Chapter 4

DEVELOPMENT AND CHARACTERISTICS OF THE U.S. SPACE PROGRAM

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INTRODUCTION

Nearly a quarter century after Explorer I and the U.S. entry into the space age, the space shuttle now presents the Nation with new and expanded opportunities for space operations. In the coming months and years, we will learn to operate and use the new capabilities of this system. It is indeed ironic that, at this time of brave new beginnings, the Nation again faces important questions about the future of the civilian space program.

At the inception of the space program, the United States perceived Soviet initiatives in space as political, military, and technological threats. Having seen space as a field in which to compete, the United States directed its space program toward the primary objective of exceeding Soviet achievements. With the passage of time, and the great success of Apollo, Soviet competition no longer challenges the United States politically. But as the Soviet challenge has vanished, so has the motivation of beating the competition. Now the United States is faced with the more sophisticated challenge of devising a balanced policy framework—a framework that will enable the United States to identify new objectives and stimulate the Nation to achieve them. Lacking such a perspective, the Nation has, instead, begun to evaluate space more pragmatically. This evaluation suggests that "activities will be pursued in space when it appears that U.S. national objectives can most efficiently be met through space activities.'"[1] It contrasts with the aggressive acceptance of the "role of the United States as a leader in aeronautical and space science and technology and in the application thereof . . . ," as prescribed in the National Aeronautics and Space (NAS) Act of 1958.[2] The act itself, however, established no spe-

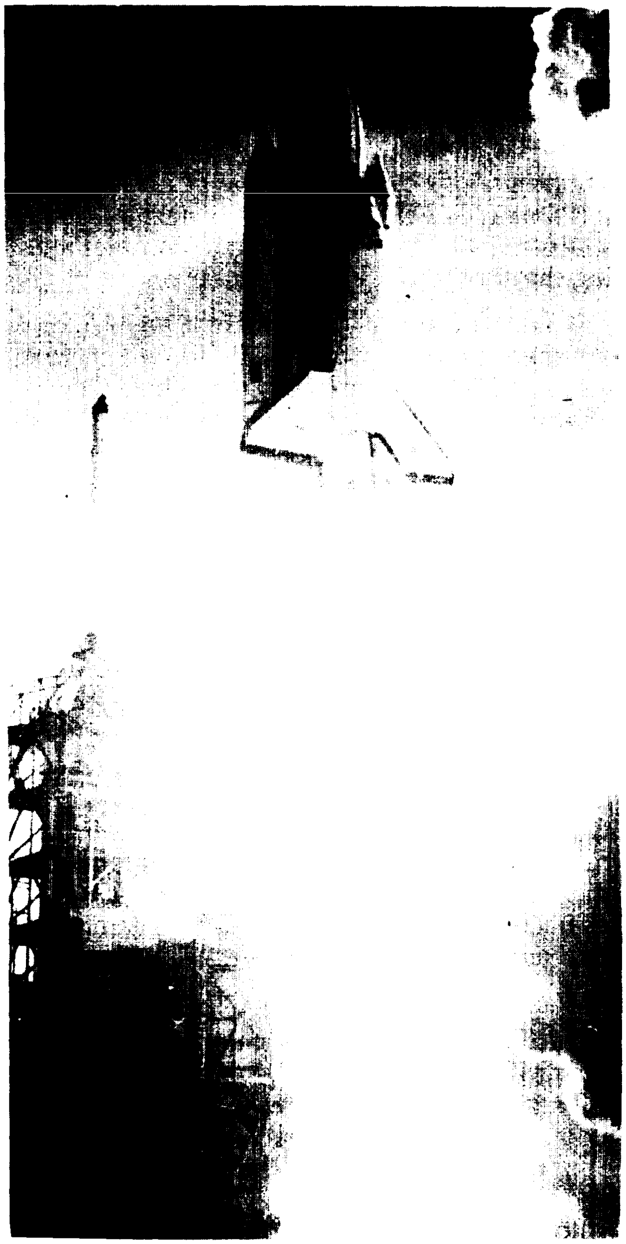


Photo credit: *National Aeronautics and Space Administration*

The dawn of a new age in space flight, Space shuttle *Columbia* blasts off Pad 39a, April 12, 1981, with astronauts John Young and Bob Crippen aboard

[1] "White House Fact Sheet on U.S. Civil Space Policy," Oct. 11, 1978.

[2] *National Aeronautics and Space Act of 1958,* as amended, and related legislation. Prepared at the request of Hon. Howard W. Cannon, Chairman Committee on Commerce, Science and Transportation, U.S. Senate, December 1978.

cific manned or unmanned missions, outlined no priorities, nor specified a funding level at which the program was to be carried out. Instead, the commitment to Apollo set the civilian space program on the expansionary course that provides the baseline for current comparisons. Likewise, this commitment generated the momentum that is largely responsible for sustaining the program today. But now, with current budgetary stringency, commitments to civilian projects are few and uncertain, though the military and national security programs continue to grow. Consequently, it is timely, as we embark on the next decade of space activity, to scrutinize and to consider revising the framework of U.S. space policy.

Basic to any overall assessment of the U.S. civilian space program, particularly one which seeks to assist Congress in setting public policy for charting the Nation's future in space, is an interpretive, retrospective review of our current posture in space, how the United States has proceeded to develop its current program and the capabilities on which the program is based, the role of various external factors such as international competition, the processes that have shaped its current posture, and other relevant forces and environmental factors that led to, or provided the foundation for, the current situation facing the United States in space. This chapter presents the results of such a retrospective review applied to the civilian space program of the United States, emphasizing those aspects that are relevant to space applications. It is intended to highlight issues and lessons learned, as well as characteristics of previous decisions regarding the program that may have applicability to current and future developments.

The civilian space program of the United States has grown from its early beginnings as part of operations in connection with the International Geophysical Year, to the great successes of Apollo, Viking, and Voyager, in the short span of one generation—a little over 20 years. Thus, history and current practice are woven together in a tapestry, with many threads still in place that bind past and present: still present are many individuals in the National Aeronautics and Space Administration (NASA) who have been with the agency since its beginning, contractors that have played a continuing role over this period, and institutional relations that are relatively unchanged since the earliest days of the agency. There are both strengths and weaknesses in such a situation. To the extent that it is desirable to prevent making the same mistakes as one's predecessors, such continuity and institutional memory is important. To the extent that it serves to limit the Nation's ability to take a fresh look at the program, how it functions and how it should respond to a changing external environment, the strong links to the past may inhibit the agency from becoming a dynamic vehicle of change and the source of new initiatives involving the use of space systems.

In addition, the relatively short span between establishment of NASA and this assessment makes it difficult to separate the objective views of participants from a tendency to defend their own decisions and roles. Because of this problem, this history and analysis is primarily based on specific events, documented roles and decisions, observed consequences, and supporting statements.

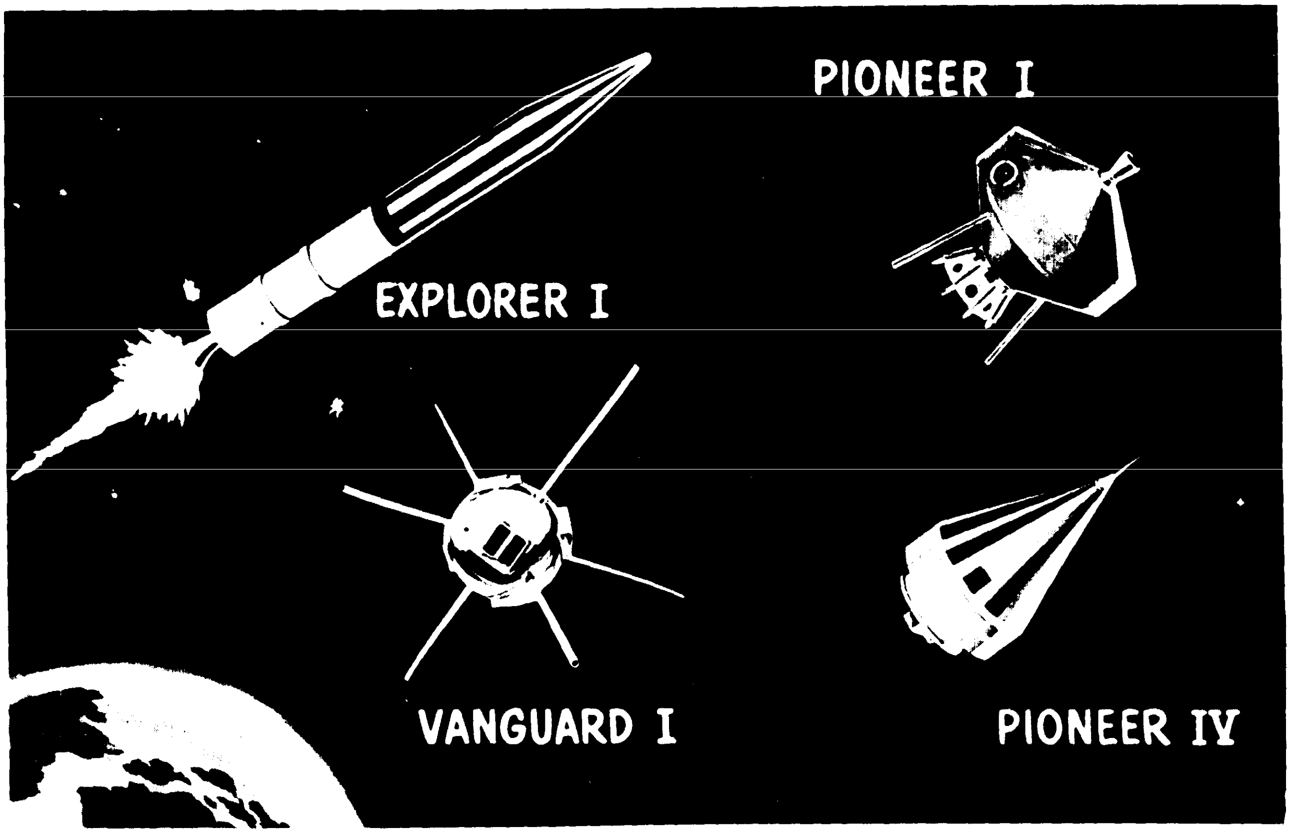
Although the civilian space program is a relatively recent activity of the U.S. Government, it is unique among Government programs in its high public visibility. It has been the subject of many historical evaluations and popular histories. NASA from its very beginning devoted attention to the development of an official chronology, and in the past there was an annual report of space activities submitted to Congress, summarizing the full scope of the U.S. civilian space program. Together, these resources report the history and evolution of the civilian space program in great detail, and there will be no effort in this report to duplicate such materials. The specific programs or decisions discussed in the sections that follow have been selected to illustrate an issue or to support a conclusion so the material selected is not a comprehensive or exhaustive lising of milestones or significant events. In keeping with this assessment's focus on civilian activities, the present chapter does not discuss the extensive military space program except as it illustrates a policy issue of significance for the civilian space program. Its focus is primarily on NASA's activities, though it includes some discussion of programs of the National Oceanic and Atmospheric Administration (NOAA).

EARLY DEVELOPMENT

The early development of the U.S. space effort was primarily a specialist's concern; that is, the scientific research objectives associated with the prospect of access to the upper atmosphere and eventually to an Earth-orbiting platform were the province of a relatively small community of scientists and engineers. This community included a few universities, not-for-profit institutions, and several defense laboratories. There was associated with this research-oriented community a larger engineering-oriented group that was developing propulsion systems, radio and inertial guidance systems, and control systems for ballistic missiles. This second group provided much of the basic launch vehicle technology for the civilian program. Before Sputnik in 1957, these groups pursued their objectives in relative obscurity.

In the wake of Sputnik, however, the public demand for a U.S. response galvanized Congress and the executive branch to act. Seeking to revitalize technological and scientific development across-the-board, they instituted programs to develop better science and engineering education, to increase Federal support for science, to attract greater numbers of young people to technical careers, and to improve military systems.

One of the first measures taken was to appoint a full-time Science Adviser to the President, Dr. James Killian, and to establish the President's Science Advisory Committee (PSAC), a group of 18 respected senior scientists and engineers. They were asked to review and comment on the measures needed to carry out the peacetime mobiliza-



Spacecraft used in the early stages of space exploration

tion of skills in science and technology called for by the President. Clearly, the major topics of review were: 1) the U.S. response to Soviet space achievements and 2) the national security programs needed to counter Soviet military developments, particularly their ability to launch ballistic missiles and to detonate hydrogen bombs.

One of the first tasks at hand was to explain to the public the significance of the Soviet and U.S. entry into space. Many people could not understand how orbital flight around the Earth was possible, and they found its realization threatening. Thus, in its first public report, PSAC found it necessary, in 1958, first, to expound Newton's laws of motion to explain "why satellites stay up," and second to assure the public that the Soviet space achievements did not signal a serious, imminent threat to U.S. national security.[3] In this same report, PSAC outlined the future evolution of the space program, including (under the categories of near-, mid-, and long-term possibilities) the full range of missions that the United States, with time, could adopt as the national space program. The remarkable feature of the report was the very complete characterization of future applications, including manned planetary exploration and a lunar base, both listed as long-term goals, and both still possible as targets for future space activity.

{n those early days of civilian space activity, the principal objectives were to acquire new knowledge, performing specific functions that were enhanced or made uniquely possible by utilizing space platforms, and to strengthen national prestige and self-confidence, badly shaken by a succession of Soviet "firsts" in space. These objectives appeared prominently in the NAS Act, which was prompted by Sputnik and very quickly drafted and signed into law in July 1958.

As is clear from chapter 5, the essential character of the civilian space program has not changed significantly in the succeeding years: we still seek new knowledge about the Earth, the Moon, the Sun, the planets, and the more distant objects in space; we remain active in exploiting applications that make use of the unique vantage point or the unique environment (low gravity, high vacuum) of space; we still attend to exploration and technological "muscleflexing" in programs such as the space shuttle. Perhaps one of the most remarkable aspects of the way the space program has developed is the fact that the opportunities and areas of activity in the space program have not changed appreciably over a quarter century. The developments in space applications, the mission opportunities in science, and the manned space exploration program have largely followed the scenario laid out by the early advisers and space proponents—if anything, they have failed to equal the imagination and vision of these early projections. This suggests that we have not yet penetrated beyond the initial learning phase of space activity to a more mature treatment of and familiarity with space systems, and how they can best serve us.

[3] *Introduction to Outer Space,* report of the President's Science Advisory Committee, 1958.

MAJOR CHARACTERISTICS OF THE SPACE PROGRAM

In order to build a foundation for the analysis of later chapters, this section will highlight a number of important characteristics of the U.S. civilian space program which have been instrumental in setting the stage for current issues.

Open and Public Nature of the Program

As the NAS Act separated civilian and military space activities, the civilian space program was open to public scrutiny from its inception. This characteristic of the program has helped to shape and, in a sense, to constrain the U.S. civilian program. As the public has become more knowledgeable about space capabilities and costs, the objectives of NASA's program have required more detailed justification, more planning, and even some marketing in order to build sufficient public understanding and acceptance. The growing complexity of technology and missions in space applications and science requires more sophisticated public understanding than did some of the earlier programs, As a result, NASA's task of justifying its activities to the public has become more difficult.

Contrasted with the public acceptance and support that NASA requires is the more restricted nature of the decision process for the space program in the military and intelligence arenas. Here, the very large majority of the program is space applications, that is, activities which assist in performing a specific mission or missions and which are therefore amenable to cost-benefit analysis. It is quite often the case that any one of several alternatives may achieve the objectives of a given mission, and that tradeoffs may determine the optimal allocation of resources from among the various alternatives available, For the most part, this decision process takes place in the closed world of the Department of Defense (DOD) or the Central Intelligence Agency. There is, consequently, no need to sell the program to the public, nor do elected public officials participate in the selection, the configuration, or the operation of missions. The important element in this process is the mechanism for generating requirements. The requirements provide a target toward which the technical community can work and by which the proposed system may be evaluated. **It** would be difficult to devise an analogue to this mechanism suitable for use in the civilian program because in the early stages of R&D, civilian users and, perforce, their requirements cannot be identified.

Use of Industry and University Support

From its very beginning, the space program has been a high-technology endeavor, and the average citizen has not easily understood its operative concepts. Early failures in both launch vehicles and satellites dramatized the problems associated with space operations and taught invaluable lessons to those who were actively participating in their development. Practices and techniques that were adequate for most terrestrial systems had to be modified and adapted to the demanding requirements imposed by the space environment. As a result, highly skilled industrial teams were formed. These teams learned to apply specialized manufacturing and environmental specifications and found ways in which they could be satisfied. They also developed a wide variety of associated techniques that could be perfected only through actual space missions. Such specialized knowledge and specialized capability in industry and universities represent a national resource that, if lost, could not be easily duplicated.

An important characteristic of the U.S. program in this regard has been the diversity of industrial, university, and Government resources that were drawn into active participation in all aspects of the program. Through this diversity of resources, there has been enough competition so that new ideas have had an opportunity to surface, space expertise has been acquired by many technical teams, and the entire program has been strengthened. Furthermore, significant diversity has always characterized intragovernment space activities. NASA's predecessor and major constituent element, the National Advisory Committee on Aeronautics (NACA), developed a major field laboratory structure (Langiey, Ames, and Lewis Research Centers), and it promoted valuable cross-fertilization through good working relations with its principal customers—DOD and the commercial aeronautical industry. When space activities began, and the level of effort was substantially raised, in accordance with our commitment to the success of Apollo, NASA elaborated NACA'S pattern: **it** created new government research centers, each playing a major role in program management, and each having unique facilities and a modest in-house research and technology development capability. NASA also enlisted the support of its counterparts in DOD, particularly with respect to launch vehicles (Thor, Atlas, Agena).

With a few notable exceptions, manufacturing and detailed system development were the province of industry, while university teams designed the instruments and experiments, formulated the overall science objectives, and constituted the user community for the space science program. For the most part, the relationships among these contributors have been beneficial and positive. From time to time, however, some concerns have surfaced. For example, the university experimenters complain about the privileged position of their competitors inside the NASA research centers, or NASA headquarters claims it lacks adequate control over the centers. An abiding concern of industry is that they will lose a significant business base from a combination of NASA's shrinking budgets and its desire to maintain an in-house establishment.

Overall, the United States continues to call on and use capabilities that were created as part of the major expansion during the Apollo program. However, shrinking NASA budgets, particularly when inflation is taken into account, have gradually eroded the contractor base supporting the civilian space program. Many contractors now prefer to work on DOD's space program. New civilian activity has slowed overall, particularly in some of the advanced scientific areas. Similarly, universities made significant commitments to space in the early expansionist days, and many specialized university space institutes or laboratories were established. Several factors threaten the ability of universities to continue their support of the space program. These factors include: increasing time intervals between successive launches; lack of funds to support continued data collection and processing of data from satellites after their initial period of operation; reduced funding for exploitation of data already gathered; and increasing complexity and leadtimes between initiation of an experiment and the actual flight opportunity. The support for the space program from universities and industry has enabled the United States to succeed in increasingly advanced and more challenging missions. This base of suport will be the key to the successful performance of commitments yet to be made. Clearly, the vigor of space-related programs in industry and universities is an appropriate subject for periodic evaluation.

Public Understanding

The community most immediately affected by the awesome character of launching artificial satellites were those who operated, constructed, and designed the various interdependent systems. The inception of manned flight brought the wonder of space exploration home to us all. For now our space program had become not only a scientific investigation of a new medium, but a human adventure into the unknown. As the first astronauts were selected, communications media hastened to canonize them as national heroes. Through extensive publicity, particularly live television coverage, people throughout the world followed the early manned flights with great interest. Familiarity with the astronauts, their space vehicles, and the new jargon of the space age led to some understanding of the relevant concepts: weightlessness (or "microgravity"), how satellites and launch vehicles operate, the difference between synchronous and low-altitude orbits, the concept of satellite communciations relay, and Earth observations from space for weather or other purposes, all became topics of casual conversation.

In addition, even rather esoteric subjects of scientific investigation, such as the structure of the Van Allen belts around the Earth, the composition and characteristics of the Moon, and the nature of the planets in our solar system, became matters of general interest. The space program, which began as the province of specialists, generated ever more publicity and discussion, so that the general public was eager to learn of, and participate vicariously in, the planning and flight of new missions.

Yet, even as the public came to understand the first steps into space, succeeding missions and systems became more enterprising: simple instruments were being supplemented by complex devices and systems, plans were made to investigate new objects, and the first surveys of these objects were followed by detailed and highly specialized analyses. In Earth-orbital applications, naive signal propagation and tracking devices evolved into sophisticated relay stations with multiple channel capacity and multiple spot beam retransmission capability; simple cameras and optical scanning devices were complemented by multispectral scanners and infrared or microwave imagers; and the tracking systems were supplemented by laser trackers of high spatial and range precision. The experiments to be performed by the next generation of space missions are even more complex.

Thus, the open and public nature of the civilian space program, coupled with its high technology content, presents a special challenge to policymakers and the leadership in the civilian space community, if there is to be some continued development of public understanding of space missions, program objectives, and the possible returns to be expected.

International Cooperation

It is impossible to discuss the overall U.S. space program without mentioning its international component. From its very beginning, the civilian space program has had an international character. International cooperation in science led to the first satellite launches as part of the multinational International Geophysical Year. The 1958 NAS Act explicitly recognized the objective of fostering international cooperation, and it charged NASA with integrating this objective into the overall program. Yet the consideration which dominated space policy in the early years was competition with the Soviet Union, and policy decisions during this period tended to protect U.S. interests against possible foreign preemption. Our treatment of international cooperation has also varied considerably, depending on the type of activity—space science, applications, or manned flight.

The approach taken to science has favored data exchange, large-scale cooperative experiments where multiple measurements at geographically dispersed locations are involved, and to a very limited extent, foreign experiments on U.S. satellites or use of data acquired by the United States (such as lunar samples). In general, the United States has regarded cooperative efforts in science as less problematic than those in other areas, although it has been assumed that the United States would participate in each area of space science with sufficient vigor so that we would remain in the forefront of current research and would not abandon any area to foreign competition.

In applications, the most notable activity has been the commitment to a single international communications satellite system, INTELSAT, and the creation of a chosen private entity, COMSAT, to represent the United States and, initially, to be technical manager for the system. In this area of commercial interest, many nations had to cooperate if links among the various communications systems were to be established. To this end, the creation of a new international institution seemed the most feasible means. On the other hand, introduction of Earth remote sensing through the experimental Landsat system has not yet required extensive international cooperation, so that no international institution to collect data has been created.Q Of course, there has been extensive international dialog regarding Earth observations, and the sale both of the received data and of ground stations for direct reception of Landsat output are proceeding apace. Thus the Landsat program has not been without substantial international participation or commercial interest. It has been customary for Government to supply meteorological data as a public service, and this practice was continued with weather satellites. As in the case of terrestrial weather observations, free and open exchange of data has been the rule, where the United States makes ground stations available for receipt of U.S. meteorological data. Cooperation has grown in this area, particularly as part of a series of large-scale atmospheric ocean observation programs that gave other nations greater experience and an incentive to create their own meteorological capability at geosynchronous orbit. Navigational aid, also largely a Government service, was originally used to support military (submarine and surface ship) operations, but was later opened to civilian and international users merely by their purchase of the appropriate receiver. A more advanced system of position location is under development; it too will be available to civilian and international users.

Manned space flight, by its nature a very costly aspect of the space program, has been carried out only by the two space superpowers, the United States and the U.S.S.R. With the exception of lunar exploration, the U.S.S.R. has pioneered this area and has flown international

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[4] *Remote Sensing of Earth Resources,* **Panel on Science and Technology Thirteenth Meeting, proceedings before the Committee on Science and Aeronautics, House of Representatives, 92d** Cong., **2d** sess.; **Jan. 25, 26, 27, 1972; No. 13, Washington,** D.C.

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crews with members from Socialist bloc countries. The U.S. program is moving toward international participation in manned flight with the advent of shuttle operations and a manned laboratory payload (Spacelab) supplied by a European consortium. Indeed, the shuttle system is an international cooperative venture, and the shuttle itself may very well be flown by multinational crews. In early manned operations, including Apollo, the need for close contact and global monitoring of flight crews and their capsules required tracking, communications stations, and recovery units around the world. These were part of a large-scale cooperative international framework established by NASA (and DOD) that supported the manned flight program and many unmanned operations as well.

More recently, other nations have designed and begun to test space systems that will compete directly with U.S. projects in communications, remote sensing, and transportation (ch. 7). Thus, cooperation and competition are both present in the international aspects of the civilian space program. As a result, there is a certain flexibility in U.S. space policy, ensuring that analysis and debate will continue.

MAJOR MILESTONES IN SPACE

The following milestones have been selected to illustrate the major issues and characteristics of the civilian space program of the United States and to lay a foundation for a retrospective assessment of our current posture in space.

The International Geophysical Year (IGY)

U.S. participation in the IGY program provided the explicit rationale for entry into civilian space activities. It was fundamental to this participation that the experiments would be open and the results published, consistent with the traditions of scientific research. There would be international discussions and exchange of results, and the knowledge gained would become part of the global scientific literature. in this work, therefore, were laid the foundations for an open and public civilian program with a fundamental objective: expansion of human knowledge. This contrasts with the military and intelligence space objectives —support of the national security of the United States–and the high degree of secrecy associated with most of their activities.

The search for knowledge is still an important objective of the U.S. space program and can serve to link people of diverse cultural and political backgrounds. It involves its own form of competition, but also enables nations to cooperate, leaving a political deposition of value beyond the scientific measurements that are made.

National Aeronautics and Space Act of 1958, as Amended

The basic foundation for the civilian space program is Public Law 85-568, the National Aeronautics and Space Act of 1958. This act was the result of compromise, but represented a victory for those who supported a space program conducted principally by an independent civilian agency. The policy guidance in the act, essentially unchanged from its original form, specified that "activities in space should be devoted to peaceful purposes for the benefit of mankind." It also enumerated a set of broad objectives:

- Expansion of human knowledge.
- Improvement of aeronautical and space vehicles.
- Development and operation of vehicles (spacecraft).
- Study of potential benefits to be gained from aeronautical and space activities.
- Preservation of the role of the United States as a leader in aeronautical and space science technology and their applications.
- Publication of information about discoveries.
- Cooperation between the United States and other nations.
- Effective utilization of the scientific and engineering resources of the United States.

Significantly, the act is silent on responsibilities for operational space systems beyond DOD's role with regard to national defense. By implication, since the "aeronautical and space activities" that are the principal responsibility of NASA, are defined as "research . . ., development, construction, testing, and operation for research purposes of aeronautical and space vehicles, and such other activities as may be required for the exploration of space, " operational roles are expected to be carried out by other agencies. At the time the act was written, however, its framers did not foresee the variety of space applications that are now possible. That the act neither specifies nor precludes operational responsibilities for NASA suggests a pragmatic approach to each functional area and a flexibility in determining which agency should take the lead in operating any given system. (NOAA's current assignment as the lead agency for Earth observational satellite systems in the civil sector may also need reexamination and evaluation in the light of its activities since assuming this role about a year ago.)

This report presents a more detailed summary of the 1958 NAS Act in chapter 3. The following observations are appropriate here, however. The legislative mandate for NASA has had great effect on the institutional configuration of the agency, but has provided little guidance on the pace and content of the program. In some areas, notably space communications R&D and Earth resources systems, the act was of no use in resolving policy differences or in guiding executive branch action. Recent congressional action, such as in the energy area, has been much more aggressive in spelling out the objective of technological programs and giving guidance on the level of intended or expected spending, but not all such efforts represent a good legislative model. Clearly, a balance between a detailed congressional mandate and a restrictive overspecification of the program must be struck.

The Apollo Commitment

No other single event has so profoundly shaped the U.S. space program and current issues as the decision for man to go to the Moon and return within the decade of the 1960's. Much has been written about the personalities and pressures that led to Kennedy's decision, and that discussion will not be rehearsed here. The most important aspects of Apollo for this assessment are its legacy and the issues flowing from that legacy.

The major characteristics of the Apollo proposal were:

- A multiyear joint executive branch and congressional commitment.
- An extremely challenging technological feat, feasible in principle, but with a great many engineering problems, and under a significant time constraint.
- A political measure–aimed at foreign policy goals, national prestige, and self-confidence.
- Commitment to a major expansion in the civil space program and in the institutional base for the program.
- Required contractor teams on a scale not previously attempted.

In the process of accomplishing its goals, NASA added significantly to its laboratory structure, creating a combined Government-contractor work force that exceeded 400,000 people at its peaks Though Apollo dominated the agency's priorities, there was also a presidential commitment to pursue satellite communications and meteorology, and programs in these areas also expanded during the 1960's. During this period, many were strongly attracted to the challenge and the promise of space activity.

However, even before the first successful lunar landing, there were signs of change. NASA budget outlays, which peaked at nearly $6 billion in 1966, began decreasing by almost $500,000 a year for the next 4 years. The total work force dropped from 400,000 to 160,000 in the same period, beginning a period of aerospace unemployment that was to have significant impact on future commitments to manned flight programs. (Of the decrease in aerospace employment over this period, over 220,000 was in direct contractor employment, while only 6,000 was in civil service or direct support service manpower.) A backlash developed in the scientific and engineering professions when individuals found that their opportunities for careers in aerospace were

[5] *The U.S. Civilian Space Program—look* at options. OMB Issues Paper, Oct. 14, 1971.

disappearing. During the peak readjustment period, the political liability of large-scale unemployment in this work force prompted direct, Government-supported, ameliorative measures. As a result of this expansion and rapid contraction in the aerospace industry, political resistance to future decisions causing major disruptions in the work force may be anticipated. (See discussion of the space shuttle decision below).

During the decade of the 1960's, therefore, the overarching commitment to Apollo focused the space program; other space activities throve amidst Apollonian largesse. By the beginning of the 1970's, however, the program had lost its focus, and the continuing projects, all smaller in scope, began to lose their way in the twilight of fiscal restraint.

The large-scale commitment to the Apollo program left a legacy that did not dissipate easily. This legacy, while mostly positive, was also somewhat disruptive because no equivalent subsequent project was identified. National prestige from such an amazing accomplishment continued long after the event, but ordinary citizens soon lost interest in space and began to ask: if we can put a man on the Moon, why can't we . . .

INTELSAT/COMSAT Commitment

Recognition of the importance of space platforms for communications came early in the space program. As the common carrier responsible for long distance communications in the United States, A.T.&T. funded a low-altitude satellite, Telstar, while Hughes Aircraft Co. constructed the Syncom series of satellites, which were intended for synchronous orbit placement. (The concept of a synchronous communications satellite was first suggested in 1945.[6]) With the beginning of the Kennedy administration and a much more activist role for Government in space, however, the role of the private sector was rewritten for the newly created COMSAT Corp., the chosen vehicle for U.S. participation in a commercial communications satellite system (a single, global system). NASA was to support COMSAT with R&D and with launch services, for which the agency was to be reimbursed. The COMSAT Act was passed in 1962, the first stock was issued in 1964, and its first satellite, Early Bird, was launched into synchronous orbit over the Atlantic in April 1965.[7]

In 1964, the INTELSAT Agreements were opened for signature, and COMSAT was designated the manager for the system. INTELSAT provided a means for gaining international agreement on the extent and type of services to be supplied, the charges for such services, the procurement policies, and a host of related matters. In the United States, where there is no single governmental entity responsible for providing telecommunications service, the relationships among the various potential suppliers of domestic satellite telecommunications services are regulated by the Federal Communications Commission (FCC). In 1970, after many years of debate, the principle of open entry and competition for domestic services was announced, followed by specific authorizations of domestic satellite services by FCC in December 1972,[8] which finally opened up the domestic market to a variety of suppliers of such services. The regulatory and commercial environment for domestic communications satellite services continues to change so as to affect the structure of the industry and the relationships among the various services and common or specialized carriers. In addition, maritime services have been initiated, backed by the U.S. Navy's guarantee to lease services from the system for defined periods. An international organization, INMARSAT, somewhat parallel to INTELSAT, was started for support of these services.

U.S. experience in the development of structures to provide services that exploit the capabilities of satellites has been unique from several standpoints:

1. New institutions were established: the quasi-public, domestic corporation, COMSAT, and the international entity, INTELSAT. Both

[6] Arthur C. Clarke, "Extraterrestrial Relays: Can Rocket Stations Give Worldwide Radio Coverage?" *Wireless World,* October 1945, pp. 305-308.

[7] *Communications Statellite Act of 1962,* Public Law 87-624, 87th Cong., H.R. 11040, Aug. 31, 1962.

[8] *Comsat @j& to the Intelsat, Marisat, and Comstar Satellite Systems,* 95 L'Enfant Plaza, S. W., Washington, D.C. 20024.

were important in gaining support and cooperation from other nations.
2. The Federal Government initially provided major support of R&D for communications satellite technology, in accordance with the act establishing COMSAT. The Nixon administration, however, as part of its policy of promoting more activity in the private sector, decided to downgrade NASA's program in satellite communications, terminating demonstrations of new spacecraft and substituting a low-level program of technology development. The Carter administration reversed field: NASA's R&D in space communications was to be returned to a higher level.
3. The aerospace industry played the role of major suppliers of satellites and ground equipment; NASA provided reimbursable launch services.

Before the space age, the communications industry was already well established: the outlines of its structure were fairly clear; the services it provided were well understood; and regulations governing its activities were in place. A new technology, space satellite communications relays, revolutionized the industry: space provided a unique, high-altitude vantage point, to and from which a variety of signals could be transmitted. Consequently, national policies had to be revised in order to cope with the new space systems.

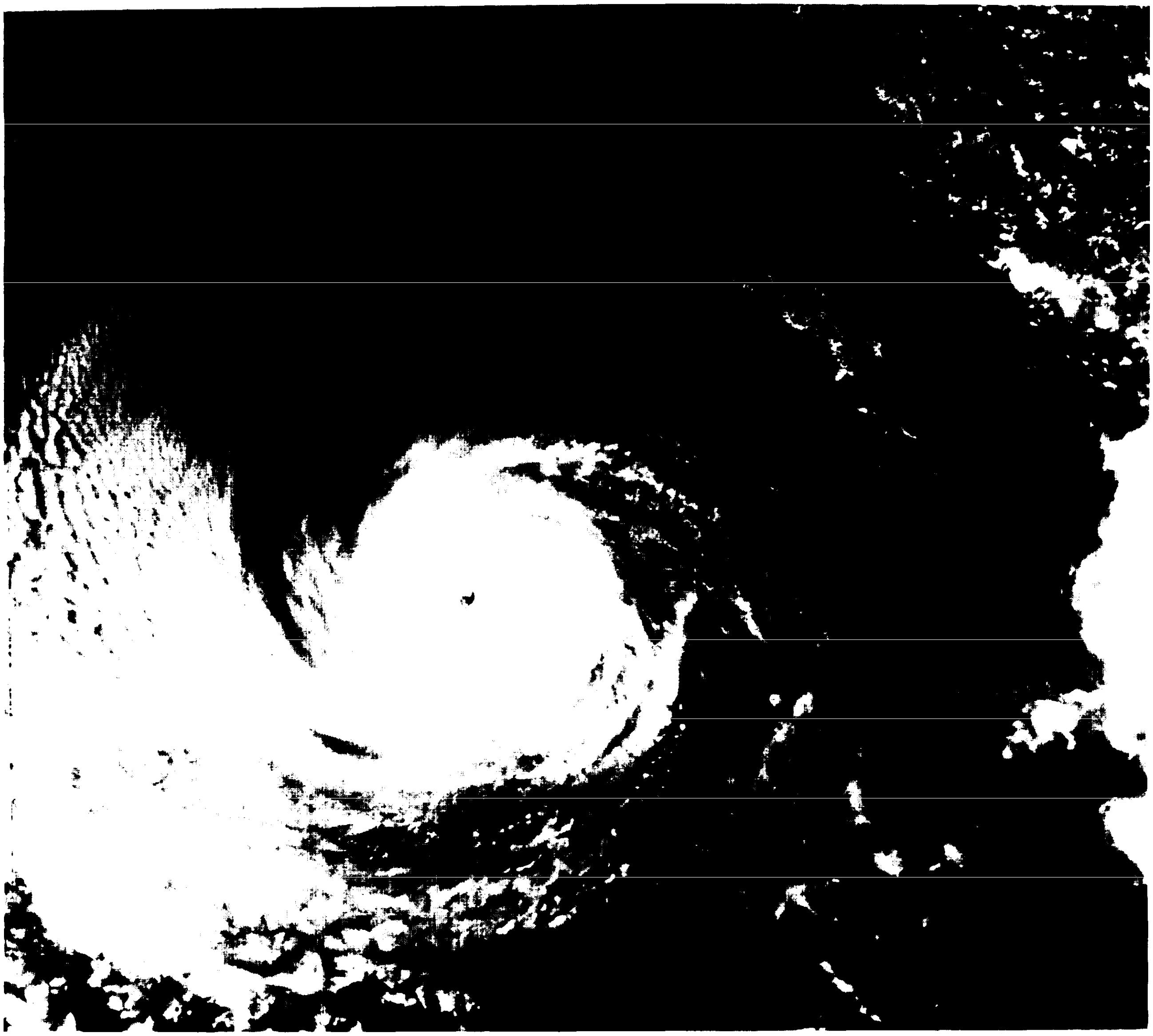
The example of satellite communications shows that NASA's role in the R&D of applications technologies may be interpreted in several ways, depending on an administration's staging of the interaction between the private sector and the agency. This history indicates some lack of clarity in the legislative mandate. Willingness to take risks in forming new institutional arrangements (e.g., COMSAT or INTELSAT) can have a beneficial effect on development of a specific service. An organized user community, the readiness of a given technology, an established tradition of commercial services with an approximate value set for each—all are important factors in determining the success of a space application.

Weather Satellite Services

The use of satellites for global synoptic coverage of the Earth began with the experimental launch of Tires 1 in 1960, as a joint effort of DOD and NASA. This satellite's global cloud coverage pictures were the first in a long series, characterized by incremental improvements in succeeding satellites and by developments in their use in obtaining atmospheric and meteorological observations.[9] Because DOD's requirements were so different from NASA's, two separate meteorological satellite programs—one civilian, one military—were established. NASA's satellites were integrated into the Federal Government's system for providing U.S. users with information regarding local and synoptic weather. These satellites also provided weather data to other nations and to international entities. Here, as well as in other civilian applications services, NASA led the way in identifying appropriate technologies for air and space platforms. In the case of weather satellites, the relationship between NASA and its user agency was a somewhat turbulent one, occasioning considerable interaction and debate before a suitable working relationship was developed. For weather satellite services, NASA functions as a launching agency and also provides (through coordination with the user) the early experimental development of satellite sensors and platforms. These are, at a suitable time in their evolution, incorporated into operational systems for whose management the user agency, currently NOAA, is specifically responsible. (The present good working relationship between NASA and NOAA forms the background for the decision to assign operational responsibility for civil operational Earth resources sensing to NOAA.) The major patterns that emerged from the early experience with weather satellites were:

- Strong ***Government role.*** NASA developed and NOAA operates a primarily civilian service.

[9] *NASA News,* Capsule History of Weather Satellites, Release No. 76-1 46; National Aeronautics and Space Administration, Washington, D.C. 20546,



NOAA's weather satellite (SMS-2) photographed hurricane Katrina off the coast of Baja, Calif., Sept. 3, 1975

- *Weather data distribution is a public service.* Data are supplied to non-Government users at cost of reproduction, the Government bearing the entire cost of development of the system and of collection and dissemination of data.

- *Separate civilian and military weather satellite systems.* Similarity of the measurements taken for the civilian and the military systems prompts periodic review of the standing proposal to join them. These reviews unfailingly conclude that specialized military applications require an independent program. Likewise, the very different requirements of the civilian system—widespread dissemination of uncensored data over various users in the United States, and interaction with the international meteorological community—militate against a merger.

- ***Extensive cooperation with other nations.*** The United States participates in large-scale experiments and provides open and ready access to the results.
- ***Open data policy.*** Data are supplied worldwide to"all users.

Because of the doubtful commercial potential of weather satellite services, the Government's role of operator (as well as developer) of weather satellite systems was not controversial. As a result, the weather program, unlike the Landsat program, has sparked no debate over management structure, data handling, or pace of development. If the data provided by the weather programs were to be of commercial value, they would require additional processing and integration with other, related data. Until the recent COMSAT interest in assuming ownership of the meteorological satellites along with the Landsat system the possibility that the private sector might convert such data collection and interpretation to its own use seemed remote.

The weather satellite program has shown that global cooperation has been most active and effective in meteorological and weather services–areas where commercial and national security interests are muted. Relations among NASA, NOAA, and the user community demonstrate that it is possible to have separate R&D, operational, and user responsibilities, and yet to maintain a viable service. Reasonable technological progress has been made under this arrangement. Separate military and civilian programs have existed because of differing user requirements, and prospects that military and civilian users can make greater use of common data streams, channeled separately to each, must remain subject to periodic review.

Scientific Research and Exploration

As pointed out in the section on the international Geophysical Year, the initial rationale for the U.S. civilian space program was based on the need for scientific research in space. A continuing strong, science-based program has been characteristic of the civilian space effort since its very beginning. There are some important features of the science program that require further comment:

- ***University participation.*** The major participants in science programs have been university-based experimenters who provided the basic ideas for measurements to be made and, in some cases, the basic designs of the instruments to be flown to make these measurements. Commercial interest is almost invisible, and the principal competition for experimenter roles is between government laboratory scientists and university science teams.
- ***National Academy of Sciences.*** [11] The National Academy of Sciences, through its Space Science Board, has done much to set the agenda for space science, identifying both a general rationale for many measurement programs and the specific nature of the most attractive experiments. The Academy's pronouncements have also had a major role in such areas as lunar quarantine and planetary contamination, even to the point of stimulating major investments for such items as a quarantine facility for handling lunar samples and astronauts on their return from the Moon. In planetary programs, the Academy's recommendations were instrumental in determining the criteria for judging the acceptable degree of risk that Earth microorganisms might contaminate a planet's surface. The Academy's influence was reflected in the programs by the requirements for prolonged heat soak sterilization, for spacecraft encapsulization, and for selection of acceptable trajectories of approach to the planet.
- ***International cooperation.*** Historically, the science program has been international in scope, and it appears to be moving toward even greater international cooperation in the

[10] J. V. Charyle, testimony before the Subcommittee on Space Science and Applications of the Committee on Science and Technology, U.S. House of Representatives and the Subcommittee on Science, Technology and Space of the Committee on Commerce, Science, and Transportation, U.S. Senate, July 22, 23, 1981.

[11] *Outer Planets Exploration,* 1972-1985, National Academy of Sciences, Washington, D. C., 1971, and *Opportunities and Choices in Space Science,* 1974, Space Science Board, National Research Council; National Academy of Sciences, Washington, D. C., Nov. 11, 1974.

design of missions and the development of experiment payloads.

- ***Difficulty of keeping project teams.*** As missions become more complex, expensive, and international in flavor, and as the time between mission opportunities grows, it becomes increasingly difficult for U.S. science teams to remain active and involved with the program. Even assuming that only the best teams are retained, there is nevertheless a narrowing of the base from which new experiments and ideas originate, with resultant long-term negative impact on the quality of NASA's science effort. Fewer flight opportunities also may bring about a subtle leaning toward NASA experimenters, although it is intended that there be no bias toward the in-house groups; and
- ***Emphasis on spacecraft.*** The tendency within NASA has been to focus on development and launch of the spacecraft and its payload, and its operation to obtain the desired data. Data analysis and interpretation and continuing exploitation of the information or material from these missions tends to be given lower priority and is almost always in need of greater budget support.

Post-Apollo Planning

In the mid-1960's, planners from NASA joined PSAC, which had kept a close involvement with space policy (despite being overruled at critical points such as the choice of lunar landing mode) to look toward the post-Apollo period and to consider possible courses of action. In February 1967, PSAC published a comprehensive report attempting to answer the basic question, "Where does the Nation go in space in the post-Apollo period?"[12] Consistent with the major emphasis of the civilian program started by Apollo, one of the major preoccupations of that report was the future evolution of the manned flight program, for resolution of this issue would affect the budget more than any other. The advisory panels that drafted the report were acutely aware of the importance of Apollo in stimulating a very vigorous and broad program, and recognized that the next step of equivalent scope would be a commitment to manned planetary exploration. They did not, however, endorse such a commitment. Instead, they recommended a more balanced program in which manned planetary exploration was still very much in the long-term picture, but which would place greater emphasis on unmanned science and applications missions in the short term. Manned flight would continue, but at a much more leisurely pace. Interestingly, the report recommended work toward a space station module in the mid-1970's, but suggested that this date could slip depending on the pace of a national commitment toward manned planetary exploration. The major justification for such a station was long-duration studies of how humans react to lengthy exposure to the space environment. In the foreword to the PSAC report, the President set a conservative tone, stating that the "opportunities in space are great but the costs are high . . . " without endorsing a future program or set of new guidelines.

NASA pressed forward with ambitious plans for post-Apollo lunar exploration, further development of the space station, manned planetary flight options using Apollo-based hardware and exotic new systems, such as the nuclear rocket then under development. No approval of such plans was forthcoming from a Johnson administration that was preoccupied with the costs and public impact of the Vietnam conflict. Thus, the dramatic decline in NASA budgets mentioned earlier began. Although NASA planning was somewhat fragmented among the various program offices and lacked coherence, the problem resulted principally not from a lack of planning, but rather from a failure to generate consensus on what the Nation wanted from its civilian space program and was willing to pay for.

Long-range planning exercises can have a beneficial result because they help to clarify the options and develop consensus on what the next steps should be. However, they have little effect on obtaining political and budgetary commitments, which often appear to depend more on external factors such as national or international crises.

[12] *The Space Program in the Post-Apollo Period*, a Report of the President's Science Advisory Committee, the White House, February 1967.

Earth Observations

The experience gained in flying weather satellites and from military reconnaissance programs (not publicly discussed at that time because of a policy decision to protect the "fact that" such activities were taking place) indicated both the feasibility and value of Earth observations, provided there was sufficient resolution either spatially or spectrally to evaluate the nature of the observed scene. J Since there were multiple uses and users for Earth observation data, and no one single user appeared to have a dominant role or need, there was considerable delay between recognition of the value of satellite remote-sensing observations and the initiation of a program to obtain them from space. There were a number of reasons for this delay. Among them were:

- ***Concern by the national security community*** that there would be some international protests if sufficiently high-resolution civil data were to be collected that would have intelligence/military value. This was resolved by setting a limit on the resolution permitted for any civil system;
- ***Lack of a clear lead agency responsibility.*** The Department of the Interior tried to solve this problem in 1967 by announcing an EROS satellite program for Earth observations primarily of geological interest, but this announcement was made without obtaining White House, Bureau of the Budget, Office of Science and Technology, or National Security Council (NSC) approval. Consequently, it was killed quietly (largely because these approval and coordination steps had not been taken) in the budget process. NASA had the responsibility for the necessary R&D, and the weather satellite experience demonstrated that a suitable working arrangement could be established between the R&D leader and the operator and user. NASA began to exercise this role and pull together the various potential users in connection with the definition of the experimental Earth Resources Technology Satellite (ERTS). But this effort occurred at a time when the general attitude toward space ventures was changing from the expansionary vision of Apollo to a more conservative and cost-conscious approach. The recommendations of PSAC are indicative:

  > . . . a reasonably clear case of potential utility must be made, which includes potential economic benefit, before significant development costs are assumed.
  >
  > .,. space technology has passed the point **where the demonstration of mere feasibility of a particular application has any technological or prestige significance.**[14]

  In this environment, NASA was initially unable to provide credible cost-benefit data and user contributions that would substantiate the need for such a system. Further studies ensued, more user support was enlisted, and still the case for ERTS did not appear persuasive. Finally it was approved, largely on faith that existence of a real data stream from the satellite would stimulate uses (and users) enough to build a positive cost-benefit case to proceed toward an operational system.
- ***Opposition from those who supported aircraft for Earth surveys.*** While not as significant as the factors mentioned above, the active promotion of the use of high-altitude aircraft as an alternative to spacecraft platforms showed the acceptance of satellite remote sensing. The arguments about the relative merits of each approach are not important to this assessment, but it is significant that aircraft data collection would probably have been carried out by one or more private contractors whereas ERTS required NASA management, direction, and participation in data handling, spacecraft operational control, etc. While NASA opposed reliance on aircraft, it nevertheless recognized their value and subsequently organized a substantial high-altitude aircraft program based on the U-2. Of course, the ease of global coverage for a satellite as compared with an aircraft was not contested. It was simply unclear at that

13*A Retrospective on Earth-Resource Surveys:* Arguments About Technology, Analysis, Politics, and Bureaucracy. U.S. Arms Control and Disarmament Agency; Photogrammetric Engineering and Remote Sensing, vol. 42, No. 2, February 1976, Washington, D.C.

14*The Space* program *in* the *Post-Apollo Period,* PSAC, February 1967.

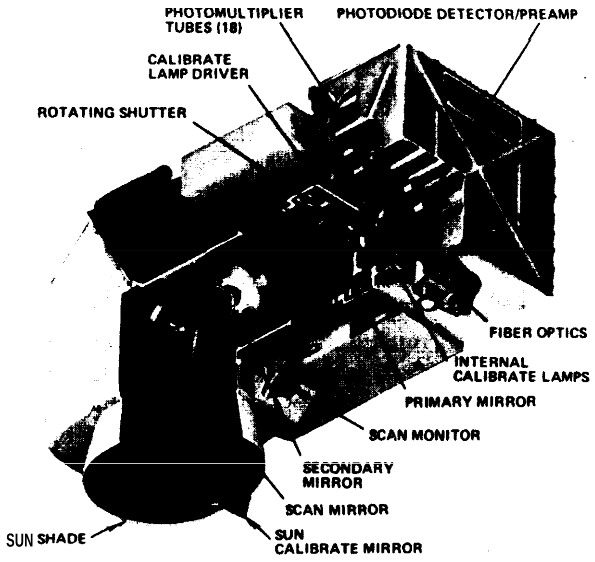


Photo credit: National Aeronautics and Space Administration

Cutaway view of the multispectral scanning system

time how ERTS data on other countries would be collected and used, particularly in a processed or interpreted form.

- ***Lack of an organized user community in the private sector.*** Much of the early interest in Earth observations from space centered in Federal Government agencies whose missions could be accomplished more effectively if satellite data were available. Neither State and local governments nor potential users in the private sector were willing to make early commitments. In each category, there was a typical pattern: the potential user might find the data useful, but was largely incapable of analyzing his needs or even of conducting the research necessary to understand them more adequately. Therefore, NASA was funded to support a wide array of user experiments as part of ERTS-1, in order to improve the base of understanding of the value of the satellite output. (Lack of an organized and established user community for ERTS, or Landsat, as it was renamed, contrasts with the situation for early space telecommunications services where the entities for long-haul telephone services already existed. Similarly, there has been no institutional innovation for Earth sensing, either nationally or internationally, as there was in the case of COMSAT and INTELSAT.)

Space Task Group

At the beginning of the Nixon administration, the Apollo program was rapidly coming to a successful close, but no clear definition of a post-Apollo space program had emerged. Early planning efforts had failed to yield a consensus, and space program budgets had decreased dramatically, presenting the new administration with growing unemployment in the aerospace industry as well as a major technological agency that did not have clear signals regarding its future. in order to address these problems, the presidential Space Task Group (STG) was established under the chairmanship of the Vice President. The STG review was the first comprehensive interagency planning effort that was carried out with respect to the civilian space program. It also included a component directed toward future military applications in space and was subject to special security classification restrictions. Its principal focus, however, was on the future nature and pace of activities in connection with the civilian manned space flight program, While NASA's leadership was not particularly pleased to have its future programs become the object of an interagency planning effort, it recognized the need for broader consensus regarding its future objectives, particularly because the new administration had made no budget commitment. (This lack of budget commitment was a continuation of the trend that had begun in the Johnson administration.) The assignment for STG included taking a rather long-range perspective extending out through the decade. As in the earlier review by the PSAC, a key issue was the question of whether to propose a new manned mission to the planets.

In their recommendations, STG recommended commitment to a balanced program that included science, applications, and technology development objectives, but no immediate commitment to manned planetary missions. They sug-

1 [5] *The Post-Apollo Space Program: Directions for the Future*, Space Task Group Report to the President, September 1969.

gested no change in institutional structure nor an operations role for NASA. Emphasizing international cooperation, STG was given special emphasis and it was suggested that NASA should give greater attention to possible cooperative opportunities. The major technological development STG suggested was the reusable space shuttle system that could eventually lead to development of a permanent space station. The clear priority was for shuttle development first, with space station modules as a potential future technical development. Manned planetary exploration was retained as a long-range option for the civilian space program with a "manned Mars mission before the end of this century as a first target."

STG presented a number of budget options in connection with these recommendations, permitting the program that was recommended to be carried out at several rates. The response to STG recommendations was not immediately forthcoming. The President's advisers, faced with other serious budget and international relations problems including the Vietnam conflict, deferred action on the basic recommendations until the subsequent budget cycle. At this point, in a very general response to the recommendations, the clear image of a relatively conservative and constrained program emerged. New mission commitments were folded into a general ceiling for the agency that was established at slightly above $3 billion.

The Space Task Group effort was notable for a number of reasons:

- It was the first major interagency planning effort with regard to the civilian space program.
- It involved participation from the general public as well as agency representatives.
- OMB was involved, with the explicit reservation that its participation would not preclude its normal budget review and analysis when specific budget requests were proposed.
- It was comprehensive in including both DOD as well as NASA interests, particularly with regard to launch vehicles.
- it took a long-term view, specifically focusing on the next decade.
- It did not attempt to seek a single consensus on the program level, but rather provided a number of options from which the President could select.

STG provides an interesting example of the difficulty of making long-term plans for the space program. The administrator of NASA was obviously in a position that he would have rather avoided (it being certainly less difficult to deal with a single OMB review on the budget and program than to obtain consensus from an interagency group, several members of which may have competitive objectives). Hence, STG represented, on the surface, a very difficult forum for presentation, analysis, and eventual development of a consensus on the NASA program. In this forum, the view of both NASA and DOD representatives tended to favor continuing large-scale space investments with a multitude of new systems identified by their technical laboratory and supporting contractor structures. A more restrained note was set by OMB and OSTP representatives. As the deliberations in STG proceeded, the question of a major new focus for the civilian program in the next decade, equivalent to the role that Apollo played in the previous decade, became a major issue.

In general, STG believed that the technology existed for a manned Mars mission and that such a mission, if accepted as a new goal, could serve to energize and focus attention on the space program in a beneficial way. The Vice President became convinced that such a mission would be an exercise of leadership which he viewed as missing from the space area and he supported this goal as a target. He was not able to convince the remaining members of the task group that this goal was realistic, and acceptable to the public, but it was endorsed in a somewhat ambiguous way as a "potential" goal or "option" for the program. In this way, it could serve to guide decisions regarding the development of new capability for man in space. In STG'S recommendations, the terminology was chosen very carefully in order to maintain an option for the Vice president and the Administrator of NASA to make further appeals that would support their program objectives and yet have a report to the President that all STG participants could approve. In addition, there were certain "code words" that were used that had considerable significance beyond their direct connotation. For example, the use of the term "new capability" implied very specifically a development program that would involve a manned, reusable launch vehicle as the first major element. On completion of this first development, the next major commitment would be to a continuing orbital habitat for man, i.e., a space station. The order in which these new systems would be developed was a major source of controversy within STG, and the eventual agreement on the shuttle as the first element represented a major change in direction within NASA.

The space shuttle appeared to be a logical and most effective way to maintain the capability for continuing use of man in space while simultaneously providing a capability for launch and recovery of unmanned space payloads as well. At the time, the space shuttle was not completely defined, but its essential and desirable operating characteristics were clearly spelled out.[16] The alternatives for maintaining a manned flight capability were: continued use of Apollo hardware in the future, wherein the cost and reliability of each succeeding hardware set would become more difficult to predict; or the development of a new capsule and launch vehicle combination such as the Titan III, a modified Gemini system.

Overall, STG accomplished several important objectives. It clarified the nature of the major options facing the Nation with regard to the space program. it identified the rough costs associated with pursuing many of these options. It suggested several new emphases for the space program (international cooperation, new systems that were reusable) and the increased development of applications. it made a clear call for continuing the man in space program and suggested the logical steps in that program. However, it did not proclaim a specific new Apollo-type goal. As a consequence, in the minds of many space enthusiasts, it did not go far enough. On the other hand, to those who were concerned about the magnitude of space expenditures and questioned the value gained from those expenditures, the STG report appeared to be too optimistic, too positive regarding the nature of new space opportunities. This ambiguity permitted individuals with somewhat different perspectives to see in it what they wished to see while the report retained some of its essential characteristics. Specifically, it permitted the Vice president to advocate a vigorous new commitment such as a manned mission to the planets before the end of the century and OMB to look at a program which eventually was projected at a very modest continuing budget level. STG issued its report as a public document after briefing the President, and it was in this period that public and congressional response was evaluated to determine the nature of the commitment that could develop around the concepts that were proposed. It was only later, in the context of specific budget reviews, that the decisions would be taken on the STG recommendations.

Interagency reviews can serve to build a constituency for space program initiatives. For example, the STG recommendation focused attention on the space shuttle program as the next major step in technology development. NASA in-house planning exercises do not appear to have the same effect. A key element is participation by elements of the Executive Office of the President in order to bridge the communications gap from agency to President. Such reviews are not sufficient to generate a political commitment to costly new programs, but may be a necessary precursor.

The Shuttle Decision

In the period immediately after the STG report, NASA programs continued with no major new commitment to a new development. During this period, the attention of the agency was focused on completing revisits to the Moon using already developed and purchased Apollo hardware, and using a modified version of this hardware in a prototype manned habitat called Skylab.[17] Skylab was an effort to stretch the utility of Apollo hard-

[16] *New Space Transportation Systems,* an AIAA assessment, Jan. 9, 1973. American Institute of Aeronautics and Astronautics, 1290 Avenue of the Americas, N. Y., New York 10019.

[17] *America's New Decade in Space,* a report to the Space Task Group prepared by National Aeronautics and Space Administration, September 1969.

ware, demonstrate manned flight in Earth orbit over a prolonged period, and perform a number of operations, including observations with a solar telescope, During this period, NASA was given initial exploratory funding for the space shuttle design and early development work on a new liquid hydrogen-liquid oxygen, high-pressure rocket engine that would be suitable for a shuttle. The need to make a major commitment to the shuttle came to a focus in the context of the review of the fiscal year 1973 budget that was carried out in the fall of 1971. At that time, the reelection campaign of 1972 loomed on the horizon for the Nixon administration. Also at that time, unemployment in the aerospace industry was a major political embarrassment, and the review of the NASA program in the fall of 1971 gave particular attention to the short-term employment picture. NASA was by this time committed to a shuttle development program as the next major step in the advancement of space technology. Also developed by NASA was a major economic evaluation of the shuttle based on an elaborate mission model that projected missions in various categories of activities out through the end of the decade. In NASA's presentations, the economic benefit of proceeding with a space shuttle was part of its argument in favor of adopting this program. To the analysts in OMB, however, this argument was unpersuasive, because, in part, shuttle development costs were highly speculative and the mission model contained a large number of questionable assumptions about the civilian program. In the analysis for the fiscal year 1973 budget, the major issue was whether or not the United States should continue with a manned flight program, and if so, with what technical systems. OMB concluded that the United States would derive a majority of the benefits from space activities without a manned flight component. However, this decision would have had dramatic impact on the nature of the NASA establishment (resulting in the closing of at least two major centers) and would have lowered NASA budgets to approximately $2 billion or less per year. At this rate, there could still be a very vigorous unmanned science and applications program. Manned flight, on the other hand, could be continued, either with modified and extended Apollo hardware, with a new-generation space capsule, or as part of a space shuttle program in which man would be involved both as a pilot and as a participant in Earth-orbital experiment programs (including the launch and recovery of unmanned satellite systems from low-Earth orbit).

A firm commitment to the space shuttle remained an open question until the very last Presidential decisions were being made on the fiscal year 1973 program. During this period, the employment impact of a positive decision on the shuttle was analyzed in great detail. In January 1972, the President made a well-publicized commitment to a space shuttle development program. This commitment was constrained by some key guidelines:

- The shuttle would be carried out under a budget target rather than on the basis of a schedule that had to be met. The budget target that was eventually agreed to was for a considerably scaled-down shuttle from the one originally projected by NASA, with a development program cost targeted at slightly over $5 billion in constant 1971 dollars.
- The shuttle was expected to be a "national" program, that is, it would serve all agency launch needs for payloads that were in the shuttle range. Specifically, this requirement implied that NASA and DOD would need to define a common, acceptable payload bay size, operating characteristics, and compatible subsystems. (At the time, the questions to be resolved included whether DOD would have its own shuttle orbiter, whether DOD would have its own crews, whether classified payloads would be incorporated with an unclassified payload, etc.) The major premise was that such a substantial investment in a new technological capability could not reasonably be made unless it would serve or be capable of serving the broadest set of national needs.
- The initial concept included the possibility that DOD would assume some degree of funding responsibility for shuttle development. This was subsequently modified in view of the rather substantial DOD budgets already in existence for other weapons systems and space developments. **It** was agreed

that DOD's share of the program development costs would be limited to DOD funding for the west coast launch site for the shuttle and a companion interim upper stage development for boosting shuttle payloads into higher orbits.

- International cooperation in the shuttle program was also an objective; it was satisfied by the eventual agreement that the Europeans would construct a laboratory module to be carried as a shuttle payload.

The shuttle decision was a multiyear development commitment, not as aggressive or substantial as NASA would have liked, but yet ensuring the continuing utilization of the technical development and management capabilities of the Johnson and Marshall Space Flight Centers and a new development activity for the Kennedy Space Center. Most viewed the shuttle as a program that would act to stimulate some technology development, but would not be so complex or difficult to achieve as to be threatened by major overruns or schedule delays. The shuttle had great potential for changing the way people would think about placing payloads into space; e.g., it would change the design of these payloads to allow reuse and repair, it would permit human tending and space checkout prior to launch into orbit, it would increase the flexibility of space operations to allow larger crews and potentially less-trained scientific personnel to conduct operations in space, and ultimately it would be the key to any continuing Earth-orbital habitat for man, since it would provide resupply at a much more reasonable cost than use of expendable vehicles.

On the negative side, the President and Congress recognized that initiating shuttle development and terminating the limited program utilizing existing Apollo hardware would result in a hiatus in manned flight for a period of 4 to 5 years. During this period the Soviet Union would have an opportunity to initiate new space spectaculars with uncertain international and domestic political impact. The commitment to substantial shuttle development funding within a constrained NASA budget implied an additional problem. As part of the shuttle commitment, NASA was given some assurance it could plan on level budgets, in constant dollars, for the duration of the shuttle development program. Thus, growth in shuttle funding requirements would have a tendency to squeeze out other new programs. It was this aspect that was viewed with great alarm by those who supported greater emphasis on space science and applications activities. Thus, the shuttle decision was not a completely happy one in this community. One of the most important lessons to be learned from the shuttle decision is that a commitment to continued manned space flight has the greatest budget impact and is the most politically driven part of the space program. Such factors as aerospace employment or national image therefore have a strong bearing on

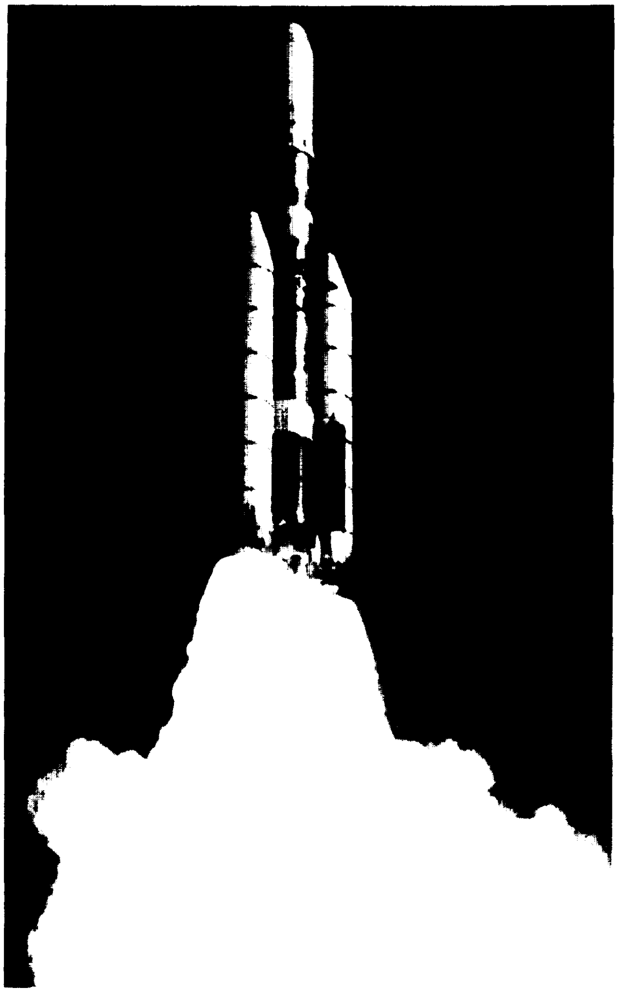


Photo credit: Nationa/ Aeronauts and Space Administration

Air Force *Titan ///-C* lifting off to **launch Applications Technology Satellite 6, May 30, 1974. The first** in a **generation of NASA communications satellites**

decisions that are made and must be factored into the technical aspects.

Communications R&D Decision

NASA responsibility for a leadership role in developing space capabilities, performing the necessary R&D in all of the areas of interest involving space systems, had included an early and substantial role in developing the basic technologies that were vital to the increasingly sophisticated civilian communications satellite business. These technologies were demonstrated in a series of applications technology satellites. The technologies included advanced stabilization techniques, the control of satellite position in synchronous orbit and, in the last satellite of the series, a demonstration of broadcast technology from the satellite to small, low-cost ground stations.

The second of these broadcast satellites that was scheduled to be launched was terminated by OMB. Additionally, OMB acted to reduce significantly the role of NASA as developer and demonstrator of advanced satellite telecommunications technology. The leadership for this change in emphasis came from the Office of Telecommunications Policy (OTP) and was consistent with the trend to place greater responsibility in the private sector for telecommunications systems developments. The assumption underlying this decision was that NASA's contributions were not necessary to maintain the sophistication of current and projected communications satellite systems. In addition, OTP believed that the revenues obtained from satellite communications to support work in the industry at such technical centers as the COMSAT Laboratories were sufficient to enable incremental improvements to be made during the foreseeable future. DOD's R&D role in telecommunications satellites was not similarly reduced, and it was expected that DOD would continue to support technology advances in this area.

The most immediate effect of the decision was to stimulate the technology development activities of a number of potential foreign competitors in the telecommunications satellite area, because the basic approach of U.S. industry was to continue to exploit the proved technologies that were available and to package these technologies in larger and more capable satellites. Thus, in the intervening years, the telecommunications technology advancements that were typically a responsibility of NASA have for the most part not occurred in the United States. Starting from a very inferior technological position, the Europeans and the Japanese have built considerable competence in this field, and in some areas appear to have leapfrogged U.S. technology.

The decision of the Carter administration to return more responsibility to NASA for R&D in satellite communications provided, somewhat belatedly, that the agency would again assert itself in this field as an agent for technology push. NASA has interpreted its charge to mean that satellite systems initiated under this new, invigorated program should have a potential direct application; the agency expects industry to support these programs to some degree. The current plan includes, first, development of collaborative agreements certifying to OMB that industry's interest is genuine, and second, provision that any demonstration system, if successful, may have a direct application,

Without Government support for high-risk applications systems R&D, the competitive posture of the United States may slip vis-~-vis other nations that do subsidize their industry. The current legislative authority for NASA does not preclude major reductions in its role as a sponsor of advanced R&D, suggesting an opportunity to clarify the meaning and significance of "leadership in aeronautical and space activities" as stated in the NAS Act,

President's Space Policy Statement of 1978

In october 1978, President Carter released a space policy statement that summarized the important aspects of the administration review of space policy and provided guidance regarding the President's view of national objectives in the space program over the next several years. This statement reaffirmed endorsement of a balanced space program and committed the administration to the continued development of the space shuttle system and its use during the coming decade. However, the statement made no new commitments and specifically rejected any major new technological development. No multiyear program or goal was set to provide a focus for the program and the general philosophy was best characterized by the statement that "activities will be pursued in space when it appears that national objectives can most efficiently be met through space activities. " Overall, the policy statement left many questions unanswered. It made several statements about what the United States would not do in space but remained very general regarding the nature of what we would do in space. In addition, it became clear that fiscal constraints were likely, and as a consequence, commitment to specific multiyear programs was very likely to be taken only with great care. This announcement was received with some dismay by the congressional leaders involved with the space program and by the aerospace community. This concern spawned a number of hearings and proposed legislative approaches to a more vigorous space policy for the United States and led to the request to. OTA for the current assessment.

NSC Policy Review Committee (Space)

The review of space policy undertaken by the Carter administration revealed that there was no procedure for adjudicating interagency disagreements about space issues. To remedy this defect, a policy review committee chaired by the Director of OSTP was established within the NSC structure to address such issues as might arise. This role had previously been played by the National Aeronautics and Space Council until it was abolished in 1973. An important consequence of utilizing the NSC structure is a rather strong orientation towards national security and military affairs. Issues arising in the civilian space program often have international importance, but as a matter of practice, they have been considered separately from those concerning national security or the military space program. The placement of this mechanism under the NSC provides a somewhat different flavor to the approach to civilian space policysetting. It is also important to note that this mechanism is intended to provide a means for resolving issues but not to provide planning or goal setting for space activities.

An alternative to the NSC structure would have been to conduct space policy review under the auspices of the Federal Coordinating Council for Science, Engineering, and Technology, a group that has a parallel function and is also chaired by the Director of the OSTP. The Federal Council has a charter, and is specifically charged with the coordination of activities among the principal agencies performing R&D, the recommendation of policy, and associated questions. Yet this mechanism was avoided in favor of the NSC setting. In part, this recognizes the great importance of space to the national security, the greater influence of the NSC, and the fact that the space policy review originally arose in the context of an issue regarding civilian/military space relationships.