Chapter 1

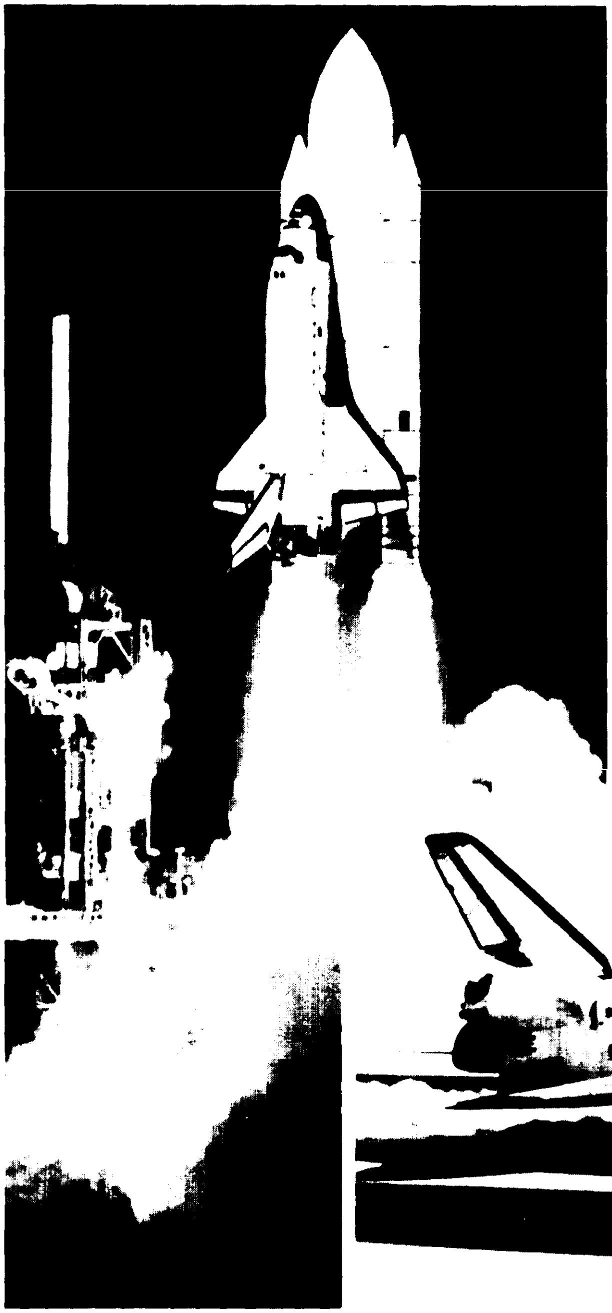
EXECUTIVE SUMMARY

Contents

Chapter 1

EXECUTIVE SUMMARY

OVERVIEW



The United States orbited its first satellite in 1958, nearly a quarter century ago. In the intervening years, the United States has made great strides in developing peaceful and practical uses of space technology. However, in spite of the dramatic successes of the space program, among which are the recent flights of the Columbia shuttle orbiter, many informed observers express considerable unease about the future of our civilian efforts in space, particularly in light of increased foreign competition and stringent fiscal restraints.

Because of these uncertainties and also because of emerging new prospects for using the space environment, this assessment was requested by the Senate Committee on Commerce, Science, and Transportation, and endorsed by the House Committee on Science and Technology. It investigates America's civilian space policy from the point of view of its effects on the primary areas of space applications technology, including space transportation. It does not address military/intelligence applications projects, activities in space science, or space exploration except insofar as

Photo credit: National Aeronautics and Space Administration

The successful launching (11-12-81) and return (11-14-81) of the second flight of space shuttle *Columbia*. The first reuse of a manned spacecraft with Astronauts Joe H. Engle and Richard H. Truly aboard

these affect civilian applications. Its aim is to investigate Federal policies, public and private institutions, and the external circumstances that shape space applications today. **In keeping with this emphasis, the assessment explores the question of Federal involvement in space research and development (R&D), the issues that arise in the transition from R&D to full-fledged operational status, when and under what circumstances commercial involvement is appropriate, and how to respond to commercial competition from overseas. It also addresses questions of space policy suggested by the Nation's experience with applications of technology in space.**

SPACE POLICY

Current Status

In 1958, the basic institutions and policy principles for civilian space activities were established in the National Aeronautics and Space (NAS) Act. This supporting structure, though amended and extended by legislation and presidential directives, remains essentially unchanged to this day. During this time much has happened–not only with regard to the space program, but also with regard to the commercial, national, and international context within which the program functions.

One of the most striking changes since 1958 is that space applications are now common and pervasive parts of day-to-day life. We rely increasingly on space for vital private and public functions (commercial communications and military reconnaissance) and for useful services (land remote sensing, navigation, and weather forecasting). In the near future, we can foresee commercial possibilities for processing materials in space. All of these applications of space technology require the support of a space transportation system, including launch vehicles, spaceports, and tracking networks.

In spite of these advances, however, **there is no overall agreement about the direction or scope the civilian space program should assume in the future.** For the most part, our increasing reliance on space systems has not been appreciated by the general public, which responds most readily to spectacular manned and scientific missions.

For space applications in particular, lack of agreement on appropriate goals has made it difficult for the executive agencies to set specific timetables for developing space systems that meet user needs, to encourage private sector investment, and to initiate new and/or implement mandated programs. In addition, there is no clear and predictable policy or process to define at what rate and by what criteria the transfer of technology from Government research, development, and demonstration programs to the private sector should take place.

The lack of consensus is of concern because many desirable space activities require continued Federal support. **The Government continues to play a crucial role in at least four areas that are essential to the Nation's future in space but have little potential for immediate commercial return: contribution to advanced R&D, continuation of space science, provision of public goods and services, and regulation/coordination of national efforts, particularly with respect to international agreements.**

The failure to agree about the aims of the U.S. space program has occurred as other nations have been expanding their own programs. When the U.S. space program began, the Soviet Union was our only competitor in space. The Soviets have never challenged our leadership in space applications. Now, however, **international competition in space applications is a reality. The Europeans and the Japanese have targeted specific space technologies for development, and they will soon be providing stiff competition for services heretofore offered only by the United States.** Their increased activities threaten the loss of significant revenue opportunities for the United States as well as a potential loss of prestige and influence. Japanese and European technologies now capture a small but growing portion of the world market in satellite communications technology. Their position is likely to strengthen in time. In the near future they are also likely to be in a similar position with respect to launch services and remote-sensing systems.

Unless the United States is prepared to commit more of its public and private resources to space than it now does, it will lose its preeminence in space applications during the 1980's. Both technological and commercial leadership are at stake. The U.S. leadership position will depend not only or even primarily on spending more money, but on effectively allocating our technical, financial, and institutional resources to meet international competition. Given the likely constraints on the Federal budget, it will be important to decide in what areas the United States wishes to compete, because attempts to maintain a comprehensive program without additional capital and manpower may lead to second-best technology and systems and/or inadequate institutional support.

Although the Federal Government must continue to play an important part in space, it cannot do the job by itself. The twin factors of diminishing Federal resources for civilian space activities and the dynamic qualities of the private sector make it important that the private sector participate more actively in U.S. space efforts. A great part of the success of the European and Japanese programs results from their institutional arrangements within which private and public sectors can work well together.

Specific Issues

Amending the National Aeronautics and Space Act

The NAS Act allows for a very broad range of activities; in itself it is not a constraint on enacting or implementing U.S. programs. However, it may need to be amended to allow the National Aeronautics and Space Administration (NASA) to operate space systems after the R&D phase is complete, or explicitly to encourage commercialization of space applications technology developed under Federal sponsorship. In addition, certain provisions of the act, such as the commitment to leadership in space, and the civilian/military separation, may have to be reinterpreted in light of current needs. Possible changes or reinterpretations are raised as appropriate in the following discussion.

Civilian/Military Relationships

The separation of the military from the civilian space program has served this country well. It has allowed both programs to develop along paths that reflect their different roles and missions. The civilian program has been conducted openly and has provided spectacular technological achievements, many useful applications, and solid scientific research results; the military and national intelligence activities, while providing critical security services, have contributed significantly to our understanding of space. Cooperation and technology transfer between the two programs have involved launch vehicles, launch and recovery facilities, tracking and communications, and an array of spacecraft technologies, to the mutual benefit of both programs.

In certain cases, the sensitive and highly classified nature of military and intelligence space systems has made it difficult to transfer technology from these programs to the civilian sector. As the military program has grown in the past decade, such difficulties have become more common. The joint military and civilian roles in NASA's central program, development of the space shuttle, have raised serious questions of how to divide financial and operational responsibilities. In addition, the rise in military activities may occasion doubt in many foreign countries about the peaceful and civilian character of the civilian space program. The current climate of domestic fiscal restraint and competition with other countries argues for: 1) **more timely transfer of military technological capacity to the civilian sector; 2) assurance that past restraints on permissible civilian applications activities be reexamined; 3) appropriate assignment of lead responsibility where classified and unclassified space programs have similar technical requirements; and 4) increased joint management of programs common to both.**

Emphasis of the Program

The current institutional structure of the civilian space program is well-suited to major programs of technology development such as Apollo or shuttle. It is probably too large and too tehnologically ambitious in an environment of level or decreasing budgets for programs having few major new projects. NASA's organization would constitute an effective base for embarking on a substantial new project, but it is not well--suited to undertake broad responsibilities for operations.

Embarking on any ambitious development project involving advanced technology carries with it the inherent risk of fiscal and institutional commitment which, unless carefully planned, could overwhelm other important parts of the space program. The experience with the shuttle is illustrative of this danger. Because of insufficient allowance for unforeseen (but not unexpected) development problems, it has been significantly more expensive and difficult to bring to full operational status than originally estimated. The unintended (and unfortunate) result is that, during a period of constrained Federal budgets, important space science and space applications projects have been slighted.

Future Programs

In considering programs in space applications, one must take into account the overall context within which such an effort would take place. The future of the U.S. space program as a whole will depend on three key factors: 1) the desire to develop space technology to meet national needs, 2) the degree and kind of foreign competition, and 3) the amount of Federal and private resources available,

OTA has selected alternatives that bracket a range of possible future space programs, with emphasis on the implications for the four applications technologies addressed in the report. In the following, three possible levels of U.S. response to foreign competition are used to order options for space applications. Foreign competition was chosen as a basis for comparison because it leads to the clearest distinctions between options.

Strong Response to Competition

This response would require a strong political commitment and a consequent increase in the Federal budget for space. A strong response to competition could lead to two different space programs, depending on the nature of the competitive threat. it would follow from the evaluation that energetic development of U.S. space technology would lead to a strong competitive position for the United States in other high technology areas as well.

- ***Apollo-1ike, Government-run program.*** The structure of the U.S. civilian space program was decisively shaped in the early 1960's by the high-risk, manned Apollo program and its associated projects. As in the Apollo era, commitment to a new large centerpiece project such as a permanent manned space station, or a manned exploration of Mars could be prompted by major new civilian and military initiatives from the Soviet Union, coupled with a desire to build on the technical and institutional resources developed over the past two decades. A strong U.S. response could also include a focus on applications projects as part of an effort to emphasize certain capabilities such as communications or remote sensing in conjunction with a central program. In either case, such efforts would be Government dominated, with commercial activities probably taking a secondary place to the goal of increasing U.S. prestige.
- ***Competitive, applications-oriented program.*** A strong reaction to European, Japanese, and possible Soviet economic competition in applications systems could lead to an aggressive Federal effort to maintain U.S. technological and commercial preeminence across-the-board. It would be based on the estimation that foreign government support and subsidy for their own programs could be met only by similar support in the United States. Such a program might well be dominated by the Federal Government, but because one of its primary aims would be to develop commercial applications, strong efforts would be made to enlist private industry as a major partner.

Summary of Operational Landsat Applications in the States[a]

A. Water Resources Management

- Surface water inventory (7)
- Flood control mapping and damage assessment (7)
- Snow cover mapping (3)
- Water resources planning and management (2)
- Irrigation demand estimation (2)
- Determination of runoff from cropland (2)
- Watershed or basin studies
- Water circulation
- Lake eutrophication survey
- Irrigation/saline soil
- Geothermal potential analysis
- Ground water location
- Offshore ice studies

B. Forestry and Rangeland Management

- Forest inventory (6)
- Forest productivity assessment (3)
- Clear cut assessment (2)
- Forest habitat assessment (2)
- Wildlife range assessment (2)
- Fire fuel potential
- Fire damage assessment and recovery

C. Fish and Wildlife Management

- Wildlife habitat inventory (9)
- Wetlands location and analysis (3)
- Vegetation classification
- Snow pack mapping
- Salt exposure

D. Land Resources Management

- Land cover inventory (18)
- Comprehensive planning (4)
- Corridor analysis (2)
- Facility siting (2)
- Flood plain delineation
- Solid waste management
- Lake shore management

E. Environmental Management

- Water quality assessment and planning (16)
- Environmental analysis or impact assessment (4)
- Coastal zone management (3)
- Surface mine inventory and monitoring (2)
- Wetlands mapping
- Lake water quality
- Shoreline delineation
- Oil and gas lease sales
- Resource inventory
- Dredge and fill permits
- Marsh salinization

F. Agriculture

- Crop inventory (7)
- Irrigated crop inventory (5)
- Noxious weeds assessment
- Crop yield prediction
- Grove surveys
- Assessment of flood damage
- Disease monitoring

G. Geological Mapping

- Lineament mapping (9)
- Geological mapping (6)
- Mineral surveys (4)
- Powerplant siting
- Radioactive waste storage

[a]The number in ( ) indicates the number of States for each application, where greater than 1.

SOURCE: National Governors Conference.

Moderate Response to Competition

This response would follow from an evaluation that foreign competition in space constitutes a significant, but not overriding commercial or political challenge. There are two variations:

- ***Single emphasis program*** (majority of resources devoted to a single project, e.g., the shuttle). This option describes the current situation, where NASA's other applications and science efforts have been steadily reduced as shuttle development has taken a dominant share of a constrained overall budget. Private sector involvement in applications would be strongly encouraged. Particular "targets of opportunity" would have to be selected to take best advantage of financial resources.
- ***Program with several emphases.*** This configuration could occur when the shuttle becomes fully operational, or if it were taken out of NASA and operated by a private firm, a separate Government agency, or the military. Though NASA's overall budget would be reduced, nontransportation applications might then have a larger and protected share of NASA'S lower budget; their portion could not be reduced as a result of increased budgeting demands from the transportation

94-915 O - 82 - 2

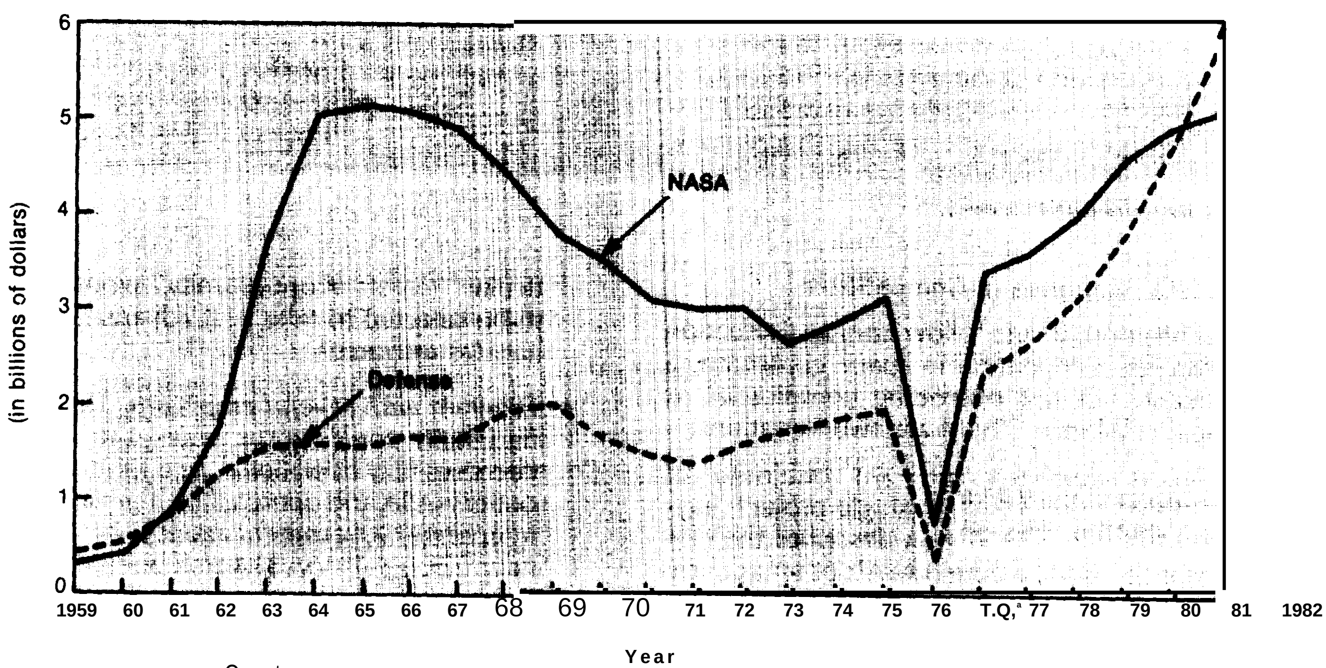
activities. Private sector participation in extended, cooperative generic R&D would be solicited to reduce costs and increase the prospects for commercialization. For similar reasons, NASA's space science programs could also be expanded.

Low Level of Response to Competition

This response would result from a view of foreign competition as either not threatening or unimportant, and a low estimate of the intrinsic value of the public benefits of space applications, coupled with severe constraints on the Federal civilian space budget.

- ***Severe/y constrained.*** Additional large cuts in the civilian space budget would leave very little room for new applications projects; the amount available for them would depend in part on the resources devoted to the shuttle. Major programs and perhaps entire categories of activities in science and applications would have to be eliminated and some field centers would have to be restructured or closed. Private sector efforts would be encouraged, but significant Federal funding for joint projects would not be available.
- ***Transfer of all of NASA's applications responsibilities.*** A possible response to civilian budget cuts and a weak competitive response by the United States would be to transfer any remaining Government applications programs, particularly the shuttle, to the Department of Defense (DOD) and other Government agencies. Appropriate NASA laboratories and facilities would be transferred to DOD, Interior, Commerce, and universities or private firms. NASA would retain responsibility only for basic research in space science and aeronautics, with little or no applications R&D or operational role, Such a scenario would require a radical restructuring of the civilian space program. It should be recognized that a transfer of some NASA activities to DOD may be desirable even without major budget cuts, as suggested above in the section entitled "Program with several emphases."

Historical Budget Summary—Budget Authority



a T.Q, s Transitional Quarter.

SOURCE: Off Ice of **Management and Budget,**

POLICY FOR SPACE APPLICATIONS

What are the appropriate roles of the U.S. Government in funding or otherwise encouraging civilian space applications research, development, and demonstration? Who should operate space systems once they are developed and demonstrated? Discussion of these two fundamental questions forms the basis of much of this assessment.

Federal Operation of Space Systems

At present, NASA is the civilian agency designated to conduct R&D of space systems and to operate launchers. The National Oceanic and Atmospheric Administration (NOAA) operates the weather satellites and is scheduled to assume operation of the Landsat system until the latter is transferred to private hands. Decisions on when a technically successful space system changes from R&D to operational status, and where operational responsibility lies (whether in NASA, a separate agency, a mission agency, or a private firm), have been made ad hoc. Insofar as the current procedure maintains flexibility, it has worked well; nonetheless, **the absence of guidelines for the transition from R&D to operations leads to uncertainty and inefficiency in the various programs.**

In particular, NASA's role in operating, as opposed to developing, applications systems needs to be clarified. The NAS Act itself gives NASA only limited operational responsibilities, and succeeding executive and congressional interpretations of the act make it clear that NASA is not to be primarily an operations agency, with the exception of providing launch services. Nevertheless, one approach to circumventing potential conflict between NASA and the Federal agencies which manage space systems and to easing the transition of applications systems from R&D to operational status would be to **restructure NASA's charter in the NAS Act and to allow it to operate selected Federal civilian space systems.** Such a broadening of NASA's role would require the agency to restructure itself internally so that it could gain expertise in specific mission areas.

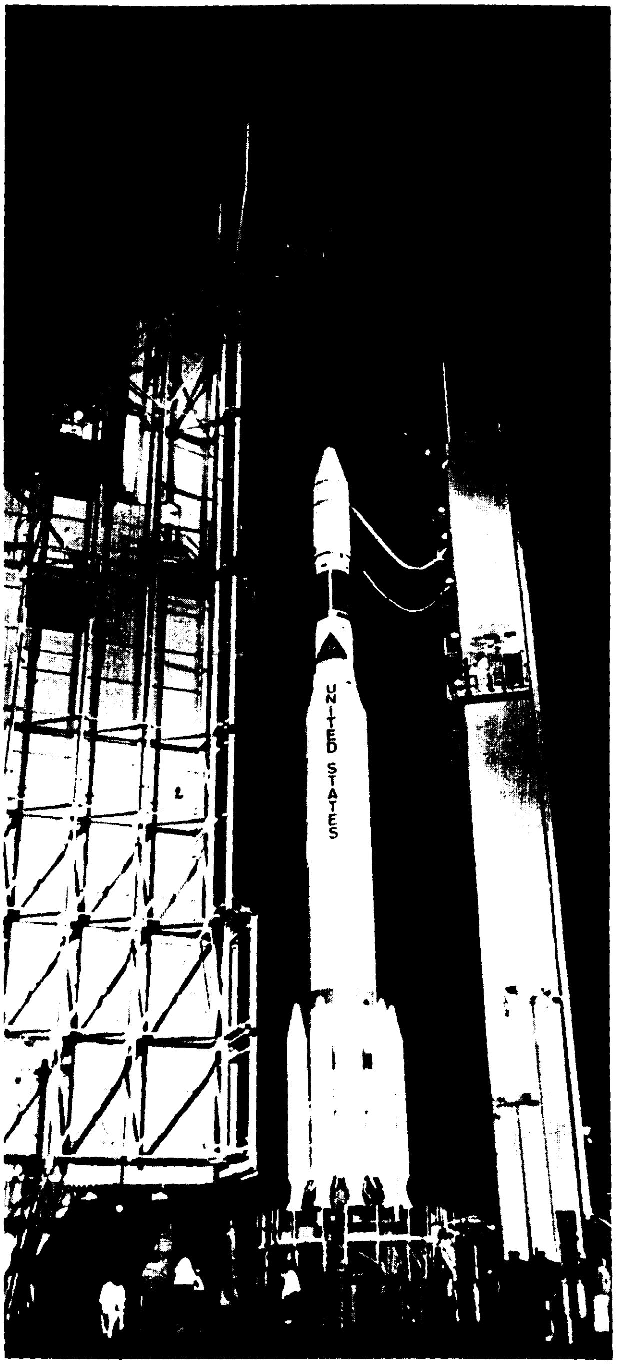


Photo credit: National Aeronautics and Space Administration

ERTS-1 satellite counting down, July 1972. The ERTS program was the first step in merging space and remote-sensing technologies into a system devoted to managing the Earth's resources more efficiently

On the other hand, insofar as the mission agencies already have the necessary knowledge and supportive institutional structures, there are good reasons to place mission-related space systems in their care. It must be noted, though, that space systems often support the activities of several mission agencies. If mission agencies are to operate space systems, the lead agency with respect to each application should be designated early in the R&D phase in order that it may be involved in designing specifications and planning for the demonstration phase, with a view to the services they are to provide to other agencies and the private sector.

Whether space systems are operated by NASA or by other Federal agencies, adequate planning for the use of space technology requires that the needs of ultimate users of the new technology be considered in the development stages. potential users must also be involved in planning and evaluating the demonstration experiments.

Commercial Ownership of Space Systems

One important way to strengthen the Nation's space program is to enlist a greater share of private resources and responsibility in space technology. To do so will require the development of innovative institutional mechanisms and incentives, examples of which are discussed later in this chapter. One way to focus attention on this aspect of the space program would be to amend the NAS Act to include commericalization as an explicit goal for appropriate space systems.

There is no single best model for commercializing space applications technologies. The particular series of steps that led to the COMSAT Corp., for example, though effective in promoting satellite communications, will not necessarily serve as a paradigm for other technologies. Commercialization of other space technologies requires that the special circumstances and different requirements of each be considered in determining whether and to what extent any system should be privately owned. At a minimum, regardless of the means considered appropriate for transfer of federally developed technology into the private sector, at a minimum interested industrial participants should be involved in planning for the demonstration phase (i.e., the phase prior to commercialization) in financing, in setting technical specifications, and in articulating the goals of potential customers.

The effectiveness of tax and other incentives (*e.g.,* patent policy and antitrust policy) for encouraging stronger industry participation in space technology R&D varies according to the technology and the industry. Though general policies such as changes in depreciation allowances or tax credits for R&D can have major effects on private investments, OTA has not evaluated the implications for space of such approaches. **The "Joint Endeavor Agreement (JEA)," recently introduced by NASA, is a promising and innovative initiative to encourage private sector interest by allowing individual treatment of industry needs in the context of NASA's overall goals.** Through JEA, NASA agrees to provide free shuttle launches and limited on-board services for private sector experiments or technology demonstration programs that meet certain criteria—such as technical merit, contribution to innovation, and acceptable business arrangements. Though originally designed to encourage private sector participation in NASA's materials processing program, **JEA, along with similar arrangements allowing for different degrees of participation, may also be useful in encouraging new advances in satellite communications and remote sensing. In addition, NASA could also encourage industrial development of space R&D by offering to launch experimental private sector devices or satellites in return for some portion of their activity being devoted to public service. Another possibility is to allow NASA to collect a royalty fee on future profits from satellites in return for a free launch.**

If the move to commercialize space applications technologies is to develop successfully, Government and industry must show an increased willingness to work together to share the risks and benefits of new technology. In particular, private firms must not expect publicly financed technologies to be transferred gratis, and Government agencies must be willing to relinquish control over their projects and to plan ahead for eventual commercialization.

Commercializing space technology raises a number of complicated regulatory issues. Domestic and international problems concerning direct broadcasting technologies, remote sensing of foreign territories without prior consent, and the development of private launch vehicles have already arisen. As the technology to support materials processing in space improves, new chemicals, alloys, and pharmaceuticals may be produced, some of which may require Government oversight to assure their content, quality, and safety. Because the technologies and the regulatory issues each raises are so different, regulation of each is best handled by agencies that specialize in each technology. In some cases, such as developing new drugs, regulatory policies (e.g., those of the Food and Drug Administration) are already in place; in others, such as private operation of launch vehicles, new policies or institutions are likely to be required.

Technologies

Of the many technologies that can be applied in space, OTA chose advanced satellite communications, land remote sensing, materials processing, and space transportation to study because: 1) these technologies raise issues that are of current interest, 2) they illustrate a range of issues faced by space applications, and 3) they have commercial potential.

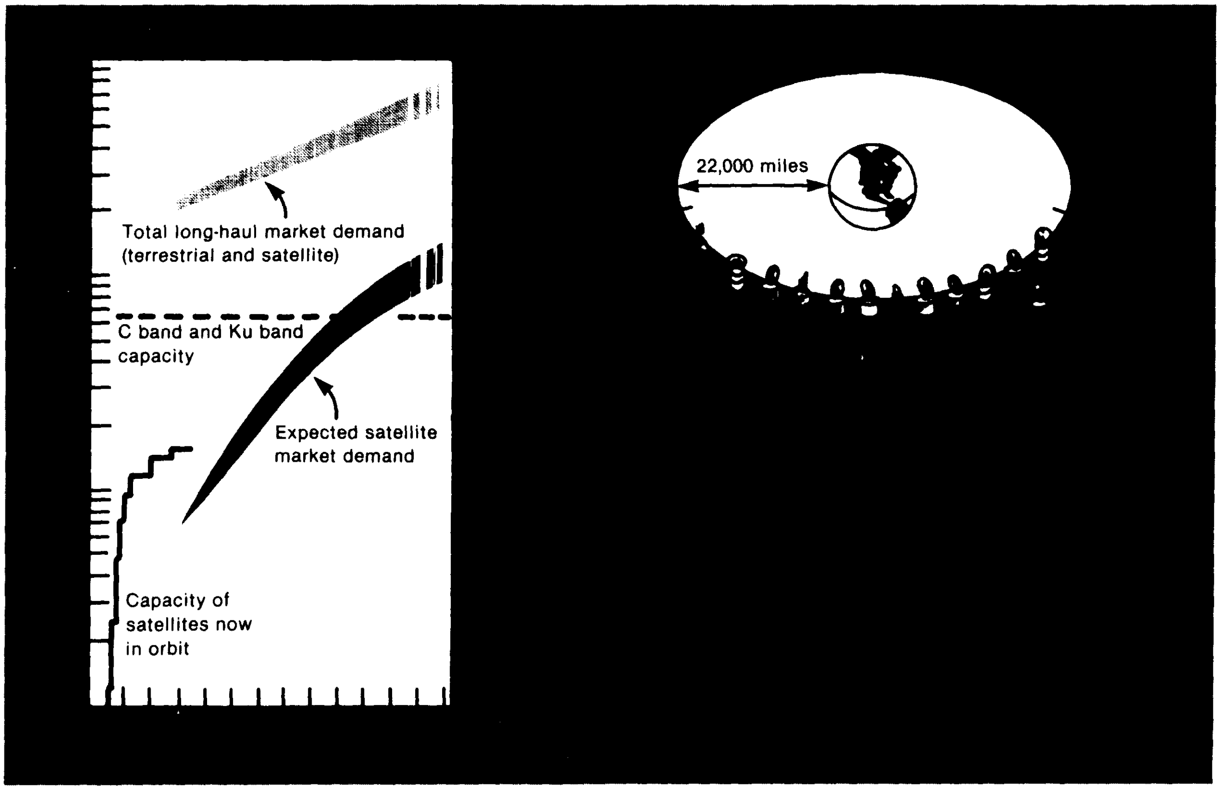
Advanced Satellite Communications

The private sector has operated communications satellite systems since 1964. Today, largely because of original research conducted by NASA and several private laboratories, the industry is flourishing. It is the most profitable area of space technology to date. In 1973, because of strong industry pressure, NASA began to phase out its advanced satellite communications research program. By 1977, however, the communications industry had decided that NASA had a role to play and urged it to begin advanced communications research again. Although NASA reinstituted a small program in 1978 ($26.7 million in 1981 and $15.9 million in 1982), it may need to be expanded. Consequently, **in order to strengthen NASA's role in supporting advances in satellite communications technology, it may be desirable for Congress to direct NASA to pursue a vigorous program in advanced satellite communications R&D.**

Projections of increasing demands for communications services, especially television distribution, indicate that technology for exploiting the Ka-band (30/20 GHz) of the radio spectrum can be developed into profitable operational systems well before 2000. Development and demonstration of this technology require at least some generic research of the sot-t not customarily done by the private sector. Already the Europeans and the Japanese are developing 30/20 GHz systems heavily subsidized by their governments. The virtual certainty that foreign systems will come online sometime in this decade has occasioned debate about whether NASA should undertake a large 30/20 technology R&D program, including flight-testing of 30/20 hardware. Proponents of a NASA program argue that the private sector alone cannot afford to develop 30/20 systems, but that if they are not developed, the United States will lose an important market and its strong lead in communications technology. An important consideration is that several companies are already doing some Ka-band work near 30/20 GHz for the military. It **appears that 30/20 development is an area in which creative new mechanisms for Government/private sector cooperation could be tried. A joint public/private demonstration project, with substantial financial participation from several corporations, might be possible and desirable. However, in order to encourage the private sector to enter into such an arrangement, appropriate incentives would have to be devised.**

On the other hand, perhaps the salient issue for commercial 30/20 systems, especially in the United States, is not whether NASA should lead the way, but when the private sector judges it appropriate to bring such systems into the market. Systems currently in use, both satellite and ground based, can still be substantially improved, and the private sector is working to do so. Until most of these improvements are made, private firms, acting alone, may not find it advantageous

The Communications Problem



SOURCE: National Aeronautics and Space Administration.

to jump to 30/20, even if firms of other nations do. However, there is no doubt that eventually the United States will need to develop 30/20. The question is when. An important consideration is that crowding of the geosynchronous orbit and the radio spectrum has led to international political problems that the private sector cannot resolve on its own. Accelerating the availability of 30/20 technology could render these problems more tractable.

The case of 30/20 demonstrates that in satellite communications, as with other space applications technology=, the United States lacks a consistent policy to assure coordination of military, civilian, and industry efforts. This absence of clear vision will again become a problem as a new configuration for communications satellites, large communication space platforms, becomes possible in the 1990's. Large communications platforms could support large multibeam antennas and the associated switching electronics needed for vastly expanded point-to-point services. The major question to be answered by a possible development and demonstration project is whether the alleviation of congestion in the geostationary orbit and reduced costs outweigh the problems of assembling them in orbit. A further important question is whether the risk of development is low enough so that the private sector will be able to develop large communications platforms on its own, or whether a NASA program is necessary or desirable, perhaps in cooperation with INTELSAT or other interested international parties.

Many of the pressing issues in satellite communications are not related directly to the use of space but concern regulation or involve questions of national sovereignty. Direct broadcast television and geostationary orbit allocation are examples of such important issues (see the recent OTA repot-t, ***Radio frequency Use and Management: Impacts From the World Administrative***

Radio ***Conference of 1979).*** Although these issues are not fully addressed **in this report, it is important to note that because the Federal Government and relevant international organizations have not decided how direct broadcast television is to be regulated, industry's investment** in this technology is laden with extra risks. Designing appropriate regulations requires considerable technical knowledge and some research. In order to aid the regulatory bodies, it may be desirable to modify NASA's legislative charter to direct the agency to support the research needs of their prospective regulatory actions.

Satellite Land Remote Sensing

The future of U.S. civilian satellite land remote sensing is in considerable doubt. The question of what to do with the U.S. system is a critical one for the future of the management and development of U.S. natural resources. Whatever is decided, the question should be resolved with dispatch. The needs of the data users make it essential that continuity of data flow be maintained and that price increases be predictable and incremental. However, at the present time, it is unclear whether the United States will have a civilian remote-sensing capability after the flight of Landsat D, and what prices will be charged for data. Landsat D is scheduled to be launched in the third quarter of fiscal year 1982 and has a mission goal of approximately 3 years.

NASA has managed the Landsat program as a quasi-operational system for several years. Under its leadership, the value of Landsat data for providing synoptic views of the Earth has been proved. The launch of Landsat D will bring this technology nearer to operational status under the management of NOAA. However, there are several general concerns about the viability of the Landsat program. First, because Landsat D will carry new and untried sensors as well as proved ones, one cannot be certain that it will provide full operational service. In addition, budget restrictions might make it difficult for NASA to complete and launch Landsat D', an identical satellite that is now in production. Finally, the determination of the French, the Japanese, and the European Space Agency to build their own satellite remote-sensing systems makes it certain that the United States will no longer have a monopoly in providing these services; the French have already begun to market their SPOT system, scheduled for operation in 1984. In addition, the Soviet Union has recently flown a new advanced land remote-sensing satellite. Although it is unclear what use they plan to make of their new capability, the Soviets could also compete with the United States in this important technology.

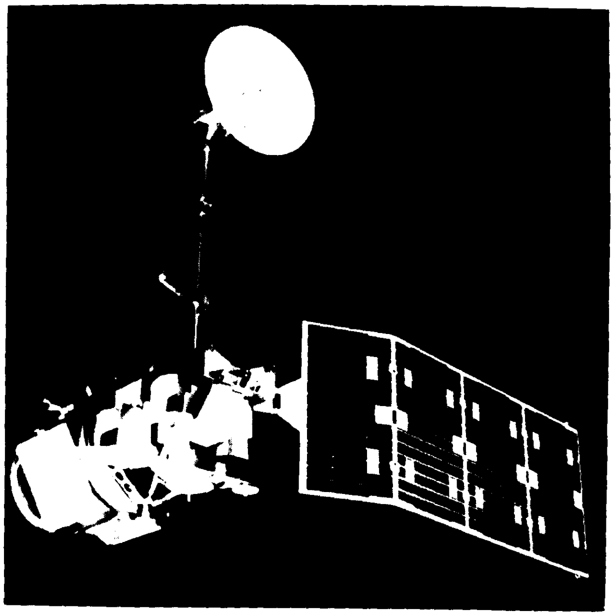


Photo credit: National Aeronautics and Space Administration

Landsat-D, an experimental satellite used primarily for monitoring and management of food and fiber resources, water resources, mineral and petroleum explorations, land cover, and land use mapping

CURRENT POLICY: PRIVATE SECTOR OWNERSHIP

Both the previous and the current administrations have **been committed in principle to commercializing a satellite remote-sensing system, but, no specific guidelines have been provided to specify the terms and speed of transition to the private sector. More than 3 years of experience in exploring the possible institutional arrangements have already demonstrated that the transition is likely to be very difficult to accomplish.** Several general proposals have been made for the means of transfer to the private sector.

- ***Designating a single entity*** (either an existing corporation, or one created by legislation) to own and operate the entire existing system (space and ground segments).
- ***Establishing a laissez-faire policy*** that would leave to the marketplace the decision to launch and operate the entire system, with the Federal Government committed to leaving the field at a specific time.
- ***Commercializing the space and terrestrial segments*** independently of one another, either through designation or laissez-faire.

Each possibility has potential benefits and drawbacks. One promising means of effecting transfer to the private sector would be to commercialize the space and the ground segments at different rates. **The ground segment already has a strong private component; the small, but important value-added industry, which processes and enhances satellite data to meet particular user needs, is certainly growing, if not yet flourishing.** The remainder of the ground segment, the receiving and processing centers, could be operated by the private sector, provided continuity of dataflow from the space segment were assured. **In the next 5 to 10 years, the market is not likely to sustain commercial operation of the entire satellite land remote-sensing system without substantial direct or indirect Government fundings.** A multilevel pricing structure, in which some users pay more than others, or an explicit subsidy to the operating entity could be used. No **matter how Government funding is provided, however, commercialization of the ground segment for land remote sensing will require a Federal commitment to the long-term, user-oriented operation of the satellite portion of the system.**

Placing the satellite land remote-sensing system in private hands creates an inherent conflict of interest for the firms that control the distribution of primary data. This might create significant problems for foreign users, particularly those less developed countries whose main economic and social potential lies in exploiting indigenous raw materials or agricultural products. Some less developed countries fear that a commercial operation may give private corporations or industrialized countries access to vital resource information before the sensed country is able to obtain it. Even if controls deemed adequate by the United States are instituted to prevent unscrupulous use of the data, other nations may still judge private control of the data to be unacceptable, and might try to promote international oversight and control in various international forums.

MULTILATERAL ALTERNATIVE TO CURRENT POLICY

The concerns of other nations might be alleviated and a much stronger market for land remote-sensing data developed if, instead of continuing a domestic system, the United States offered to share the ownership and operation of Landsat with other nations. A single multilateral management authority could assume responsibility for global operation of a land remote-sensing system; its responsibility would include establishing technical specifications, procuring and operating satellites, and receiving and preprocessing satellite data. Such an approach would spread the investment risk, as well as encourage member nations to be more aggressive in developing their own internal markets for satellite data. It could also contribute to the development of a strong market for U.S. data-processing hardware and software, and broad data-processing services. In addition, a multilateral system might make it easier to use the power of Landsat data in combination with weather satellite data to tackle some of the pressing global problems that face the world, such as the buildup of carbon dioxide, or deforestation. If the United States is to pursue the initiative of a multilateral system, it must do so soon. The French SPOT system is well along in the planning phase and the Japanese system will follow a few years after SPOT is in place. India, Brazil, and China are planning to develop their own systems in the 1990's.

However, if the system were internationalized, the United States could no longer determine its characteristics unilaterally. The United States could not guarantee that the resulting system would continue to serve U.S. needs to the same extent as the current Landsat system. To retain control, the United States would need to develop and market its next generation of Landsats in a much more aggressive manner.

CONTINUED FEDERAL OWNERSHIP

An alternative to either a privately held or an internationally owned satellite remote-sensing system is a thoroughgoing commitment to a system owned and managed by the Federal Government. Meteorological satellites, which, like Landsat, provide data of benefit to the general public, have always been owned and managed by the Government. Unlike satellite communications technology, which is already fully commercialized, and materials processing in space, which, if successful at all, seems particularly appropriate for private sector operation, satellite remote sensing could certainly be retained as a Government system on the grounds that the good it provides is primarily public. At the present time, 100 percent of the costs are borne by the Government through the budgets of NASA and the Department of the Interior, and about so percent of the data sold are "purchased" by various Government agencies. The Government, in effect, makes the market.

Materials Processing in Space

The prospects for manufacturing commercial products in space are unclear, based on data obtained to date from limited in-space and terrestrial studies. Additional fundamental science and technology research such as will be conducted in Spacelab is required before the private sector can be expected to initiate large-scale, expensive manufacturing of goods in space. However experiments that have been conducted so far do suggest that the pursuit of space processing techniques might yield unique high-value, low-volume products for the pharmaceutical, electronics, chemical, "specialty" glass, and advanced alloy industries. Much of this research will also lead to greater understanding of the effects of gravity on chemical and physical processes. At least two commercial ventures to produce commercial products or services in space are underway through joint endeavor agreements with NASA. Other firms have also begun to express interest in similar projects.

In addition to the lack of adequate knowledge, other factors that will affect the willingness of some companies to invest in space R&D are: 1) the cost of experimentation in space, 2) the leadtime needed to design experiments and schedule shuttle flights at optimal times, 3) need for multiple-flight opportunities in many cases, 4) uncertainty of return on investment, 5) industry distrust of long-term arrangements with Government, and 6) unfamiliarity with space systems and the benefits they may offer.

The United States can expect significant competition in the long term from Germany, France, Japan, and the Soviet Union, all of which are conducting a wide range of experiments in materials processing. [n the near term, according to their published plans, their efforts will concentrate on the basic science end of the R&D spectrum. Although at present it is sharply curtailed by budget reductions, the U.S. effort is directed toward commercializing this technology as well as pursuing R&D. At present it is unclear which programs will produce the greater near-term results.

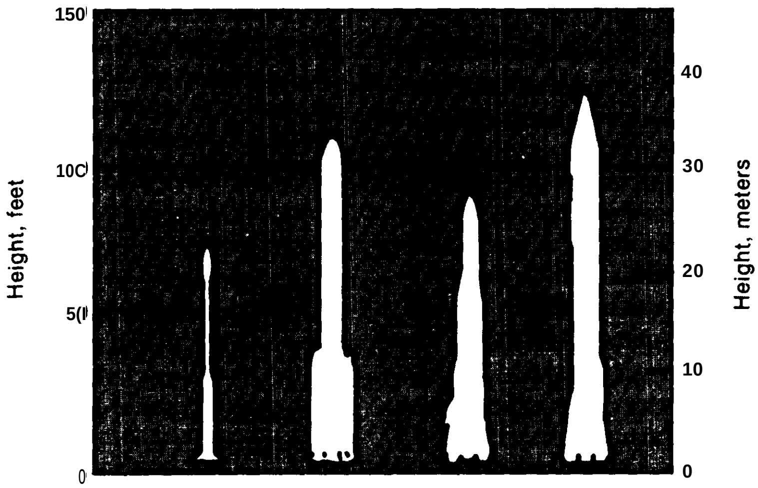
Space Transportation

Civilian space transportation, by means of both the reusable shuttle and expendable launch vehicles, is likely to remain a function of the Federal Government throughout this decade. The aerospace industry is reluctant to assume ownership of the presently operating space launching systems because: 1) the majority user is the Government, 2) the Federal Government owns and controls the existing facilities, 3) the initial investments are very high compared to expected revenues, and 4) indemnification in case of disasters (e.g., an explosion on the launch pad, or misguidance) could be very expensive.

The aerospace industry has been willing, however, to operate any and all space transportation services under contract to the Government. There has also been some limited commercialization of space transportation hardware. Upper launch stages are routinely sold directly to the user, rather than through the Government. All lower stages of expendable launch vehicles (Scout, Delta, Atlas, and Titan), however, are still purchased and launched under the control of the Federal Government.

If the Space Transportation System (the shuttle and its related components) is to be commer-

Current NASA Expendable Launch Vehicles



a) Payload values are for **east launch from Eastern Test Range for Delta and Atlas Centaur**
b) Scout values are for launch from wallops,
c) Atlas E/F values are for launch from Western Test Range

SOURCE: National Aeronautics and Space Administration.

cialized, the Federal Government will have to offer realistic incentives to the private sector. These might include: 1) committed purchase of an attractive number of flights, 2) provision of an accelerated schedule of investment credits, 3) low rental costs for Federal launch facilities, and 4) decision by the Government not to recoup invested costs,

NASA had planned to phase out most expendable launch vehicles in the mid 1980's as the space shuttle becomes fully operational, However, it appears that the growing future need for launch services will exceed the shuttle's availability, If demand outpaces availability, and if the United States has no expendable vehicles ready to launch commercial satellites at affordable prices, then the private sector will be forced to continue to purchase launch services from the French. NASA is now reconsidering its policy, As experience is gained with the shuttle, the launch needs for the future will be clearer than they are today, and decisions regarding the phaseout could be made in light of more realistic demand projections. It may even be appropriate to continue R&D of expendable launchers, particularly to develop a low-cost reliable launcher for boosting small payloads to geosynchronous orbit.

U.S. dominance of free world space transportation faces strong competition. The Ariane Expendable Launcher, developed by the European Space Agency, is being marketed by a private, French-incorporated company. Several U.S. companies have already changed their plans to launch on the shuttle, in favor of launching on Ariane. The Japanese now launch their own satellites by means of Delta-class launchers, which they construct under agreements with the U.S. firms that developed the technology. The Soviets and the Chinese also launch their own satellites, but with locally developed technology. The Soviets are willing to place satellites of certain other countries in orbit. Thus, although the foreign market for satellite launches is growing, foreign capability is also growing rapidly.

in addition to launch vehicles developed by the Government, at least one private U.S. company plans to build and launch its own commercial expendable launchers. This fact has caused the Federal Aviation Administration, the Federal Communications Commission, the State Department, and NASA to begin to analyze the regulatory problems that may result from private launches from the United States and other nations. At this writing, it is unclear what agency(ies) will have the responsibility for such issues as: launch authorization, aerial and maritime clearance, the development of new commercial launch sites, the need for a system of indemnification, and payload authorization. **These issues are more likely to be resolved if a lead agency is designated to coordinate launch regulations.**

International Issues

NASA has had marked success in arranging cooperative ventures in space with other countries. However, as has been noted previously, foreign competition is almost certain to increase. One result is some kinds of cooperative international ventures will become more difficult to initiate or sustain. In particular, projects having potential commercial payoff, such as future activities in materials processing that may prove of interest to chemical or pharmaceutical companies will be problematic. On the other hand, there may be more scope for joint ventures, or subcontracting, between companies from different countries, notably in selling equipment and services to the third world.

Proliferation of direct broadcast satellite systems and improvements in the resolution of civilian remote sensing data raise issues of national sovereignty and open data policy. Many countries fear that unregulated translational radio and (especially) Tv broadcasts direct to home receivers will undermine their sovereignty and their cultural values. Direct transmissions would also provide unwelcome competition for national broadcast monopolies. Issues surrounding the appropriate use of direct broadcasting systems are likely to be raised in the context of recent international proposals to regulate the free flow of information. Similarly, many countries fear that unrestricted dissemination of high-resolution remote-sensing data would threaten their sovereignty and national security. The question of requiring the prior consent of a country before selling or otherwise distributing high-resolution satellite data has been debated frequently at the United Nations and other international bodies.

Policy for Science

U.S. leadership in developing innovative technology results from the strength of its scientific, engineering, and educational institutions. innovations in space applications require that these institutions maintain their interest in the opportunities for science and engineering made possible by continued operations in space. **If the vitality of the U.S. space program is to be preserved, the United States must also be willing to commit sufficient resources and attention to basic science research and advanced engineering in all areas related to space, including space sciences.** A healthy program includes: support of educational programs in science and engineering, innovation in laboratory equipment, and basic research in science and engineering. It would maintain a strong space science effort: new missions to gather data in and from space, a corresponding set of projects to guarantee adequate analysis of these data, and a stable infrastructure of facilities and support technologies.

Charting the Policy Future

The discussion in the first section of this summary describes current problems that reach all segments of the civilian space program. A pervasive element is the lack of consistent long-term goals and clear policy initiatives, from either the executive or the legislative branches of the Government. This situation derives in part from the fact that since the Apollo decision was made in 1961, the number of major actors in civilian space activities has increased from one agency (NASA) to include six Federal agencies and numerous private firms. Not surprisingly, the many groups with direct and indirect interests in space agree neither about the overall importance of the civilian space program nor about specific applications projects. In the absence of broad consensus and a means for deciding between opposing views, the scope of individual projects is determined by the annual budget deliberations among the executive agencies, the Office of Management and Budget (OMB), and Congress. Over time, the sum of these decisions determines the overall course of the space program. However, the annual budget cycle bears little relationship to the long-term, evolutionary cycle of space systems. In addition, OMB has not chosen to view investment in space activities from a long-range perspective. Until such time as a broad consensus is formed, it is left to the President or Congress to set forth a coherent, strategic framework for civilian space policy. In the absence of such direction, the current drift will continue and worsen.

Periodic, open, high-level discussion of the space program is needed to focus attention and sharpen debate on our national objectives in space. Reviews of space policy such as those being conducted by the President's Office of Science and Technology Policy, and by Congress, including this assessment, serve part of this purpose. Nevertheless, such one-time efforts cannot substitute for a sustained forum for debate about the program. **In order to plan for the future of the space program in the context of other national needs, the United States needs a multi-representative forum to discuss and recommend comprehensive, long-term goals. Such a forum could coordinate the interests of all the major actors in order to allow equitable and stable decisions to be made about the overall direction of the civilian space program.** Though such a body would not itself direct the course of the space program, because this responsibility lies with the President and Congress, it could focus the debate and provide timely advice.

Several different institutional options are discussed in this report. They range from establishing a new Department of R&D, of which NASA would be a part, to establishing a commission to advise the President and Congress on space. One attractive option in the executive branch would be a reconstituted and broadened National Aeronautics and Space Council, with representatives from civilian agencies, DOD, and the private sector.

Because Congress is the Government's major forum for the representation of differing views, it is there that one would expect to see the interests of different parties debated. However, space issues have not always received the coordinated attention from the committees that they probably deserve. In addition, the space activities of the Federal Government are carried out by a variety of mission agencies, most of which are not concerned primarily with space. As space technologies have developed and begun to affect so many aspects of our society, space issues have come to be dealt with in several different committees and subcommittees. If the different views are to be synthesized into a consistent space policy, coordination of responsibility is necessary. Congress would then be in position to formulate a comprehensive space policy that would set long-term goals for the U.S. space program, military and civilian.

If the congressional committees wish the issues to be raised and debated in a noncongressional environment, an option for bringing together the major interests in space would be a Presidential commission with a limited lifetime, established under concurrent resolution by Congress. To be most effective, it should also include representation from Congress. After the commission's business was completed, congressional hearings on its report could be held, followed by a new or revised charter for the space program and a clear statement of goals. This option would not remove the need for further governmental action. A temporary commission, though highly useful for initiating a new focus for the space program, cannot substitute for longer term policymaking and coordinating bodies in the executive or the legislative branches.