawbacks and limitations. In some cases, the government's potential savings from commercial purchasing may be offset by the higher relative costs of private financing and insurance, which are included in the prices that the government pays for commercial products and services. In other cases, the substantial risk involved in developing the new technologies necessary for some NASA programs makes commercial purchasing inappropriate. Finally, the risk of loss of human life in piloted spaceflight may preclude applying the more hands-off government position typical of commercial purchasing to those programs.

Streamlining

Proposals for streamlining overlap with the call for NASA to buy more on commercial terms. They focus on increasing the authority and responsibility of program managers and prime contractors by loosening procurement and acquisitions regulations and decreasing the role of NASA's field centers in program management.

Advocates of streamlining NASA's procurement process point to two examples to support their case: classified military space projects and the recent experience of the Strategic Defense Initiative Organization (SDIO). Yet no public studies have shown that the universe of classified military projects has demonstrated superior cost, schedule, and technical outcomes compared with NASA or open military acquisitions. The SDIO claim also seems un-

ported by serious analysis. Moreover, regarding the federal acquisitions regulations in particular, the General Accounting Office's "High-Risk Series" review of NASA's contract management found that the agency has often failed to comply fully with procurement requirements. That failure has led NASA's field centers to approve contract changes without adequate technical evaluation and to allow unpriced contract changes to persist. Such factors have contributed to cost overruns and unsatisfactory performance.

New Cooperative Ventures

The Cold War prevented NASA from taking full advantage of joint ventures with the U.S. military or with foreign governments. Now that that conflict has ended, many observers have suggested that NASA could increase its productivity by entering into new cooperative efforts. The agency has taken up that suggestion and is aggressively pursuing new international cooperation in piloted spaceflight with the Russian Space Agency. The Administration is also examining the prospect of integrating NASA's Earth observation efforts with the polar satellite programs of DoD and the National Oceanic and Atmospheric Administration.

The major focus of the new cooperation with Russia is to develop and subsequently operate a space station, an effort that carries both risks and rewards. The evolving and preliminary plan for the new international station would restore some of the capability lost in the earlier redesign and virtually all of the lost schedule. The costs of the venture would be lower than those estimated for Freedom (an earlier design) and would not exceed the \$2.1 billion cap that the Administration has placed on annual spending for the station for the next five years. Whether the current estimates of costs hold up will not be known until late summer 1994, when final contracts with the prime contractor, Boeing, are expected. Integrating U.S. and Russian hardware, computer software, and operating procedures could prove difficult, however. In addition, political tensions could always stop the project in its tracks, forcing NASA to either cancel the station (and lose the chance of a return on its past investment) or redesign the program yet again.

Total Quality Management

Total quality management (TQM) is a managerial philosophy whose objective is to achieve customer satisfaction through continuous improvement of production processes. Customer satisfaction and the positive performance indicators that go with it are achieved by committed managers and empowered employees seeking to continuously improve their products by applying empirical data and analysis to production processes. First adopted by private manufacturing firms in Japan, the approach spread to private manufacturers in the United States in the late 1970s, achieved wide acceptance in the 1980s, and by late in that decade was being adopted by large parts of the federal government. Although TQM originated in manufacturing, it has spread to the service sector, where it has gradually won adherents.

NASA was one of the first federal agencies to adopt TQM during the late 1980s. According to a 1992 GAO survey, eight NASA installations employing roughly 20,000 people have adopted TQM. GAO asked respondents to place themselves in one of five phases of TQM. Four of the NASA installations placed themselves in the second phase, "just getting started"; three in the third phase, "implementation"; and one in the fourth phase, "achieving results." (The first phase is "deciding whether to implement TQM," and the final phase is "institutionalization.")

The GAO survey reported two sets of results: external organizational performance--the implementing agency's assessment of its relationships with its customers--and internal operating conditions. For NASA installations and for a larger survey sample of more than 2,200 other federal installations, self-reported improvement was correlated with progress along GAO's five-phase scale. Those improvements included reductions in costs, although GAO did not report the size of the reductions or the categories of effort in which they occurred.

Even if NASA's adoption of TQM is ultimately successful, it is unlikely to lower the cost of the agency's program or to have a significant budgetary impact, at least in the next several years. The private sector's experience with TQM indicates that it

is most effective when consistently practiced over a long period and when improved quality precedes reduced costs. The federal experience with TQM, including NASA's, is relatively limited. These findings should create skepticism about claims that immediate cost savings will follow the decision to employ TQM.

Alternative Programs for NASA

An alternative to NASA's strategy of adjusting to lower future budgets is to narrow substantially the focus of the agency's activities. If NASA's problem is trying to do too much with too few dollars, one solution is to do less. Narrowing NASA's focus directly addresses the issues of cost and program content and might even provide more opportunities for effective reform of the way NASA does business. By explicitly forgoing some benefits, budget costs could be reduced. Moreover, the likelihood would be increased that NASA could actually achieve results and obtain benefits in the areas in which its resources were concentrated.

CBO has developed and evaluated three alternatives to NASA's current program, each of which illustrates the option of a more focused strategy. Each emphasizes one of the three major objectives that NASA historically has pursued, although no alternative is a specific proposal of NASA's critics. The annual budgetary cost of each alternative is \$14.3 billion or less, ranging from a program focused on piloted spaceflight for the full \$14.3 billion to a program emphasizing technological development and robotic space science for \$7.0 billion. The budgetary cost of each of the programs ranges downward from the current level of funding because of the national emphasis on deficit reduction and the prospect of diminishing returns to dramatically larger investments in programs with more limited objectives than the current one. The budgetary costs of the second and third alternatives are presented as point estimates. Actual costs could vary as much as a \$1 billion above or below the estimates.

The three alternatives presented here are broad outlines that might be better viewed as end points in a process of adjustment rather than starting points. They neither include strategies for transition from the current program, nor do they take account of transition costs. The three alternatives are:

- o **A program that emphasizes piloted spaceflight at a sustained budget of \$14.3 billion annually.** To fund this option, plans for robotic space science would be cut. This alternative concentrates on the space station program and on new technology to support future piloted exploration of the solar system. It would fund the space station program at a higher level to ensure its timely completion and secure the benefits of the program, including improved relations with Russia. This alternative also responds to the criticism that NASA's current program does not give a high enough priority to future human exploration of the solar system. Spending for space science and technology activities in areas that do not directly support human exploration would be reduced dramatically. Yet the pace of piloted exploration is likely to be slow, as most estimates of the cost of a base on the Moon or a piloted mission to Mars make such activities difficult to afford within a constrained budget.
- o **A program that emphasizes robotic space science at a budget of \$11 billion a year and includes piloted spaceflight only for scientific purposes--a criterion under which the space station would be canceled.** This alternative emphasizes the creation of new knowledge, including that gained in piloted spaceflight, but it does not support piloted spaceflight for the purposes of improving relations with Russia or preparing for future piloted exploration of the Moon or Mars. This content mix addresses

the criticism that NASA's program places too much emphasis on piloted spaceflight when the agency's major contribution is creating new scientific knowledge. This alternative does not directly address the "cheaper, better, quicker" criticism of shuttle-era space science. It should, however, permit experimentation with small satellites within the space science program and the execution of long-planned, large-scale missions.

- o **A program budgeted at \$7 billion annually that eliminates piloted spaceflight and instead emphasizes robotic space science and developing new technology for both private industry and public missions.** This alternative, which would effectively end the current era of piloted spaceflight by the United States, addresses the criticism that NASA's activities do not contribute to the competitiveness of U.S. industry. The alternative would concentrate resources in areas that are most likely to produce tangible payoffs--technology development directed toward specific industries and space science activities with significant applications value. For example, funding would be available for refurbishing aeronautical facilities, including new wind tunnels, which was included in the President's request for 1994 but dropped from the 1995 plan.

Posing alternatives to NASA's current program and providing estimates of their cost do not solve the problem of valuing what NASA produces. They can, however, illustrate that the balances struck in the current program--between piloted and unpiloted activities or between science missions and the development of new technologies--are neither the only options nor necessarily the best ones for NASA as it attempts to adjust to the lower budgets that it anticipates in the future.

