Chapter 2

ISSUES AND FINDINGS

Contents

GENERAL

NASA's Circumstances

A general and most important conclusion of this assessment, one that touches on all its other findings, is that any serious discussion of the Nation's future civilian space aspirations and activities, both publicly funded and privately sponsored, must be carried on with a full appreciation of the present and near-term circumstances of the National Aeronautics and Space Administration (NASA).

Since soon after NASA's inception, its space programs have had two major components: 1) a core of continuing space science and space exploration activities, later joined by space applications activities, and the development of that technology specifically required to conduct them; and 2) singular major technological forays, centering on people in space. It is worth noting that while the core science and exploration activities were mandated in NASA's founding charter, the National Aeronautics and Space Act of 1958, as amended, the succession of big programs seems to continue as a matter of tradition–with the explicit approval of the President and Congress.

Such major undertakings as Mercury, Gemini, Apollo, Skylab, and Shuttle take years, even a decade, to complete, involve a large fraction of NASA's engineering staff, and cost billions or tens of billions of dollars. Because the magnitude of NASA's commitment to these undertakings is so complete, other, smaller programs—including the core science and exploration activities—are always at some risk of seeing part of their funding delayed or transferred to cover overruns in the big programs. A small percentage overrun in a major program component can represent the whole of a smaller, but perhaps equally important science or application program.

For the most part, it is this spectacular kind of activity that takes most of NASA's attention and resources, is of most interest to the general public, here and abroad, and serves the important national objective of projecting the civilian technological prowess of the United States on the world stage.

From the viewpoint of the technologists who make up most of the continuing leadership of the U.S. publicly funded space effort, these major NASA programs serve several important objectives:

- they keep NASA in the public eye in a particularly gratifying fashion;
- they attract the services and loyalty of outstanding space engineers both within NASA and the closely related sections of the U.S. private space industry;
- they allow the development of a great deal of new technology otherwise difficult to justify on a piecemeal basis–technology that allows further space advances subsequently;
- they are more difficult to interrupt or cancel than smaller and/or less generally appreciated space activities;
- once approved, they require relatively little further engagement by engineers in "political justification" activities for some time; and
- they provide perhaps the most visible and apparently effective civilian response to the widely publicized in-space activities of Soviet cosmonauts.

And to date, it is this kind of activity that has obtained the most attention, and approval, of the president and Congress. But these large programs also have another, rather troubling set of characteristics. Because they are primarily technological in nature, they are inherently difficult to explain satisfactorily to those who are not professionals or not particularly interested. They are initiated by Government technologists and their supporters who are convinced of their value, rather than being initiated in response to large segments of the general public's specifically calling on NASA to provide them. ' Perhaps most im-

'The implication here is *not* that there is *no* public support for the civilian space program in general or the big technological spec-

Photo credit: National Aeronautics and Space Administration

Dramatic manned space missions such as the Apollo 11 lunar landing have generated public support for NASA,

portant, **the completion of any one of the large, high-technology, "manned" programs faces NASA's management either with making a fundamental move toward a more equal distribution of agency funds among *all* its R&D programs, or with creating and securing support for another program of the same general character and size.**

Thus, the first successful flight of a Shuttle orbiter in early 1981 found the NASA management confronting this problem again. Within a relatively few years thereafter, either another large new program would have to begin, or a number of relatively small existing programs would have to be considerably enlarged (or new ones initiated)—or else as many as one-quarter of NASA's professional staff and approximately $2 billion per year would be lost.

Without an internal or external mandate to achieve a more nearly equal distribution of funds among all its R&D programs, NASA leaders opted to pursue another large, high-technology, "manned" program. **The particular program chosen has been the subject of study and discussion within the civilian space community for decades: "the space station" program.** After

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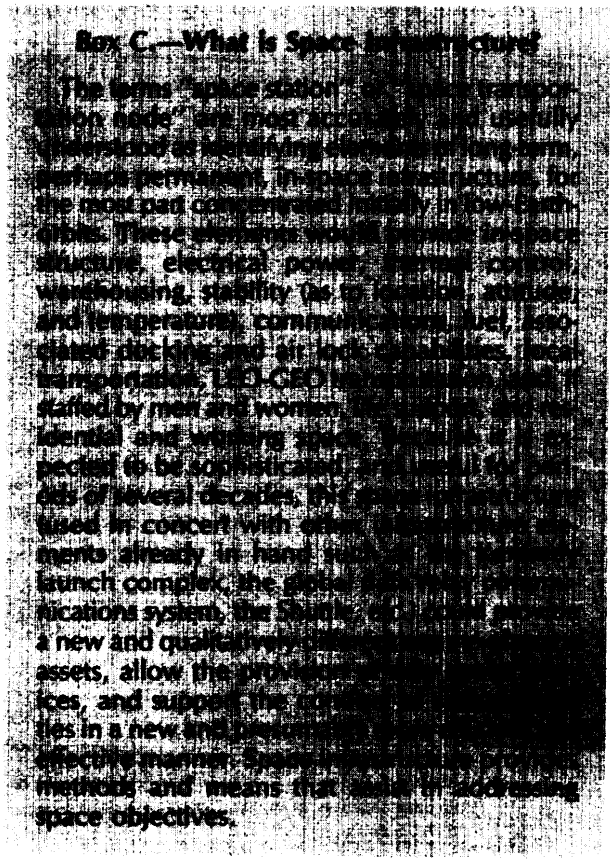
taculars in particular, but that this support might be broadened if wide public discussion were encouraged. One need only compare the extent to which the public, to date, interests itself in space issues with the extent to which it interests itself in education, health services delivery, housing, defense, transportation, etc.

detailed engineering study, the public acquisition of in-space infrastructure under this program would proceed for several years at an average rate of some $2 billion per year. It would involve the development of high technology, much of which would address the problems attendant on seeing people reside and work in space in a permanent fashion under safe and sanitary conditions. Its buildup could be phased to match the reduction in the Shuttle development program so that, overall, NASA's present and anticipated "budget envelope" could be maintained, and the Shuttle program's professional skill mix could be satisfactorily reassigned.

Given, first, its institutional end of maintaining its current size and, second, its choice of a space infrastructure program as means to attain that end, NASA has been somewhat reluctant to consider new modes of acquiring the infrastructure envisioned. For example, NASA **could** choose to employ a great deal of already developed, space-qualified, and already paid-for technology. It **could** prompt the U.S. private space industry to come forward with proposals to provide major infrastructure elements to NASA in an economical fashion, elements that the private sector, using its own resources (including private funds), would design to the Government's performance specifications (rather than to detailed design specifications under contract). It **could** seek international collaborative arrangements under which foreign partners would bear a substantial fraction of the present $8 billion estimate,[2] thereby significantly reducing the cost to U.S. taxpayers. However, with the two givens, these new approaches could result in an insufficient program base to maintain the agency's present size and, perhaps, even its present character as an independent, civilian, national resource.



In view of NASA's internal circumstances and the many other external desiderata which its resources could alternatively address, the question arises: is a "space station" program the best way for NASA to spend the foreseeably available $2 billion per year[3] to serve the needs of the Nation—and the world? The President and Congress have just approved a "space station" program in principle, and allocated $150 million to commence engineering studies—studies now expected to take 2 years. Decisions as to the character, magnitude, and pace of this program would be made after the completion of these studies, and any others that Congress might request.

If: 1) NASA'S basic decision not to move toward a more nearly equal distribution of funds among all its R&D programs remains unchanged, 2) its overall aspirations for its "space station" program are not realized, and 3) **no adequate substitutes appear and are approved within the next 2 years, then the basic character of the present U.S. publicly funded civilian space pro-**

[2]It is important to appreciate that this *$8* billion figure covers only the initial capital outlay, not the continuing operations and maintenance costs or subsequent capital outlays to acquire additional capabilities.

[3]The $2 billion per year figure is predicated upon two projections: that NASA's overall budget will remain level in constant (1984$) dollars at somewhat over $7 billion per year, and that the roughly $2 billion per year currently spent for Shuttle development will be made available for space infrastructure acquisition.

gram itself could be placed in question. If NASA's professionals were convinced that they could not see a reasonable future for the exercise of the skills they so successfully displayed in the Shuttle program, they would soon begin to explore employment alternatives—and the more accomplished, more imaginative, and more independent employees, which any outstanding R&D organization simply must retain, would be the ones most likely to do so. One of the clear alternatives would be to work on what now appears to be another rapidly growing high-technology space program area—that of the space elements of the new military Strategic Defense Initiative (SDI), a program now headed by a former associate administrator of NASA who was responsible for the Shuttle development program.

If large numbers of professionals left NASA, and if their leaving the civilian space R&D area were accompanied by similar departures from that part of the private space industry long associated with NASA, an already significant and increasing imbalance between our military and civilian publicly funded space programs would be magnified. A vigorous, independent NASA has served the Nation well; any trend toward reducing it to mere adjunct status cannot be viewed, in the overall national security context, without concern.

Thus, the NASA management may have "bet the company" on the successful outcome of a campaign to obtain approval for one more large, new, high-technology, publicly funded civilian space program. Unfortunately, even if approval is received, such a program could foreclose, perhaps for 5 to 10 years, the possibility of NASA's undertaking other, more desirable options or its effecting any fundamental changes either in its major program mix or in the way it acquires space technology. Yet, in OTA'S judgment, serious consideration must be given, now, to preserving these options and making these changes, if NASA is to maintain U.S. space leadership. For fundamental shifts in other national and international circumstances that will importantly affect the conduct of future space activities are already under way.

Just as unfortunately, because the Shuttle development program is expected to be essentially complete within 2 years, any moves to effect large and desirable changes in the NASA program mix and/or acquisition processes and/or international collaboration policies must also be made within that time. Making such moves effectively would call for a high degree of institutional imagination and political statesmanship by both branches, and NASA particularly.

Whatever else the executive branch and Congress decide to do at this decision point, they should resolve that they will not be required to face such circumstances again. The publicly funded civilian space program of the United States is too important, and the scientists and technologists heading the program too competent and responsible, to continue to be treated with the form of "benign neglect" that has been the rule since the successful completion of the grand Apollo program.

Transitions

Transitions are under way. And they are so fundamental, and moving so rapidly, that we

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should not be surprised to see them have significant, although presently unpredictable in detail, impacts on any "space station" program, even in the next few years. The key institutional question is this: will U.S. leaders see to it that NASA meets these transitions head-on and moves out smartly to "lead the parade" by orchestrating the growing and increasingly varied foreign and domestic space interests?

For nearly a quarter of a century, the United States and the Soviet Union were the only major players in the civilian space arena.[4] Except for satellite communications, all of the U.S. civilian space activities were formally conceived, funded, and managed by the Federal Government, primarily NASA.

Similarly, during this interval, NASA, the National Oceanic and Atmospheric Administration (NOAA), and the National Weather Service decided, with regard to the weather and climate area, what space-related scientific, technology-development, and infrastructure-acquisition programs should be conducted; developed their characteristics in some detail; mounted almost always successful campaigns with the President and Congress to receive direction, legal permission, and Federal funds for their conduct; and then conducted them using large numbers of in-house scientists and engineers and contracting with their counterparts in universities and the space industry.

NASA has frequently been willing to consider international cooperation in science with other countries, and has reached cooperative agreements with many countries—agreements that saw other countries spend significant amounts of money to support their space professionals and to provide them with equipment in order to effect such cooperation. But there has yet to be any major cooperative agreement reached that would see truly significant equipment jointly designed and produced by the United States and one or more other countries that would result either in important technology sharing, in U.S. program risk sharing, or in large savings to the public purses The Department of Defense (DOD) often does so within NATO and elsewhere, as do major aerospace companies in order to reduce their own financial, technological, and market risk exposure in large complex programs. NASA officials are making overtures to other countries regarding their participation in any "space station" program, but it remains to be seen whether these overtures will result in the kind of collaboration that would realize major cost savings to the United States.

With a single recent exception,[5] there has been no important instance in which our private sector has set out to develop major items of space-related technology of acknowledged central importance to NASA programs on its own, using its own resources—including financing—to do so. **All such critical elements are still procured by the Government, with Government funds and some considerable Government oversight in the process.**

However, over the past few years, international civilian space circumstances, the circumstances of our own space-related private sector, and the attitude of our Government toward the civilian space area have begun to undergo fundamental shifts-shifts that, in the next few years, cannot but have great impact on what our publicly funded civilian space program does and how it does it.

As a result of the sustained and generous assistance of the United States, and by working in close concert with NASA and the U.S. space industry over the past few years, several other countries have conceived of, developed, produced, installed, and used substantial space and space-related equipment. Such equipment, some of it designed primarily for scientific research, some

[4] **Since the adoption of the 1958 National Aeronautics and Space Act, the United States has maintained identifiably separate civilian and military space programs, though there has always been cooperation between the two. The extent to which one can make a similar distinction with respect to Soviet space activities remains a vexing question.**

[5] **Spacelab is the exception that proves the rule. NOAA, on the other hand, is moving to obtain further contributions of space-related technology through the Economic Summit process, and is pursuing the development of international polar-orbiting meteorological satellites; both of these initiatives could result in important cost savings to the U.S. public program.**

[6] **The exception is the agreement, on an 'upper stage, between NASA and the Orbital Science Corp. of Vienna, VA. McDonnell Douglas upgraded the Delta and developed the Payload Assist Module (PAM) using its own funds, and other private groups are now developing expendable boosters of various kinds.**

primarily for commercial applications, is of a sophistication that often matches that of U.S. equipment, and of a sales magnitude that, in some instances, now clearly offers serious competition to the generally acknowledged preeminence of the United States (cf. Spacelab; Ariane; the Canadian Remote Manipulator System; DBS spacecraft; etc.).[7] These countries now have sufficient confidence in their own skills and experience to encourage them to ask for a much closer kind of cooperation with the United States. It will not be long before they can and probably will insist on it, for they will have the ability and the motivation to "go it alone" if they cannot see that their basic interests would be adequately served by the kind of cooperation extended to them by the United States.

Similarly, one of NASA's outstanding successes (shared with DOD) has been that of shepherding the aircraft, electronics, chemical, and other high-technology areas of our private sector into the civilian space business. This is now a very sophisticated and confident part of our overall national commercial-industrial capability. But significant segments of the private space sector are increasingly restless with the prospect of having to produce high-technology space items under what they perceive to be the no-longer-necessary, and wasteful, "close control" of NASA managers.[8]

Also, the past few years have seen a growing number of entrepreneurs beginning to enter the civilian space area. These "newcomers" are not limited to those who would **use** the assets and services that NASA expects to acquire; some would **provide** such assets and services to both the Government and others in the private sector on what they believe to be inviting financial terms. Both the President and Congress are clearly determined to see that the private sector plays a much more prominent role in the civilian space area generally, that it is encouraged to make major investments therein, and that the country finally begin to reap the large and direct economic benefits so long hoped for by civilian space leaders.

Finally, the great, persistent, and projected deficits in our Federal budget now require Congress to take an even more careful look at deferrable expenditures, especially "new starts. " Indeed, the central issue of the President's request for congressional approval of the first phase of a "space station" program is that of its capital cost, even though NASA now estimates the size of the initial portion of the program (in constant 1984 dollars) to be less than one-half that of the Shuttle program, and not much more than 10 percent of the Apollo program, and its acquisition schedule would seemingly not require NASA's budget to be increased over today's amount.[9]

These new national and international circumstances have begun to command the attention of the executive branch, and important first steps toward addressing them have been taken. However, although many of the leaders of the U.S. publicly funded space program are convinced of the importance of these circumstances, few of them have the professional and business experience required to ensure an effective response. Furthermore, it appears that most of those beneath the top management levels as yet have little enthusiasm for making indicated changes. And, indeed, it is not clear that leaders of the executive branch have thought out, clearly, just how far they are willing to see innovative arrangements arrived at that would carry NASA and NOAA into much closer collaboration with other countries and with our own private sector.

National Commission on Space

In July 1984, Congress enacted, and the President signed into law,[10] the National Aeronautics and Space Act of 1985. Title II of this Act estab-

[7] For a thorough discussion of this issue, see the OTA report *International Cooperation and Competition in Civilian Space Activities,* in press,

[8] At least some in the private sector believe that they can do as good work on space hardware generally as they do on commercial air transportation and communications satellites, and they are willing to assume the financial responsibility of doing so and to risk grave financial penalties if they fail.

[9] However, consider the following: "In recent decades the average overrun on major programs, in constant dollars and constant quantities, has been slightly over 50 percent. The average schedule milestone has been missed by a third of the time initially projected. The average time to develop new systems has, until recently, been increasing at the rate of 3 months per year . . . each year. " Norman R. Augustine, "The Aerospace Professional . . . and High-Tech Management," *Aerospace America,* March 1984, p. 5.

[10] Public Law *98-361.*

lished a National Commission on Space. The deliberations of the National Commission can be expected to have a fundamental impact on the entire civilian space future, including the future course of any civilian "space station" program. This conclusion is based on the assumption that the Commission will provide an appropriate mix of prestige, broad concern for the national interest, technical expertise, and diverse outlook.

There are great opportunities now perceptible in the civilian space area, but the rapidly changing circumstances that make their achievement possible have raised difficult issues and created institutional inconsistencies. If the new opportunities are to be realized, these issues must be faced and the inconsistencies resolved. OTA has earlier expressed the view that many of these issues and inconsistencies cannot now be dealt with adequately by the annual authorization process and that, therefore, some more fundamental mechanism, such as a Presidential Commission, should be created. The newly authorized Commission is the first opportunity in a generation for Congress—and the Nation—to set a truly fresh course in space. It is critically important to the Nation generally, and to a successful U.S. future in civilian space activities specifically, that the Commission be successful.

NASA now plans to spend the next 2 years making studies of a fairly specific low-Earth-orbit (LEO) infrastructure complex that it would acquire, operate, and use in a manner similar to the Shuttle. This plan was set in motion some years ago. **Over the next year and a half, the deliberations and eventual findings of the National Commission could offer NASA, and others seriously interested in the space future, the opportunity to develop new program options, and to compare these new options, new methods, and new attitudes with the civilian "space station" program as currently defined.**

Afresh, basic and uninhibited review of policy issues might well result in a fundamental change of NASA views on the following matters:

- **the appropriate character of the "space station" program;**
- **the character and mix of its various large, long-range programs;**
- **the ways in which it might orchestrate the civilian space interests of all friendly countries; and**
- **the ways in which it could act to prompt greatly increased private sector investment in space.**

CIVILIAN "SPACE STATIONS"

The Case for Infrastructure in Low-Earth-Orbit

on balance, a persuasive case can be made for acquiring some long-term infrastructure in near-Earth space, some of which would allow a human *work force* to be retained there for extended periods.[11] This case rests primarily on tangible rather than intangible considerations.

The persuasive tangible reasons are that the United States would then be able to explore the possibility of more efficient transport staging between LEO and geostationary orbit (GEO), the Moon, and beyond; to commence certain important life science[12] and materials science experiments early in the next decade, the conduct of which would otherwise border on the impossible; to warehouse space assets and consumables, so as to improve the efficiency of very costly surface-LEO transportation; to aspire to much more ambitious and dependable servicing of ever larger and more sophisticated, and therefore more costly and complex, space assets, thereby containing their total life-cycle costs and increasing their effectiveness; and to undertake new

[11] It is of course assumed that the character and location of the infrastructure elements would be chosen to meet the specific, important expressed needs of those expected to use the services that these elements would be expected to provide—i.e., not chosen by the technologists who would design, produce, and install them.

[12] Life science research could include studies of long-term response to in-space conditions (in preparation for possible staffed expeditions to the Moon, Mars, or the asteroids) as well as studies relevant to the general human population on Earth.

and innovative space activities with confident freedom.

These reasons reflect not only the many years of conceptual studies of infrastructure arrays that could support space activities but, as well, a general consensus as to the value of space infrastructure elements gained with actual experience in Skylab, the Shuttle Orbiter, the Soviet Salyut, Soyuz, and Progress, the Tracking and Data Relay Satellite System (TDRSS), Spacelab, the Manned Maneuvering Unit (MMU), the West German SPAS platform, the Canadian Remote Manipulator System (RMS), etc.

Indeed, it seems likely that, in retrospect-some two decades hence—at least a large portion, perhaps all, of the space infrastructure capabilities now advanced by NASA as necessary will be seen to have been so. But this eventuality gives no guidance as to how and when the various elements should be acquired.

Another reason advanced is that, eventually, there may be important economic payoffs from materials processing in space that would require the use of space infrastructure. What is now required is a great deal of imaginative and sound in-space basic and applied research in the materials science area.

The intangible reasons for acquiring such infrastructure—reasons of maintaining space leadership generally, of creating further heroic role models, of exhibiting our capacity for high-technology development, of enhancing national security, of maintaining a strong NASA, etc.—are much less compelling. "Space buffs" and perhaps some in the private sector (those who have called for a long-term Government commitment to provide R&D facilities in space before they would consider investing there themselves) argue that general-purpose space infrastructure (i.e., a "space station") would address such great and intangible purposes. But there is no evidence that large segments of the general public agree with this assessment, and they have not been offered the opportunity to express their views on other major space ventures that might more forcefully address such intangibles. A number of alternative intangible goals have already been put forth; undoubtedly, more will be articulated in the future.

The Concerns About Low-Earth-Orbit Infrastructure

But while the case to be made for acquiring some long-term, habitable, LEO infrastructure is persuasive, **there is no compelling, objective, external case either for obtaining *all* of the particular array of elements that** NASA **now describes under the rubric of "the space station," or for obtaining this or any other array in the general manner that NASA is now expected to pursue, nor for paying the particular public cost that it now estimates is required to do so.**[13] (The important **internal** case for proceeding with a large, early "space station" program is discussed above.) As the infrastructure would be of a very general-purpose nature, to be used to support myriads of conceptual uses, few of which have been sharply defined or have gained wide acceptance as important objectives of our publicly funded space program, there is no necessity for obtaining all of it soon. And, under these circumstances its value to the space program is quite difficult to estimate objectively.

Three groups are particularly concerned about a nearly $10 billion (1984$) commitment to a "space station" program:

- those, particularly space scientists, who fear that such a relatively large commitment would represent a hazard to their own space interests;
- those space professionals who would prefer NASA to take a more measured, evolving, learn-as-we-go approach; and

[13] Some contend that the substantial and growing U.S.S.R. space infrastructure (including Salyut, Soyuz, Progress, and Cosmos 1443-class modules) constitutes a valid, and important, justification for the United States to mount a comparable, if not more capable, program. This report does not address this contention. However, even if keeping up with the Soviets or beating them at their own game were to become the motivation for a major civilian space infrastructure acquisition program, it does not follow that such a program would resemble that which NASA has described. Indeed, it might be quite different. See the OTA Technical Memorandum, *Salyut: Soviet Steps Toward Permanent Human Presence in Space,* OTA-TM-STI-14, December 1983.

- those particularly concerned with the commencement of any new and costly Federal initiative who are sensitive to its impact on the Federal budget even if it falls within NASA's present, and hoped-for, "budget envelope" of some $7 billion per year.

Of course, if the projected capital cost were well less than the near $10 billion (1 984$) now estimated for the initial operating capability (IOC) (i.e., the initial phase of the infrastructure acquisition program that NASA has in mind; the full cost of the program would approximate $20 billion [1984$] by the year 2000), the concerns of these groups would be significantly lessened.

The Cost of Low-Earth-Orbit Infrastructure

The eventual cost of any in-space infrastructure depends on the chosen size, capability, degree of new technology involved, and method of acquisition. It is not now possible to make another estimate of the IOC cost that is significantly different from that made by NASA for what it describes as "the space station" in which one would have greater confidence. There simply are too many large potential "cost drivers, " the significance of which cannot be judged under today's rapidly changing circumstances.

All of the experience with the acquisition, over a relatively long time, of large amounts of space technology, much of it to be newly developed, suggests that the $8 billion (1984$) figure will eventually be seen to have been a floor, not a ceiling, on cost. In spite of, or rather because of, this experience, NASA is determined that it will not be repeated.[14]

There are several options available relating to acquisition practices, international collaboration, and the more imaginative use of the U.S. private sector that, if effectively grasped, could reduce the cost impact on the Federal budget. Acquisition of in-space infrastructure is inherently different from the acquisition of a Shuttle or a commitment to develop and deploy those resources required to send a person on a safe round-trip to the Moon. To use NASA's own earlier, correct, and quite illuminating expression, space infrastructure can be bought "by the yard."[15]

One thing is clear: NASA, if it wished, or were persuaded, could opt for obtaining now a "core" fraction of the total infrastructure capability that it believes that the country will need over the long term—a core fraction that would allow many useful scientific studies to be made and infrastructure support operations to be explored and evaluated, at a net U.S. capital cost of one-quarter to one-third of the $8 billion that it now seeks. To this core fraction other elements could be added incrementally as experience is gained in its use and as requirements become sufficiently persuasive.

The technological and programmatic options exist for doing so. There is clearly a great variety of U. S., other Government, and private in-space infrastructure (some already in hand, some in development, some that is receiving detailed study) from which selections could be made to provide various kinds and amounts of in-space assets and support services—assets and services that would be expected to allow some new activities to be undertaken, and to increase the efficiency and effectiveness of others.

Properly encouraged by NASA, private sector firms are almost certain to come forward in the next few years with proposals that would provide some of the desired infrastructure elements and/or support services now thought to require Government development and acquisition. Some such developments are already under way.[16]

Alternatives

Some large sophisticated civilian space ventures such as the Space Telescope are pushing at the frontiers of technology. This is not (or, at least, need not be) the case for in-space infrastructure. Indeed, there is little doubt that, with appro-

[14] See Augustine, op. Cit.

[15] "Space stations are the kind of development that you can buy by the yard." James Beggs, NASA Administrator; *Committee Report of Hearings before the Subcommittee on Science, Technology, and Space* (Senator Gorton, Chairman) of the Senate Committee on Commerce, Science, and Transportation, Mar. 8, 9, and 15, 1983, p. 51.

[16] These developments are discussed in some detail in ch. 3 of this report.

priate congressional approval and funding, the Nation could see the capabilities described by NASA in place and operating satisfactorily well before the middle of the next decade. Because, in OTA'S view, technology development for space infrastructure envisioned in the near-term should present no significant problem, it has not been given central attention in this assessment. However, some general observations on technology matters may be useful here.

- Three basic kinds of in-space infrastructure elements are worthy of separate, but related, attention:
  1. one or more relatively large central complexes, with work crews as required– complexes where the bulk of the relatively innovative work could be carried on;
  2. normally unattended "free-flying" platforms, nearby or remote from such complexes, where various equipment could carry on activities precluded by the orbital locations, micro-gravitational circumstances, or effluents associated with a central complex; and
  3 .transportation between the surface and such a complex, and between the complex and the platforms, and between the complex and much higher orbits or even out to solar system distances.
- OTA is not persuaded that all of the particular capabilities now being emphasized by NASA, when measured against alternatives, are the ones that have the greatest value to the Nation's publicly funded civilian space program. NASA's present selection of the initial set of infrastructure elements and their location in space would provide many of the desired support capabilities. But they would not serve the interests of those attempting to service remote-sensing platforms of importance to weather and climate from low, near-polar orbits, or from geostationary orbits, nor the interests of those in the private sector whose communications, and perhaps navigation/position-fixing, satellites are located in much higher, including geostationary, orbits, nor the interests of those who would like to see less costly transportation provided between the Earth and GEO, and the Moon, Mars, and asteroids.
- Providing safe, sanitary, and suitable infrastructure elements 'for long stays by human crews will be costly. But however much some may be interested in exploiting unattended sophisticated machinery in LEO, the state of the art is not yet capable of providing the wide range of functions and confidence that human workers can provide until well after the early 1990s. However, given the substantial emphasis that, to date, NASA has placed on human work crews in space, it would be the prudent course, now, to raise the level of support for the development of in-space automation and remote operation from Earth. Emphasis on R&D for space-related automation and remote operation could also be expected to have a salutary influence on automation R&D for applications here on Earth, U.S. industrial competitiveness, and its introduction into commercial-industrial activities.
- There are two quite different reasons that can be advanced for the development of new technology to be employed in space infrastructure. One reason is to provide capabilities there that present technology cannot; the other is to reduce the life-cycle costs of its ownership—i.e., to reduce O&M costs and extend its useful lifetime. Both are laudable objectives. But they must be balanced against the simple fact that "there is no such thing as enough money," and any decision to provide anything more (or less) than the vitally needed capabilities, and to do so at an earlier than necessary date, and any decision to try to predict the far future so as to provide for all possible uses of such capabilities, will simply result in at least the unwarranted, and perhaps wasteful, use of funds. OTA is not convinced that a good enough balance has been struck between the competing demands for funds for infrastructure and funds for other space activities.
- Diligent and imaginative exploitation of the Shuttle fleet, along with use of free-flying platforms and local in-space transportation systems for individuals (all already under way), could provide much useful information and experience that would be of great value in making later decisions about the characteristics and operational employment

of long-term in-space infrastructure. Over time, this broadening experience will increase the confidence with which eventual infrastructure selection decisions are made.
- Significant extensions of the time that an Orbiter could remain usefully on-orbit (to, say, double or triple today's 7 to 10 days) would provide many of the capabilities desired for work crews in permanent infrastructure, and provide them sooner and at relatively modest cost, thereby relaxing the cost and schedule requirements associated with the latter.
- Space lab's operational characteristics also could be amplified at relatively modest cost, with the same helpful consequences.
- Private sector development of large in-space electrical power supplies, occasionally attended platforms, and other infrastructure elements could be successfully completed before the end of the decade. If done with imagination and economy they could offer attractive alternatives to Government development and acquisition of these capabilities.

OUR FUTURE IN SPACE

Long-Term Space Goals and Objectives

The United States can now make major strides in the civilian space area, but it is not adequately prepared to do so.

We need to "re-visit" the substance of the 1958 Space Act, reaffirm those of its policy principles that are judged to be still valid, add others as appropriate, and lay out a set of new goals that are responsive to contemporary and foreseeable circumstances, interests and values. An initial family of end objectives also should be identified that would address those goals over the next years and decades.

U.S. civilian space activities should be designed to protect, ease, challenge, and improve the human condition, In addressing its long-term goals, the Nation should strive to move its space interests and activities closer to the mainstream of public interests and concerns, maintain space leadership, enhance national security, and position its civilian space activities to respond to finding the unexpected in the cosmos.

For the purpose of prompting public discussion, OTA has developed an initial set of such goals, and a family of initial objectives to address these goals. Chapter 6 of the assessment treats these in some detail. The objectives are suggested for consideration as additions to, not substitutes for, the continuing "core" programs of space science and exploration, space applications, and the development of the technology needed to conduct all three. The family was generated to encourage much greater and more direct involvement of interested segments of the general public in civilian space activities, and to strive for economic, political, and cultural ends in addition to the scientific, exploration, and technology-development ends of today. And the family contains some elements that are simply "bold. "

The national goals OTA proposes for discussion are:

- to increase the efficiency of space activities and reduce their net cost to the general public;
- to involve the general public directly in space activities, both on Earth and in space;
- to derive scientific, economic, social, and political benefits;
- to increase international cooperation and collaboration in and for space;
- to study and explore the Earth, the solar system, and the greater physical universe; and
- to spread life, in a responsible fashion, throughout the solar system.

Brief descriptions of the national objectives suggested to prompt public discussion follow; they are not rank-ordered.

- A space-related, global system/service could be established to provide timely and useful information regarding all potentially hazardous natural circumstances found in the

Earth's space and atmosphere, as well as at and below its surface.

- A transportation service could be established to and from the Earth's Moon, and a modest human presence established there, for scientific and other cultural and economic purposes.
- Space probes could be used to obtain the information and experience specifically required to plan for further exploration of the planet Mars and some asteroids.
- Medical studies of direct interest to the general public, including study of the human aging process, could be conducted through scientific experiments that compare physiological, emotional, and social experience in the absence of gravity with experience gained in the conduct of related surface studies.
- At least hundreds of members of the general public per year, from the United States and abroad, could be selected on an equitable basis and brought into space for short visits there.
- A direct audio broadcasting, common-user system/service could be established that would be available to all of the countries of the world on an economical and equitable basis.
- In general, all of the nonclassified and nonprivate communications from, and nonproprietary data generated by, all Government-supported spacecraft and satellites could be made widely available to the general public and our educational institutions in near-real-time and at modest cost.
- Radio and optical free-space electromagnetic propagation techniques could be exploited in an attempt to allow reliable and economic long-distance transmission of large amounts of electrical energy, both into space for use there, and from space, lunar and remote Earth locations for distribution throughout the world.
- The unit cost of space transportation, for people and equipment, between the Earth's surface and low-, geosynchronous-, and lunar-Earth orbit could be sharply reduced.
- Space-related commercial-industrial sales in our private sector could be stimulated to increase at a rate comparable to that of other high-technology sectors, and our public expenditures on civilian space assets and activities could reflect this revenue growth.

Under present circumstances, the infrastructure that NASA would acquire in its "space station" program is best described as general-purpose, i.e., designed to support well over 100 in-space activities. As a consequence, it must contain a large number of sophisticated and costly elements, and there is considerable difficulty in setting objective acquisition priorities among them and acquisition schedules for all of them.

Were a specific family of space end objectives established, it would then be much less difficult to establish which are the more important in-space support assets and services that are required, and the time by which they would need to become available.

A rough estimate of the cost of meeting this family of objectives over the next quarter of a century amounts to some $40 billion to $60 billion.

To put this cost into perspective, it should be noted that:

- completion of the Shuttle development program would reduce NASA expenditures by $2 billion per year, or $50 billion over this interval;
- if the 1 percent per year "real-growth" principle is accepted and is extended indefinitely, another $25 billion would thereby be provided;
- collaboration with other countries could provide the equivalent of perhaps another $25 billion; and
- the private sector should be able to reduce costs and make direct space R&D investments that, together, could amount to the equivalent of billions of dollars.

Clearly, under such circumstances, funding limitations would not prevent the United States from undertaking an ambitious publicly supported civilian space program throughout the next quarter of a century.

Long-Term Space Strategies

If Congress and the President together re-establish a formal set of basic civilian space goals, they—and the general public—could turn their attention to identifying a family of specific objectives to address them. Then, on a year-to-year basis, as these plans were completed to the satisfaction of both branches, Congress could decide which one(s), if any, to pursue as technological, financial, political, and other circumstances suggest and allow.

In the case of each objective, detailed program plans could be laid out for attaining it. Such plans could:

- identify required technological developments and space infrastructure support capabilities;
- identify operational and/or political concerns;
- reflect circumstances in the civilian space area generally, both here and abroad;
- estimate the schedules and costs to accomplish each;
- judge who would be expected to be the major participants in their conduct;
- judge what the most likely end results of their successful completion would be;
- identify who would benefit from their successful completion, and what sources of funds should be looked to to meet both initial capital costs and any ongoing O&M costs; and
- suggest who would have the responsibility for any long-term ownership, operation, maintenance, and use of assets produced in the program.

Every 5 years or so, a review of the progress of programs addressing the initial list of objectives could be conducted as at the outset, and a new family established. In this fashion, Congress would always have before it well-thought-out civilian space activity and investment options—options to which a great deal of professional study and general discussion had already been given before any decisions to proceed were required.

In this general fashion the two vital questions of "can we do it?" and "should we do it?" would be separated, and the latter could be taken up by our political process in a more paced, thoughtful, and confident manner.

It is helpful to remember that broad, public, national debates on other important and *com*plex issues–on housing policy, for instance, and defense policy–take place regularly. While it is true that, historically, there has been little or no national debate on civilian space issues, that is because the Nation's space capabilities are only now coming of age—in the sense that after 25 years real options, worthy of discussion, finally exist.

Cost Reduction

However else the publicly funded space activities of the United States might be described, they certainly would have to be characterized as being very, very costly. Today, the kind and number of space activities is no longer hindered by ignorance of the physical characteristics of the Earth's space domain, by concern about the reliable in-space lifetime of well engineered and tested equipment, or by fear that men and women going into and remaining in space for as long as weeks at a time would be harmed. The unit cost of these activities is the greatest inhibition to our development and use of space. If these costs were lowered by 10 to 100 times, many individuals and organizations would be attracted to doing things in and concerning space that today are not seriously considered or even thought of.

Consequently, if space is ever to be widely used, a fundamental thrust must be to reduce these unit costs sharply and across the board—and particularly the cost of space transportation. The Shuttle is an outstanding technological and operational success, but achieving the objective of a much lower dollar per pound cost for passenger and cargo transportation between the Earth's surface and LEO, GEO, and beyond still remains to be accomplished.

Some elements of space infrastructure now under consideration by NASA for the first (IOC) and second (full-capability) phases of its "space station" program could improve the efficiency

of Shuttle use and offer the promise of lowering the unit cost of LEO/G EO/Lunar trips, and these elements should be singled out for early and specific attention. But cost reduction is such a fundamental matter that it should receive major support by NASA, and by the Department of Transportation, and by our private sector generally, and this support should call out for technological, operational, and institutional innovation, and the objective, tough-minded, pursuit of any such innovations that show significant promise.

There are many opportunities open to NASA for reducing unit costs in its own acquisition processes, and these are spoken to in some detail in appendix D.

The Private Sector

Both the President and Congress have expressed their determination to see the private sector play a much more prominent role in our civilian space area, and NASA and NOAA must pay this determination particular heed. But it is OTA'S view that, as yet, this serious matter is not receiving all the attention within the executive branch that it warrants, except perhaps at the highest levels. " This lack of attention seems to result from the fact that most of the space engineers and scientists in the Government simply do not have the professional and business experience required to work closely and imaginatively with the private sector. Perhaps even more important, their long-term experience within the Government "space club" has not provided them with the perspective to appreciate how important it is to the future of the publicly funded space program that the private sector assume this more prominent role.

In general, most NASA and NOAA scientists and engineers can appreciate that successful private sector investment in the civilian space area (as well as any other area, for that matter) will result in increased employment opportunities, the production of needed and desired capital goods and commercial services, the strengthening of our economy generally and our international trade position particularly, etc., and do express the general sense that these are laudable national objectives. Yet almost all are still more interested in addressing their own internal science and engineering agendas.

There is another aspect of the successful interjection of large-scale private sector activity into the civilian space area that is perhaps most important to the long-term prospects of the publicly funded portion of these activities: they could increase the tax base and increase tax revenues.

Today, U.S. private sector space sales amount to some $2 billion per year, are increasing at an average annual rate of some 15 percent per year, compounded, and are probably generating a total of some $½ billion in taxes of all kinds. It appears to be a reasonable conclusion that such an average annual rate of increase could well be maintained for at least the next decade or two.

Such a rate of commercial and industrial space-related sales- and tax-revenue increase could figure most importantly in the future of the publicly funded civilian space program. Already, today, while the Federal outlays for this program cost some $7 billion per year, private sector space sales return some $1/2 billion annually in the form of taxes. Were the 15 percent per year, compounded, rate to continue throughout the end of this century (and setting aside consideration of any negative impact that this growth could have on other segments of our economy), the resulting tax revenues could approach half of our public cost for supporting a civilian space program of today's magnitude. indeed, in 20 years these growing tax revenues could equal the cost of such a public program. And, by then, private sector space-related R&D activities also could be funded at a level of billions of dollars per year.

The funds now being spent on NASA and NOAA programs are "discretionary" not "entitlement" funds. At some time in the future, our national financial circumstances could prompt serious questions to be raised about the continuance of such large, deferrable, expenditures. Of course, there are arguments that can be, have been, and would be advanced for not reducing the present level of such public expenditures, but these levels have been sharply curtailed in the past. To the

[17] **The July 20, 1984, issuance by the White House of a "National Policy on the Commercial Use of Space" fact sheet is an encouraging development.**

extent that objective evidence of the direct importance of the R&D and other activities of NASA and NOAA to this kind of economic growth is in hand, it is an argument for the continuation of these activities.

OTA concludes that two important, perhaps the most important, activities that NASA could undertake today, and for the indefinite future, would be to reduce the unit cost to the private sector of their conducting activities in space, and to be of assistance to them in their making productive investments in space.

Developing methods of truly useful and acceptable assistance could well be a thorny matter, inasmuch as in many commercial-industrial-financial areas there is a somewhat adversarial relationship between the Government and the private sector. And for some time the Government will continue to be the largest purchaser of any private sector space goods and services. Consequently, just as in, say, the supercomputer and nuclear energy areas, the space area will have to see the appropriate roles of the Government and the private sector sorted out to ensure that the interests and responsibilities of each are clear, so as to best serve both—and the Nation.

Finally, it can be anticipated that the private sector's particular concern for cost reduction will eventually result in lowered costs in public space activities also.

International Space Cooperation

For most of the space age, there has been considerable cooperation in space activities between the United States (by NASA, NOAA and DOD) and several other friendly countries—effective and useful cooperation. The changing circumstances of the civilian space area call for a reappraisal of the kind and magnitude of cooperation that now should be sought.

The OTA report *International/ Cooperation and Competition in Civilian Space Activities,* studies this area in some considerable detail; here we will confine our conclusions to two:

1. The European Space Agency (ESA), several of its major member countries, Japan, and Canada have evidenced interest in working closely with the United States on a "space station" program. Now may be the time to inquire as to whether our best interests, and the interests of at least some of these countries, would be best served by moving beyond yesterday's and today's kind of cooperation, and to attempt more direct collaboration or even joint venturing with them on any such program.

   As yet, NASA appears to be giving insufficient thought to establishing the kind of multi-national, interleaved, development and production program of the type often entered into by the Department of Defense in NATO and elsewhere, and by some of our large private sector organizations and their analogs in other countries.

   In the DOD case, considerations of military security, the additional complexity of working on programs involving other countries, the hazards of undue technology transfer, and eventual commercial "spinoffs," have oftentimes been resolved, to mutual advantage, in favor of sharing costs and important professional skills. There may be, indeed, similar, legitimate concerns about technology transfer arising in any future international civilian infrastructure development program. However, the technology developed in such a civilian program would, in the main, be general-purpose, and the cost-sharing incentives would remain.

   The general economic circumstances of many of these countries are basically sound; they desire to work with us on civilian space matters in general, and any "space station" program in particular; they have exhibited technological prowess in Spacelab, the Canadian Remote Manipulator System, Ariane, and various communications satellites provided to INTELSAT. They were willing to trust the good offices of the United States and NASA in going ahead with the $1 billion European Spacelab program–a program that could be rendered valueless at any time that the United States were to withdraw the opportunity of their employing *it with* the Shuttle.

   Given all of these circumstances, it is not beyond imagination that a major international collaborative civilian "space station" pro-

gram could be negotiated that, among its other virtues, could lighten the total burden on our public purse perhaps by as much as $2 billion to $3 billion. This is not the approach to dealing with other countries on any "space station" program that is now being taken by NASA. The present approach is one of asking other countries to add funds to the United States' estimated and anticipated $8 billion commitment. The alternative approach has not been debated in the United States outside of NASA.

The alternative approach is being explored by NOAA: NOAA is soliciting important cost-sharing, perhaps as much as one-half, on the part of other countries who share the U.S. interest in maintaining, and improving, weather-related space sensing systems. This alternative approach to working on a "space station" program with other countries is worthy of careful consideration by Congress. For no reasonable way of reducing the Federal debt burden by billions of dollars should be passed by unless Congress convinces itself that it is not in the Nation's interest to do **SO.**

2. Except, perhaps, for the smallest and poorest countries, all of the countries in the world must have at least some interest in space: the devices and people that orbit above them, the activities that go on there, and how they all could affect their own interests. But only about one-tenth of the world's countries play an active role in space today.

   Here is an extraordinary opportunity for the United States!

   Our determination to exhibit "space leadership" need not and probably should not be confined to dealing with the richest and/or most technologically advanced countries. We could broaden our approach to "international cooperation" by taking as an explicit goal the incorporation of the space interests and activities of any other country in the world into our program, if that country would be at all inclined to participate in space ventures along with us, Of course, such an initiative would require hard work, patience, imagination, and generosity on the part of the United States. But these characteristics are not usually in short supply in the United States generally, and certainly not among the professionals in NASA and the Department of State. Indeed, it was the combination of just these national characteristics in the U.S. approach to working with a few countries in the past that enabled them to begin to work in space.

   Recall that INTELSAT now has over 100 member countries, joined in a common interest to see space used to improve communications. The United States could now begin to use any in-space infrastructure program to start orchestrating the interests of all of the countries in the world that would be willing to work with us in reasonable ways to see space developed and used for any and all peacefu l purposes "for the benefit of all man kind."

Space as an Arena of Peaceful Cooperation

Even now, when discourse between the United States and the Soviet Union is modest in the extreme, and the practical possibilities of effecting cooperative space-related activities between the superpowers are severely limited,[18] many cannot but hope that the two countries will find ways to initiate important cooperative civilian space endeavors in the future.

To date, most visions of such cooperation form around scientific activities. They are important, and they should continue to be given serious and thoughtful attention.

Together, the United States and the Soviet Union have some 600 million people and a gross national product of some $5 trillion between them, and both have global interests and power. Therefore, possible joint cooperative space activities need not be confined to science; indeed, a broad range of space-related activity

[18] U.S.-U.S.S.R. cooperation in space-related activities has not entirely vanished. The SARSAT search-and-rescue program, a joint U.S.-Canadian-French undertaking, continues to interoperate successfully with the parallel Soviet COSPAS system. Both the United States and the Soviet Union are members of INMARSAT, the maritime equivalent of INTELSAT, and both are cooperating, along with Europe and Japan, in the International Halley Watch program.

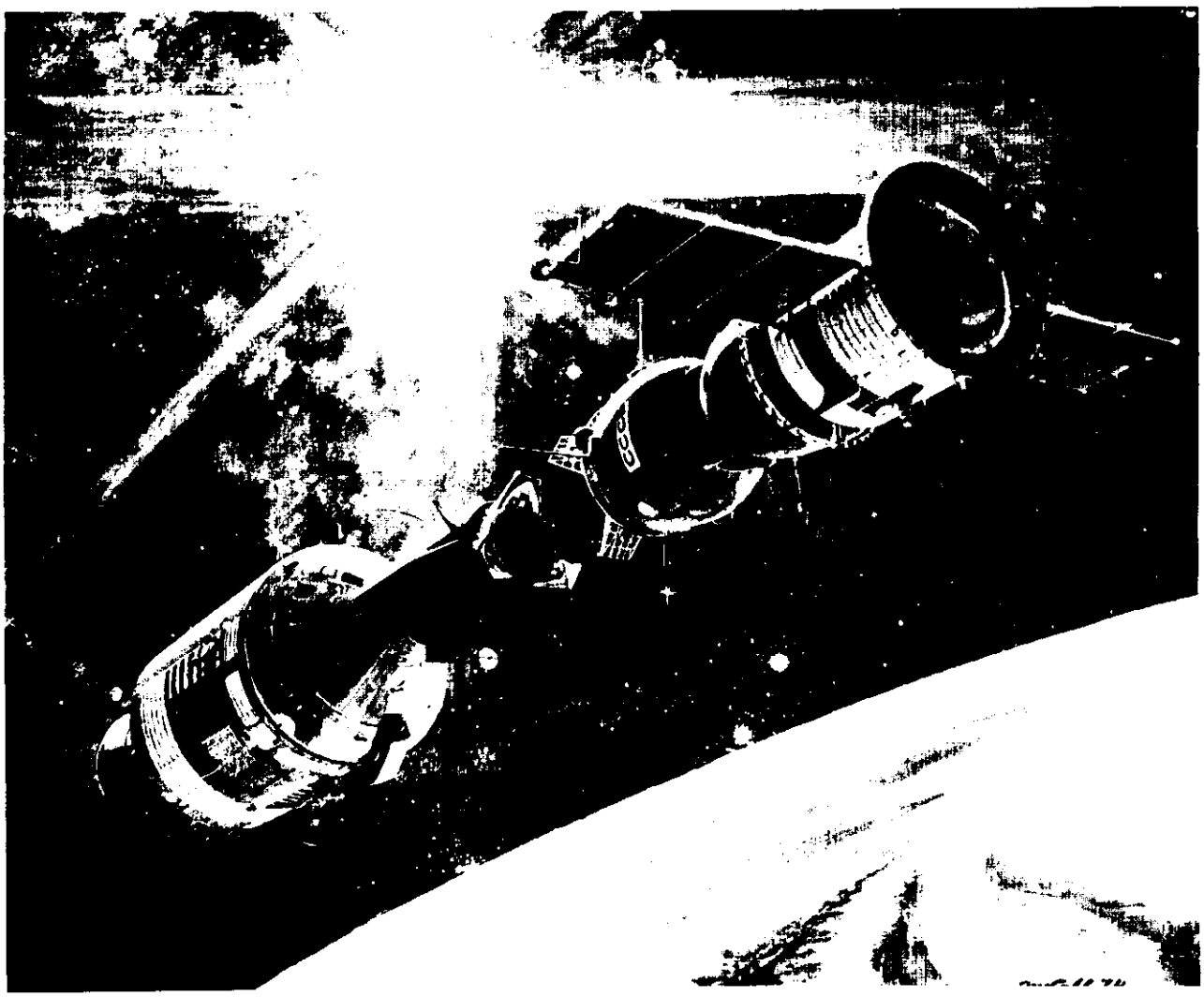

Photo credit: National Aeronaut/es and Space Administration

NASA has had agreements with more than 100 countries for cooperation in space activities. The pinnacle of international cooperation in space to date was the Apollo-Soyuz Test Project (ASTP), in 1975 (shown here), in which a U.S. Apollo spacecraft docked with a Soviet Soyuz spacecraft for several days of joint manned operations. However, no international cooperative agreement (including ASTP) has yet involved significant sharing of technology or saving of costs.

areas might well be explored, imaginatively and determinedly.

OTA plans to report on some of the issues in this area in the fall of 1984.

NASA'S Changing Role

Until a few years ago, and except for the satellite communications area, NASA has, since its inception, organized, staffed, and managed itself to see that it, and its contractors, did essentially all that was done in the civilian space area.

Throughout most of this time, and probably without conscious reflection on NASA's part, or the part of anyone else, it has simply been assumed that once our country decided that something was to be done in or for civilian space, NASA was to do it. That is, the responsibility for seeing that something got done in the civilian space area was equated with NASA's doing it itself.

But the changing circumstances of the past few years now clearly suggest a fundamental reappraisal of NASA's responsibilities and role in the development and further study, exploration, and use of space.

Although this study of civilian "space stations" and the U.S. "future in space" has brought these changing circumstances into clear, at times painfully clear, focus, it has not attempted to search out what NASA's new role should be in detail. It is to be noted, however, that the Nation's interests now are becoming much broader than those of NASA and, indeed, in some instances, may lead to conflicts with what NASA may perceive to be its own interests.

NASA could and, in OTA'S view, might well now give increased attention to making some fundamental shifts of attitude and operation. In the past, it has been NASA'S **responsibility to meet any given national space objective; in the future, it could be NASA's responsibility to see that the objective is met. That is, NASA could now aspire to the much broader role of encouraging others in the private sector and throughout the world to do much more of what it does today.**

If NASA is to rise successfully to the challenges now emerging in the national and international space arena, it must place relatively less emphasis on accomplishing by itself those things that our private sector or other friendly nations can satisfactorily do, either alone or with NASA assistance. it can succeed in this only by continuing to cooperate with both, and by broadening this cooperation so as to prompt and assist both to extend their space-related capacities, confidence, and commitment. And it could emphasize such cooperation in the acquisition of in-space infrastructure, i.e., a "space station. "

Released from its relatively near-term focus, NASA could concentrate more of its own professional activities on the most important and exciting of questions regarding space, the things that no one else can or will do: the very best of space-related science; the cutting edge of space-related technology development; the boldest of space-related explorations and developments.

Finally, NASA could see that its activities continue to be conducted, and the results continue to be used, not only to increase knowledge and to address important social and political goals, but also to enable our private space sector to increase its non-Government sales—the sales that generate the taxes that help to pay for NASA's activities.

Non-Government Policy Studies

It **is inherently difficult for the Government to make some kinds of policy studies and, indeed, it is potentially hazardous to have all such studies made by the Government in areas of important national concern.**

Particularly in areas where Federal programs take a long time to develop and carry out (say, a decade: cf. Apollo, Shuttle, Landsat, "space station") vested interests are naturally created within the Government and closely related sections of the private aerospace industry. Later these interests can present serious problems of resource re-allocation on the program's approaching completion unless new avenues for their employment have been carefully explored and publicly agreed on beforehand.

Our free, and increasingly educated, mobile, diverse, rich society is bound to generate ideas, desires, value judgments, and activities about which the Government simply has difficulty in keeping well informed, particularly if the ideas are quite different from those with which the Government has been dealing for some time and are generated and pursued by persons and organizations that are "new to the scene. "

Civilian space activities continue to be of importance to the United States in many intangible ways, and they are now beginning to be appreciated as offering tangible and growing private sector economic prospects as well. "Space commercialization" has become a popular topic. But in the absence of a "bottom line" and competitive economic forces, the Government has a more difficult time than does our private sector in sharply reducing unit costs. And Government offices only rarely, by themselves, originate

large innovative and challenging programs and carry them out to satisfactory completion.

In the area of the physical sciences, for instance, U.S. leaders can look to several policy study centers for independent guidance on issues of broad national concern, In the space area, however, there are only a few dedicated individuals who can provide similar guidance.

In view of the increasing importance of civilian space activities to the American public generally, it might well be desirable to establish one or more independent space policy centers whose professional staff would not be required to respond to the contemporary institutional concerns of the space community. Such centers would control their research agendas and allocate resources as they believed best, rather than simply responding to directives. An example of this type would be a university-based institute with several funding sources. The continuing study efforts of such centers could provide the American public a better opportunity to consider, and to help initiate, space activities that would address important cultural, economic, social, and political ends.

POSSIBLE LEGISLATIVE INITIATIVES

In the context of the circumstances and issues discussed in this assessment and the conclusions reached therein, Congress could now give consideration to taking a number of initiatives.

Some of these suggested initiatives are directly related to "the civilian space stations" area; others are related to broader areas that are of general importance to "our future in space. "

Strategies for Acquiring Any New In-Space Civilian Infrastructure

The response of Congress to the President's formal request for the commencement of a "space station" program should take account of the general circumstances discussed in this study and the existence of options beyond those proposed by NASA. Given these general circumstances and the variety of options, Congress could adopt one of four positions:

1. decide that it is premature and/or inadvisable to set out, soon, to obtain any large amount of new long-term in-space infrastructure, and refuse to accede to an executive branch request to do so a year or two hence; or
2. at least by implication simply agree, in principle, to provide the kind and number of in-space assets and services that NASA judges to be necessary and, accepting its $8 billion cost and 7 to 8-year schedule estimate as working numbers, be prepared to approve a year or two hence the acquisition of the general kind of infrastructure elements that NASA is now focusing on; or
3. specifically identify any major space services to be provided, ask NASA to present various estimates of costs, schedules, and procurement strategies that would be involved in providing them and, subsequently, select from these estimates the elements and strategies to be approved; or

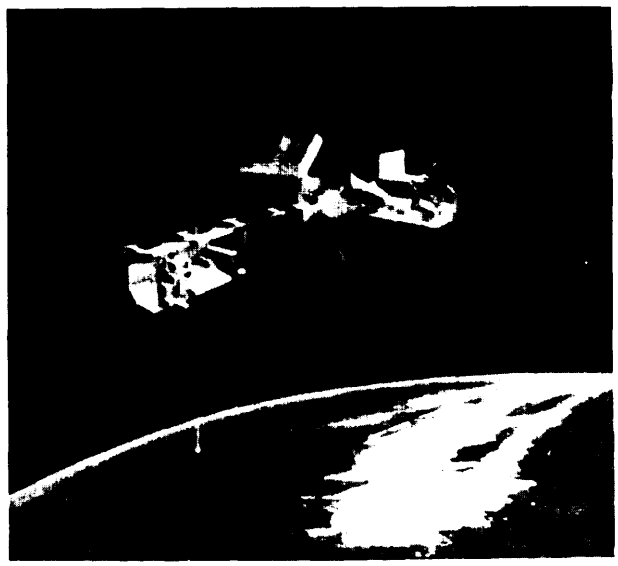

Photo credit: **National Aeronautics** *and Space Administration*

Free-flying platforms such as the one depicted in this artist's concept offer one option for relatively low-cost space infrastructure elements.

4. for the acquisition of any in-space infrastructure, simply approve an average annual expenditure rate for its acquisition and allow NASA to select the elements, acquisition schedules, and procurement strategies in the light of NASA's judgment regarding their relative cost and value.

Congress need not imagine that it is required to commit itself to accepting any of these positions at this time, inasmuch as the President's fiscal year 1985 request was restricted to the first year of a 2-year study activity that would cost a relatively modest amount (some 5 percent of the projected total acquisition cost) for such a major implied space activity. But there is a sufficiently persuasive case for our obtaining some additional space infrastructure so that thoughtful and comprehensive study of what it should be and how it should be obtained is now warranted. Therefore (setting aside the very important matter of our Federal budget's present and projected circumstances and the implications thereof for any deferrable "new starts") Congress could use the next year and a half to become better informed about the options available to it and the implications of selecting particular ones from among them. And it could task the executive branch to make additional, broader, studies than it now has in mind—studies that could assist Congress in arriving at its crucial judgments a year or so hence.

The House Committee on Science and Technology has taken an important step in the direction of raising such broader issues in requesting a study by NASA that will look into "space station" program management and procurement matters.[19] A report of this study, to be provided by NASA to the committee by December 15, 1984, is expected to speak to both " . . . [the] Space Station development management plan and procurement strategies with a description of the alternatives available and the basis for the [NASA] choices taken."

Similarly, Congress could request the executive branch to inform it regarding:[20]

- The priorities it places on the various services and assets that it sees as generally desirable. That is, if Congress were to allocate more or less than the $2 billion per year now being discussed for the acquisition of IOC elements of space infrastructure, what are the most important services to be made available and elements to be selected?
- The ways that are available to keep the U.S. public cost to a minimum, and the bases for the executive branch's pursuit or rejection of them. That is, there are two important opportunities for reducing the public cost of any space infrastructure, but it is not clear that NASA—with its institutional interest in retaining present personnel force and appropriation levels—has incentives to pursue either with sufficient imagination and vigor. These opportunities are:
  1, Other countries could collaborate closely with the United States so as to produce any agreed infrastructure in a fashion that would see their financial contributions reduce the demands on our public purse to well below the $8 billion figure, rather than simply producing additional, perhaps essentially duplicative, infrastructure elements at no savings to the United States.
  2. Our private sector could be encouraged to use its own resources to develop, produce, and install as much of any agreed infrastructure as would meet the Government's performance specifications at a cost lower than the Government's present procurement practices allow, rather than have Government funds used to purchase all of it and Government personnel used to manage the process in detail.
- Other important space initiatives that NASA could undertake. That is, if Congress were to decide that the acquisition of any infrastructure should proceed at an average annual public expenditure rate appreciably less than $2 billion per year, what other important programs could be mounted with the remaining professional staff and the difference in dollars?[21]

[19] See Committee report of Mar. 21, 1984.

[20] It should be noted that this assessment makes the assumption that NASA's overall funding level will remain relatively constant as it has in recent years.

[21] Ibid.

- Conceptual programs of cooperation with the Soviet Union in civilian space activities. That is, while a case can be made for mounting large and continuing, technologically challenging, U.S.-U.S.S.R. cooperative civilian space programs, essentially nothing of this nature is now being seriously considered because of the low state of political accommodation. In anticipation that today's tensions may abate someday, it is important that conceptual programs now be identified and described that would: 1) be of little inherent political sensitivity, 2) offer little prospect of significant technology transfer, 3) allow for important involvement of other space-experienced countries as well, and **4)** offer the promise of important cost savings to any country that, otherwise, would pursue any of them alone. The conduct of some such programs could well require some related elements of in-space infrastructure.

  These broader studies would be carried on at the same time, and for a small fraction of the cost of, the "space-station" engineering studies that NASA is now beginning to conduct, and the conclusions of their satisfactory completion would clearly be of importance to Congress 1 ½ years hence.

Civilian Space Policies, Goals, Objectives, and Strategies

Except for a few changes in the basic space law, Congress has been satisfied to deal with evolving circumstances through specific year-to-year changes in NASA's authorization bills. But these circumstances are now so greatly changed, and our space assets and experience are now so great, that it has become clear that Congress could reassess our civilian space laws' goals, objectives, institutions, policies, and plans with great profit.

For instance, Congress and the general public should not find themselves in the position of having to decide on large, complex, and very costly items of space infrastructure such as a "space station" without having a much clearer understanding of what these items will all be used for over the long term, and without being confident that their character, the uses to which they will be put, how they are to be acquired, owned, operated, and paid for, have all been carefully considered and conclusions reached that most would accept as reflecting our broadest national interests—not primarily the interests of the space community.

Congress is now moving to effect some important changes in space law and policy. Legislation has already been enacted in 1984 by Congress and accepted by the President that makes an important change in the Space Act.[22] The act now declares " . . . that [NASA should] seek and encourage, to the maximum extent possible, the fullest commercial use of space."

Although a sufficient, and sufficiently broad, base of thought, analysis, and discussion of fundamental considerations is not yet in hand to allow Congress to proceed to make other fundamental changes in our national civilian space posture with great confidence, the National Commission on Space authorized for in Title I I of this year's legislation,[23] and its subsequent activities, could go far toward calling widespread attention to our civilian space problems and opportunities. The Commission is expected to give the first broad consideration to our national space interests in a generation—consideration that would encompass interests in addition to those of science and technology that receive by far most of the attention today. It is the kind of consideration that would guard against our continuing to be caught up in either fascination with or the details of exotic space technology, and would focus instead on sensible and generally acceptable methods whereby we can proceed with the development of space, meet human needs in so doing, and fashion new ways of paying for it as we go. And it could identify new policies, goals, objectives, and strategies, and structural changes that, put in place, would increase the likelihood that the great promises of the next quarter-century of the space age would, in fact, be realized.

All of those within and without the Government who are truly and seriously interested in furthering our prospects in space should be prepared to assist this Commission.

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[22] Public Law 98-361.
[23] Ibid.

The Creation of Space Policy Study Centers

The number of professionals engaged in space policy analysis is extremely small. The President's science advisor spoke to this lack of independent expertise in testifying before a House subcommittee in February 1984.

And in March the House Committee on Science and Technology[24] spoke to " . . . the changing character of national and international space activity [that] translates into issues and policy considerations of increasing breadth and complexity, " and went on to say that "[d]uring the next year the Committee intends to look in greater depth at the elements and character of the current institutional apparatus for setting space policy [and] examining the process by which decisions and policies are reached on civil space issues. "

In these circumstances, Congress could consider prompting the establishment of one or more modestly sized, policy-related, study centers outside of the Government. Provided with sufficiently broad charters, and funded in such a fashion as to assure both independence in, and long-term support of, truly challenging studies, professionals would be attracted to conduct the kinds of broad inquiry and analysis that the civilian space area now so badly needs.

[24] See Committee report Of Mar. 21, 1984.