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Practical Applications of Space Systems

Supporting Paper 10

Institutional Arrangements

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A Panel Report Prepared for the

Space Applications Board

Assembly of Engineering

National Research Council

PREFACE

In November 1973, the National Aeronautics and Space Administration (NASA) asked the National Academy of Engineering* to conduct a summer study of future applications of space systems, with particular emphasis on practical approaches, taking into consideration socioeconomic benefits. NASA asked that the study also consider how these applications would influence or be influenced by the Space Shuttle System, the principal space transportation system of the 1980's. In December 1973, the Academy agreed to perform the study and assigned the task to the Space Applications Board (SAB).

In the summers of 1967 and 1968, the National Academy of Sciences had convened a group of eminent scientists and engineers to determine what research and development was necessary to permit the exploitation of useful applications of earth-oriented satellites. The SAB concluded that since the NAS study, operational weather and communications satellites and the successful first year of use of the experimental Earth Resources Technology Satellite had demonstrated conclusively a technological capability that could form a foundation for expanding the useful applications of space-derived information and services, and that it was now necessary to obtain, from a broad cross-section of potential users, new ideas and needs that might guide the development of future space systems for practical applications.

After discussions with NASA and other interested federal agencies, it was agreed that a major aim of the "summer study" should be to involve, and to attempt to understand the needs of, resource managers and other decision-makers who had as yet only considered space systems as experimental rather than as useful elements of major day-to-day operational information and service systems. Under the general direction of the SAB, then, a representative group of users and potential users conducted an intensive two-week study to define user needs that might be met by information or services derived from earth-orbiting satellites. This work was done in July 1974 at Snowmass, Colorado.

For the study, nine user-oriented panels were formed, comprised of present or potential public and private users, including businessmen, state and local government officials, resource managers, and other decision-makers. A number

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*Effective July 1, 1974, the National Academy of Sciences and the National Academy of Engineering reorganized the National Research Council into eight assemblies and commissions. All National Academy of Engineering program units, including the SAB, became the Assembly of Engineering.

of scientists and technologists also participated, functioning essentially as expert consultants. The assignment made to the panels included reviewing progress in space applications since the NAS study of 1968* and defining user needs potentially capable of being met by space-system applications. User specialists, drawn from federal, state, and local governments and from business and industry, were impaneled in the following fields:

Panel 1: Weather and Climate
Panel 2: Uses of Communications
Panel 3: Land Use Planning
Panel 4: Agriculture, Forest, and Range
Panel 5: Inland Water Resources
Panel 6: Extractable Resources
Panel 7: Environmental Quality
Panel 8: Marine and Maritime Uses
Panel 9: Materials Processing in Space

In addition, to study the socioeconomic benefits, the influence of technology, and the interface with space transportation systems, the following panels (termed interactive panels) were convened:

Panel 10: Institutional Arrangements
Panel 11: Costs and Benefits
Panel 12: Space Transportation
Panel 13: Information Services and Information Processing
Panel 14: Technology

As a basis for their deliberations, the latter groups used needs expressed by the user panels. A substantial amount of interaction with the user panels was designed into the study plan and was found to be both desirable and necessary.

The major part of the study was accomplished by the panels. The function of the SAB was to review the work of the panels, to evaluate their findings, and to derive from their work an integrated set of major conclusions and recommendations. The Board's findings, which include certain significant recommendations from the panel reports, as well as more general ones arrived at by considering the work of the study as a whole, are contained in a report prepared by the Board.**

It should be emphasized that the study was not designed to make detailed assessments of all of the factors which should be considered in establishing priorities. In some cases, for example, options other than space systems for accomplishing the same objectives may need to be assessed; requirements for

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*National Research Council. *Useful Applications of Earth-Oriented Satellites, Report of the Central Review Committee.* National Academy of Sciences, Washington, D.C., 1969.

**Space Applications Board, National Research Council. *Practical Applications of Space Systems.* National Academy of Sciences, Washington, D.C., 1975.

institutional or organizational support may need to be appraised; multiple uses of systems may need to be evaluated to achieve the most efficient and economic returns. In some cases, analyses of costs and benefits will be needed. In this connection, specific cost-benefit studies were not conducted as a part of the two-week study. Recommendations for certain such analyses, however, appear in the Board's report, together with recommendations designed to provide an improved basis upon which to make cost-benefit assessments.

In sum, the study was designed to provide an opportunity for knowledgeable and experienced users, expert in their fields, to express their needs for information or services which might (or might not) be met by space systems, and to relate the present and potential capabilities of space systems to their needs. The study did not attempt to examine in detail the scientific, technical, or economic bases for the needs expressed by the users.

The SAB was impressed by the quality of the panels' work and has asked that their reports be made available as supporting documents for the Board's report. While the Board is in general accord with the panel reports, it does not necessarily endorse them in every detail.

The conclusions and recommendations of this panel report should be considered within the context of the report prepared by the Space Applications Board. The views presented in the panel report represent the general consensus of the panel. Some individual members of the panel may not agree with every conclusion or recommendation contained in the report.

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INTRODUCTION

The National Aeronautics and Space Act of 1958 (P.L. 85-568) established, as national policy, that aeronautical and space activities of the United States "should be devoted to peaceful purposes for the benefit of all mankind." The National Aeronautics and Space Administration (NASA) was charged with responsibility to:

"(1) plan, direct, and conduct aeronautical and space activities;

"(2) arrange for participation by the scientific community in planning scientific measurements and observations to be made through use of aeronautical and space vehicles, and conduct or arrange for the conduct of such measurements and observations; and

"(3) provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof."

The progress made in fulfilling these charges serves as a dramatic example of what can be achieved in a carefully planned, well-managed, and technically sound national effort relying on the capabilities of all sectors of the nation. Less than a decade and a half after passage of the act initiating the U.S. space program, an entirely new technological capability had been developed and demonstrated. It provided an important extension to our ground, air, and sea capabilities for a wide range of uses that benefit mankind. Indeed, operational satellites have already significantly changed technological approaches in the fields of weather and communications and have had beneficial influences throughout the world. Space systems that survey earth resources are serving experimental uses, clearly demonstrating the capability of providing large amounts of information about a wide variety of dynamic characteristics of the earth.

The U.S. and the rest of the world, however, have only scratched the surface of potential useful applications of space technology. The United States has not yet committed itself to a program designed to assure the widest practicable useful application of this new capability "...devoted to peaceful purposes for the benefit of all mankind."

The Panel on Institutional Arrangements believes that space systems capabilities are now at the stage where an effort to apply those capabilities is warranted. Achieving full return on U.S. space investments will require a deliberate program to apply space systems (1) as a supplement to existing ground, sea, and air systems, (2) as a more effective alternative to present methods, and (3) as a means of providing previously nonexistent capabilities. The Panel recognizes that such an effort will require continuing federal investment in technological research, development, and demonstration activities. The Panel believes that federal funding will be required -- and should be provided -- for many user-oriented institutional and infrastructure developmental activities that will constitute a major part of this new phase of the national space program. In this phase, the Panel believes it is necessary to encourage funding as well as in-kind support from state and local governments and from private organizations that in many cases will be the implementers in applying space technology.

In defining institutional arrangements to assure the widest practicable application of space systems, the Panel has considered a number of factors. Among them are the following:

Many federal, state, and local government agencies, private groups, and international organizations are involved in activities that can benefit from space systems.

There are very few fields in which the potential user community (users within federal, state, and local government and agencies in the private sector) is sufficiently well aggregated to assure that user interests and needs can be adequately represented by a single group. Generally, it is difficult for interested federal agencies or even bureaus within one agency to agree that any one of them can speak for the needs of all. Nonfederal users also are not generally prepared to accept one member as representative of all.

The ability of users to understand the significance of space systems and space-derived data and to apply them in their operations varies widely. Some individuals and organizations interested and technically competent consider as *operational* their use of information or services provided by space systems that actually are experimental and developmental. At the other extreme there are large numbers of potential users who have never considered whether or not space systems can be of help in their activities, and in fact have no idea what is available. Perhaps the greatest problem is to provide, to an organization that has attained a position of technical leadership using long-standing and well-developed techniques, a basis upon which to objectively evaluate the possible benefits of switching to new techniques based on space systems.

Users generally are reluctant to discard their existing systems and methods and even to try using new systems based on spacecraft unless they are reasonably assured that there will be continuity in the data or services provided by the satellites. The usefulness of the information or services which spacecraft provide can be most accurately

assured by encouraging the involvement of potential users. The resulting feedback should assist in judging the potential benefits from use of the space system. This is the normal market evaluation process used by industrial organizations.

From the experience already gained in using the products of the first earth resources technology satellite, and with the capabilities that the space shuttle and its space laboratory will provide, it seems clear that each spacecraft or each manned flight mission can serve many different users. For such multiple-use spacecraft or missions, however, there do not exist adequate institutional arrangements for establishing payload priorities, guaranteeing users an input to spacecraft and mission definition, and coordinating user requirements. Integration of the requirements of multiple users and evolution of realistic mission plans for space systems will be sufficiently complex and costly to make it essential to have an effective and disciplined mechanism for feedback and negotiation on mission characteristics, costs, optimum arrangements of sensors, scheduling, etc.

As should be expected, especially in view of tight federal budget constraints and current economic problems, the Office of Management and Budget (OMB) is skeptical of efforts to establish any operational space system capability until hard assessment has been made of potential benefits in relation to costs. The OMB tries to assure that options for program and budget determination are not foreclosed by implied or explicit operational commitments.

Data from the Department of Defense (DOD) space missions are not generally available for use by civilian federal, state, and local governmental agencies and by commercial and other private users.

To date, charges to users of space-derived data have covered only direct costs, for example, the costs of pictures or tapes. However, when programs proceed from the experimental to the operational stages, it may be appropriate to increase user charges to cover costs of increasing capability to provide data and to conduct special missions for particular users. It must be noted, however, that pricing policy could have significant impacts beyond the simple raising of revenue. Pricing policy could be used to shape the transition from research and development to operational uses. For example, a price which just recovers out-of-pocket reproduction costs during the research and development stage could encourage transitional use while a higher price in the operational stage could help recover system costs.

In addition to the above factors, the Panel also took into consideration numerous established practices and existing agreements, as well as relevant organizational experiences. Nevertheless, the Panel recognizes that its analysis is not a complete one. Time did not permit the Panel to deal with certain specific and detailed issues that arise from the work of various other Panels. For example, there are clearly institutional barriers to direct broadcasting from satellites to individual homes in dispersed and sparsely populated areas,

as suggested by the Panel on Uses of Communications for certain public services; to international banking systems based on use of satellites to relay data, as also considered by the Communications Panel; and to some of the activities envisioned by the Panel on Materials Processing in Space.* Substantially more study is needed of such issues. More analysis is also needed to define institutional requirements adequate to permit practical applications of space systems to achieve fully their potential.

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*See also *Practical Applications of Space Systems, Supporting Paper 2: Uses of Communications*, and *Supporting Paper 9: Materials Processing in Space*. Reports of the Panels on Uses of Communications and Materials Processing in Space to the Space Applications Board, National Research Council. National Academy of Sciences, Washington, D.C., 1975.

PHASES IN THE EVOLUTION OF SPACE SYSTEMS USES OR APPLICATIONS

In the months immediately following the launch of the first man-made earth satellite, the concern of the nation was with developing a capability to do things in space, and the National Aeronautics and Space Act of 1958 accordingly placed major emphasis on research and development associated with the exploration of space. Space activities now range from research and development to operational systems, so that a broader view of the scope of the national space program is required. In its deliberations, the Panel on Institutional Arrangements identified three distinct phases in the evolution of space systems, each requiring different institutional arrangements. The phases are (1) research and development, (2) transitional, and (3) operational.

RESEARCH AND DEVELOPMENT PHASE

The R&D phase is that phase in which the required technology is acquired, system characteristics are determined, experimental systems are developed and launched, and the systems and technological capabilities are tested and evaluated. Typically, in this phase scientific Principal Investigators (PI) suggest techniques to be tested for their capability to aid in carrying out a particular disciplinary research interest. The PI -- an experimenter -- is, in fact, the "user" of the space system in this phase, and the scientific community is encouraged by NASA to participate in the PI process. At this stage, NASA has typically viewed as additional "users" other federal agencies which have programs closely related to the capabilities of the experimental space system: for example, the National Oceanic and Atmospheric Administration (NOAA) for weather, the Department of Agriculture (USDA) for agricultural research, and the Department of the Interior (USDI) for mineral resources, range management, and forestry. It should be noted that the R&D phase is not always clearly defined, since users frequently consider the early space systems to be providing operational information and capabilities in terms of their particular needs, when actually they are still regarded by the the developers as experimental.

TRANSITIONAL PHASE

Nearing the end of the R&D phase, user classes may begin to be recognized and it may be possible to postulate or even define missions. An important

constraint to further progress is that the capabilities of the technology and the requirements of the potential users are not yet well matched. The user market is neither fully identified nor developed. There is then, what the Panel defines as a transitional phase.

During the transitional phase, the emphasis shifts from experiments in technology to experiments in putting the capabilities of the space system to practical use. Demonstration projects, which give potential users an opportunity to try the new capabilities, are implemented but users do not have to abandon conventional techniques and commit to dependence on the space system. Potential users must test and evaluate the application of space systems to their particular needs. Equipment and operating procedures advance out of the experimental stage toward the "off-the-shelf" status needed for the operational phase, and the management and institutional arrangements make such a transition as well. The market -- the potential users and the manner in which they will use the new capability -- becomes better defined. In this phase preliminary benefits from demonstration projects can be assessed to provide a basis for operational investment decisions.

OPERATIONAL PHASE

Toward the end of the transitional phase, it has been demonstrated that the technology is reliable, key potential users have been identified, and capabilities of the technology have been matched with user needs. The nature of institutional interactions should have become apparent, and in some cases, the number and activities of potential users should have become clear. The system is ready to enter into practical use. If it is to do so, however, an appropriate institutional framework is essential. Questions -- such as who is responsible, who pays, who has access to the service or the information which the system will provide -- must be answered. The operational phase may require -- particularly in the case of the Space Shuttle -- that users who have unique requirements justify their own payloads and pay certain costs. For an operational earth resources system, where needs for many users must be integrated into packages, institutional arrangements will require prioritization of user requirements.

SOME PAST EXAMPLES OF INSTITUTIONAL ARRANGEMENTS FOR SPACE SYSTEMS USES OR APPLICATIONS

In considering institutional arrangements, it is appropriate to examine some institutional arrangements which already exist or have existed in the past, and which might serve as precedents or examples appropriate to one of the three phases in the evolution of space systems. The Panel recognizes that few institutional mechanisms fit the different phases exactly, and that the perception of the phase in which a given system falls may change with time and viewer (for example, as cited earlier, a system which is viewed as experimental by the developer may be perceived as operational by a user).

RESEARCH AND DEVELOPMENT PHASE

The Interagency Coordination Committee for the Earth Resources Survey Program (ICCERSP), chartered by the Office of Management and Budget in 1972, constitutes a formalized mechanism for interagency coordination of the earth resources survey program -- a program which is now in the research and development stage. An Earth Resources Survey Program Review Committee (ERSPRC), established in 1968, was a forerunner of ICCERSP but had fewer members and slightly different objectives. The ICCERSP charter remains in effect until early 1975. The Committee is chaired by the Deputy Administrator of NASA, and includes members from NASA, USDA, U.S. Department of Commerce (DOC), DOD, USDI, U.S. Department of State (USDS), U.S. Army Corps of Engineers (USACE), the Environmental Protection Agency (EPA), and, until its dissolution in 1973, the Office of Science and Technology (OST). Official observers are appointed from the Council on Environmental Quality, the National Security Council, OMB and the National Aeronautics and Space Council (until it was disbanded). The charter provides that each user agency shall be responsible for developing applications and test programs for evaluating and justifying the usefulness of earth resources survey activities to the community it serves. Each agency also is responsible (working with NASA as the lead development agency) for appropriate data dissemination to the citizens of the United States and abroad. User agencies are defined as those which may potentially use earth observations data or information, either to improve internal operations or as part of their services to the public in accordance with their established missions. With regard to the Committee's influence on funding of earth resources programs, it should be noted that the charter provides that the Committee will coordinate the plans and programs which comprise the national program and review and comment, on a timely basis, on budgets for the various elements of the program.

The charter also provides that federal user agencies will continue to propose and justify funding for space applications that are of interest to their constituencies.

Some observations pertinent to the effectiveness of ICCERSP as an institutional mechanism for assuring the exploration by research and development of potential beneficial uses of space systems include:

> The charter did not originally provide for consideration of an operational system; a provision was added later to the effect that the costs of moving toward an operational system should be considered within existing resources;
>
> The Committee has no full-time or independent staff; and
>
> While the Committee includes representatives from many (but not all) federal agencies having an interest in earth resources programs, it does not include representatives from actual or potential nonfederal users.

Another institutional arrangement, of very different scope, is the provision of support in the R&D phase by the development agency (NASA) to agencies with environmental responsibilities. An example is a current series of interagency agreements between NASA and EPA. Here agreements are made between specific NASA program offices or research centers and EPA program offices or field research centers related to automobile engine emissions technology, as well as the sensor technology for detecting or measuring pollution, and are supplemented by a set of informal working relationships. Such institutional arrangements are in many ways typical of those set up during the R&D phases of space systems, and tend to be characterized as follows: (1) they are based on bilateral agreements between two federal agencies; (2) they sometimes include transfer of funds from one agency to another to carry out a specific experiment (but not to shift large elements of program cost); (3) they imply that the user agency is voicing the research interests and needs of its constituency (imply because nonfederal users are represented in no other way); (4) by their nature, they require no independent staff; and (5) they often are open-ended in that they remain in effect until the research objective has been accomplished. (While termination dates may be specified for administrative purposes, they are frequently and easily extended).

TRANSITIONAL PHASE

A basic agreement of 1964 between the U.S. Department of Commerce and the National Aeronautics and Space Administration concerning an operational meteorological satellite system had aspects related to both transitional and operational phases. The agreement established a basis for the U.S. Weather Bureau to reimburse NASA for providing operational spacecraft and supporting technology for the development of satellite meteorological programs. Under this arrangement, the Television Infrared Research Observational Satellite (TIROS) series of satellites was modified to meet operational needs; the TIROS series was later operationally designated as Environmental Survey Satellites. Certain of the

Applications Technology Satellite (ATS) and NIMBUS series were covered under the agreement. The 1964 agreement was superseded by a 1973 agreement designating NOAA as the responsible agency within the Department of Commerce. The transitional phase, as defined by the Panel, occurred while the 1964 agreement was in force. The operational phase is now covered by the 1973 agreement. The arrangement provides for a Meteorological Satellite Program Review Board. It also provides that funds can be transferred from DOC to offset costs to NASA of support services.

It should be noted that the Panel on Meteorology of the 1967-68 summer study* recommended that NASA continue R&D to measure atmospheric temperature, moisture, winds, and cloud cover. Implementation of the recommendation is an interesting illustration of the transitional phase in that the agreement (1) is related to a single application area (meteorology); (2) specifies a review board between the two involved agencies; (3) uses fund transfers from the user agency to reimburse NASA for support services; and (4) recognizes that NASA will continue funding for R&D during the transitional period.

Another significant institutional arrangement is represented by the Communications Satellites Act of 1962 (P.L. 87-624) which established the Communications Satellite Corporation (COMSAT). This act assigns to NASA the obligation to advise the Federal Communications Commission on matters relating to the technical characteristics of communications satellite systems and designs. This legislated requirement led the 1967-68 study panel on Point-to-Point Communications to conclude that "There are no alternatives to NASA's accepting responsibilities for further R&D because NASA has a statutory obligation...to provide the technological support for the pertinent policy-making agencies of the government...."** The need for NASA to maintain competence in satellite communications was recognized by the Office of Telecommunications Policy in January 1974, in a memorandum to all agencies within the Executive Branch, which set forth the arrangements under which NASA would continue to provide technical support for communications satellites.

The Communications Satellite Act of 1962, as a mechanism for institutional arrangements, may be evaluated as follows: (1) it is a legislated mechanism, carrying implications for new funding arrangements (while NASA would be reimbursed by COMSAT for launch and support services, a funding arrangement is implied that is qualitatively and legally different from usual interagency fund transfers); (2) COMSAT decisions on program scope and priorities important to its own constituency are taken outside the federal budget process; (3) the duration of the arrangement is not fixed; (4) representation*** from nonfederal users is extensive and is controlled by user organizations; (5) the mechanism itself does not establish the basis whereby the entire scope of U.S. interests, such as those of the Department of State are expressed, rather, these are expressed in separate agreements with international organizations; and (6) the mechanism has limitations as a policy example because of the nature of the technology involved, the U.S.

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*National Research Council. *Useful Applications of Earth-Oriented Satellites: Report of the Panel on Meteorology* (Panel 4). National Academy of Sciences, Washington, D.C., 1969.

***Report of the Panel on Point-to-Point Communications*, (1969) p. 5.

***This consideration relates less to the act as an instrument for transition and more to the operational nature of the program conducted after passage of the act.

climate in 1962 regarding peaceful uses of space, and the clearly international nature of the program.

OPERATIONAL PHASE

The 1973 basic agreement mentioned in the previous section established a DOC-NASA Satellite Program Board. This Board is a coordinating group with two members and a co-chairman from each of the agencies, NASA and NOAA. The agreement provides that each major project initiated under the agreement shall require a separate memorandum of understanding, stipulating fund transfers and other joint responsibilities. Disagreements which may arise are resolved by referral to higher authorities in both agencies. This represents an institutional mechanism for an operational system which (1) relies on fund transfers from the user agency to reimburse support costs; (2) is not statutorily based (except insofar as enabling legislation permits agencies to enter into such agreements); (3) is not of fixed duration but subject to termination or modification by either agency at any time; (4) specifies no direct involvement of nonfederal users; (5) implies that the needs of the user community are expressed by NOAA as the prime user; and (6) extends beyond the narrow scope (meteorology) of the previous agreement to include environmental satellites. This last point is of interest because, while the agreement is categorized here as relating to the operational phase, perhaps only activities relating to meteorology (and relating directly to the superseded 1964 agreement) are actually operational. Activities relating to other areas are more properly classed as in the transitional or R&D phase.

A PROPOSED INSTITUTIONAL FRAMEWORK FOR SPACE SYSTEMS USES OR APPLICATIONS

TECHNICAL SUPPORT SERVICES

In examining how technical support services might best be provided to the user community, the Panel considered four key factors:

The technical expertise required,

The high capital investment involved,

The possible cost savings, and

The need to maintain a core capability, as required, to support all users.

The factors involving technical expertise and high capital costs are self-explanatory. The third factor -- possible cost savings -- while it relates to the other factors as well, in this case is intended to identify the savings achieved by providing a common-use capability, human or physical, which would be under-utilized and would cost more if developed by each user to satisfy his own requirements. The fourth factor is perhaps the most important of all. It is the belief of the Panel on Institutional Arrangements that access to space should be available to all users having the ability to pay. This is not intended to imply the exclusion of others; some potential users may possess neither the technical ability nor the desire to develop their own operations capability. In many cases, too, the need for a space-based operation may be a singular or infrequent requirement and thus not justify the development of an integral capability. The Panel believes that a core capability should be maintained to provide potential users with an opportunity to purchase support services as required.

The Panel recognizes that the Department of Defense must have its own space-related facilities and technical capability for reasons of national defense. The existence of these facilities, capabilities, and resulting space data is sometimes used as an argument against the development of parallel systems for non-military use. Unfortunately, security considerations or pre-empting military requirements prevent the facilities, capabilities, and data from being available to meet civil needs. Joint use of facilities, capabilities, and data should certainly be

encouraged in areas in which national security is not violated, but some duplication is unquestionably necessary to meet all of the nation's needs.

After considering the four factors, the Panel has identified areas in which technical support services to meet civil needs can best be provided by a single civil organization. The Panel concludes that NASA is the logical and appropriate organization to provide these services and believes that NASA can do this in a manner consistent with its present operating mode.

Launch Operations

The launch operation is a unique function, technically demanding and involving complex interactions between such elements as a standardized launch vehicle, checkout and launch facilities, range and tracking networks, and range safety. The management of these interrelated activities demands the services of a single launching organization. The present mode of operation, in which individual hardware elements are checked out by the user organization and then turned over to the launching organization for final processing and launch, is well developed and appears adequate for continuing use. In all launches of U.S. spacecraft to date, the service has been provided by either NASA or DOD. The Panel feels the division of this responsibility between these two agencies is appropriate and should be continued in the future.

Spacecraft Development

Operations in space involve long duration exposure of the systems to zero gravity and total vacuum. The systems must depend upon internally generated power and must have a highly reliable capability for sophisticated thermal control, data acquisition and handling, communications, and attitude control. Design and development of these systems is very specialized and technically demanding. Negotiating contracts, defining systems, developing specifications, monitoring technical compliance, and identifying and resolving problems all are technical and management specialties which even the most sophisticated users outside of NASA and DOD should not be required to develop independently and can not be expected to develop easily. For these reasons the Panel believes that non-defense services in these areas should be made available by NASA to all users requiring them or that NASA should at least be prepared to provide appropriate advisory support.

As part of its role in support of spacecraft development, NASA should offer alternative packaging and mission planning data, and define corresponding costs to the user. NASA, working simultaneously with users from DOD, from science and technology organizations, and from organizations with broader applications, also should develop integrated (that is, combining needs of several users) hardware packages and mission time lines (schedules of events and the precise time at which their occurrence is planned). More sophisticated users and those employing already developed space systems should be allowed to purchase fewer of these services than less sophisticated users and those who are still defining and evolving their hardware.

Provisions should also be made to account for the varying requirements of federal, other public, and private sectors.

Payload

NASA should work on a cost reimbursable basis with various users in the definition and development of payload packages. This support service should be provided in a manner similar to that outlined for spacecraft development.

Ground Facilities

Certain large and unique ground facilities are required in the launch and operation of spacecraft. These facilities include the launch complex, the tracking and data-acquisition network, and the mission operations complex. In view of the unique and sophisticated nature of these facilities and their use, the Panel believes that it is appropriate for NASA to provide and operate the facilities. Additionally, certain other development facilities which are unique and non-competitive, such as thermal vacuum chambers, structural and vibration test facilities and appropriate simulators, should be recognized as national facilities and managed by NASA employing institutional arrangements similar to those now involved with wind tunnels.

Spacecraft Command and Control

Whereas the need for unified technical support services is clear, the areas of responsibility in spacecraft command and control are not so clearly defined. On one hand, the high capital investment and the specialized technical capabilities involved support the need for common facilities for spacecraft command and operation. This view is supported by the fact that many users may require data from a single spacecraft and that problems related to interaction and different requirements (in sensors, for example) may be difficult to resolve. On the other hand, in the future many user agencies will be involved in this activity in a major way and on a continuing basis (for example, NOAA in the operation of weather satellites) so that some user agencies probably should develop their own capability. A concept of user command and control is supported by the fact that detailed knowledge of the technical aspects of the mission is required in order to operate and control the spacecraft. Usually the user is most involved in and knowledgeable of this part of the mission. It appears, then, that the issue of spacecraft command and control should be decided on a case-by-case basis after consideration is given to the points raised here as well as to other issues which may affect a particular decision.

Data Processing

The case of data handling is similar to the question of spacecraft command and control in that it does not appear to be a function which clearly should be performed by NASA or clearly should always be left to users. In favor of centralization are the high costs of data acquisition, calibration, conversion to engineering units, storage, and analysis. For users with low volume requirements which are not time-critical, a centralized organization appears most logical. In the experimental phase, data processing should be a service available from NASA to

all potential users in order to assure open access to space generated data. A mechanism to implement such a policy in one specific area is discussed later. However, users may find it advantageous to develop their own capabilities when they have a continuing need for large amounts of data or require detailed knowledge of the end use of the data in order to properly analyze it. Other factors that may lead individual users to establishing their own capabilities for data handling include (1) need for direct access to raw data, (2) proprietary or sensitive features of the data, (3) time sensitivity and urgency, and (4) possible use of the data in some control or monitoring sense which could have legal, control, or sensitive international implications.

Recommendation

It is recommended that, with the exceptions or qualifications noted in the foregoing discussion, NASA provide the technical support services identified.

DATA MANAGEMENT

Earth observations by satellite-borne sensors generate large quantities of data, and thus pose unique problems of institutional arrangements. The data serve many users, with differing requirements for data acquisition, data processing, dissemination, data formats, and timeliness. The Panel believes that decentralized systems for data processing, matching user capabilities and needs, should and are certain to evolve as space systems for earth resource surveys attain the operational phase. Decentralized data systems will permit meeting the unique needs of many users, and may provide better data processing capabilities at lower cost.

The Panel emphasizes that every effort must be made to assure that users of space data in specific disciplines are not so tightly tied to particular data sources that they are precluded from using the data acquired from space systems in diverse ways not anticipated by the particular data dissemination source. For example, only recently has it become widely appreciated that the data generated by meteorological satellites could have a strong impact on agriculture. The Panel notes particularly the comments of the 1974 study of the Panel on Weather and Climate* in relation to this point.

Unique Needs

The Panel believes that experimental use of data provided by ERTS-1 has demonstrated the broad applicability and many benefits of remotely sensed data. Overall benefit is likely to become optimized when many specialist users apply to their problems space-derived data combined with data from other sources. The analysis and application methods which each user employs will probably be

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*Panel on Weather and Climate. *Practical Applications of Space Systems, Supporting Paper 1: Report of the Panel on Weather and Climate.* Report to the Space Applications Board, National Research Council. National Academy of Sciences, Washington, D.C., 1975.

unique to his area of resource management, often regional and peculiar to specific organizational needs. Broad applicability and specialized methods of application are placing many demands upon the current system for disseminating LANDSAT data. In the future, a single centralized data facility (such as the USDI Earth Resources Observation System Data Center) probably will be unable to meet processing needs efficiently and within the time frame many users require.

Data Processing Capability

Data processing technology has been in a period of explosive growth, marked by increasing capability and decreasing cost. Increasing capability is needed to handle projected data acquisition rates, to perform corrective preprocessing functions, and to provide output of a variety of standard products for analysis by individual users. Decreasing cost will enable users to perform more computer analysis and to enter the data flow at a point where value received exceeds investment cost. Ground stations in foreign countries are prototypes of specialized (agency, regional, or special-interest) data centers which will come into being after data continuity is assured. Decreasing costs and unique processing needs combine to encourage decentralized and specialized data centers.

Data Flow

The current policy on data dissemination provides open access to all earth resources data by marketing them through federal centers, principally the USDI facility at Sioux Falls, South Dakota. Figure I is a simplified flow chart for current LANDSAT data. Demonstrated benefits, unique user needs, competitive advantages to nations or commercial firms, and steadily decreasing costs of data processing will result in more users of earth resources data. Some of these users will be prepared to make the investment necessary to acquire data directly from the spacecraft. Some nations have already done so.

In the R&D phase of earth observations, data collection and dissemination were centralized, users were few (and they were principally scientific users), and benefits were being developed and demonstrated. In the transitional phase, decentralization becomes necessary and has already begun. Foreign data centers are receiving and processing data and government agencies and commercial firms in this country are increasing their processing and analysis capabilities. Acquisition of data directly from the satellite by some users is likely to occur eventually. Continuing restrictions on acquisition of data or encoding of data would add complexity to the system and be of uncertain effectiveness. Open and equal opportunity for access to data should foster program growth and extend benefits.

Data systems and operating precedents for the processing and dissemination of meteorological data are well established and effective. Continued advances in meteorology and earth resources and related satellite technologies should bring increasing opportunities for data exchange. Agriculture and water resources management are expected to benefit substantially from advances in weather forecasting, especially from precipitation forecasting and monitoring.

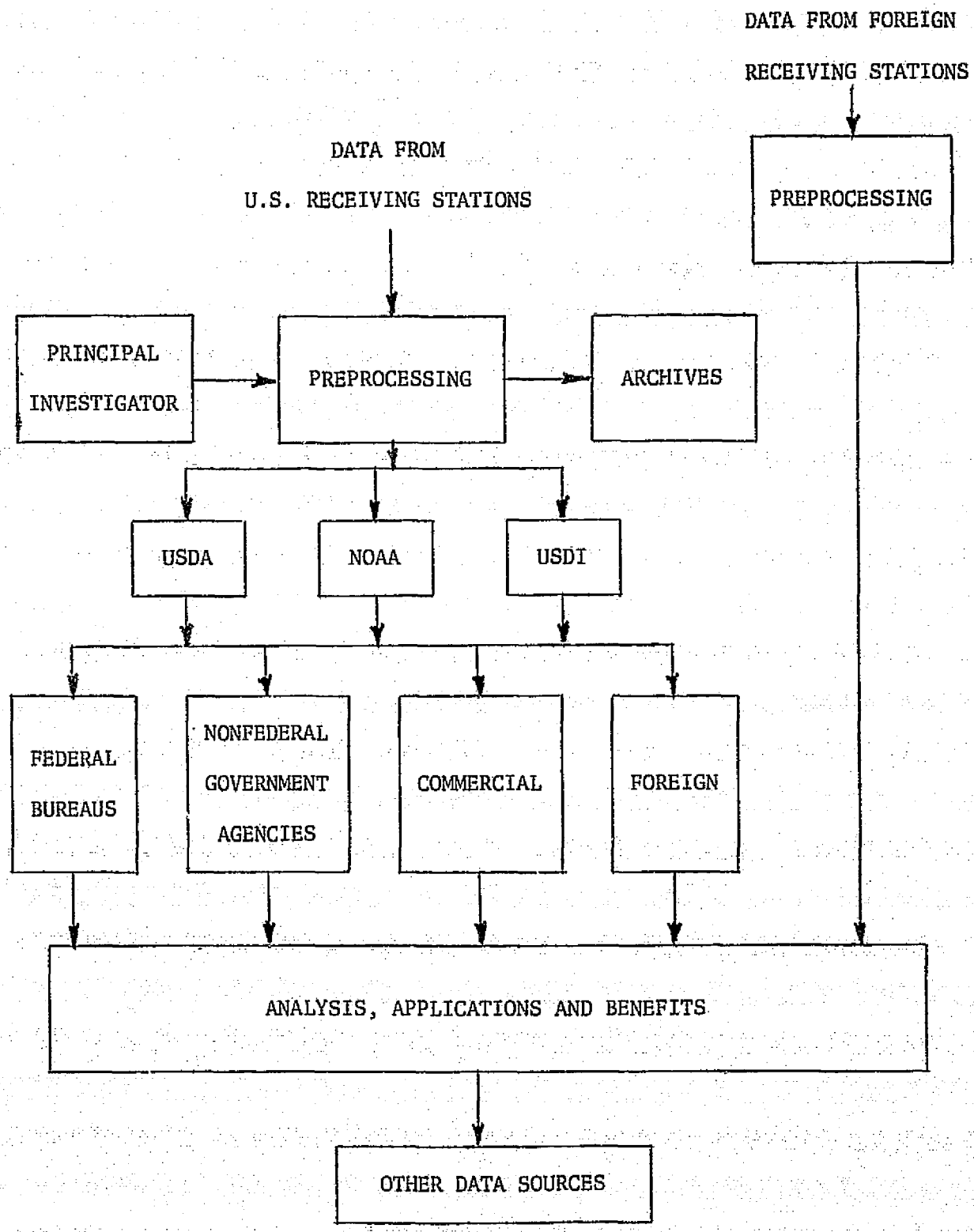

FIGURE I LANDSAT DATA FLOW

Meteorology will benefit from the use in earth resources programs of sensors of higher resolution.

Recommendations

The Panel on Institutional Arrangements offers the following recommendations in the area of data management:

(1) *That the present policy of equal and open access should be continued, and should be extended to permit access at any level in the multi-tiered data flow system.*

(2) *The price of data obtained by users from federally-operated data centers should cover the cost of processing in the research and development phase and a share of the capital investment in the operational phase. Priority or quick-response processing should be provided at a price commensurate with added costs. Pricing should reflect the broad issues discussed later in this report.*

(3) *A master archival system, operated by the U.S. Government, should provide a repository for all earth resources data collected by satellites and federally-operated aircraft. This master archival system should provide standardized formats for data processing and retrieval.*

(4) *The Space Applications Board of the National Research Council should explore means for promoting beneficial and timely interchange of technologies and data between earth resources programs and meteorology.*

RESEARCH AND DEVELOPMENT RESPONSIBILITIES

The National Aeronautics and Space Act clearly assigns to NASA responsibility for research and development of space systems hardware. It is generally agreed that this charge applies to work done during the R&D phase of space systems evolution as that phase has been defined earlier. However, major issues have arisen within the Executive Branch about whether federal support of R&D to improve capabilities and applications needs to continue during the transitional and operational phases and after significant operational uses are being made of existing space systems.

During the transitional phase, a well defined market is not available even though technology applicable to various uses has already been demonstrated. In such a situation it is obvious that only limited, if any, incentive exists for private investment. Even when a space system is operational, incentives for further R&D investment by non-federal governmental or by private users may not exist.

Various factors may contribute to the lack of investment in followup R&D. First, the benefits of space system applications are spread among many users.

In such a circumstance, while the total benefit may be large, the direct individual benefit is too small to make it worthwhile for any one user to undertake a significant R&D investment. Aggregation of user investments would probably be needed for broadly based follow-up R&D. Anti-trust laws and various federal policies, however, may inhibit such cooperative efforts. In addition, as described earlier, aggregation of a diverse user constituency is difficult. Also, an organization, whether it be private or governmental, operating an existing system and applying its results will generally continue to rely on that system in order to amortize fully an investment already made instead of undertaking operations with an improved system. Further, the tendency is to continue use of a present system unless the new system offers substantial opportunities for increased market and reasonably early return on investment. Improvements that are justified by public needs and that are directed principally to the public good, on the other hand, are not normally initiated with private funds. This lack of incentive for advanced R&D is particularly evident in fields where competitive arrangements have not yet evolved and also where market opportunities and advantages are still small or uncertain.

It is not clear at this time how many satellites will be needed in the operational phase to meet continuing requirements for the wide variety of earth resources applications which must be expected. Private manufacturers will have little or no incentive to fund R&D unless they can see that large numbers of systems will be needed and that they will have a reasonable chance of acquiring enough of a market share to recoup R&D costs. It does not now seem likely that they will do so even in the operational phases of space systems since their market share will probably continue low and sporadically fluctuating. It appears, furthermore, that an incentive for the private community to invest in R&D will not exist in the transitional phase since, by definition, a market is not yet available and encouragement of user interest, involvement and organization is implied.

The Panel therefore concludes that some mechanism must be defined to assure continuing improvement in space systems at least during the transitional phase since analysis indicates that potential benefits to users may ultimately be derived from such improvements. The Panel believes there is logic in continuing to rely on NASA to organize and manage this followup R&D. It remains, however, to determine how such activity should be funded and how to assure user involvement in program definition.

NASA obviously has a responsibility, in accordance with the Space Act, to define and budget for its own R&D needs. The Panel believes that during the transitional phase, while institutional arrangements are being worked out, users should play an increasingly strong role in the definition of R&D programs planned and conducted by NASA. During this phase NASA should continue to budget for the R&D. (The Panel will propose later in this report an institutional mechanism which it believes can help to assure user participation in defining R&D programs.)

During the operational phase of space systems, a different approach seems appropriate, even though a lack of incentive for private investment may also be evident in certain cases. In the operational phase, systems are developed and a user community exists. Satellites owned and operated by government agencies or by private organizations are in place. At this stage, certain improvements, specifically aimed at public benefits, may be needed. When these improvements are clearly within the responsibility of existing federal agencies, it may be

expected that these agencies will provide the funds for the needed R&D. When the R&D requirements are not within the jurisdiction of any single agency, however, they must be identified by some mechanism (such as that proposed later in this report). In these cases it appears appropriate for NASA to respond to identified needs by including R&D within its budget. The same is true of broad national needs. When the private sector is involved in an operational system or a user has identified R&D needs for such a system, the following alternative arrangements are possible:

1. The private organization itself can conduct the work or it may reimburse NASA if NASA does the work.

2. When the magnitude of the risk precludes direct private investment in R&D but the federal government agrees that potential benefits are of significant value, the government may undertake the R&D on a payback, royalty, or user-charge basis, designed eventually to recover the cost.

3. The work may be done with joint private and federal funding within a system in which users pay back the investors.

The federal government will have royalty-free rights to the systems derived from the federal R&D program.

These arrangements are outlined as possibilities for assuring that this still-new field of space technology continues to develop and does not become stagnant after first applications. Our foresight is not considered adequate to anticipate future benefits, market situations, etc., that may develop. Great care is needed to assure that lack of private investment in R&D does not halt the continuing improvement of systems while they are being usefully applied. Also, as further uses are defined and as replacement of less efficient techniques appears possible, development of needed improvements must be assured. In addition, the Panel believes that there will be a continuing need for scientific research which should continue to be supported by NASA through its established Principal Investigator system to evaluate the feasibility of significant advances.

SOME ALTERNATIVE INSTITUTIONAL ARRANGEMENTS FOR FEDERAL ADMINISTRATION

Several major institutional options for determining and coordinating federal policy with respect to practical use of space systems have been considered and are discussed here. The Panel recognizes that many variations of each option are possible, including combinations of two or more of the arrangements discussed. However, the options are presented here as alternatives.

It is assumed that satellite applications will be perceived as increasingly valuable; otherwise, most of the need for new organizational structure disappears. Nevertheless, the current diversity of formal and ad hoc interagency arrangements for matching user needs with supplier capability underlines the importance of formalizing an operating framework that anticipates a growing need

for consistency in interagency policy. It is further assumed that organizational arrangements will need to adapt to the evolution of programs from the R&D phase through a transitional stage to the operational mode. Finally, it is assumed that NASA will remain the source of launching and related services, regardless of arrangements for user participation or funding.

Principal Functions

The Panel believes that a central federal administration is required to perform the following principal functions:

Providing general policy direction: Some focal point is required where general questions of program initiation, emphasis, growth, effectiveness, and duration can be debated and decided, subject to review by the President of the United States.

Setting priorities: Where there are competitive demands for limited facilities, products, or space missions (and all proposals fall within established guidelines) some authority must determine under what conditions and in what order competitors are entitled to use available resources.

Maintaining open access to data: The size and structure of the market for the output from space systems will be largely determined by the ease of access to data and by the extent of governmental commitment either to process the data as required by various users or to furnish technical assistance (and perhaps financial aid) to train users to do their own processing.

Assuring continuity and standardization: If it is to attract potential users, any system must provide a structured process for changes, improvements or termination, and, even in the R&D stage, must include some assurance of continuity and use of accepted units or data formats.

Establishing prices: A central mechanism must determine how prices and user charges will be established for data or information products, use of facilities and other services. It must be recognized that the mechanism established for pricing will probably play a significant role in whatever international structure evolves for the application of space systems.

Assuring formal contact between users and suppliers: In addition to the inevitable and largely desirable plethora of informal points of contact between suppliers and users of space technology, there must be some formal structure for exchange of ideas, proposals, criticisms, and evaluation. It is particularly important to guarantee regular and effective access for important users within nonfederal governmental agencies, for example, within states, metropolitan areas, counties, and cities.

Coordinating and evaluating program development and implementation: There must be a central point where program implementation is carefully considered and where integration is assured in the likely event that more than one agency is involved in implementation.

Encouraging non-federal involvement and investment: There must be a steady increase, particularly in the transitional stages, in the amount of non-federal capital applied to programs aimed at marketable products and services. The maximization of this, as well as imaginative institutional innovation to provide for joint public and private ventures, should be entrusted to a central body capable of involving operating agencies as required.

The Panel examined in some depth the advantages and disadvantages of three options for an institutional arrangement designed to perform the functions just discussed.

Option I - Central Authority in An Existing Federal Agency

Option I consists of placing in one of the existing Executive Departments or agencies having a major interest in useful applications of space systems, the primary responsibility for performance of the required functions and the decision authority, subject to appeal to or review by the President when disagreements arise or allocative decisions are required. This designation would not rearrange present assignments of operating responsibilities or location of substantive expertise. It would simply establish a leadership role (a lead agency) with final authority and responsibility much as the State Department operates in the field of foreign affairs. This option would require formal arrangements for other agencies and non-federal users to be consulted prior to decisions and provisions for the lead agency to be informed about action on its decisions and the results thereof.

Advantages resulting from the choice of Option I include:

1. A focal point, now missing, would be provided for the establishment of policy related to practical use of space systems. Clear lines of authority and responsibility would be established, little start-up time and expense would be required, and ultimate decision authority would be vested in one person -- the head of the agency -- subject only to appeal to the President.

2. If NASA were the designated agency, a close relationship would be assured between policy decisions on uses and the realities of operational and technological capabilities. Somewhat more expeditious progress from proposal to policy decision to execution might be achieved because a single agency would control the entire process. NASA itself not being a user, its substantive neutrality might lessen fears that some specialized discipline might get unfair advantage in the competition for funds. Also, there would seem to be some possibility of greater financial support, at least for R&D projects, since the lead agency would be expected to seek appropriation of a larger share of funds

than the other participating agencies and NASA has, at least to this point, a history of relative success in getting financial support.

3. If NASA were not the lead agency, a closer and more mutually informed relationship might develop with at least some major users. The lead agency would presumably have facilities for and experience in delivering services directly to the public. There should be less danger that the program would be driven by technological capabilities and aspirations rather than by realistic prospects of uses with reasonable cost benefit potential. The odds would improve that the lead agency would invest in systematic training of present and potential users and thereby increase the market for data products, at least in the agency's own field.

4. There would be great bureaucratic strength in having the point of coordination in an established and functioning agency with line responsibilities, budget leverage, congressional and public constituencies and direct communication with the White House.

On the other hand, disadvantages of Option I include the following:

1. Jealousies and discontents in the agencies not chosen as lead agency and their constituencies might make Option I unworkable in practice. Refusal of agencies (and their congressional constituencies) to accept subordinate status could lead to pressure for splintering of functions and systems and for multiple exemptions from the writ of central authority.

2. There could be widespread worry that programs would be biased in favor of the substantive specialty of the chosen agency. The effects could be unfortunate if the agency actually indulged such biases or unduly penalized its own users in order to appear to remain neutral.

3. If NASA were the lead agency, there could be a continuation and perhaps even a worsening of the gulf that now separates present and potential users from decision and management processes except within small and informal networks of individuals whom NASA now consults. There might be very strong pressures to emphasize programs that pursue theoretically defined technology capabilities. Also, any other agency would be a professionally familiar and acceptable judge of the merits of proposals in at least one specialized user field. NASA has recognized expertise only in aeronautical and space technology and related ground support systems, in space sciences and in management of large or complex projects. Finally, NASA would be taken out of the service role it has traditionally considered most conducive for effective development and operation of technology.

4. If NASA were not the lead agency, there would be a greater possibility of impasse between users and suppliers. Also, because substantially less expertise in space technology exists in agencies other than NASA, large-scale technical training of the agency's personnel would be required or the agency would need to hire a substantial number of new people.

5. There are dangers inherent in relying on the budget and appropriation process of any one agency as the principal support for space application programs. The size and nature of the effort could be greatly affected by a few individuals (for example, the chairman of a congressional appropriations committee, an OMB unit chief) whose attitudes toward the lead agency might be determined by factors other than the effectiveness of the programs but who could be extremely influential in deciding the nature and scale of approved investments.

Option II - Central Authority in New Federal Agency

Option II assumes the creation of a new agency whose sole purpose is to perform functions discussed at the beginning of this section. Operational responsibilities of other agencies would remain undisturbed. An analogous example may be the original form of the Office of Economic Opportunity (OEO) (excluding its operating functions) or the role of the U.N. Development Program vis-à-vis the U.N. special agencies. In both these cases, the principal leverage of the coordinating agency has been that the bulk of the funds involved flowed through it. This would have to be the case for Option II as well. To be effective the new agency might have to be placed in the Executive Office of the President.

Advantages of choosing Option II include the following:

1. A new agency would carry no historical baggage of substantive bias nor any scars from past bureaucratic controversies. It could be the focal point for developing a new multidisciplinary constituency for practical applications of space systems as the trend continues toward overlapping needs and uses.

2. Interagency jealousies should be minimized as should dangers of substantive bias. Existing agencies might find a new agency easier to accept than a lead agency selected from among them. The objectivity of a new agency should be more credible to the President, the Congress, and the public than that of an existing agency.

3. A new agency would leave NASA with the responsibilities for service and technological development that it has always preferred.

Option II appears to have the following disadvantages:

1. Current budgetary considerations and the attitude of the general public toward priority for space programs make Presidential and/or Congressional approval of a new agency very dubious. Additional costs would be unavoidable and highly visible as new appropriations were requested and debated. Start-up time would be considerable.

2. A new agency would probably be in a weak position in dealing with the well-established Executive Department and agencies, including NASA. The OEO example is not an encouraging one, even though the agency leverage has included allocation of billions of dollars.

3. A new agency would create unpredictable new patterns of user aggregation, Congressional responsibility, and constituency formation, a new environment which could as easily be unfavorable to progress in practical use of space systems as it could be favorable. It would also add to the image of complex and generally impenetrable federal agencies which already discourages many present and potential users.

4. A new agency might be strongly attacked, as central allocative agencies frequently are, by specialized constituencies. In such a case, as a new agency, it would be at a disadvantage in having no tradition of established and indispensible functions.

Option III - Central Authority in Statutory Interagency Committee

The most logical implementation of Option III would be to build on the present Committee (ICCERSP) which at present deals only with earth resources survey programs. ICCERSP was established pursuant to an OMB directive which gave it official life through the beginning of calendar year 1975. Chaired by the NASA Deputy Administrator, who is charged with acting as an impartial moderator and not as a representative of NASA, the Committee consists of assistant secretary or comparable level representatives from major user agencies. Its principal charge has been to draw up a comprehensive plan for federal investments to be used in observations of earth resources. Issues of general policy raised by one or more members are discussed and the Committee performs limited analyses. It has no veto nor other formal power nor is there any mandate that issues be brought before it. Nevertheless, there is evidence that its deliberations carry some weight in NASA and other participating agencies, despite the fact that OMB has twice rejected draft plans it has proposed.

Advantages offered by Option III include the following:

1. An interagency committee with broad representation should minimize agency feelings of exclusion and professional subordination.

2. The arrangement should require only minor new expense and start-up time. Compared with the legislation which would be required for other options, an authorization for such a committee would probably be the most likely to be adopted by the Congress at this time.

3. An interagency Committee would help to keep all participants aware of priorities and problems in different fields and might reduce tendencies to parochialism.

4. No major adjustments would be required in the existing structures of agency and Congressional constituencies, in appropriation structures, or in operating responsibilities.

5. It would provide a forum for debate and a clear point of decision on all issues raised.

The following disadvantages may result from Option III:

1. Interagency committees are notoriously weak structures for decision making. They tend to be useful forums but not effective in decision making because they are rigidly structured and rather indefinitely linked to operational control. They can often be ignored with impunity by strong agencies, even when their representatives serve on such committees.

2. Action within a committee format might be slower on the average than with other options. There might also be a danger of "lowest-common-denominator" policy formulation which could compromise program substance.

3. The position of the chairman might become delicate and difficult as data become more valuable and competition more intense. The chairman probably could not function unless he had the personal and visible confidence of the President. Most successful examples of interagency committees with decision making powers have been chaired by cabinet officers or members of the Presidental staff. In this arrangement the Committee often is dominated by the chairing agency. However, the National Aeronautics and Space Council was an example in which the chairman was not a line operating official and a lack of impact was apparent.

4. The Committee might be less effective than other suggested structures in bridging the gap between users and suppliers. Federal agencies would possibly screen the needs and suggestions of users and might receive little challenge from other agencies who might wish reciprocal treatment when their own interests were at stake.

Some Options Not Analyzed

Several arrangements are regarded as possibilities too remote for serious consideration within the time available at the study. Among these are the following:

1. A multi-tiered governmental entity (for example a federal-state-metropolitan-local governmental construct) with some form of proportionate representation from all levels.

2. An independent public-benefit corporation, including representation from several levels of government and from the private sector. (It should be noted that such a corporation was considered by the Panel on Agriculture, Forest, and Range* and is discussed in the report of that Panel.)

3. An organization which includes representatives of foreign governments and/or corporations.

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*Panel on Agriculture, Forest, and Range. *Practical Applications of Space Systems, Supporting Paper 4: Report of the Panel on Agriculture, Forest and Range.* Report to the Space Applications Board, National Research Council. National Academy of Sciences, Washington, D.C., 1975.

4. Allocation of central functions to OMB, the National Science Foundation, a re-established independent Office of Science Advisor to the President, or some other element of the Executive Office.

5. Division of central functions among several existing operating agencies.

A Proposal for an Institutional Mechanism

Extended discussion of the options has led the Panel on Institutional Arrangements to two conclusions concerning the possible options for determining and coordinating federal policy and implementing programs to meet user needs in applications of space technology:

1. No practicable option is free of defects or risks.

2. The urgent need for effective performance of the eight central functions is best met, under present circumstances, by a variant of Option III, a statutory interagency committee.

Accordingly, the Panel recommends that a National Council for Space Applications be established by act of Congress.

Implementation of the Proposed Institution

The Panel fully recognizes that much in history supports skepticism about an interagency committee, particularly one which must include representation from most of the large federal agencies. There are, however, examples of such committees that have been reasonably effective. The Panel believes, for example, that the history of ICCERSP provides some reason for confidence that a pattern of cooperation among agencies interested in space applications has been established which may carry over into a broader structure. Since ICCERSP as structured has serious inadequacies which preclude broadening its mandate by simple executive action, the Panel believes that the National Council for Space Applications must have statutory authorization. The Panel strongly believes that the Council cannot function within the federal bureaucracy and deal effectively with controversial issues unless it has a full and specific mandate from the Congress. It should be established by statute and charged with responsibility for the eight central functions for all practical applications of space systems: general policy direction, priority setting, maintenance of open access to data, assurance of continuity and standardization, pricing, establishing formal contact between users and suppliers, coordination of implementation and evaluation of program development, and encouragement of non-federal involvement and investment. As in all federal executive office programs, this authority will be subject to the review and approval of the President. We also believe effective performance of the proposed Council requires statutory provisions for the following:

1. Expansion of membership so that the Council includes as participating members all federal agencies with legitimate and substantial interests in the application of space technology. This probably should include most Executive Departments, NASA, the National Science Foundation, and other independent agencies. A precise list should be worked out as part of the authorizing legislation. The Panel also believes that state and local governmental agencies should participate and that the law should direct the Council to evolve effective and equitable means of assuring their representation. These agencies should acquire voting status as soon as possible and certainly within a very few years. The statute should specifically prescribe that, in the meantime, state and local observers must be invited to all Council meetings, whether open or executive sessions.

2. Designation of the chairman since, despite the reasonableness of the case for an independently appointed chairman, the Panel believes that the relevance and effectiveness of the Council will be best served by a statutory designation of the NASA Administrator as chairman. We believe he has a strong position as an operating official, an incentive for space application programs, and impartiality among users. Experience has suggested that it can be feasible to vest the authority for a government-wide leadership role in the head of an existing operating agency *provided* distinction between the two positions is maintained. In the case of the proposed Council the distinction can be reinforced if the Chairman does not also serve as the NASA representative on the Council. The role of the Chairman should be *objective* leadership and should include as needed his acting as a moderator.

3. Establishment of independent staff which should be small and professional with no bureaucratic allegiance to or dependence upon any member agency. The staff, under Council direction, should be empowered to prepare agendas, perform analyses, and coordinate the activities of operating agencies.

4. Specific responsibility for user involvement, in that the Council should be charged with (1) building a nationwide process whereby user views are solicited, aggregated, and taken into account, (2) determining the U.S. role in such a process worldwide, and (3) developing a procedure by which, where possible, non-federal interests gradually assume control and funding of space systems and their applications as they become operational. Delegating these responsibilities to the Council does not imply that weakening connections between operating agencies and the user community is necessary or desirable. The Panel believes that a central body with a broad mandate and perspective can help effectively in phases of user involvement that now are somewhat neglected.

5. Appropriations administered by the Council for financing experimental programs in institutional development. Many of the end users of space-derived information or services will be personnel in state and local governments, and in business and industry, who have little knowledge of or interest in space systems. For the data or services to be used effectively, however, these people must be aware of what is available, its usefulness, and they must have the knowledge and skills to put it to practical use. It is essential, too, that they be involved in making their needs known, to help in matching requirements with the

capabilities of the space systems. Thus, in carrying out its mandate, the Council should budget a small allocation of funds for experimental institutional development programs -- programs aimed at strengthening the capability of non-federal users to participate effectively in the useful application of space systems. The programs should be carried out not by the Council but by appropriate federal agencies.

6. Public reporting, in that the Council should be required to prepare for the Congress an annual report summarizing major issues and decisions and outlining future plans and assessing future implications. The Panel feels that a strong commitment to open debate and full disclosure has been one of the strengths of the U.S. space program. Interim reports could be requested by the Congress at any time.

7. Establishment of specialized subgroups which, in order to function effectively in each of the specialized disciplines for which space technology applications are useful, should include working-level officials from the agencies most concerned with each field of application. Specific subgroups could be set up when involvement and development are fairly clear (for example, in communications) and the Council should be empowered to establish such groups as it feels appropriate. The Council also should be empowered and encouraged to delegate to duly authorized subgroups appropriate operating and decision functions. This provision for a substructure should reduce the multiplicity of committees, panels, and task forces that have evolved in the past to meet the institutional needs which now will be met by the Council.

Given these statutory provisions, it is the judgment of the Panel that a National Council can perform the central functions which the Panel feels are vital to sound programs of space applications. The Council will not displace any current or future operating agency nor will it in any sense eliminate the normal budget process. It should have flexibility and accept readily the need to adjust its role according to the requirements of R&D, transitional, and operational phases. The goal should be to provide a vital center and a basic point of reference for a constantly evolving program. With this goal and a strong sense of common purpose, we believe that the federal and non-federal suppliers and users can join together in a responsible operational arrangement that exercises the care needed in developing applications of space systems and, at the same time, realize their full potential.

INVOLVEMENT OF NON-FEDERAL USERS

The Panel has recognized the evidence of problems in the involvement of non-federal users in applications of space systems to planning, decision making, and providing and regulating public and private services. It has focused on the roles and functions of various users in the planning, design and development, test and evaluation, and implementation of such applications. It specifically has addressed institutional arrangements, developments, and realignments that can foster effective involvement of non-federal users in the decision process and make it possible for them to use such applications more effectively and extensively.

It should be noted that the guidelines for the 1974 summer study provided by the Space Applications Board included the following limitations:

> Major focus was to be on the applications of space systems; "spin-offs" and utilization of technologies developed as part of the space program were to be treated only peripherally.
>
> The question of basic research and science activities was not a subject of the study.

Consideration in this discussion is limited to the distinction between private and public non-federal user groups. It is clear that these users fall into many categories, such as operating agencies, planning and support agencies, and executive management agencies in both the public and private sectors as well as elected policy-making officials in the legislative and executive branches of government and corporate policy officials in the private sector. It is also clear that each such category of users will relate differently to the applications process and any extrapolation and refinement of the general treatment here should accommodate such differences.

Several additional assumptions were made by the Panel, as follows:

> An effective space applications program must integrate the innovative process throughout, from R&D planning to widespread use;
>
> The pattern of user concern and involvement follows the pattern of investment and information requirements illustrated in the investment decision model of the Panel on Costs and Benefits*, that is, both increase from R&D through the operational stage; and
>
> The changing nature of federal-state-local fiscal and program responsibilities requires changing federal-state-local relationships in research and technology, more effective and pervasive application of research and technology in domestic problem areas, and changes in the extent and nature of technical assistance needed by state and local governments.

Major User Concerns

The desire for (and the nature of) involvement by non-federal users varies within each of the three phases of space systems evolvement. Institutional arrangements for technical support functions are of relatively little concern to either public or private users at any phase, if the functions are being provided. Of course, however, several policy questions such as who pays, pricing mechanisms, and access to such services are of major importance to both public and private users. Institutional arrangements for the conduct of R&D in space

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*Panel on Costs and Benefits. *Practical Applications of Space Systems, Supporting Paper 11: Report of the Panel on Costs and Benefits.* Report to the Space Applications Board, National Research Council. National Academy of Sciences, Washington, D.C., 1975.

technology also are not a major concern of public and private users. Again, however, a number of policy questions, such as the level of investment in R&D, the directions and trends of the R&D, and the priorities assigned are of interest to both public and private users.

Policy and operational services are areas of major concern, particularly in the transitional and operational phases, where substantial involvement of non-federal users is necessary. Operational questions about data systems such as the nature of the data, their character, precision, and density, the frequency and area of coverage, the response rate from demand to delivery, and the ease and cost of access are all important. Also of interest to the public sector user is the degree to which accessiblity to data and services is based on cost or ability-to-pay or is based on capability-to-use, rather than on some priority of public benefits.

Substantial user involvement is required to assure that user needs govern or, at least, are effective in defining collection, distribution, and analysis systems so that users have the opportunity and the capability to utilize the data. The same is true for communications and other space-derived services. The nature and form of such involvement are major institutional problems requiring innovation.

Users desire substantive roles in the making of policy decision. The principal functions listed in the preceding section of this report are of substantial interest to non-federal users and must be responsive to their requirements. Some user groups have federal counterparts which represent their interests to some degree, but it is clear that user groups often do not see their federal counterparts as speaking adequately for their interests.

Because non-federal public agencies may not have the same capability as the private sector to develop an integrated picture of needs and requirements nor the well developed political mechanisms that the private sector has to represent their needs and influence executive policy, the need may be more acute for direct participation by non-federal public agencies in the policy making. At the same time, however, problems develop in providing for direct participation because it is difficult to determine who speaks for agencies within the states, counties, or cities. In spite of these difficulties, institutional mechanisms must be worked out to assure the representation of state and local users in the policy making process.

Institutional Problems and Barriers

Many problems and barriers to the effective application of space technology by non-federal users have been touched on earlier in this report. It is useful to discuss briefly specific ones that are prominent in the literature and have been brought out by user panels in the present study.

Many problems arise because of the breadth of possible applications. Information or services provided by space systems can be applied to a wide range of substantive domestic problems as in environmental management, earth resources management, land use planning, public works, transportation, health care delivery, education, housing, etc., and hence serve a great diversity and multiplicity of users. The diversity of users who currently apply data or services from many sources entails discovery of unique and localized application needs.

However, economies of scale argue for developing standardized programs to serve multiple uses. This puts a significant requirement for adaptation on the user.

Many problems stem from the nature of the user community within the non-federal public sector. First, it is fragmented both in levels of jurisdiction (that is, cities, counties, substate regions, and states) and within multiple jurisdictions at the same level. Even within a single jurisdiction, many agencies may be involved in a problem in a given area, with little or no coordination. Moreover, there are few provisions for systematic transfer or dissemination of information between or within various levels of government. This user fragmentation not only inhibits the development of an aggregated set of needs upon which to base a realistic and useful applications program, but also creates a major marketing problem for programs which might be responsive. Second, many state and local agencies have insufficient awareness of technological opportunities and inadequate capability to assess the opportunities and to adapt them to their own needs. Third, potential users generally lack the ability to articulate needs in language that is meaningful to developers of technology, that is, in terms that assist suppliers in providing solutions to user problems. Finally, among users there is a lack of management experience in specifying goals and policy objectives, in planning programs and budgets to achieve objectives, and in monitoring and assessing functions for program modification and improvement.

Similarly, problems arise on the supplier side. There is a lack of awareness among technologists about state and local decision making processes and about the institutional, financial, and political constraints within the systems. Many programs for technology application provide incremental improvements to ongoing functions and the supplier does not have an appreciation for financial, political, or organizational costs of change.

While these deficiencies have significant impact on the R&D phase, they are particularly important in the transitional phase. The decision to go to an operational phase depends on demand and the ability to demonstrate an extensive potential market. Yet, while the need may be recognized, the demand may not be articulated. The awareness, capability, and hence demand of many potential users lag behind available technology, and very few mechanisms exist for the aggregation and expression of user demands.

Recommendations

It is clear that serious institutional problems relative to non-federal users hinder the effectiveness of practical uses of space systems. The Panel has recommended the creation of a National Council for Space Applications. Certain aspects of that recommendation are germane to the question of non-federal user involvement.

The principle of formal membership for non-federal public user agencies on this recommended National Council addresses a major institutional concern of such users namely, a substantial role in policy direction and priority setting at every stage of the applications program. In addition, the assignment to the Council of responsibility for assuring formal contact between users and suppliers, for assuring aggregation and representation of users, and for initiating experimental institutional development programs deals directly with the

problem of assuring involvement of non-federal users. The following recommendations expand upon these points, particularly in the interim period before the Council begins to function:

1. *In order to capitalize on the benefits made possible by federal investments in space technology R&D and to increase the productivity, level, and quality of service provided by state and local governments, increased scope and level of utilization of space derived information and services by state and local governments should be a specific objective. Therefore, systematic development within the non-federal public sector of a capability to use specific applications should be a major part of the applications program and an explicit responsibility of the proposed National Council for Space Applications.*

2. *In furtherance of the preceding recommendation, experimentation with institutional arrangements that, in cooperation with users, increase the utilization of space technology in the non-federal public sector, should be an integral part of space applications programs. Such an experimental program should include pilot projects using field testing techniques that:*

   a. *Are not regarded as precedent setting before the fact,*

   b. *Do not imply advocacy of a particular institutional approach,*

   c. *Do not imply continuing federal support, and*

   d. *Provide for independent evaluation.*

The expected outcome of such pilot projects would not be standardized institutional models but rather a better understanding of and experience with various institutional arrangements in different geographical, political, socioeconomic, and cultural contexts. Experiments should focus on stimulating the acquisition and use of data from space systems through specific attention to:

1. User mechanisms to define and assess user requirements. Emphasis should be placed on a diversity of mechanisms and on encouraging incorporation of technical talent from universities, nonprofit research organizations, and the private sector to assist and to increase user capability.

2. Capability-building programs to educate user groups on the nature and potential uses of data and services and on the kinds of software systems to utilize them, to provide skill training, to encourage the development of user management capability, and to provide assistance for adaptation of multiple user packages to specific local needs.

3. User systems for aggregating and communicating standardized requirements by jurisdictional levels, geographical regions, and

functional areas of use such as earth resources, environmental quality, etc.

Planning of recommended experiments should take into consideration the results of assessment of previous and current institutional arrangements for technology application, other NASA efforts at fostering non-federal involvement, and current experimental efforts being conducted by the National Science Foundation, the National Bureau of Standards, and the technology transfer activities of other federal agencies. Potential institutional arrangements for experimentation should be designed and proposed by users.

3. *The Panel has recommended that responsibility for this program be assigned to the proposed National Council for Space Applications. However, because the Panel considers that this recommendation is of great importance, it believes that implementation should not wait for the establishment of the proposed National Council. Accordingly, the Panel strongly recommends that a program of experimentation be initiated immediately by NASA with the cooperation and involvement of relevant federal user agencies. Detailed planning for experimentation and other early implementation should begin as soon as possible, preferably this year.*

INTERNATIONAL CONSIDERATIONS

As foreign countries continue to develop interests in space, it must be expected that they will have increasing impact on the U.S. space program and upon space applications in particular. Practical applications of space systems have demonstrated an array of benefits which most sovereign nations will want to provide for their citizenry. It is natural for them to want to participate for maximum benefit with minimum investment. The U.S. policy of free dissemination of technology has encouraged foreign participation. It is reasonable to expect that this policy has led and will continue to lead to decreased international tensions and can and will assist the U.S. in its international relations.

Early in the space age, foreign countries provided sites for communications satellite ground stations and followed with varying degrees of understanding the accomplishments of the U.S. space program. In later phases scientists of other nations have furnished experiments to be carried on board U.S. satellites. The European community has successfully launched scientific satellites. Ground stations for receiving satellite weather data have proliferated until now there are more than 1,000 stations in the world for receiving weather pictures transmitted automatically by U.S. satellites. An international telecommunication satellite consortium (Intelsat) has been formed and more than 89 countries are now members. Intelsat currently has 6 satellites operating which can provide more than 24,000 channels for voice communication or 72 channels for television relay.

Today, a European space agency is building the Spacelab and various countries are building or contracting for domestic communication satellites, broadcast satellites, and weather satellites. Navigation and control of international aircraft via satellites will soon be initiated. Brazil, Canada and Italy have installed ground stations to receive earth resources data from LANDSAT, and at least five other countries are planning to install such stations. These countries are aware that the LANDSAT series of spacecraft is experimental and that the U.S. has not made a commitment to provide continuity in the flow of data. NASA and user agencies have, however, been seeking approval of programs intended to provide continuity of data.

Increasing participation of foreign countries in space increases their ability to exploit its potential. Recent licensing agreements have given Japan the technological capability to develop a low-cost space transportation system. The time when foreign countries have the capabilities to "go it alone" is fast approaching. Obviously, economic factors will have a major effect on the ability of any country to develop an independent capability.

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These factors contribute to a new series of challenges and constraints for the U.S. space applications program as follows:

1. Continuity of data flow is needed. An increasing number of foreign ground stations provides impetus for the continuation of earth resource surveys by satellites. However, foreign investment in ground stations and data processing facilities tends to constrain the ability to increase capability, or to significantly change the characteristics of the space systems. Implied commitments to foreign states are a major international consideration and must be considered in planning of space systems, whether current or future.

2. Data security may become increasingly pertinent. Current U.S. policy provides for open dissemination of all data acquired by NASA satellites. Dissemination takes place within a relatively short time after data acquisition. Countries with ground stations have agreed to open dissemination of data for the present. Currently, however, NASA satellites are *experimental* satellites. As technologies advance, as abilities to extract key resource information from data advance, and as we move toward operational systems, it must be expected that questions of data security will arise. If the United States is not to be deprived of the benefits which operational systems can bring, it should take the lead in developing policies relative to data dissemination, data processing and information extraction.

3. The technological leadership of the U.S. in space communications is being challenged today. Concurrently, the fact that communication satellites have entered into the operational phase for the conventional services provided by commercial communications carriers has led the Executive Branch to a decision to drastically curtail federal R&D on communication satellites. Meanwhile, foreign countries are increasing their investments in space communications R&D and may leapfrog U.S. achievements. Government sponsored R&D is required to assure U.S. leadership in the emerging field of space materials processing and manufacturing. U.S. leadership in the area of earth resources may be similarly threatened unless R&D is pursued vigorously. Combined government-industry teams in foreign countries are pursuing development of space data processing technology.

4. Cooperative as well as competitive programs for applications of space systems are beginning to emerge. Meteorology is an example in which close cooperation has occurred in exploiting space technology. International programs such as the Global Atmospheric Research Program (GARP) are closely interrelated with the U.S. meteorological program. The Japanese are building a synchronous orbit meteorological satellite to work in conjunction with the U.S. Synchronous Meteorological Satellite (SMS). Communications is an area of cooperation ready for international competition. Earth resources and space processing are programs that are nearing the possibility for either international cooperation or competition.

Foreign countries and international organizations such as the U.S. and the World Bank have the same problems as the U.S. in aggregating user needs, consolidating requirements, and establishing focal points for program participation. The recommended National Council for Space Applications, with strong assistance

from the Department of State, should establish methods for making foreign information needs available to U.S. program planners. These needs then should be considered in the formation of the U.S. programs.

The Panel offers the following recommendations relative to international considerations:

1. *The proposed National Council for Space Applications should encourage international cooperation in space applications programs. Forums should be encouraged for discussion of requirements and aggregation of international user needs. Agreements reached with foreign countries should be compatible with U.S. objectives for space applications programs and should not impede development of these programs.*

2. *U.S. practices in dissemination of earth resources survey data should be subject to regular review and modification to assure consonance with domestic and foreign policy objectives. Space applications technology should be considered a factor in achieving the broad objectives of U.S. foreign policy.*

SPECIAL ISSUES WHICH RELATE TO PRICING POLICY

The attention of the Panel has been drawn to a number of special issues related to pricing policy which while they clearly impact the deliberations of other Panels require particular consideration in the context of institutional arrangements. These include selected examples, existing legislation, and experiences and provide a background for consideration of pricing policy.

USE OF GOVERNMENT FACILITIES

Existing legislation and implementing Executive Orders provide that certain specialized government facilities (such as NASA wind tunnels) can be made available for use by public and private groups. A determination must usually be made that the proposed work is in the public interest, that it does not interfere with the primary mission of the facility, that it does not unfairly compete with comparable private facilities, and that reimbursement is made for incremental costs of facility operation and technical support. An interesting question is whether experimental results so obtained must be made public. At least in the case of NASA wind tunnels, companies paying for the use of the facilities have proprietary rights to the data.

CENSUS DATA EXAMPLE

Data derived from a U.S. census can be released to users in a special form, provided that data are sufficiently aggregated that individual reporting units cannot be identified. The U.S. Census Bureau will undertake, on a non-interference basis, special studies or tabulations provided that the request is deemed to be in the public interest and on condition that the information so derived is made publicly available. Reimbursement for the incremental cost is required from both public and private users and usually is stipulated in a specific contractual agreement.

PATENT LICENSING

Patent licensing policy for the U.S. government as a whole is under review because of recent litigation. Currently, NASA patent licensing policy provides

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that NASA products may be licensed either exclusively or nonexclusively. Equal opportunity to apply for licensing is provided, and the applicant must specify a royalty fee (which may be zero) that he is willing to pay. This fee is subject to negotiation, as are other terms of the license. Exclusive licensing requires a determination that the proposed use is in the public interest and that protection through exclusivity is needed to commercialize the technology. NASA has made it clear that the size of the proposed royalty fee will not be the sole basis for awarding licenses. Monies derived from royalty payments flow to the U.S. Treasury and are not retained by NASA.

SPACE PROCESSING

Cost sharing agreements, both international and domestic, are common. An experiment to grow crystals of relatively insoluable substances, to be conducted as a part of the Apollo-Soyuz Test Project (ASTP), is apparently the first case of industrial cost sharing that has occurred in the program of experiments on processing of materials in space. Development costs are being shared equally by NASA and Rockwell International Corporation.

OVERALL POLICY

Pricing for several kinds of standard products has been developed within the federal government. Reports from the U.S. Government Printing Office or the National Technical Information Service are priced according to a general principle of generating enough revenues to offset the publishing and operating costs. Currently prices for earth observation images and data from the Department of the Interior, Earth Resources Observation Program Data Center at Sioux Falls, South Dakota, and from other federal data centers are based on recovery of costs at those centers. The objective is that the dissemination centers will eventually become self-supporting.

The Panel feels that pricing for space systems data and services should be based solely on the objective of revenue generation, but should include consideration of other effects of price on demand and user involvement as discussed below. There are areas in which prices should not only offset incremental costs but also help to recoup the costs of R&D. There are other areas in which prices designed to generate profits will shut off long term revenue flow and prevent realization of the largest possible benefits by reducing incentives to users and limiting the number of consumers who can enter the system. The Panel recommends that pricing be decided according to policies established by the proposed National Council for Space Applications, and should take into account the following factors:

1. The phase of system development. In general, prices should include more of the costs as the system proceeds from R&D to operational status.

2. Public benefit to be derived from the product or service.

3. Marginal value of having a large body of users assessed in terms of

   a. Efficiency of large scale systems (for example, number and scale of launches, integrity of national or global data systems), including economies of scale in manufacture and operation;

   b. Sensitivity to price of non-federal investments in perfecting technology and supporting systems; and,

   c. The effects of providing a large number of centers for dissemination of space derived data, particularly in the transitional phase between R&D and operational.

4. Effects of alternative price levels on market structure and equity.

5. Effect on international commerce.

6. Effect on U.S. capacity to maintain sufficient technological capability to

   a. Continue the U.S. role as a leader in development of peaceful use of space, and

   b. Assure continuity of service necessary for users to decide that they can safely make long term commitments and investments.

7. Ripple effects of prices on economics of components and supporting systems which may be needed for military or other federal programs, in other words, effects on *total* revenue and expenditures of the U.S. government.

The Panel recognizes that the cost of space derived information or services will involve a wide range of prices, rates for one-time and continuing services, and a variety of cost sharing arrangements. However, the Panel believes that consideration for each situation of the factors just listed will produce a pricing system which is sensitive to most of the elasticities and ancillary effects which should be taken into account. In no case, in the Panel's view, should pricing policy be governed solely by short-term first-order effects on the revenue of the agency involved or of the U.S. government as a whole.

SUMMARY AND RECOMMENDATIONS

The capabilities of space systems constitute a totally new technological force developed within the United States beginning in 1958. In the decade and a half since the start of the space program, rapid progress has been made in the application of space technology. Operational uses of weather and communications satellites already have important worldwide influence. The Panel on Institutional Arrangements believes that the full extent to which this still-new technology can serve mankind is not yet recognized. Indeed, the Panel feels that only the surface has been scratched in applying space systems to earthly problems that are recognized as currently or imminently critical. The Panel, therefore, recommends that deliberate and planned programs together with the necessary institutional arrangements be established to *assure the widest possible application of what has been and is still being learned and what is and can be done with technology already available.*

The Panel's recommendations are aimed primarily at providing means for involving potential users (within federal, state, and local governmental agencies and private sectors) in the early stages of planning and implementation of space programs, and continuing their involvement throughout three successive phases in the evolution of space systems, defined as follows:

1. R&D phase, characterized principally by the need to develop, test, and evaluate technological capability with some advisory involvement of potential users.

2. Transitional phase, characterized by a demonstrated technological capability but still without a fully developed and, generally, with an unproven user market. It is necessary to bring the technologists and potential users together. Needs of potential users are tested and evaluated directly through institutional arrangements that can be effectively used for the third phase.

3. Operational phase, characterized by available technology and defined user market. Weather and communications are obvious examples of areas in which space systems are operational although parts of these applications are still in the transitional phase.

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The Panel has examined the requirements of these three phases of space systems evolution to assure that its recommended institutional arrangements are suitable to each. The principal resulting recommendations are as follows:

1. *NASA should continue to furnish the capability for technical support services through the operational phase, with particular emphasis on launching and tracking, data acquisition, and general advisory space system support.*

2. *Open access to data for all users must be assured through a federal data management system but any user who has the incentive to do so should be permitted to establish his own data gathering and processing system at his own expense. We therefore propose the possibility of a variety of data processing centers, with at least one fail-safe link that assures to all users an opportunity for equal access.*

3. *A continuing R&D process must be assured through all phases of space systems activities. NASA obviously has that responsibility in the R&D phase. Lack of a well-defined market makes necessary a strong and continuing federal role in supporting (funding) R&D during the transitional phase. At the same time formalized user guidance should define R&D needs and evaluate results through that phase. Thus, joint funding with non-federal users should be encouraged. NASA should continue to serve as the agency responsible for operation and funding but should receive multi-agency support and participation. During the operational phase, users should fund R&D that is specifically intended for their systems while broader national needs, defined by users, will be satisfied by NASA with federal funds when private investments are not adequate. A systematic means should be devised for user payback of federal funds spent for R&D in this phase.*

4. *Although the Panel is concerned about the weaknesses of committees as operating organizations, it nevertheless strongly recommends the establishment of a National Council for Space Applications. Potential users of space applications exist within federal, state, and local governmental agencies and within the private sector and their needs extend through a wide variety of disciplines. The proposed Council should have top-level representation from involved federal Executive Departments and agencies and should provide for state and local governmental representation in its deliberations. Such a Council is needed to assure systematic policies and arrangements for coordinating user needs with the technological capability that has been and is being developed. An existing multiplicity of agreements and committees emphasizes the need for such a coordinating framework, particularly as users and the desirability of user aggregation increase. The proposed Council would exercise the following functions:*

General policy direction

Priority setting

Maintenance of open access to data

Assurance of continuity and standardization

Coordination and evaluation of program development and implementation

Establishment of pricing policy and provision for impact assessment

Assurance of formal contact between users and suppliers

Encouragement of non-federal government involvement and investment.

The Panel believes that the proposed National Council will have sufficient power to perform effectively these eight major functions only if the following requirements are met:

1. *The Council is statutorily established.*

2. *Its membership includes all federal agencies with a substantial interest in space applications and a system is developed by the Council for state and local governmental agencies subsequently to become members.*

3. *The Chairman is the Administrator of NASA.*

4. *An independent professional staff is provided to the Council.*

5. *The Council administers its own budget that should provide for, among other activities, experimental programs conducted through appropriate operating agencies by which institutional arrangements are developed by users.*

6. *The Council is responsible for assuring aggregation and and representation of users of space-systems applications.*

7. *The Council is required to report at least annually, and otherwise as requested, to the U.S. Congress.*

8. *Substructures in disciplines requiring specialized applications are developed and delegated certain functional responsibilities by the Council.*

The Panel emphasizes that Council recommendations will be carried out by existing agencies and that the Council will not replace the existing budgetary process, operational responsibilities, or regulatory functions.

5. *The Panel recommends the formal establishment of an experimental program for institutional development and evaluation to determine the most effective means by which non-federal potential users can be organized and encouraged to make effective use of space systems. This program should be initiated immediately by NASA but should be assigned to the National Council as soon as the Council is operable.*

In conclusion, the Panel on Institutional Arrangement believes space applications carried out in a mature way with reasonable constraints to assure a soundly paced program should provide major long term benefits to all mankind. Technology is clearly at the point where expanded and extensive uses can be made and should be encouraged. Implementation of the recommendations of this Panel and of other Panels in the 1974 study require enlarged legislative authority. We believe that policies and authorities defined in the National Aeronautics and Space Act of 1958 should be extended to assure the means and to emphasize the importance of applying the space systems capability that has been and is being successfully developed.