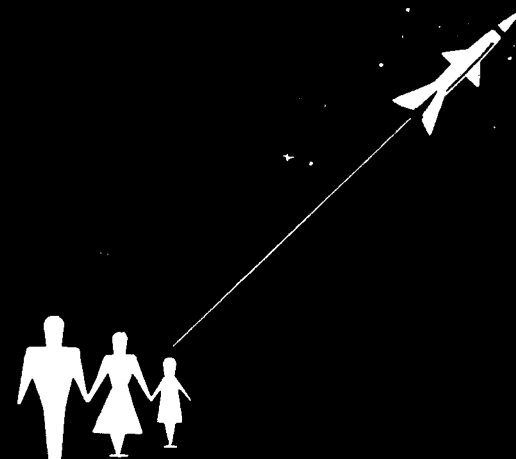
Proposed Studies on the Implications of Peaceful Space Activities For Human Affairs

by

Donald N. Michael



With the Collaboration of:

Jack Baranson
Raymond A. Bauer
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Prepared for the Committee on Long-Range Studies of the National Aeronautics and Space Administration by the Brookings Institution, December, 1960

P R O P O S E D S T U D I E S on the
I M P L I C A T I O N S of
P E A C E F U L S P A C E A C T I V I T I E S
for H U M A N A F F A I R S, Vol. 1

by

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A Report Prepared for the COMMITTEE ON LONG-RANGE STUDIES
of the NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
by
THE BROOKINGS INSTITUTION, Washington, D.C.

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LETTER OF TRANSMITTAL

The Brookings Institution
Washington, D. C.
November 30, 1960

HON. JOHN A. JOHNSON
Chairman, Committee on Long-Range Studies
National Aeronautics and Space Administration
Washington, D. C.

DEAR MR. JOHNSON: I am pleased to transmit herewith a report on "Proposed Studies on the Implications of Peaceful Space Activities for Human Affairs," which has been prepared for your Committee on Long-Range Studies of the National Aeronautics and Space Administration, pursuant to Section 102(c) of the National Aeronautics and Space Act of 1958. This section specifies that the "aeronautical and space activities of the United States shall be so conducted as to contribute materially" to several objectives, among which is "(4) establishment of long-range studies of the potential benefits to be gained from the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes."

In seeking assistance in carrying out the objectives of this section, NASA, through your Committee, and the Brookings Institution agreed that there was a wide range of studies in the social sciences that could be made of the potential benefits and problems arising from the peaceful use of space. In fact, the full range of possible studies was so great that some guidelines had to be established to aid in the orderly selection and proper support of those studies that would contribute most effectively to the policies and purposes of the Congress as stated in the National Aeronautics and Space Act. It was believed, therefore, that if a program of such studies were to be developed, NASA would be in a better position to discharge its statutory responsibilities. The attached report is designed to assist in the development of that kind of comprehensive and long-term program of research and study. The report recommends for the consideration of NASA a wide range of studies regarding the social, economic, political, legal, and international implications of the use of space for peaceful and scientific purposes.

The agreed upon multiple objectives of the report would be well served if it generates research activities within as well as outside of NASA in accordance with the interests of those in the academic community, private research organizations, industry, and other government agencies. Therefore, some material is included which, while familiar to NASA, is felt to be necessary background for those who have not been close to some of the problems discussed.

The Brookings staff members and the consultants responsible for the study collaborated through a series of monthly two-day conferences. In addition, over 200 people were interviewed throughout the course of the project. These persons by contributing their experience, imagination, and critical insight have been of great assistance in the preparation of this report. Throughout the preparation of the report the Institution has had the wholehearted cooperation of your Committee on Long-Range Studies, whose assistance the Institution acknowledges with gratitude.

Midway in the project, the views of the staff were evaluated and enhanced by the participation at a two-day conference of: Lincoln P. Bloomfield, Director, United Nations Project, Center for International Studies, Massachusetts Institute of Technology; George Clement, Assistant to the President, the RAND Corporation; Deane Davis, Project Engineer, Centaur, Convair Astronautics; Alfred J. deGrazia, Director, Center for Applied Social Research, New York University; Joseph M. Goldsen, Senior Staff, the RAND Corporation; H. Field Haviland, Jr., Director of Foreign Policy Studies, the Brookings Institution; Bert F. Hoselitz, Director, Research Center in Economic Development and Cultural Change, University of Chicago; Melvin Kranzberg, Editor, Technology and Culture, Case Institute of Technology; Daniel Lerner, Professor of International Communications, Center for International Studies, Massachusetts Institute of Technology; Jiri Nehnevajsa, Professor, Department of Sociology, Columbia University; Jack C. Oppenheimer, Executive Secretary, NASA Committee on Long-Range Studies; Harvey Perloff, Director, Program of Regional Studies, Resources for the Future; Henry W. Riecken, Head, Office of Social Science, National Science Foundation; and Oscar Schachter, Director, General Legal Division, United Nations.

The study was directed by Donald N. Michael, who is primarily responsible for the interpretations, conclusions, and recommendations in, and the final drafting of this report. Collaborating with him were Jack Baranson and Herbert E. Striner of the Brookings Institution; Raymond A. Bauer, Professor of Business Administration, Harvard Graduate School of Business Administration; Richard L. Meier, Professor, School of Natural Resources, University of Michigan; Aaron B. Nadel, Technical Military Planning Operation, General Electric Company; Herbert A. Shepard, Professor of Behavioral Science, Case Institute of Technology; and Christopher Wright, Executive Director, Council for Atomic Age Studies, Columbia University. Substantial contributions in the form of work papers on specific topics were made by Jack Baranson and Mary E. Robinson of the Brookings Institution; Curtis H. Barker, Center for International Studies, Massachusetts Institute of Technology; Earl W. Lindveit, Washington, D. C.; and Messrs. Nadel, Wright, and Bauer (with Edward E. Furash, Assistant Editor, Harvard Business Review). Research assistance was provided by Ruth Darmstadter, Leonard Schwartz, and Jane Webbink. Charles Clapp, Robert W. Hartley, H. Field Haviland, Jr., Bert G. Hickman, Mark Massel, and Ralph W. Watkins, all of the Brookings staff, reviewed sections of the report; appreciation is expressed to them as well as to Kathleen Sproul, who edited the transcript. The study was made under the general supervision of James M. Mitchell, Director of the Conference Program on Public Affairs.

The Brookings Institution is particularly indebted to the following people who took time out of their busy schedules to review specific sections of the draft report: Lloyd V. Berkner, President, Associated Universities, Inc.; Scott Buchanan, Consultant, Center for the Study of Democratic Institutions; John J. Corson, Director, McKinsey and Company; Cora Du Bois, Professor, Department of Anthropology, Harvard University; Morton M. Grodzins, Professor, Department of Political Science, University of Chicago; Caryl P. Haskins, President, Carnegie Institution of Washington; James R. Killian, Chairman of the Corporation, Massachusetts Institute of Technology; Herbert E. Krugman, Director of Research, Raymond Loewy Associates; Nathan Maccoby, Professor, Mass Communications, Stanford University; Margaret Mead, Associate Curator of Ethnology, American Museum of Natural History; Rhoda Metraux, Associate Director, Project on the Factor of Allopsychic Orientation in Mental Health, American Museum of Natural History; Charles Morris, Professor, Department of Philosophy, University of Florida; Oscar Schachter, Director, General

Legal Division, United Nations; Gerald W. Siegel, Lecturer on Business Administration, Harvard Graduate School of Business Administration; and Stephen B. Withey, Director, Public Affairs Studies, Survey Research Center, University of Michigan.

Finally, it should be noted that the time available for the completion of this report has been short in view of the broad range of subjects and the new areas of research to be considered. The authors have made a pioneering exploration into new fields of investigation in the attempt to foresee types of research which space activities make desirable. The treatment, findings, and recommendations are those of the authors and, in accordance with usual procedures, do not necessarily reflect the views of other members of the Brookings staff, its administrative officers, or members of its Board of Trustees.

Robert D. Calkins
President

SUMMARY

I. INTRODUCTION: GOALS AND METHODS

1. In November 1959 the National Aeronautics and Space Administration contracted with the Brookings Institution to "undertake...the design of a comprehensive and long-term program of research and study regarding the social, economic, political, legal, and international implications of the use of space for peaceful and scientific purposes."

2. The long-term program of research set out in the report (and briefly outlined in this Summary) includes:

a. Sufficient description and evaluation of speculations on the implications of space activities to provide a basis for judging which implications may have sufficient impact on human affairs to merit research.

b. Specification of criteria for selection of high priority research.

c. Specification, when feasible, of high priority research areas for initiating a long-range research program; specification of other research areas which will extend the utility of the initial research; and specification of research which may become central under later circumstances.

d. Suggestions as to methods, persons, and organizations that might assist the conduct of research. (The suggestions are made chiefly through footnote citations of pertinent publications and projects and are therefore not included in this Summary, which carries no footnotes.)

e. Suggestions on the organization and function of a NASA research capability to implement the program (Chapter 2).

3. Space activities require great investments of money, men, material, and creative effort and thereby compete with the needs of other areas of human endeavor. They contribute to rapid rates of technological change and thereby give rise to social and personal readjustment problems. Thus it is most desirable that the problems and opportunities they may imply for society be understood. Since the potentialities of space activities are wide ranging, so, too, must be a research program on their implications: examined herein

are the problems and opportunities that may be introduced by hardware (such as a weather satellite forecasting system); events (such as the adventures of astronauts in space); and ideas (such as those embodied in discussions of the degree to which national prestige may be dependent on success in space accomplishments). Certain implications may be directly related to aspects of a specific social environment; in such cases, these aspects will be examined.

4. Research on the implications of space activities requires a reasonably clear picture of the associated larger social context. Given the complex problems facing various components of world society and the technological developments that are believed possible in fields other than space, it appears impractical to speculate beyond the next twenty years, and perhaps even beyond the next ten. Even within this time span, however, the consequences of space activities can be foreseen only in part, since the effect of any given development in space may be vitiated by unexpected but contingent scientific, technological, or social developments. This report, therefore, does not attempt to predict what <u>will</u> happen to society as a result of space activities. Rather, it poses questions about what <u>might</u> happen and specifies contingent factors which <u>may</u> affect the likelihood of one implication being realized rather than another.

5. Certain potential products or consequences of space activities imply such a high degree of change in world conditions that it would be unprofitable within the purview of this report to propose research on them. Examples include a controlled thermonuclear fusion rocket power source and face-to-face meetings with extraterrestrials.

6. The impact of innovation is no respecter of differences in academic disciplines. To stress the interdisciplinary nature of research on the implications of space activities and to permit a coherent exploration of specific products, events, and ideas the report is organized into chapters that (except for Chapter 2) each represent a major area of problems and opportunities. Within these major areas, all pertinent aspects of the problems are discussed, whether economic, political, or social, or combinations thereof. Certain chapters necessarily overlap, since some of them cover general aspects of problems which are specific to the subjects of other chapters.

7. Time, resources, and especially the lack of a single formulation of social science theory, broad-ranging enough to encompass the variety of problems involved, imposed arbitrary limitations on the amount of research undertaken to back the speculation underlying the report. Thus, the report is not exhaustive in its research recommendations, but the descriptions of the problem areas (developed through interviews, conferences, and reading) are intended to provide the reader with a basis for proposing specific research projects in connection with the study areas recommended here. It is important to note that, as a consequence of this approach, the first specific research project to be undertaken with regard to many of the problems here discussed should be an assessment of the literature to determine what existing knowledge, if any, can be applied directly and what further study needs to be done.

8. Suggesting a comprehensive research program makes it necessary to examine the range of implications needing study, irrespective of who might conduct the research. Not all the research suggested should or could be sponsored directly by NASA; some proposals are more properly within the interests of other groups.

9. "Research" is broadly used herein to refer to a variety of approaches, including "think-pieces," sophisticated logical and/or mathematical evaluations and analyses, and empirical studies in the field. Studies would range from broad programmatic research to detailed inquiries. Most of the projects are phrased in terms of space activities, but many of the suggested investigations could as well be stimulated by or applied to a number of other major on-going or contemplated scientific developments. Examination of the implications of space activities also provides a new standpoint from which to observe human behavior before, during, and after social change resulting from innovation. Thus, the proposed research program offers extraordinary opportunities for fundamental social science research as well as applied.

10. The recommended high priority research areas (listed at the end of each Summary section) are intended to provide NASA with a "mix" of projects to be an <u>initial</u> basis for a long-range research program. The priority criteria emphasize:

a. That the results of the research would have important applications to the social consequences of specific space activities.

b. That the study is urgent in order to identify and resolve operating and policy problems associated with imminent or on-going developments.

c. That the study is non-deferrable in that if the data and methods are to be available when needed it is necessary to begin acquiring them now.

d. That the study would significantly forward the development of a program of peaceful and scientific uses of space.

e. That the study would, through the development of methodology, facts, or theory, contribute exceptionally to understanding or foreseeing the social implications of space activities.

Which projects NASA may choose to implement, even among those which might be thought of as urgent, will depend on factors not within the purview of this report, including budget, availability of research capabilities, important events which have transpired, and the extent to which previous research has paid off.

11. Research areas are included in the report which are not now considered of high priority, but which are likely to become so as social developments and space activities evolve and as high priority research is completed.

12. No assumption has been made as to whether or not specific studies are already underway. If an area recommended for study is presently being competently researched, the priorities here assigned to the area would alter.

13. The magnitude and direction of a long-range research program on the social effects of space activities will depend on the organization NASA establishes to select, monitor, and conduct the studies. One of the most pressing and continuing research challenges for this capability will be to:

> . . . develop effective methods to detect incipient implications of space activities and to insure that their consequences are understood.

14. Each section of this Summary corresponds to a chapter of the full report and sets forth the main points of the chapter and the recommended high priority research for the problem area. In the body of the report, the presentation of potential implications involves discussion of and suggested research on all the issues that seem to be pertinent to a problem area -- including some that do not warrant research at the present stage of the

problem area's development, and some that it would be inefficient to study until other recommended research is completed. This supportive discussion constitutes the bulk of the report and in a summary can only be suggested. Its intent, however, is to make clear (1) the significance of the research recommended, (2) the variety of the projects implicit in the research areas, (3) the order in which related projects could be carried out, and (4) the opportunities for approaching various problems in broad or narrow contexts of research and application. Therefore, although for some readers this Summary chapter may provide sufficient information -- since these four clarifications may not be of central interest to them -- it is assumed that the potential researcher will find it essential to read the body of the report.

II. COMMENTS ON THE ORGANIZATION AND FUNCTIONS OF A NASA SOCIAL SCIENCE RESEARCH CAPABILITY

1. An integral part of the research program as proposed herein is the development of a research facility capable of conducting and evolving a series of long-range research projects pertinent to NASA's directive to study the problems and opportunities implied in peaceful and scientific space activities.

2. To develop within NASA an understanding of the need for these studies and support for their conduct, to assure the maximum likelihood that the research findings will be applied, and to keep in close touch with the technical developments which presage social implications, it is recommended here that the research capability consist of a NASA in-house core of senior social scientists, which would have available to it over time the services of outside organizations. Which functions can best be conducted in-house and which might be handled through the services of outside organizations can only be determined as the scope and pace of the program evolves.

3. The functions that a social science research facility must be able to perform if it is to organize and implement a long-range research program include the following:

a. Identification of problems to be researched. (This report is intended to be a major aid in this area, but its suggestions will need frequent revision, redefinition, and supplementation.)

b. Selection of high priority research. (This report suggests criteria for selecting research, but these must be supplemented by criteria pertinent to NASA goals and circumstances.)

c. Determination of resource allocations, including funds, available research personnel, and field situations for specific studies.

d. Informing and stimulating potential researchers in other government organizations, universities, foundations, nonprofit organizations, and private research organizations.

e. Developing and stimulating potential supporting facilities to provide research tools and other services.

f. Selecting, developing, and implementing research proposals.

g. Liaison -- with divisional groups within NASA, with potential research personnel, and with interested government agencies whose research or activities have significance for the social implications of space activities.

h. Assessing the progress and direction of research in progress, to insure that the studies continue to be pertinent to the evolving situation and that their quality merits continued support.

i. Distributing the research findings to those for whom they were specifically developed and to other pertinent professional people and organizations.

j. Assisting in the application of the findings. (Arrangements regarding applicability of findings should be initially planned, with the participation of the user, during the early definition and selection of the research to be undertaken.)

k. Keeping track of pertinent social science research that is applicable to space activities research, but not a part of NASA's program.

4. In establishing an organization to fulfill these functions, three general points are important:

a. The research which NASA will regard as appropriate to sponsor directly will vary with circumstances. Systematic means should be devised for (1) anticipating the important studies which other research organizations, foundations, and government agencies might be better adapted to carry out and (2) encouraging participation by other research facilities in the program.

b. Recommended research will vary in duration from a few months to several years. Operations procedures for supporting research will differ for longer and shorter time spans, and these procedures will need to be developed.

c. Research is also a device for training researchers. It will be beneficial to support a certain amount of research whose aim is in part to help train social scientists to deal with the implications for society of space activities.

5. To provide the necessary intellectual stimulus for the development of a vigorous program and to carry out the intricate and varied tasks that will be required, it is recommended that no fewer than three senior social scientists of high competence compose the professional staff of the in-house core. Their first tasks are seen as including:

a. Selecting first-order research.

b. Establishing in-house relationships.

c. Establishing outside connections with the research fraternity.

d. Laying the organizational groundwork for the conduct of the first-order research.

e. Establishing a library of selected social science materials especially useful for fulfilling the functions of the facility.

6. The research facility, as a staff function, should have access to those concerned with the over-all interests of NASA. Formal arrangements should also be made to insure the social science staff access to information on technical, political, and economic aspects of the space developments that derive from NASA's divisional activities. Such information will familiarize the social scientists with the space program's operating problems and with the possible research opportunities implicit in them.

7. A person familiar with both the social sciences and the technological activities of NASA and versed in interagency relationships should be responsible for arranging interagency liaison so that research on the social implications of space activities will be forwarded efficiently through the sharing of information on pertinent activities.

8. A committee is needed to assess and review research in progress.

9. A committee analogous to the Space Science Board of the National Academy of Sciences is needed to keep the in-house organization cognizant

of on-going or anticipated social developments related to an evaluation of the implications of space activities.

10. Aside from the liaison function and the awarding of contracts and/or grants, other functions could, as time and circumstances dictate, gradually be transferred to outside organizations. However, the in-house core will need to keep in close touch with assisting services and with personnel carrying out research projects to insure participation at all stages of those who will most directly use the findings and to maintain its essential role as the spark and drive of the program.

III. IMPLICATIONS OF SATELLITE-BASED COMMUNICATIONS SYSTEMS

1. Involved scientists and engineers believe that in a relatively few years the world will be wrapped in a communications net based on the several advantages of communication satellites. The problems and opportunities associated with financing the development and application of communication satellites, with legal and political arrangements for their use, and with their specific applications are closely related to their technological characteristics. Research and development efforts have been concentrated on two operational types of systems: the passive reflector (e.g., "Echo"), which requires very large ground-based transmitting and receiving antennas and powerful transmitters, and the active repeater, which is itself a complex transmitting and receiving station, and thus requires much less large ground-based transmitters. Under many circumstances, signals from repeater satellites could be received directly on private receivers. Careful scheduling is required, however, if active satellites are not to be overloaded, whereas passive satellites can be used anytime they are in range of any facility with transmitting and receiving antennas. To varying degrees, technological problems remain to be solved for both systems -- problems having to do with system capacity, reliability, weight, and the use of higher frequencies for radio and television.

Organizational problems and implications

1. The economics, technology, organization, and utilization of satellite communications cannot be resolved wholly within the framework of the United States' interests and operating methods. Since such a system will be of major utility to international communications, planning must take into

account the potential users abroad and the problems that international use will imply. Research will be necessary to delineate and suggest resolutions for such organizational and operational problems as these:

a. Frequency allocation and/or sharing. Here and abroad, frequency control is already rife with economic, social, and legal problems which would be intensified by the broad coverage and relative non-directionality of satellite signals and the different frequency control requirements of active and passive systems.

b. International agreements on compatability of equipment components used by various nations and produced by various manufacturers.

c. Privileges and priorities of satellite use. Cost-sharing arrangements may be more difficult to enforce with passive systems, and the scheduling of messages requires special agreements when the active satellite system is used.

d. Receiver antenna control and sharing (and in some cases, transmitter antenna, too).

e. Access to audiences: privileges and priorities. Active satellites provide better opportunities for control over transmission. Passive satellites provide better opportunities for control over reception.

f. Program content control, including: amount and type of propaganda, advertising, entertainment, information, and education.

2. Central to the resolution of these organizational problems are the national philosophies which have defined the structure of local operational procedure and organization of present telecommunication facilities. The differences between one philosophy and another as to the purposes and proper use of telecommunications may have substantial implications for the way satellite systems might be used and for the negotiations and organizational inventions necessary to reconcile competing interests within each involved nation, competing national interests, and international interests. Systematic study of these problems is recommended.

3. The United States' role in developing and using a satellite communications system is complexly bound up with questions covering the relationships of our national (government) interests and private profit motives. For example, under what circumstances should the United States government provide launching facilities and research and development in connection with satellite development? If taxpayers are to finance portions of the

technological development of communication satellites, what provisions are to be made about patent ownership and satellite utilization? If the government is the major developer of a satellite communications system, what should its policy be about present privately owned and operated systems which may be displaced or made obsolete?

4. The possibility that the USSR and/or other nations will develop competing communications satellites has implications that need study. Further, some informed observers argue that only by placing satellite system radio and television facilities under United Nations or other international agency auspices can frictions resulting from their use be minimized and the benefits maximized. Anticipation of either competition or internationalization would affect the evolving relationship between the United States government and private enterprise concerning development and use of a satellite system, since private incentive to invest in research and development depends on the profitability that could be expected from the system's operation.

Possible uses and their implications

1. With the initiation of a satellite communications system, large amounts of the newly available channel capacity will most probably first occur for radio telephony rather than for television. High-speed, inexpensive voice communications should provide far-flung business and other organizations with a further capability for extending themselves through the increase in control and coordination thus made possible. Ever larger organizational entities might thus be encouraged, to the detriment of existing small organizations. Alternately, the increased communications capacity might increase the ability of small organizations to survive, through better control and coordination of their resources. The implications of these alternatives and their consequences for organizational growth and stability merit study.

2. The advantages of increased voice-to-voice communication for world diplomacy are not clear, since the present pace of diplomatic communications is sometimes deemed already too swift for careful analysis. However, the availability of sufficient telephone channels might encourage the evolution of an international "secretariat" at the working level, in the long run more identified with task goals than specific national interests. Research should help clarify the special problems and opportunities for diplomatic relations.

3. World-wide data search, coding, retrieval, and processing and the integration of far-flung systems operating automatically via computers and feedback control would be made possible by large-capacity communication satellites (or by their freeing-up of conventional facilities for this use), to the great benefit of scholarship, science, business, and government. Handling of data for a world-wide weather forecasting facility (as discussed in Section IV) and coding the contents of the major libraries of the world for machine search are important examples of this utility. Substantial increases in computer production and data-coding personnel would be required, and computer programing and system building and maintenance would involve extensive operations. International standards of component compatibility and reliability would be mandatory, thus further extending multinational interdependence. The social, economic, and political prerequisites and consequences of these potential developments need study, especially because such facilities may provide a tool and stimulus for a concerted attack on the problem of efficiently using the overwhelming amount of data presently threatening to swamp this civilization.

4. In view of the possibly radical increase in the pace of organizational activities resulting from high-speed interlocking of data, decisions, and actions, it is not clear whether more or less strain would be put on decision makers. Further, the opportunities for coping with increased organizational complexity could make society vulnerable to serious disruption should the communication system break down. The possibility of tying together data, men, and decisions in a world-wide interdependence has vast implications for attitudes about man and his meaning in the context of his society. Preliminary inquiry may help provide perspective and prepare the way for more systematic study as the situation evolves.

5. The use of satellite-based radio and TV for teaching in underdeveloped areas has been much discussed. However, unless the development of satellite-based, multichannel TV is accelerated specifically for this purpose, other more conventional teaching means may develop to a degree that would challenge the advantages of education via telecommunications. In any case, behaving and believing according to the standards and information conveyed by telecommunications involves a number of complex cultural and psychological factors, especially in an area which may lack the literacy and at least some degree of urbanism normally associated with learning from TV and radio. Research

is clearly necessary to specify and understand these pertinent factors. Problems are also posed and study is needed in regard to the capacities in such localities for distribution, maintenance, and replacement of receivers.

6. In already advanced nations, the immediacy of exposure to world-wide events and ideas via radio and TV could affect general education levels. However, important changes in perspective that might lead to greater tolerance and understanding merely on the basis of this exposure are not guaranteed by the evidence so far available. Research will help clarify the factors involved here.

Using satellite communications for formal learning sessions may not be generally efficient in view of expected developments in film and video tape libraries, teaching machines, and air-borne TV. Nevertheless, special "live" events, which otherwise would have to be taped and distributed singly to local schools or local transmitters, could be presented by an active repeater system if such problems as scheduling and time zone differences can be solved. A satellite system could also transmit TV tapes from central libraries to local schools for retranscription. The costs of TV tapes might thus be lessened, and access would be provided to a much larger and up-dated library of materials than many schools otherwise could afford. The social and economic costs and benefits of these schemes will need careful examination.

7. A combination of powerful active satellites and simple receivers and antennas could be used to enhance or splinter political identification via propaganda, incitement, or information in areas lacking local ground-based transmitters. Research will be necessary to determine under what circumstances such communication methods would be sufficiently effective to merit their use -- and if effective, how to control their use.

8. If large TV channel capacity becomes available -- via satellite or via conventional facilities freed-up by the satellite -- conferences via multiple closed circuit linkages are possible. This would save time, inconvenience, and physical risk and permit a greater marshaling of home-based resources for each participant. Technological capabilities and social, psychological, and economic considerations will decide whether such conferences would become routine. Should they become routine, the consequences might

be serious for the travel and hotel industries, for which conferences of all kinds have been of great importance.

* * * * *

To provide social criteria for decisions regarding communication system design, research should determine:

. . . The specific sources of demand for increased communications capability, and the assumptions, made by those claiming that they would pay for the use of satellite services, about the capabilities of the communication system for meeting their needs. What are the implications for system design?

An important group of decisions related to government policy for communications system development support would benefit from study to discover:

. . . The advantages and disadvantages of various means whereby the government might fulfill its obligations to private enterprise, the nation as a whole, and special interest groups with regard to: supporting the development of a satellite system; ownership; frequency assignments; allocating profits and costs; and assuring the use of the product in the best interests of the nation. What are the most appropriate and effective roles for government, private enterprise, and other organizations in financing, developing, owning, controlling, using, and negotiating for the use of satellite communications domestically and internationally?

A good place to begin studies which will help in eventual negotiations on satellite use is to determine:

. . . What economic, cultural, and technological factors, in each nation or region involved, could complicate or facilitate the conciliation of interests in using and controlling satellite-based communications? What technological, economic, organizational, and legal arrangements could be developed to overcome specific major difficulties for conciliation as detected in the above? To take advantage of specific major opportunities?

Since the benefits for society could depend on the organizational approach taken, and since these problems are better studied before imminent developments obscure issues, research should be begun now to determine:

> . . . The cost and benefits of turning over to an international agency those communication functions which are inherently unprofitable for private interests and/or which have the potential for stimulating international unrest. Under what conditions would such a transfer of function be in the interests of the United States? In the event the facilities were internationalized, what activities might be prohibited or subjected to international control and what should be the functions and powers of such an international body?

Because the effective use of satellites for teaching purposes will require much more understanding of learning factors in relation to telecommunications than we now possess and because the application of such findings would be very important for world society, it is most desirable to begin now to:

> . . . Apply and further develop knowledge of and methods for understanding the factors -- such as culture habits, literacy, subject matter, auspices, format, and opportunities to use what is learned -- which affect the degree and type of learning from telecommunications. These studies must be aimed at meshing the content and purposes of telecommunications with other forms of communications from interested government groups, private organizations, and international agencies.

IV. IMPLICATIONS OF A SPACE-DERIVED WEATHER PREDICTING SYSTEM

1. Space activities are expected to contribute in two ways to the development and maintenance of a world-wide system for accurate long-range and short-range weather forecasting: (a) information for improvements in meteorological theory and the routine observations necessary for its application will be provided by space probes and satellites; (b) theory development and application will require a correlative and interacting world-wide net of ground-based, lower-atmosphere data collecting, processing, and distributing facilities, for which communication satellites appear to offer the most feasible system for handling the expected vast amount of data. Once the ground facilities are established, which may be in the relatively near future,

many nations may have access for the first time to systematic science-based forecasts similar to those presently available in regions using conventional forecast methods. Implications meriting research will presumably derive from the problems and opportunities inherent in the establishment and maintenance of the world-wide, integrated satellite and ground-based system, and in the uses made of the forecasts. The degree of utility will depend in part on what other technological, social, and political developments have occurred by the time the capability is available.

Establishing and maintaining a world-wide weather organization

1. A world-wide forecasting system will require the evolution of a globally standardized set of rules for the complex operations and negotiations involved. The increased emphasis thus placed on the interdependence of all components of world society might well help diminish international friction. Nevertheless, the system's development period will probably take place amid some degree of the mutual national suspicion and economic and political competition that now pertain. Further, since weather information will continue to be important for all types of warfare -- including economic -- the exchange of weather data may be inhibited under some circumstances. If potential inhibiting circumstances can be delineated through research, it may be possible to anticipate and thus avoid them.

2. The many decisions that must be made about the location of ground-based facilities for collecting, processing, and distributing weather data imply the need for studying the potential legal, economic, and political complications. For example, who will pay for and control the installation and maintenance of the facilities? It is very probable that some countries would not wish to contribute to the effort during its developmental stage, while others might from the beginning consider participation highly desirable, especially if facilities could be installed within their borders. There may be conflicts between technical and political criteria concerning the "best" placements for facilities. Study of potential conflict factors might resolve them before the fact. Who, for instance, will make such decisions and on what bases? Are these to be national or multinational decisions, or should they be made by an international organization? If decisions are not to be made by individual nations, what is the appropriate role for the United States in facilitating the development of theory and practice? Given the military

utility of weather data, what criteria should be used for evaluating the strategic cost and benefits of releasing specific weather information? How would various possible policies affect the various possible interests of specific nations?

3. Once the alternatives of ownership, funding, and control have been clarified, negotiations must be undertaken to establish the operating organization, its standards of quality and equipment compatibility, and the procedures for handling sporadic, deliberate nonparticipation or continued noncompliance of members of the network. The negotiations will be subject to complex pressures arising from the differing motives, legal procedures, and political arrangements of the various nations participating in them. Systematic inquiry might valuably elucidate these factors and their relationship to negotiation alternatives.

4. Highly trained meteorologists have been in short supply for some time, but many will be needed as well as many other personnel to operate equipment, develop theory, make local forecasts, and distribute them. People especially trained to translate weather forecasts into meaningful ideas for users unfamiliar with them will also be needed. Questions are thus implied that require research. Who, for example, will pay for the training of the needed personnel? Where will they be trained, and who will train them (teachers being in short supply)? What major changes in and additions to curriculum content will the developing field require? Some nations may prefer to use their scarce, talented manpower in other technological endeavors that they consider of higher priority than weather forecasting. Others may welcome participation as a way to train personnel in the general idiom of technology so that they would thereby also be useful for other high priority purposes. How, then, should the training and use of personnel for a weather system be planned so that it will aid in expanding the world's general supply of scientists and technicians?

Implications for weather control

1. The possibility of a space-derived forecast system has aroused much discussion of relatively immediate advances in weather control. However, with the exception of possible occasional experiments or a certain amount of localized, legally acceptable, rain-making, developments in weather control will probably depend on meteorological knowledge made available only

through the gradual development of a weather theory adequate for world-wide, long-range forecasts. There may nevertheless be pressures for experimenting with such devices as nuclear explosions to disrupt typhoons and hurricanes. Conducting such experiments without jeopardizing human safety would involve international agreements. Preliminary research could help to prepare a basis for solving the collaborative problems as their nature became clearer.

Implications for product raisers

1. Long-range or seasonal forecasts will face the farmer and those who make farm policy with many decisions. Given a partially unfavorable forecast, for example, how much land should be kept in use and what crops grown? What techniques might mitigate the weather effects? Associated decisions would have to do with the availability of easily obtained and adequate financial support when the direction of a prediction made it desirable or necessary to cover costs of seeds, fertilizer, equipment, stockpiling facilities, and the like. All these decisions imply an alteration in the behavior patterns of both farmers and government policy makers in tradition-oriented agricultural areas. Changes in traditional farming patterns would eventually produce profound changes in distribution and marketing methods and in consumption patterns and government policy. Much careful research and advanced planning will be necessary if full advantage is to be taken of the opportunities for raising standards of living, and if the disruption attendant on the transition is to be minimized.

2. Methods must be developed for handling such consequences of responses to forecasts as bumper crops of the same product being grown in several different parts of the world. International crop planning and allocation procedures may be necessary to balance out economic and substantive inequities and otherwise assure the distribution of supply in keeping with the immediate demand and with longer-range storage requirements. Such international arrangements, implying major changes in a nation's policies regarding its domestic farming, would require much anticipatory study.

Implications for tourism and related recreation industries

1. For recreation facilities, the main consequence of both short- and long-range weather forecasts may be a sharp increase in overloads and underloads.

The forecast of a bad season for regions having tourist-dependent economies -- the French Riviera, parts of Florida, Switzerland, etc., -- could have major national or regional economic repercussions, and could strain international relations. Economic reorganization of the tourist and recreation industries might become necessary, so that facilities unused because of expected bad weather could be balanced against facilities where there is expectation of good weather. Other questions raised concern the role of the government in mitigating major national and regional imbalances, given its part in providing the forecasts. All of these problems will benefit from research.

Implications for water resources and fossil fuel utilization

1. Seasonal forecasts would permit optimum use of multiple-purpose dams that now retain part of their capacity to cope with unforeseen seasonal overloads or underloads.

2. More efficient use and realistic stockpiling of fossil fuels would be permitted if seasonal demands are known in advance. With urban and population growth, the world demand for fuel is continually increasing; an advanced planning capability should encourage world-wide programing of fuel allocations, both to fill routine needs and to alleviate suffering in times of weather emergency. Important questions of pricing, production regulation, and national and private profit interests arising in this connection merit study.

Weather disaster mitigation

1. Many nations may relatively soon have the advantage of hurricane and typhoon forecasts, if Tiros-type satellite observations prove to be as useful as it is believed they can be. Such disasters as droughts and major floods may eventually be predicted also.

2. Providing forecasts of imminent disaster does not by any means assure that they will be acted on. Emergency action depends on the physical resources available, the motives of the leadership that must decide what information to make available to the public, the psychology of the public about action, and the time available. Quick and productive reactions to disaster forecasts require a certain amount of education of both leadership and the public. Much more research is needed on how to educate for disaster, especially in the many world cultures where a traditional fatalism has

prevailed. Decisions must also be made about what expenses any community or any nation wishes to sustain to be prepared for infrequent disasters such as tornadoes or hurricanes; these decisions would benefit from cost and benefits studies and operations research on preparation arrangements.

3. Long-range forecasts of such lingering-effect disasters as drought and heavy flooding will confront involved nations with the need for preparations to cope with the people and institutions that would be displaced by or threatened during the disaster. In many nations this would require an organization of personnel and an allocation of resources -- both of which do not now exist or are needed for or absorbed by other activities. Governments warned publicly of disasters with which they have little competence for coping may be seriously embarrassed. This implies opportunities and problems for other nations in deciding how and to what extent they would provide personnel and resources to mitigate the consequences of a disaster in another nation. The resolution of the many facets of these problems deserves intensive pursuit through systematic inquiry.

<u>Implications for transportation</u>

1. More efficient use can be made of commercial transportation facilities if accurate forecasts make it possible to anticipate transportation needs as functions of the effects of weather patterns on clients' shipping plans.

2. In nations with somewhat primitive transportation systems, weather forecasts would provide the opportunity to use weather-dependent transportation methods and routes more efficiently. This may also help to raise living standards and further the development of rationalized decision making and of the requisite technical and human systems to implement it. Research would be desirable into methods for helping these areas take advantage of the opportunities provided by the forecasts.

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As a prerequisite for planning further research activities on the implications of the uses of weather forecasts study is necessary to determine:

. . . The activities that will be most advantaged or disadvantaged by varying amounts of improved forecasts. Here it is necessary to consider the time at which improved forecasts are expected to be realized and the technological and social contingencies which may affect the degree of weather-dependence. In particular, legal, political, economic, and cultural factors must be considered for their influence on the advantages and disadvantages of long- and short-range predictions.

In view of the likelihood that many nations will have access in the relatively near future to forecasts of hurricanes and typhoons, via satellite observations, research should begin at once to determine:

. . . What needs to be done and what can be done in other nations as well as the United States to prepare for various types of imminent disasters at various levels of destruction, in whatever time would be available. Here it is necessary to examine (a) the communication facilities and organization required to provide the requisite information soon enough, and (b) the organizational and personnel equipment and, possibly, the legal procedures required to cope with emergency action.

The ground-based facilities needed for developing better weather theory may of themselves provide reasonably good forecasts in many areas. Since they may be installed relatively soon, and since such forecasts could have major effects on farming methods and product distribution and utilization, it is most desirable to begin now to plan activities to make the transition as comfortable and effective as possible. Basic to such plans will be research which will determine:

. . . The extent to which the requirements for using science-based forecasts are compatible with the perspectives and behavior of those who will directly use the ideas or methods and of those at higher levels who must approve the ideas or methods for use. Among factors of special interest with regard to product raising methods and ideas are: the degree of acceptability of scientific statements as a basis for action; existing methods for making long-range forecasts; reactions to shifting the customary rhythms of crop processing behavior, and to both growing and eating alternative crops; how directions or advice are taken from higher echelons; and what the definition of "qualified authorities" is.

The implications for national interests of supporting a national or international weather system are many. These will take much study and time to clarify. It is recommended that research be initiated to determine:

. . . The relative advantages and disadvantages -- economic, political, cultural, and military -- of international, national, or nongovernmental control of all or parts of the theory development system and, eventually, the weather predicting system. What problems need to be resolved regarding ownership, funding, and staffing of facilities in each of these cases?

V. THE IMPLICATIONS OF TECHNOLOGICAL BY-PRODUCTS

1. The term "by-products" is used here to define those technological items or methods whose development probably would not have occurred or would not have been accelerated to the present extent had space activities not existed, and only items meeting this definition are examined in this section. Many other products given glamour by being popularly called by-products of the space effort are more logically ascribed to the general trend of technological invention.

2. Even for the "legitimate" by-products, more importance seems in some cases to be claimed than is justified by a review of their implications. Better understanding is needed of the economic relationships between the derived products and the original products, and methods also need to be developed for recognizing whether by-product developments have or are likely to have really important social implications.

Derivation, uses, and implications

1. Putting man in space will systematically expose him to great physical and emotional stress. Special methods, drugs and medicines, and equipment are being developed for measuring stress and possibly for coping with it. Although it is known that human capabilities are sometimes extraordinary under stress conditions, systematic information on the matter is sparse. The studies being made in relation to the Mercury astronauts contain important space by-products, in their potential for contributing to knowledge on this subject. They may also, especially if the information and new medical techniques they produce are applicable to the general public, change attitudes about subjecting man to stress, thereby generating basic ethical and moral questions, the resolution of which may have profound implication for man, both in space and on earth.

2. Telemetry, the technique whereby the state of an object is sensed by electronic or mechanical devices, transformed into an electrical impulse, and transmitted to recording and analysis equipment, owes its recent rapid development almost entirely to the space effort. Given associated equipment, it could be used in any situation where information at a distance was required, thereby permitting new orders of human and physical control. Among the many potential uses of this space-stimulated by-product, its utility for the field of medicine is of special importance and interest. The possibility of conveying medical and emotional data to central computers via surgically imbedded microminiaturized telemetering equipment appears to be realizable. This could permit continuous two-way monitoring of a person's state of health whether he is in the hospital or ambulatory -- and release doctors to some extent for specialized work, thus helping to relieve the anticipated aggravation of the doctor shortage. Such an approach to routine medical surveillance presents legal, political, moral, and ethical problems, which doubtless would be vigorously argued and which would benefit from careful study. An extension of this application of telemetering devices involves monitoring emotional states by obtaining the physiological information that is associated with them. The process would be useful for psychiatric therapy. It could also be of use to institutions and governments in various ways, some of them perhaps not acceptable to the democratic ethic. There are profound moral implications inherent in the possible applications of this space technology which deserve study to clarify the problems and opportunities involved.

One likely consequence of making very broad use of telemetry (in association with computers and with other communications devices) will be an intensification of arguments on whether man can continue to be master of his machines. If preoccupation with the problem increases, attitudes may be affected to an extent that the possibilities of use would not be permitted full exploration.

3. Of the power sources being developed for space craft, at least three could be used on earth. (a) Plasmas and magneto-hydrodynamic power would seem to have no new implications for the using environment. (b) Solar power could operate small devices, such as data recorders, in isolated areas (which thus would be helped to accumulate new knowledge) and low power appliances, such as small radios; it is limited as a power source, however, and storage is needed for night operation and cloudy days. (c) Nuclear-powered

thermionic converters could provide isolated areas with more substantial amounts of power and do not need storage devices. Either of the latter two could be used in highly urbanized societies for operating equipment remotely and reliably, but they probably have no special implications for change except as the power sources for telemetry equipment. In underdeveloped areas their highly compact and reliable characteristics might provide power sources without requiring major ground transport into the region as is usually the case when conventional power sources are used; the implications for social change under these circumstances deserve study.

4. New plastics, alloys, and combinations of metals and plastics may compete strongly with conventional metals and other fabricating materials because of their extraordinary strength, lightness, and temperature resistance. But the demand for conventional ores may not be reduced, given the demands of increasing population and urbanization throughout the world. The social implications of the new materials include their potential for displacing extant technologies and manpower, disrupting supporting communities from the mine to the fabrication plant, and changing the patterns of the international metals trade. Study will be necessary to assess the possible extent of changes thus produced, and, if the changes appear large, to discover means of coping with them.

5. The need to develop highly reliable components for space activities is generating a variety of changes in manufacturing technology, quality control, equipment design, and utilization philosophies. Many of these changes are applicable to products for general use. Highly reliable consumer products would free repair and service personnel for other tasks. Moreover, materials now applied to the replacement of short-lived components would be available for other use. Such changes would provide many opportunities as well as problems for consumption-oriented economies, especially in the light of the developing nations' aspirations for higher standards of living and the international competition for resources. Research on the interrelationship of these matters is therefore recommended. Reliable components also have important implications for bringing telecommunications to underdeveloped areas (see Section III).

6. The closed cycle ecological systems being evolved for maintaining human life during space travel by reprocessing biological waste into

food, water, and air are applicable in principle to certain human situations on earth. However, within the twenty-year time span observed by this study, such systems would probably not outweigh the advantages of other sources of these necessary elements.

7. The social and economic costs of rocket propulsion for humans and for freight (the costs for the latter including packaging, transport time to launching sites -- which must be distant from cities -- unpackaging, and transhipping) need careful study before the implications, if any, can be evaluated. Research is also needed to ascertain whether there is significant utility in ever faster human transport if the world has easy telecommunications via satellite and reliable, comfortable jets. Aircraft braking and lifting rocket boosters would provide access to areas not now directly reachable by jets, but the implications, if any, for society will not be clear until the plans for and need of such projects are further clarified.

8. Given the anticipated development of precision guidance systems within the next twenty years, it is very possible that all kinds of vehicles could be so guided without human intervention. However, the legal and ethical problems in regard to responsibility in case of malfunction will need study. Possible personnel displacement may also present problems. Systems analyses studies will be needed, as well as research on means (if needed) for coping with personnel problems and on the relative merits of replacing a multifunctional human with complex and expensive guidance equipment.

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Since known by-product implications may take on new importance rapidly and new by-products will be developing continuously, research should be begun now on:

. . . Means for establishing, maintaining, and operating "watchdog" groups to alert and inform appropriate authorities and organizations to the foreseen or discovered applications and consequences of space technology by-products. Thus appropriate research or action can be undertaken to maximize the benefit to mankind.

Because of the potential importance of reliability to the operation of our consumer economy, study should determine:

. . . By means of cost and benefits examination, the effects of increases in reliability at various steps in the production-consumption sequence.

Since the long-range implications of telemetry uses may well be profoundly good or bad, research on the combined impact of telemetry, microminiaturization, and compact mobile power supplies should begin to:

> . . . Delineate as systematically as is now possible the specific economic, legal, social, and moral problems and opportunities implied in future society-machine relationships, so that opinion leaders and policy makers can be aware of what must be resolved and planned for before, during, and after major developments in this communication and control capability.

VI. IMPLICATIONS FOR GOVERNMENT OPERATIONS AND PERSONNEL USE

1. Space activities require an extraordinarily large number and variety of scarce professional personnel and very large funds (funds also desired by other federal agencies and programs in science and technology). They divert public attention from and direct it to other government scientific efforts; they obscure cherished organizational distinctions between science and engineering, and basic research and applied; and they are important for international as well as national goals, and military as well as scientific and commercial goals. Thus, they have significant implications for a variety of agencies in the government, and in turn they may be vitally affected by these agencies. These implications are expressed as an imposing set of demands for efficient personnel utilization, complex organizational arrangements, and the resolution of ambiguous relationships between space, science and technology, and policy making. Much research on these problems will be necessary to understand and meet these demands.

Manpower implications

1. NASA's needs for large numbers of highly specialized personnel put it in competition with industry and nonprofit institutions, which have similar needs, and all three groups compete with other social needs for these personnel. Efficient personnel use requires special study on how to train and up-date the experience of personnel associated with NASA as well as how to anticipate the more complex training requirements for new personnel for the years ahead. Certain very important experience and training can only be acquired in the field environment, where the research, construction,

and launching of space activities are actually under way. Since there are relatively few such environments, new legal and procedural means may have to be devised for exposing professional personnel to requisite experiences by circulating them within NASA and among other involved government agencies, and perhaps even among industries and nonprofit institutions.

2. Motivational factors that help to attract appropriate personnel include salaries, opportunities for professional advancement and stimulation, and the special work environment required to stimulate research. Research and development activities clearly require different kinds of organizational structure and managerial philosophy from those which are traditional for other large-scale undertakings in industry and in government. The uncommon degree of complexity in space research and development, combined with the fact that a research manager usually has a different range of relevant knowledge and skill from that of the professional group he leads, emphasizes the importance of undertaking research to find alternatives to a command system for laboratory administration. At present, understanding is limited as to why professionals choose to join or leave government space research and development. Research can provide a more comprehensive understanding.

3. Efficient planning for space activity manpower needs requires studies providing methods for obtaining data on the types and numbers of personnel that might be available now and that will be needed in the future. Present manpower directories are inadequate in their coverage. NASA and other government agencies with complementary and supplementary personnel interests have need of a formal means for collecting and sharing knowledge about potentially available personnel and of a cooperative plan for their efficient use. Appropriate studies are necessary to meet this need.

4. Long-range planning on space activity manpower needs would help to assure that the right number of students could be encouraged to seek careers in specific professional fields applicable to space activities. There is also a need to make balanced use of scarce human resources between this area and other fields of great social importance. In view of NASA's longer-range personnel needs, the implications of space activities for career aspirations in the younger generations are especially important to study. The glamour of space activities and the play given them in newspapers and magazines may affect the attitudes of parents, adolescents, and career advisers toward these career

possibilities compared to those of other areas, but study is needed to understand how information and sources of advice finally affect career choices. There is also a need to examine and indicate academic training requirements for space activity careers, in view of the special demands placed on such training by the very rapid and complex technological advances characteristic of the field.

Organization

1. NASA's wide-ranging needs and impacts present it with problems of organizational coordination, competition, and cooperation with other agencies which are at once new and at the same time characteristic of the conflicts always inherent in complex organizations. The problems are especially complicated by the large variations in size, political power, monetary resources, types of functions, and personnel composition of other government organizations having interests that are complementary or supplementary to NASA's.

2. Because of the growing costs and requirements for specialized resources for space programs, it will be worth while to explore means for more effective coordination and cooperation between agencies having related interests with NASA. For example, developmental, operational, jurisdictional, and policy considerations in connection with present and future specific space activities will involve the U.S. Weather Bureau, the FCC, Office of Civilian Defense Mobilization, the Department of Agriculture, the Department of State, the Defense Department, etc. Careful study will be necessary to discover the best means for arranging functions between agencies. Wasteful jurisdictional disputes over the control of related science and technology development can be expected unless research reveals means to avoid them.

3. If space activities expand and some development and launching facilities are established independently of military reservations, state regulations regarding siting and control of dangerous space operations or health hazards may affect space activity planning. States may promote testing, launching, and research facilities for space activities to attract and retain academic personnel and bring good students to the universities, and as inducement to industry. All of these possibilities may present federal-state regulation and control problems as well as opportunities to expand space activities; study should be undertaken to anticipate and resolve the problems.

<u>Implications for science advisory activities and government policy</u>

1. Space activities have become inextricably intertwined with science in general at the government policy making level and vice versa. This is not new to science or government, but it has received special emphasis as a result of the special and spectacular role of space activities in domestic and international government policies. Probably more than any other scientific and engineering area, the space effort has emphasized and dramatized the complex and unresolved problems of assigning priorities to competing and cooperating scientific and technological efforts. It has also emphasized that the problems inherent in the many roles played by the scientist in government -- pure scientist, government adviser, special pleader, promoter, everyday citizen -- have become confused in the scientist's own eyes, in the eyes of non-scientists with whom he must work at the policy levels of the government, and in the eyes of those outside of government who report on and interpret the interrelated activities of scientist and non-scientist policy makers.

2. The role of the scientist as scientist and as citizen and its relation to his role as an adviser to the government is especially important in the space area, where national, international, and political factors become central to some policy positions, and where the scientist representing these positions may find himself in conflict with his personal values as a scientist.

3. Confusions and differences of opinion about the proper and useful roles for and relationships between science advisers, science administrators, science advisory groups, and non-scientist policy planners and policy makers must necessarily interfere with the effective performance of their functions. Research will be necessary to clarify this situation and to provide a basis for remedying it.

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Studies useful for policy planning to assure adequately trained personnel for NASA can be initiated by research to determine:

. . . The present and foreseeable experience and training requirements for scientific personnel affiliated with space programs in the government. What are the legal and procedural means by which personnel could be exposed to the requisite experience and training in such ways as to benefit them and the government's activities in the space field mutually. Included should be examination of means for encouraging or discouraging turnover and circulation of personnel between and outside of government agencies as is appropriate.

As a first step toward increasing the opportunities for interagency cooperation and thereby the advancement of the scientific and peaceful space program, research should determine:

. . . The possible advantages and disadvantages of particular cooperative and coordinated arrangements for the use of manpower, money, and physical resources between specific agencies having interests in present and anticipated space research, developments, and applications.

Understanding the complex relationship between career selection, career advice, and information about space activities will require, as one major input to the problem, research which will show trends about:

. . . The evolving images, in the minds of parents, teachers, career advisers, and young people, of the space scientist and engineer, and how these compare with the images of other possible career models. In particular, what values (e.g., craftsmanship, dedication) are perceived as involved in particular careers? Are these seen as attractive or unattractive? What knowledge, ignorance, events or experiences alter or emphasize the nature of the images held?

Preliminary to studies on alternative means for resolving the problems involved in utilizing science advisers and science administrators in policy making in regard to space activities, case-study research is necessary to determine:

. . . The operating relationships between the science adviser, the science administrator, and their respective users in the area of space policy. Precisely in what ways do the missions and perspectives of the three groups complement or confound, in specific circumstances, operating procedures, policy making, and administration?

VII. IMPLICATIONS FOR SPACE INDUSTRIES

1. The high rate of change of space technology and the heavy government participation in stimulating, directing, and consuming this technology seem to have confronted some corporations, government, and other parts of society with economic, organizational, and social problems. Some of the problems may be new; some are old problems made acute by space activities; and some may be old problems exaggerated in the telling through the novelty of space activities. Much research will be required to clarify and resolve these problems, and the results may have significant implications for corporate philosophy and organization, government-industry relationships, and the allocation of certain national resources.

Many of the problems to be summarized derive from a background of military rockets and missilry rather than peaceful space activities. Differences in national purpose and, thereby, the allocation of national resources may affect the nature and importance of these problems as peaceful space efforts increase.

Corporate response to space activities

1. Characteristics of present space enterprise affecting corporate outlooks about investments and risks are: negotiated profits from limited production of custom-made space equipment; high precontract competition costs from company-sponsored research and development and contract preparation costs; large proportions of professional personnel and corresponding problems in personnel management and utilization; and the need to continually adjust and evolve facilities to provide the capabilities for developing space equipment.

2. Estimates about what investment to make and risks to take depend in part on what view is held of the future of space activities for peaceful uses. Some feel that quasi-production line quantities of stabilized components useful for a series of space activities will permit better profits and more traditional operational organization. Some take the view that the many technological alternatives for ambitious space efforts will provide research and development support for many firms. Others feel that the industry will evolve until a very few companies produce all the major components and, in the process, will gain the know-how which will assure them the next series

of contracts, and so on. Research is necessary to make clearer the factors which are acting or may act -- tending to drive the evolutionary process one way or the other.

3. One response to these evolutionary alternatives has been heavy investment in broad-ranging research and development facilities intended to supply ideas for diversification into new markets, as well as to develop space-related items and ideas which will put the firm at the forefront of a new government-supported technological wave. These R & D activities pose three important questions needing study to understand their consequences.

a. Who should own the rights to developments produced under government funds -- and, if the government is the owner, how can it be sure it receives all pertinent information?

b. What research should the government do in-house and how much on contract to support and take advantage of these private capabilities, and what is the optimum mix of outside multipurpose R & D facilities to special purpose facilities?

c. What are the consequences for the over-all quality of industrial performance -- and for the needs of the rest of society -- of competition for scarce personnel "stockpiled" for capability demonstrating purposes as well as for doing wide-ranging R & D?

4. Under the prime contractor system, there is a question of whether small firms can compete and survive as the space industry evolves. Limited staffs, intermittent roles, small profits, and small financial resources, all seem to confront the small firms with special difficulties in the space field. These difficulties deserve clarifying study so that possible solutions could be suggested.

5. Government-industry R & D cost-sharing and public finance policy would benefit from research providing better measures of corporate costs and profits over the long run, which also involve public funds. Research is also warranted to develop means for measuring performance efficiency in the absence of a price mechanism.

6. One question assumes many guises in this area: what is the best way to allocate government and industrial funds for the development and production of space systems in the absence of conventional market relationships? The negotiated contract is not unique to space activities, but the use of this

form of cost arrangement presents special problems in reconciling industries' interests in higher profits with the national interests in what is advisable in space activities.

Personnel utilization

1. Space activities use large numbers of engineers, scientists, and managers. Their special capabilities and the organizational problems of complex team activities involve managerial and personnel relations problems needing much more study to resolve them. In particular, research is necessary on means for operating complex research operations in a manner that will induce high levels of creativity. Certain rates of turnover and of circulation between industry and other types of research environments may improve or degrade creative quality; study of this point should help clarify it.

2. Recruiting enough craftsmen with "watchmaker" quality standards or motivating workers to produce that quality of work may be a sufficient problem that it would be useful to conduct studies on means for improving the requisite motivation and performance among workers building space equipment.

3. There will be great competition for high-quality professional personnel in future years, since they will also be wanted by other industries and for other socially pressing areas. In view of these other needs and in view of the expected scope of future space R & D, much careful study is needed to determine whether there will be sufficient numbers of high quality professional personnel to fill later personnel utilization goals. Excessive competition with universities and nonprofit research organizations may weaken necessary teaching and institutional research, thus jeopardizing the general state of social development as well as the supply of new high-class personnel for the space industry. However, intensive industry recruiting and competition for personnel may stimulate more people to become scientists and engineers and encourage quality attitudes toward craftsmanship. Study of these matters is well worth while, so that allocation needs, trends, and other implications may be better understood.

Government and industry relations

1. Government regulations that are related to space firms include the franchising of activities such as satellite operations and launchings. Sharing regulatory responsibilities between states and the federal government is

also possible (see Section VI). Also involved are regulations concerning international inspection, safety standards and traffic control (including those for launching and recovery areas), noise and radio frequencies, and indemnity liabilities. These and other potential regulatory actions will require study to make them adjustable to the changing opportunities in space activities while still providing the needed public protection.

2. Patent policy problems are not unique to space activities, but they have been emphasized by them. NASA so far owns the ideas developed under government contract (subject to waiver of these rights), but industry feels the ideas should be theirs for private exploitation, partially to compensate for the small return on space R & D. The patent problem is nevertheless larger than this important issue, and needs to be clarified by further study so that effective solutions may possibly be supplied. For example, since the federal government itself is a major stimulator of space innovation, how important are patents now for the purpose they were originally intended to serve? To what extent has dissemination of new knowledge, and hence the exploitation of new technology for the benefit of the United States, been helped or hindered by the patent system? What have been the effects on scientists and engineers who prefer more professionally straightforward means for disseminating new knowledge which they have acquired?

3. Some claim that space enterprise will encourage larger economic units, and in some cases, the pooling of capabilities. Already, exchanges of scientific and engineering information necessary for R & D make questions of collusion in restraint of trade difficult to resolve. The general question arises of how much reliance needs be put on competition or regulation, and how much can be accomplished through the government's own purchasing policies. Study is recommended on the relation of antitrust philosophy to the needs of space developments so that the nation is able to protect its interests in both areas.

4. The European defense budget, other foreign markets, overseas manufacturing costs, and the opportunities to benefit from foreign professional competences are contributing to American industrial space activity outside the United States. However, commercial goals and foreign policy goals may not always be congruent in this area, given space activity's close relations to military activities and other national policies. On the other hand, it may

be that in such areas as communications satellites, it would be in the national interest to support them, as it was in the national interest to aid our world maritime and airpower positions. The implications of the interplay of these private and public interests will be well worth studying for the insight they can provide for planning to assist the goals of all concerned.

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As a basis for understanding the implications of more specific aspects of space industry problems and opportunities, and as a stimulus for the development of needed measures for designing efficient R & D organizations, research is recommended which will:

> . . . Examine the history of technological change in an environment of government participation to (a) try to discover tendencies and directions in corporate adjustment to such change and (b) see if such discoveries can be applied to understanding and anticipating present and future changes in the space industry. In applying (b), study is necessary to attempt to foresee the factors which will contribute to the eventual thinning down or expansion of the number and variety of organizations producing prime space activity products. At least a preliminary study is in order on the advantages and disadvantages of various levels and kinds of apportionment of R & D between the space firms and NASA and the advantages and disadvantages of various mixes of multipurpose R & D facilities and special-purpose facilities.

Because regulation is related to many aspects of government-industry space activities and to policy planning, and because of its importance in forwarding peaceful space activities and its implications for society at large, a continuing research effort should be begun soon on:

> . . . The economic and political objectives of regulation of space activities. Major questions concern which space activities are to be regulated and what contingent factors are involved.

VIII. GENERAL IMPLICATIONS FOR INTERNATIONAL AFFAIRS AND FOREIGN POLICY

1. Practical appreciation of the long-range international aspects of space activities from the viewpoint of the United States requires study of space plans and events in terms of: the technical features of space projects, United States policies on the uses of outer space and on the goals and conduct of foreign affairs, and the available and required characteristics of institutional arrangements for implementing these policies.

2. The need for increased numbers of individuals with the breadth of understanding for coordinating the international aspects of the technical, social, legal, economic, and political problems of space programs suggests study of the ways in which existing training for these tasks is adequate or can be improved. In particular, attention needs to be given to discovering means for incorporating pertinent knowledge from the behavioral sciences into the training and experience of natural scientists and administrators.

Technological characteristics, costs, and international participation

1. The many novel technical features of existing and proposed space projects can be expected to introduce unusual international situations. These features and conditions associated with them include: the technological requirements for world-wide telemetering and satellite tracking; the relative dependence of specific programs on access to specific geographic areas; inspection and regulation through built-in technological characteristics of systems; operation of earth satellites launched anywhere in the world; transport of men into outer space and their recovery; the possible uses of obsolete space hardware and related equipment abroad for non-space purposes. Each of these invites study to elucidate the international problems posed and to provide answers to them in the light of American space policies and foreign policies. A related area which merits special attention has to do with problems and opportunities pertaining to international sharing of costs, project planning, and operations.

Multinational personnel participation

1. The fact that great numbers of personnel will be needed to implement world-wide space activities presents the United States with opportunities to advance its space and foreign policies through the use of skilled foreign

personnel in connection with our own or multinational space projects. It may also be possible to provide training generally useful for other technological purposes, as well as for space activities, for nationals from countries presently developing their scientific and technical resources for the first time.

2. Certain problems, however, are implied in the use of multinational personnel in space programs. Complications could be introduced by differences in political and scientific procedures, security standards, and language. Equitable apportionment of professional recognition may be difficult, and interpersonal problems may arise from national differences in styles of team research and from differing ideas of the goals and means for space programs. Much research will be necessary to determine the specific potentialities for multinational personnel participation and to solve the problems involved in realizing these opportunities.

Space policy as related to foreign policy

1. The general objectives of United States foreign policy may be significantly affected by our space programs and space policy. Study is thus desirable concerning the implications for foreign policy of space activities that influence the attitudes of and the nature and degree of support or opposition forthcoming from international organizations, allies and adversaries, neutral nations, and individuals and special groups, including scientists. The military aspects of some of our space activities and the actions of nations with competing space systems will be additional important factors affecting the application of space policy to foreign policy -- and these too will merit study. In particular, study is necessary on the inclinations or disinclinations of other nations to support or participate in U. S. space programs as a result of deliberate or inadvertent mixing of U. S. civilian and military space activities.

2. Opportunities to advance and coordinate the objectives of United States space and foreign policy may be provided by systematic advanced planning for legally based regulation and control and appropriate methods for inspecting, observing, and operating space projects and related activities. Such plans and methods require study. In particular, detailed examination is suggested of the operations of existing national, international, and nongovernmental organizations which have had experience implementing and

guiding other technical-political activities. Research is also necessary to discover means of evaluating how new types of space programs and new forms of organization might further United States space and foreign policy objectives, including the possibility of multinational or totally international space programs. In connection with such research, it would be useful to re-examine the assets and liabilities of administrative and diplomatic distinctions such as those between private and official, technical and political, and military and peaceful activities or functions in the light of the profound interrelations of these factors and space programs and policies. There is also need to study the possibilities of using space activities to facilitate other needed international rules, regulations, or controls.

3. Scientists and engineers, acting in their various capacities as nationals, private scientists, and cosmopolitans, may have important roles in influencing space policy and various national reactions to our space policies and those of other nations. Whether or not such influence is likely to be an important factor, and, if so, under what conditions, needs examination.

4. The factors involved in assessing and interpreting national prestige and in the behavior of other nations and individuals toward a nation assessed as having or not having prestige are poorly understood and would benefit from field studies and experiments. To the leadership and public of an underdeveloped nation, for instance, a display of our space activities may suggest only that United States' efforts and money might be better spent on further assistance in raising their standard of living and in solving social problems that are more importantly pressing to them than the problems of space use. For other such nations, however, an opportunity to participate in the United States space program may be seen as a means for gaining or enhancing their own international prestige and for training personnel in technologies that would also be useful for other technical and scientific tasks of value to national development. More needs to be known about the effects of space activities on evaluations of our humanity and usefulness to other nations.

7. Specific space projects may confront some nations with problems which, given prevailing national attitudes, values, and social and institutional arrangements, they may not be able to manage easily. For example, adjusting to the requirements for applying scientific methods and for

operating functionally designed organizations may involve completely unfamiliar behavior patterns. Research begun now could help such nations to begin altering certain of their life ways so as to permit them to take advantage, with a minimum of disruption, of the future opportunities that space activities may provide.

8. To the extent that the United States intends to compete with the USSR in forwarding its space program in the international arena, it would be desirable to explore systematically the assets and liabilities in certain "asymmetries" in the international positions of the two nations. Such factors as secrecy vs. publicity, feasible alternative space programs, effective internal competitors for funds, relations with scientists in other countries, and access to other nations' territory may be of advantage or disadvantage to one side or the other in pursuing specific space programs for national policy purposes.

* * * * *

Because of the likelihood that international cost sharing may produce results useful for forwarding a peaceful space program, it is recommended that background research be initiated to determine:

. . . The size and nature of costs that may be sharable for facilities or pieces of hardware required for worldwide networks associated with contemplated space activities. Alternate means for such sharing should also be examined.

It is recommended that a study be made of the problems and opportunities which may be produced by those international organizations which by their purpose and procedures do not make clear distinctions between technical and political subjects (or the other distinctions mentioned above). Understanding of the possible unique contributions of a space program, or its planners and implementers, to the promotion of international cooperation would be aided and policy planning benefited by a study of:

. . . The distinctive, complementary, or competing space roles played by existing international groups including the United Nations, UNESCO, the Committee on Space Research, the International Astronautical Federation and others in existence or proposed.

Long-range planning for United States space activities as part of our foreign policy, and the advantages of optimum use of extranational resources for forwarding a peaceful space program make research desirable to produce:

. . . . A systematic and comprehensive identification of significant political, legal, social, and technological asymmetries in the positions of the United States and the Soviet Union as they may affect the international implementation and effectiveness of possible space projects. (Such a study should include historical and theoretical analyses of the concept of political parity between the Soviet Union and the United States.)

As a prerequisite to further study of the effects of space activities on the attitudes and behavior of decision makers in other countries, research should determine:

. . . How, in other countries, particular types of space activity influence specific people and the institutions in the governmental decision making process. What other factors enter into the decision making process which may vitiate or amplify, to our benefit or detriment, the effects of particular space activities?

IX. ATTITUDES AND VALUES

1. Science and technology and space activities in particular have the potentiality of reinforcing or changing attitudes and values. A democratic government sensitive to the implications of its public's opinions, especially in connection with government-sponsored programs, benefits from exploring and anticipating the impact of its programs on attitudes and values. A major product of space activities has been a variety of stated opinions about the present and future impact of space activities on attitudes and values. Whether or not these statements are valid, they have become common currency and hence can affect public opinion and the interpretation by decision makers of that opinion. Thereby, research on these supposed implications is warranted.

2. The impact of space activities on the attitudes and values of the more thoughtful members of the various publics discussed below is evidenced by their concern with problems of national goals and strategies: i.e., in

terms of national needs and world responsibilities, what is the proper apportionment of our aspirations, funds, and scarce creative manpower? Space, because of the great claims it is expected to make on all of these, thus becomes central to discussions about social, political, and moral priorities, and research is badly needed to supplement these concerns with knowledge and methods for setting priorities.

Selected publics

1. Many of the scientists and engineers directly associated with space activities are enthusiastic about their work and the uses to which it is being put. Others show varying degrees of disillusion and cynicism, to which a number of factors apparently contribute; it is not known, however, how widespread such attitudes may be. The extent and specific aspects of the situation need study, as do the consequences it may have for space activities and for other activities which can also use these special competences. If the attitudes are widespread and persistent, creative personnel may leave and the type of personnel attracted to space activities may change. Research would help reveal the implications of such changes for the quality of creative work going into space activities. If the situation is serious, research will be needed on how to produce a more satisfactory relationship between the scientists and engineers of the space community and those who have the responsibility of using their creations for various purposes.

2. The attitudes of astronauts now in training, and their perception of the attitude held toward them and their efforts, may have important implications for their training, their ultimate performance capabilities, and the selection and training of future astronauts. Research is needed on the relation of attitudes and values to aspiration and fulfillments of performance requirements in this specific situation.

3. There is a range of reactions among scientists outside the space community to space activities. Some are delighted with them as tools for other areas of research; others are indifferent or hostile. If scientific space programs are to expand, they must depend partially on the ideas and support of many scientists -- including some of those in the latter group. Research is necessary to supply a better understanding of the reasons for and extent of these unsupportive attitudes and their implications for the harmony

of the science community, for research in areas other than space, and for space activities. Study is also warranted on means of encouraging participation in space activities by both the natural and social scientists who are favorable to space activities but unfamiliar with the opportunities for making contributions to their own fields through them.

4. Given the role of business in politics and economic life, the attitudes and values of business executives as affected by space events may have important consequences for the future direction and intensity of the space effort. Interviews indicate much enthusiasm, especially for the activities in which science plays a major part. However, further research is necessary to determine the tenacity and depth of enthusiasm and what expectations are held regarding the payoff from space.

5. The impact of space activities on the attitudes and values of today's children is likely to be much stronger than on those of today's adults. Space is "real" to them, since they are not encumbered by a lifetime of attitudes and values that had no need to consider the uses of space. Study of their attitudes and values now,and as they change over time under the further impact of space activities and other events, should help in foreseeing the role of space activities in future years as these children become voters and doers.

The general public

1. As with other matters not central to day-to-day living, the public, considered as a whole, is probably only selectively attentive to and knowledgable about space activities. The relationship between the impact of events on indifferent or only occasionally interested people and their attitudes and values is but partly understood and needs further study.

2. It has been alleged that the "public" is optimistic about space activities. If this is so and if the optimism is widespread,the present support it generates for the space program may not be lasting if the difficulties inherent in space efforts have not been appreciated enough to make the failure of specific projects understandable. The resulting disillusionment may be a serious factor in reducing public support as space efforts become more grandiose, the consequences of payoff more exciting, and the losses from failure more dramatic. On the other hand,this optimism, if it exists, may produce a state of mind tolerant of failures. The factors

affecting optimism, realism, and tolerance of frustration need more study as an aid in preparing for this situation. The roles of the promoter-spokesman and the mass media in encouraging expectations of great and imminent accomplishments are integral to this problem area and would benefit from research.

3. The conviction that space activities will broaden man's horizons are presently based on the perspectives and special interests of a relatively few people in western societies. The claim may be justified, but there is need for research to assist understanding of the conditions under which innovations broaden or narrow perspectives in various cultures. For example, sufficient emphasis on space as the proper expression of man's highest aspirations may result in the evolution of a broadly based belief that this is so. But whether or not this is likely to be the case cannot now be decided in view of our limited understanding of how new ideas disseminate through societies. If and as horizons were broadened as a result of space activities, other aspirations would compete with them for attention and resources, and continuous study would be required to evaluate the appropriate position of space in this competition.

4. Though intelligent or semi-intelligent life conceivably exists elsewhere in our solar system, if intelligent extraterrestrial life is discovered in the next twenty years, it will very probably be by radio telescope from other solar systems. Evidences of its existence might also be found in artifacts left on the moon or other planets. The consequences for attitudes and values are unpredictable, but would vary profoundly in different cultures and between groups within complex societies; a crucial factor would be the nature of the communication between us and the other beings. Whether or not earth would be inspired to an all-out space effort by such a discovery is moot: societies sure of their own place in the universe have disintegrated when confronted by a superior society, and others have survived even though changed. Clearly, the better we can come to understand the factors involved in responding to such crises the better prepared we may be.

5. Man-in-space programs in their early days will confront some groups with value conflicts over the proper circumstances for risking life, family integrity, etc. Arguments are already intense on the merits, or lack of them, of investing heavily in man-in-space efforts. Later efforts may expose astronauts to living conditions with which many of the public cannot,

or will be reluctant to,identify. The threat and isolation of space thus emphasized may repel many people,especially as urban living becomes ever more the life pattern, and support for these efforts, therefore, might be less forthcoming. In some people, however, the adventures of the astronauts may fire a latent pioneer spirit; support for man-in-space programs might be strong among this group -- but it also might be displaced by their newly stirred personal pioneer aspirations. There may be possibly profound effects on attitudes and values if through the astronaut experiences it is found that the extraordinary abilities sometimes displayed under conditions of extreme physical or emotional stress can be made available to man for use in more normal circumstances.

However, it should be kept in mind that intense solar radiation and heavy-particle cosmic rays may make more than an occasional manned essay into deep space too dangerous to be practical during the time period under examination. If so, the consequences for attitudes and values are not clear. Understanding of the impact of the man-in-space program on attitudes and values in general, and on those toward the program itself in particular would benefit from a series of studies of public expectations and beliefs as these change over time.

* * * * *

Since commitment of effort to competing programs for social betterment fundamentally depends on attitudes and values about their relative merits, a research area with potentially profound implications for society and space activities,which is also urgent for policy purposes,concerns the development of:

. . . Systematic methods for assigning priorities between competing scientific and social efforts (where competition may be over the long term and involve personnel, money, public support, and conflicting attitudes and values).

A variety of more specific studies on public opinion and values as affected by space activities will depend on research providing trend data describing:

. . . The state of knowledge, values, and attitudes regarding space activities, both on-going and contemplated; and what assumptions, expectations, and values underlie the attitudes and interpretations of this knowledge. What are the effects over time of new knowledge and events on attitudes toward space activities, and what are the effects of the sources of information on the acceptability of the information?

In view of the conflicting attitudes and values so far expressed about the Mercury program, and in view of the possible favorable and unfavorable consequences of astronaut launchings, it is urgent to plan studies that would provide information on what the public needs to know and would assist in interpreting public reactions by determining:

. . . Present public knowledge and expectations about, and underlying attitudes toward, the Mercury program, and the astronauts. These should be continuing studies so that the impact of events can be anticipated, evaluated, and planned for.

While the discovery of intelligent life in other parts of the universe is not likely in the immediate future, it could nevertheless happen at any time. Whenever it does occur its consequences for earth attitudes and values may be profound. Hence a long-term research effort, which would aid in preparing for this possibility, could usefully begin with:

. . . A continuing determination of emotional and intellectual understanding and attitudes regarding the possibility and consequences of discovering intelligent extraterrestrial life.

While space activities offer a special opportunity to study the relationship of innovation to social change, understanding the relationship will require examination of other innovation situations, too. Research is recommended to determine:

. . . What factors historically have entered into support or rejection of new ideas or technologies. What was and wasn't appreciated about the potentialities (or lack of of them) in the innovation and under what personal and social circumstances did this occur? In particular, what were the roles of physical environment, politics, personalities, limited systems analysis capabilities*, insufficient communications to decision makers, etc.?

1. INTRODUCTION: GOALS AND METHODS

Genesis and Intentions

THE NATIONAL AERONAUTICS AND SPACE ACT of 1958 states that among other things "the aeronautical and space activities of the United States shall be conducted so as to contribute materially to...the establishment of long-range studies of the potential benefits to be gained from, the opportunities for,and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes." In furtherance of that directive, the National Aeronautics and Space Administration contracted in November 1959 with the Brookings Institution to "undertake... the design of a comprehensive and long-term program of research and study regarding the social, economic, political, legal, and international implications of the use of space for peaceful and scientific purposes."

It is especially desirable that the space effort be concerned with the consequences of its own activities, for it will very probably be the most costly of the various exploitations of technology and science that present societies are currently prepared to undertake during peacetime. The exploration of space requires vast investments of money, men, material, and creative effort -- investments which could be profitably applied also to other areas of human endeavor, and which may not be so applied if space activities overly attract the available resources, inspirations, and aspirations. Hence, there is a pressing need to examine carefully the claimed benefits and goals and the possible consequences and problems of space activities both in relation to their implications for social institutions and in relation to other potentially competing endeavors also aimed at benefiting man's lot.

A conclusive demonstration that some space activities provide superior means for benefiting mankind is still in the future -- but possibly a near future. Meanwhile, they are already an established factor in our society that confronts mankind with special problems. Major breakthroughs in science and technology have always produced acceleration in the rate of succeeding innovation, but space activities appear to be pushing the pace of innovation to unprecedented levels. Thus it is especially important that the implications be recognized, understood, and planned for -- and soon -- if we are to avoid the too usual and profoundly disturbing lag in personal and social readjustment to technological innovation.

It must be clearly understood that this report does not attempt to predict what will happen to society as a result of space activities nor to anticipate all the implications of a given space activity. The interactions of the products of space activities and our present social institutions cannot be foretold precisely. But by posing questions regarding what might happen and specifying those contingent factors which may affect the likelihood of one implication being realized rather than another, we will be better prepared to take advantage of the implications of space activities than we would be without such inquiries.

The report identifies areas worthy of research and, when feasible to do so, suggests which studies merit high priority attention. In explaining why particular areas of research appear necessary or desirable the report indicates the potential utility of the research for:

1. Aiding policy-making
2. Increasing enlightened public participation and understanding
3. Providing a better understanding of the processes of social change, and
4. Helping to fit space activities into a balanced program with other competing and complementary national and multinational technological and social efforts.

The research areas were discovered by examining the implications of such overlapping aspects of space activities as (1) hardware, such as a weather satellite, (2) events, such as a landing on the moon, and (3) ideas, such as those embodied in statements about the desirability of competing in space developments. Clearly, the implications are contingent upon other factors operating in national and world society both before and at the time the space product is applied. Therefore the potential interrelationships of various possible economic, political, technological, and social developments and their objectives to the possible uses of the results of space activity were examined to provide the basis for the proposed research and the priorities assigned to some of it.

In general, three types of research are proposed:

1. Research aimed at developing a better understanding of specific implications for society of particular space activity results -- for example, the economic, legal, political, and personnel requirements for a world-wide ground-based weather data collecting and processing system necessary for use in conjunction with weather satellites.
2. Research on methods for anticipating and evaluating specific impacts of space activities -- for example, how to incorporate important non-economic factors more effectively into formal cost and benefits economic studies.
3. Research on fundamental aspects of human behavior and institutional processes where an understanding of these is necessary to take full advantage of the products of space activities -- for example, an examination of the processes which determine the rate of acceptance of innovations in different societies.

Space activities are wide ranging and therefore so too must be the research regarding their implications. To assess the possible implications, in many cases research on the associated social environment will be mandatory. Further, since it is obvious that space activity will not affect all of society equally, research is frequently suggested here on the implications for "specific publics" -- scientists, the "general public," farmers in developing countries, astronauts, and so on.[1/]

The report also endeavors to:

1. Suggest persons and institutions that might conduct such research. For the most part such recommendations are implicit in various references throughout the report, and especially in the footnotes, to persons, research projects, research institutions, and the professional literature. The listing should by no means be considered exhaustive or definitive.
2. Suggest possible means for conducting, monitoring, and sponsoring such research as herein recommended.

Methodology and Philosophy

Some limitations on foresight and hindsight

The conceptual problems involved in developing the sort of research program presented here are typical of those in similar efforts at foresight: they have not been solved with complete success. Even with hindsight, it is exceedingly difficult to assess exactly the impact or implications of a particular event or development; much of historical theory has to do with attempts to cope with the difficulties inherent in such analysis. In trying to use foresight on innovations, one must be able not only to imagine how older methods can be bettered, but also to understand that innovations create ideas and needs not thought of before. The situation both for the historian and the speculator on the future has become progressively more complicated in recent years as the rate and complexity of societal interaction have increased. Most of the many new technologies have far-reaching potentialities, and communication facilities make access to information about the potentialities available in a far broader social context than was the case a generation or so ago.

There is, furthermore, a risk that all extrapolations into the future take. The rate of introduction and magnitude of what appear to be technological "discontinuities" in social trends, as represented by the atomic bomb, radar, the transistor, the modern rocket, and the like, make it especially risky to attempt to foresee in detail the particular pattern of implications to be expected from presently existing technologies and social structures, even though we are well aware that our future social and technological context is changing rapidly and probably radically, and that the world may very well be profoundly different a generation hence.[2/]

Developments growing out of space activities themselves could possibly change the operation and character of the social context to such a degree that it would not be profitable to recommend research now on the implications of space activities for the new social context. For example, the development of a compact thermonuclear fusion power source for space craft would undoubtedly open up space for many kinds of large-scale activities -- but it would very likely also change the political, social, and economic features of the earth radically, since unlimited power for all uses would soon be available. The resulting interaction between space and society would be comprised of factors too broad and too complex for useful speculation in our study. So, too, with such developments as anti-gravity, a face-to-face meeting with intelligent extra-terrestrials, or an intensive pan-national attitude favoring all-out scientific research (as a result of the salutary consequences of space research).

The foregoing constraints on foresight, however, by no means reduce the opportunities and, indeed, the requirements for research on the implications of peaceful space activities. There are two reasons for this. First, there are presently a number of space activities already under way which clearly have important consequences for the immediate future. The implications of these can certainly be studied intensively and effectively. Second, there are logical implications in certain space activities which are very likely to arise if these activities occur in the next twenty years or so, especially if it is assumed that no technological, ideological, or social invention fundamentally alters the generally expected trends of history. To be sure, variations in social context may still affect in some degree the importance of the particular implications, and the report will point up some of these variations.

<u>How far is it profitable to look ahead?</u>

There was general concurrence among those consulted that it would be futile to recommend research about the implications of space activities based upon speculations for more than about twenty years ahead. The social pressures and changes that could possibly accumulate within the next twenty years might be so great as to make present speculations footless about specific interactions. In fact, there was some opinion that only speculations concerning events of the next decade could be truly fruitful, given the complex political and social problems facing all nations and the many imminent technological developments -- other than those related to space -- that are expected to evolve rapidly in the next decade.

Most of the social and natural scientists interviewed also agree, in view of the political and social prospects of the near future and the tremendous physical and social engineering efforts required to develop reliable equipment and personnel for the more glamorous space proposals, that it seemed highly unlikely -- "barring just plain fantastic good luck" -- that lunar colonies and manned flights to Mars will be more than newspaper headlines in terms of their implications for the man on the street during the next two decades. Thus, while we have discussed research on the symbolic effects of such events, we have risked underestimating the rate of evolution of space activities and have not attempted to derive research areas assuming more direct interaction between these dramatic aspects of space and the public at large. On the other hand, such space products as communication and weather satellites have been examined in detail, although they may not actually result in full-scale operating systems with large implications for society within our chosen time period. There is, however, a very good chance of substantial implications being generated by them in the next two decades, and therefore it seemed important to describe research areas concerning them.

Within this time frame, the implications for society of space activities can be examined in two temporal categories: (1) on-going implications, which are effects on society presently under way, and (2) those implications, deriving from hardware and social situations, which will not be realized for some years and which depend on the successful development of a sequence of as yet unfulfilled space activities and organizational developments.

<u>The "Problem Area" approach</u>

It was decided that the report could be organized more effectively by considering aspects of space activities as problem areas than by grouping parts of each aspect under the headings of such traditional disciplines as political science, sociology, economics, anthropology, law, and so on. The problem area approach also serves to emphasize that an interdisciplinary strategy for the suggested research would be the more useful approach -- since the impact of innovation on society is no respecter of differences in academic disciplines. We are convinced that the utility of the findings will usually depend on using the several disciplines and their techniques in concert. Further, we feel that the researcher reading this report will appreciate that those parts of the various problem areas of special interest to him are best illuminated within the context of the total, many-faceted problem. NASA's internal social science capability (see Chapter 2), by judiciously combining these interests and techniques, may thereby gain research results broad and deep enough to meet the many problems and opportunities specific space activities will present.

The chapters of the report (excluding Chapter 2) each reflect a major problem area representative of the implications of space activities as derived from the many interviews and conferences and the extensive reading which have provided the background for this report. We believe that, within the context defined for the report, no important area has been left out, but the reader, depending on his predilections, may find the problems which interest him distributed among several chapters, where the economic, political, or other aspects of different problems recur.

There was, of course, no way to insure that we had foreseen all the implications of a particular space activity and appreciated all the specific factors affecting the implications. Certainly, one area of research for NASA is to:

> . . . Develop effective methods to detect incipient implications of space activities and to insure that their consequences are understood.**

Research on research

How much research should be done to determine what research needs to be done? The answer must necessarily be arbitrary, partially bounded by the requirements of time and limited resources. But the answer is also partially a consequence of the present state of the social sciences where a variety of theories are used to account for and predict a variety of events, and where no adequate means are generally available for continuously and systematically coordinating the multiplicity of research efforts under way. The situation is further complicated by the obvious fact that a study such as this must embrace all fields of social and methodological research; therefore, the study could not afford the luxury of confining itself to special theories and special problems in order to arrive quickly at a precise determination of the utility of available research and the need for further research.[3/]

Moreover, it was necessary to devote a good deal of attention to deciding whether or not the implications of a particular space activity were likely to be distinctive or important enough to merit careful examination as areas needing research to better understand and plan for them. In this regard it was necessary to separate the non-space activities that are significantly involved with space from those that are trivially or not at all

** The asterisks indicate priority assignment. See page 10 for discussion.

involved but which regularly claim association with this glamorous technology.

Thus, the "design of a comprehensive and long-term program of research" seemed best accomplished by devoting major attention to discovering, reflecting on, and describing the major research areas that could be revealed through the combined approaches of interviews, conferences, and reading of special reports and the pertinent literature.

The specific research problems recommended are not to be considered exhaustive. We are confident that research personnel both within and outside of NASA will discover many additional pertinent projects, not herein listed, in the light of individual competences and interests.[4/] Nor is it intended that all the research recommended should or could be sponsored directly by NASA. Some of the proposals are more properly, for instance, within the interests of nongovernment groups. To suggest a research program it is necessary to examine a wide range of implications needing study, irrespective of who might conduct the research.

There is a special and important consequence of our approach to "research on research" which must be kept in mind while reading the report. One example will help to clarify this point. The communication satellite may well have a potentiality for affecting teaching methods in developing areas. On the basis of what is already known about teaching via television, further research is clearly necessary if such methods are extended to people in developing areas, regardless of the source of the signal.[5/] However, for the purposes of this report we obviously could not survey the monumental literature on learning from audio-visual devices in order to determine precisely what research still needs to be done and what completed research is directly applicable to this special case of learning. A research project of first priority in this area, then, would be an assessment of the literature, to determine what more needs to be done and what can be used.

The footnotes for the report (which are bound separately for easier use) are intended to serve three special purposes. (1) In order to keep the discussion in the body of the report short and straightforward, much of the supporting evidence for the positions taken is placed in the footnotes. (2) For the technically sophisticated social scientist there are references to related research and essays which can provide a deeper appreciation of the particular implication under examination. (3) Many of the technical studies referred to in the footnotes will provide a variety of leads to appropriate methodology for undertaking the research suggested in connection with a particular implication.

What is meant by research?

The term "research" is broadly used in this report to refer to a variety of approaches -- including "think-pieces," sophisticated logical and/or mathematical evaluations and analyses, and empirical studies in the field. Some readers may find this research approach more speculative than the traditional examination and explanation of past or on-going social phenomena in that it is preoccupied with exploring future results of possible future actions. It is an approach, however, that has in recent years attracted ever more interest in a growing variety of social sciences; combined with the methods of operations research, systems analysis, and decision theory it holds much promise for aiding the policy planner and decision maker.

A particular utility of "anticipatory" research is the attention it draws to the need for methodological developments which permit better assessments of the consequences of alternatives. For example, throughout this report research is recommended on the costs and benefits of particular developments or applications. In some cases a rigorous economic interpretation of cost and benefit studies cannot be applied because the non-economic factors which will importantly define the situation cannot now be delineated sufficiently to permit their assessment. Better means of measurement for future social costs and social benefits are needed, and the exercises undertaken herein should help to indicate what these methods should be able to measure.

The report, however, also emphasizes that whatever the alternatives or possibilities envisioned, our capacity to cope with them and turn them to the good depends on the application and extension of what we now know about man, his institutions, and his ways of life. Thus, those who prefer to work with extant social phenomena will find much to interest them in the substantive research recommended, as well as in the methodological problems posed by some of it.

The phrasing of many of the recommended projects deserves comment here. A problem is usually couched in terms of space activities, since the report's purpose was to emphasize the implications of space. However, much of the research suggested could be equally stimulated by or applied to a number of major scientific developments presently on-going or contemplated, such as automation, the widespread use of small atomic energy units, synthetic photosynthesis, the broader use of computer facilities, and similar developments. This is not surprising; after all, space exploration is a product of an on-going technology and on-going socio-cultural environment. As such, its development and its applications are subject to most of the same basic struggles, perspectives, ambitions, distortion, and ideals which characterize any other important activity in our culture. Thus, much of the research here recommended, if successful, would be equally useful for planning and understanding the consequences of other major technological changes either under way or contemplated.

Space activities can also be seen as tools for developing a basic understanding of human behavior and especially social change and its relation to innovation. The proposed research, and clearly the research areas, should be considered not only for their utility to the "applied" social sciences, but also for the extraordinary opportunities they provide for fundamental social science research. Indeed, much of the applied research recommended can only be fruitfully undertaken if the requisite fundamental studies are accomplished first.

<u>Assigning research priorities</u>

When feasible, high priority research will be designated. (The typographical device of two asterisks at the end of a study proposal is used to indicate the priority recommendation -- as on page 7 of this chapter.) Considerations which have entered into priority assignments are:

1. That the results of the research would have very important applications to the consequences of specific space activities (e.g., the discovery of means for resolving international differences over wavelength allocations and control would have important consequences for the use of communication satellites).
2. That the study is urgent in order to identify and resolve operating and policy problems associated with imminent or on-going developments (e.g., there is need to understand the factors affecting public expectations and attitudes about our man-in-space program).
3. That the study is nondeferrable in that, while the methods and findings may not be used for a long time or for a particular purpose, it is necessary to begin now to acquire them (e.g., base-line data and measuring techniques for obtaining such data, where changes are

to be expected due to space activities and where understanding of the changes depends on trend data).

4. That the study would significantly forward the development of a program of peaceful and scientific uses of space (e.g., the development of means for encouraging and enlarging the role of foreign scientists in space activities).
5. That the study would, through the development of methodology, facts, or theory, contribute exceptionally to understanding or foreseeing the social implications of space activities (e.g., acquisition of a detailed understanding of the impact of high rates of space-induced technological change on the structure of particular business organizations).

Many of the research areas discussed in the report are not now assigned high priority. They are included as indicators of research areas which may become central as societies change, as space activities develop, and as the high priority research herein recommended is completed and applied. These additional research areas provide the necessary perspective for establishing a long-term research program.

An important consequence of this approach to program planning is that frequently a series of projects is recommended wherein each succeeding one depends in good part on completing the previous one. Frequently, too, because of the broadness of the implications, the research approach to a problem area must be a matter of the personal preference of the researcher and/or NASA's particular interests. For example, a project that began as a detail study might later be expanded into the broader aspects of the problem and vice versa.

The projects selected are intended to give a "mix" with various combinations of projects conforming to the above listed criteria. The objective is to provide NASA with a variety of projects of sufficient importance to offer an <u>initial</u> basis for long-range programs of research. Which of the projects NASA may choose to implement, even among those which might be thought of as urgent, will depend on factors not within the purview of this report. Among them may be the following:

1. The size of NASA's budget for such research and how it wishes to distribute funds among the projects.
2. What competent research capabilities are available at a given time to undertake specific projects.

3. What pertinent technological or social developments and events have evolved more rapidly than expected.
4. The depth at, and inclusiveness with which, a particular research area is to be explored.
5. The personal interests of NASA executives and the in-house social science research personnel.
6. Whether at a given time a particular research area is seen as peripheral or, through the evolution of events, has become a central problem.
7. Whether or not previous projects have paid off as expected.

No assumption has been made about whether or not study is already under way in some of the areas recommended for research. If some areas or parts of areas have already been adequately studied or are being studied this, too, will affect NASA's choice of high priority projects.

Finally, the magnitude and direction of a long-range research program in the social sciences will depend on the organization NASA establishes to select, monitor, and conduct this research. The resolution of the priority problem can be more fully understood after the reader is familiar with the proposals concerning the organization and functions of a NASA research facility as set forth in Chapter 2.

2. COMMENTS ON THE ORGANIZATION AND FUNCTIONS OF A NASA SOCIAL SCIENCE RESEARCH CAPABILITY

IN READING THIS CHAPTER, three general considerations should be kept in mind. (1) Certain of the research projects which are now or will later be proposed to NASA might more reasonably and efficiently be supported by other government agencies or by private foundations which perhaps have a long-standing interest in the subject of the research proposal. NASA therefore should establish criteria for deciding whether a project is one it wishes to support directly or jointly, or one which might be better realized within another organization's purview.

(2) Research projects will vary in duration from a few months to several years. Such variations in time span imply variations in financial and personnel support and recruitment philosophy. Generally speaking, the projects of shortest time span are probably the ones that need to be done immediately, and thus will make relatively greater demands upon available personnel and funds. The mode of approval and implementation required for them will be quite different from that required for projects needing less sudden starts. NASA will need to develop a logic of operational procedure for supporting research lasting over a variety of time spans.

(3) Research, broadly conceived, not only discovers and transmits information, but is also a device for training researchers. If a social science research program is to become a continuing part of the NASA establishment, consideration should be given to the extent to which research may need to be supported which has as part of its purpose the training of social science personnel to deal with the specific study problems of the implications for society of space activities.

Organization

In principle there are three organizational possibilities for the kind of research facility contemplated here: (1) it could be completely in-house;

(2) it could be conducted completely by an outside service organization, as in the arrangements between RAND and the Air Force, or between the Jet Propulsion Laboratory and NASA; (3) it could be conducted by means of an in-house core, with various parts of the activity arranged through contracts and grants to outside individuals, groups, and service organizations, the amount and kind of such assignments to be determined as the effort evolves over the years ahead.

A complete in-house facility appears impracticable -- first of all because there is no reason to suppose that adequate numbers of high-quality social science personnel would be interested in leaving their present well-paid, high status environments to join NASA full time. Moreover, the specific research facilities and competences needed will vary with the type and amount of research under way at any given time; to employ a full-time staff of all the types of personnel and to house all the facilities needed over a period of years would be inefficient.

On the other hand, an arrangement that would contract out the total activity to a service organization which would provide management and research facilities -- or would contract out research but manage the program -- has two profound disadvantages. In the first place, a research program on the social implications of space requires the understanding and cooperation of other NASA personnel, if the research is not to risk being stifled or left unapplied. Institutional rapport can be best developed by making the key personnel of the program an integral part of the NASA institution, identified with it in their own eyes, by their professional colleagues, and by the non-social scientists in NASA.

In the second place, research on the social implications of space needs to be generated fundamentally out of the enlightened interests of NASA. A clear perception of the opportunities for research in the social sciences requires personnel familiar with the interests of both the agency and the social science fraternity. Here a comparison with the RAND-Air Force relationship is instructive. The Air Force has had for a long time an extensive internal social science research and application capability, and thus it has been able to generate its own social science research requirements as well as to evaluate internally the research proposals submitted independently by RAND. NASA has made a commendable start, but understandably does not yet have a similar complete internal social science research capability. It cannot be expected to develop such a capability soon enough to have the necessary experience to contract out its whole social science research effort, yet still control the quality, direction, coordination, and utility of the products.

Thus, the most practicable initial arrangement would seem to be an in-house staff core of social scientists with the evolving capability to handle certain functions and research itself and to monitor and direct other functions and research through contracts, and through outside service organizations as experience, program demands, and opportunities develop.

Functions To Be Performed by a Research Facility

The functions outlined below were initially assembled in the form of a general exercise to discover what the performance capabilities of any organizational entity should include if it was to realize and extend the kind of research program proposed in this report. Once described, they were re-evaluated and to some extent restated in the specific light of NASA's individuality as an agency. It was on the basis of these functions that the organizational recommendations in the preceding section were made.

Identification of research problems

This report will emphasize frequently that an important function of any research program on the social implications of peaceful space activity is an ability to foresee new problems and opportunities and to detect new research areas. Such a capability entails the active seeking out of problem areas arising from trends or changes in various parts of national and world society, due to actual or anticipated developments in space activities; political, social, and economic relations; and in applied physical and social sciences. However, seeking out research areas implies more than merely pointing to them. Two types of research identification tasks devolve: what knowledge is available which can be applied to the problem or opportunity, and what further research is necessary to generate pertinent knowledge?

Selection of high priority research

Once the research areas are identified the question of priorities will confront the research facility. The section in Chapter 1 on the criteria employed by this report in designating priorities for the projects proposed will be useful here. However, it is possible that the evaluation scale most pertinent to the established research facility would emphasize the payoff significance and feasibility of any given project. Aspects to be considered might include the political and administrative feasibility of a project -- the whole research program could be made impotent if sufficient leadership and commitment are not forthcoming; the availability of the qualified manpower and the requisite research environment for the period of time a study would require; or the extent to which an immediate activity might affect the field situation so that desired research not currently feasible would become feasible later. The selection function will in any event be related to the successful fulfillment of the next function described.

Determination of resource allocation

The allocation of funds, manpower, and time for the support of research on the social implications of space activities is intimately related to NASA budgeting problems. Its success depends largely on ability to establish a logic for distributing costs within and between projects, and to assess the availability of funds to pay qualified personnel. Knowledge is necessary, too, concerning the sources and resources of pertinent personnel.

Informing and stimulating potential researchers

With research priorities and time and money allocations outlined, the function of conveying this information to potential researchers becomes most important. When the research facility is first established, and probably for considerable time after that, a great deal of emphasis will need to be put on the task of making clear to research personnel throughout the country the opportunities which are available, within the range of NASA's direct and indirect interests, for creative research, both basic and applied. More is involved here than the simple dispensation of information about problems to be studied; ways should be found to stimulate a direct personal interest in studying them.

Developing and stimulating potential supporting facilities

Supporting facilities include money, professional capabilities other than research, and technological resources (such as computers) that might need to be available to researchers if NASA's resources or those of the researcher are insufficient for the project. This function is intended not only to provide services, but also to generate interest and participation among organizations which might not otherwise realize that they have valuable contributions to make to this research field.

Selecting, developing, and implementing research proposals

It is the experience of those who have observed the selection, development, and implementation of research proposals in new areas that these three tasks generally need to be performed more or less simultaneously and certainly interactively. NASA's interests and criteria as to research suitability and those of the researcher will not necessarily be the same, especially during the early days of the research program. Time will be saved and rapport between the research community and NASA more quickly and firmly established if, beginning at the earliest stages of the development of the research idea, the researcher and NASA's representatives can work out the proposal together.

It is advisable that the in-house staff select the research to be supported by NASA, with the aid of non-binding outside advice. Since assessing the quality and utility of research in progress should be the responsibility of others (see below) the in-house staff may in this way feel freer to support imaginative research.

Liaison

Social scientists, at least in the early stages of this program, will not as a rule be familiar with or have easy access to the specialized information associated with space activities which may be important for their research. Here a specific in-house liaison capability will be necessary to augment the researchers' access to information, persons, and events. It is also likely that there will be space developments about which the researcher will have to depend upon the NASA liaison function to keep him informed.

The nature of the space effort is such that other government branches and agencies have or should have major contributions to make to its development (as this report stresses throughout), and it is probable that there will be both social and technological research conducted and applied which will have important implications for NASA's social science research program. Conversely these activities could be affected by the studies conducted through NASA's efforts. Clearly, NASA's liaison function should encourage coordination of effort and mutuality of interests. At a very minimum, NASA and its potential contractors should know of the work other agencies are doing and these other agencies should know of NASA's work.

Assessing the progress and direction of the research

A specific program for reviewing and assessing the progress and direction of research in process is a vital function of a research facility. The objective view of an outside assessment group -- none of whom have had anything to do with the selection or allotment of the research projects and who are not staff-connected to the contracting parties -- will be especially important to NASA's research for several reasons. (1) The knowledge that the responsibility for assessment of progress will be taken by another group will permit the project-selecting group to make bolder initial choices. (2) Developments in space activities, other technologies, and society in general may outmode some of the applied research while it is in process, or at least require a shift in its emphasis. The program of review will keep a project pointed in the optimum direction. (3) A certain amount of unproductive or poor research must be expected. Some means of cutting a project off, when it appears untenable, is necessary; the cut-off proposal can much better come from the review group than from the contracting source. This arrangement would lessen the chances of hostility toward the contracting organization and help maintain rapport with the professional resources upon which NASA will be dependent for good research.

Distributing the research findings

A weakness of many research efforts, and indeed at times, of the whole structure of the research process, is a lack of adequate planning for the distribution of findings. NASA's social science research effort should insure that the findings reach (1) those for whom they were specifically developed and (2) other pertinent professional people and organizations. Disseminating findings to the latter group is an important way not only of maintaining the status of NASA's research facility among its peers but also of suggesting to the research profession that NASA may have projects of interest to them.

It is also frequently assumed that the distribution of information to professional personnel somehow insures that it will thereupon get to the appropriate internal agency individuals and groups and external audiences. However, there is ample evidence from many organizational studies that this further dissemination almost never takes care of itself but must be specifically provided for.

Assisting in the application of the findings

The function of "applying the findings" begins, not with the end of the study, but at the very beginning. One of the surest ways to discourage the application of findings from social science research is to present them to the client for the first time when the project is completed. It is imperative that intentions regarding applicability be arranged for with the participation of the user, during the working out and selecting of the research to be undertaken. Thus the client, the researcher, and NASA's research staff will all be clear as to the project's probable aim and implications.

There are four subfunctions pertaining to the application of the research findings: (1) to keep the client familiar with developments during the progress of the research; (2) to help him to understand the full implications of the findings; (3) to help plan for the implementation of the findings; and (4) to assist with the implementation of the findings. This is the approach used by reliable space "hardware" developers during the application and testing of a product under operational conditions.

Keeping track of pertinent research at large

Research projects will no doubt be conducted by other facilities that may not realize their pertinence to NASA's interests. The contacts established through the above-listed functions should increase the possibilities that NASA will become aware of such studies, but the matter should not be left to chance. The NASA research facility will have a large responsibility to be in the van of all developments concerning social science and space.

Operating Considerations

Growing pains

During the establishment of a program of this sort, interpersonal and intraorganizational adjustment problems are bound to arise. To the often prevailing differences in perspectives and goals between technologically oriented and administratively oriented personnel will be added those differences provided by the social scientist faced with his special mission. The varying images of human nature and society held by administrators, engineers, and natural scientists are sometimes, for a variety of reasons, not necessarily compatible with those of social scientists. If the views differ widely and especially if the social scientist's views or knowledge complicates the task of the engineer or the natural scientist, the hostility, frustration,or anxiety thus aroused may find relief only in the charge that the social scientist doesn't know what's going on -- or, if he does, his knowledge isn't important or relevant. He may also quite innocently present threats to the administrator because his professional mission carries the implication that the categories into which the administrator has divided his operational world are inadequate for coping with the problems that space activities pose or the opportunities they open.

It is likely that each operating subdivision of the organization will at one time or another feel that if a given research project is to be done it ought to be done within the jurisdiction of its division and its interests. This report tries to make it clear that little if any research worth doing would fall so precisely into one division or another and that unless the research office can perform an over-all staff function, its efforts will be frittered away -- split between contending divisions in the organization and forced to constrain research within unrealistic boundaries.

The various potential difficulties can be mainly overcome -- as similar difficulties have been overcome in many other organizations -- through careful and deliberate efforts by all parties to understand each other's functions and goals. Although such efforts are never easy, it will be helpful if all concerned recognize at the outset that these and similar discomforts may be a natural accompaniment to the first stage of incorporating social science research into an organization that has thought of its mission chiefly in terms of natural science and engineering.

Persons and procedures

This report has urged that the social science research facility should be a staff function, but it would be inappropriate for us to recommend how the office should be fitted into the formal organization of NASA, since this is a matter which must be viewed in the light of NASA's internal policies. The lines of authority linking the members of the in-house core, other divisional working groups, and administration decision makers are the concern of NASA alone.

There are, however, a number of other important operating arrangements for the research program which seem to be within our province to suggest.

1. We recommend that the professional staff initiating the in-house research effort consist of at least three senior social scientists. A single individual would not be adequate, because a developing program needs the exchange and evolution of ideas which only the day-to-day effort and intimacy of talking problems through provides. A staff of two risks needless impasses in the many decisions that will have to be made. Most important, a staff of three or more can better represent the necessary range of competences and more effectively contend with the array of tasks and functions to be performed.

   Among the attributes that would be desirable in the personnel selected to establish the program, the following would obviously be of special importance at the beginning: skill in interpersonal relations, an interest in and some familiarity with space technology, and high professional competence in at least one of the social science disciplines.

2. The new staff will need to undertake at least four tasks at once: (1) selecting first-order research, (2) establishing in-house relationships, (3) establishing outside connections with the research fraternity, and (4) laying the organizational groundwork for the conduct of specific research. In addition, steps should be taken to establish a library of selected social science materials -- a documentation center covering the type of sources cited in the footnotes of this report, for example, and others that would be recommended by the core group and their advisers.

3. If the research office is to be successfully launched and maintained, it needs the active approval and support of other NASA personnel. It should have direct access to those persons having in their purview the over-all interests of NASA. Further, membership in the divisional deliberative committees should be arranged for the senior social scientists, so that they can become familiar with and appreciate the operating problems of the divisions and sense the research opportunities in them.

4. The liaison function described briefly earlier in the chapter will be of importance from the beginning. Its incumbent (who would be, not one of the senior social scientists, but a member of the supporting staff) needs to have a wide understanding and appreciation of the problems of both the social and natural scientist and a working knowledge of research operations in general. One of his main early and continuing responsibilities will be to facilitate the exchange of information both between divisional groups <u>within</u> NASA and between NASA and the <u>outside</u> professional personnel, agencies, and organizations (governmental and nongovernmental) so that all involved can be kept abreast of each other's activities and findings pertinent to the program.
5. Besides the committee that will assess and review the progress of research projects (as described in the section on functions), at least one other outside committee would be of great value. Acting in a capacity parallel to that of the Space Science Board of the National Academy of Sciences and comprised of persons of stature who had a direct and active interest in research and in the impact of technology on society, such a group could establish liaison with the Space Science Board for the mutual enhancement of perspectives; keep the in-house organization cognizant of on-going or anticipated social developments pertinent to an evaluation of the implications of space activities; and stimulate professional interest in the NASA program by encouraging research proposals and independent support from other organizations with compatible research interests.
6. In connection with the recommendation that the NASA research capability be organized as an in-house core, it was also suggested that a distribution of functions might eventually be made between the in-house group and outside contractors and service groups. Which functions aside from liaison should be retained by the NASA core can only be decided in the light of the competences and interests of the core personnel, the size of the budget NASA assigns to the research office, and the complexity and anticipated growth rate of the program. (A growing program would seem to be inevitable if the products of space activity increase.)

Clearly, the awarding of contracts and/or grants must be an in-house function, although it could be expedited by assistance from outside services and through formal or informal advisory groups. Whatever the eventual distribution of functions, however, the in-house core will need to keep in close touch with the assisting services and with the personnel carrying out the research projects, both to insure the participation at all stages of those who will most directly use the findings and to maintain its essential role as the spark and drive of the program.

7. It should be recognized at the outset that a program of research to clarify the implications for society of peaceful space activities cannot be accomplished by fits and starts. A great amount of basic research needs to be done; although some projects can be achieved in less time than others, the "crash" approach will seldom be appropriate. Such an approach is usually very costly and for this program especially is unlikely to produce the quality of information that will furnish the wanted understanding and perspective.

This report is intended to emphasize the need for a capability that can deal with the potential of space activities to affect society for better or worse. We believe that such a capability can be developed and maintained only through a planned program of research, originating in a profound appreciation of the problems and opportunities implied in the space effort and with a continuing commitment to contribute to future understanding and action.

3. IMPLICATIONS OF SATELLITE-BASED COMMUNICATIONS SYSTEMS

INVOLVED SCIENTISTS AND ENGINEERS are strongly of the belief that in a relatively short time the world can be wrapped in a communications net based on the several advantages of communications satellites. Communication by spoken or written symbols has been central to every stage of man's attainments and progress. If his attempts to make himself understood have often been less than crystal clear, he has never stopped trying. It is therefore not surprising that in this new sphere of potential attainment--the space effort--one of the first undertakings involves a very bold exploit in communication. Given this ages-old, central concern of mankind, such a world-wide net of inexpensive, rapid, and pervasive communication links can be expected to have significant implications.

However, given the importance of telecommunications to the modern world, strong preconceptions about content, purposes, and format will underlie responses to the problems and opportunities arising from the availability of such a system. The preconceptions will probably be embodied in laws about usage, economic criteria for development, and formalized philosophies about purpose. Patterns of viewing, listening, and responding to communications differ substantially even among countries with a common historical heritage and even within nations--as is evident in our own perennial arguments over the proper function of television.[1/] These differences will constitute one major area of the multitude of problems that must be resolved if full advantage is to be taken from the use of a satellite system.

The quick and full realization of the system is also dependent upon costs and technological factors involved in its development. Because of the high costs and the heavy-rocket technology intimately associated with satellites, government support and control is necessary. Yet because the field of telecommunications in the United States has been traditionally the domain of private enterprise, the government's role is especially complex. The national interests-private enterprise relationship becomes all the more important because of the dominating role of governments in the telecommunication systems of most countries of the world and because there is a good chance that the United States system will be matched by a USSR system. 2/ A related factor is the possibility that eventually there may be pressures to internationalize radio and television broadcasting--which is the part of a communication system that holds the greatest potential for international good and evil.

Another major set of problems related to the implications of communication satellites has to do with the uses to which they are put. Because communications have become so salient a part of our interests and activities, we are apt to assume that more is known by authorities in the field about the role, function, and consequences of communication than actually is the case. 3/ Considering the magnitude of the question, relatively little has been learned about their specific effects as they impinge upon people in the multifold context of daily life. It is, however, known in considerable detail, that communications in the United States often have effects quite contrary to those that opinion leaders believe they have. In other cultures knowledge of the effects is correspondingly weak. Much more information and insight is needed in this area before the many hopes expressed for the utility of world-wide communications can be fulfilled.

Purely on the basis of the technology there seems to be no good reason to believe that a high-capacity radio telephone and radio broadcasting network could not be realized in a decade or less. Perhaps the many technological problems associated with high-quality, many-channeled TV could also be solved in about the same period. When the requisite costs and the multinational negotiations (particularly over frequencies, as discussed below) are considered, however, it seems likely that telephony will come first, high fidelity radio second, and many-channeled TV last, and that the development period could easily extend over more than a decade. The farther away in time communication satellites are, the greater the opportunity to assist in the preparation of an environment that would encourage maximum benefit from them. Thus study of these problems should not be delayed--and if certain uses, with their consequent problems, are believed to be imminent, the research suggested for that area should be undertaken and the findings applied with all dispatch.

Technological Characteristics and Their Implications

Communication satellite systems [4/]

The utility of a satellite-based communication system largely depends on the operational characteristics of the satellite and the associated ground-based equipment. These characteristics therefore have relevance to the economics of development and operation and to the kind of implications the system would have for society. Research and development efforts have been concentrated mainly on two operational types of systems--the passive reflector (e.g.,Project Echo) and the active repeater (e.g.,Project Courier).

A passive reflector system is what its name implies--containing no electronics, the satellite reflects, or bounces off, the signal to ground-based receiver antennas. The signal range would be limited, at presently contemplated altitudes, to an area with a radius of about 4,000 miles. Satellite life depends on orbital stability, as affected by air drag, solar deflection, and micrometeors. High-power 100,000-watt transmitters--two to ten times as powerful as any typically used in commercial broadcasting operations in the United States--along with fast-tracking, highly sensitive, receiving antennas, 250 feet in diameter--would be required at the ground installations. Thus, private reception (at least under circumstances presently envisioned) would be via a central distributing facility rather than directly to private receivers. The advantages of passive reflectors include their unlimited two-way channel capacity (between all points which can simultaneously see the satellite), at various wave lengths, and the fact that modification and improvements in the ground equipment could be effected without changes in the satellite. However, to assure general global coverage, at least twelve satellites spaced around the world would be necessary, and for the foreseeable future the large, complex, and costly receiving apparatus rules out direct private set reception.

An active repeater satellite contains its own receiver, transmitter, antenna, and the power supply for the unit; a signal received from the ground is re-transmitted to another remote ground receiver. One proposed arrangement for near-complete global coverage would include three satellites in an equatorial orbit at 22,300 miles altitude. Orbiting velocities would in effect fix each of the three relative to a position on the earth. Each satellite, weighing from several hundred to several thousand pounds (depending on the equipment complexity), would need to have a life of two to three years if the system were to be profitable at contemplated payload costs. The number of messages which can be relayed simultaneously and the frequencies which the satellite will receive and transmit are limited by its specific design characteristics. Careful scheduling of messages is required so as not to overload the capacity. To change frequency and capacity characteristics would require changing satellites and, as such, this is an inherent disadvantage of the system. However, among its advantages are the nominal ground transmitter power required -- under 100 watts might suffice -- and the fact that conventional receivers using simple fringe-area antennas could receive messages directly. However, if expensive antennas are used (in a manner similar to the use with passive satellites), active satellite message capacity could be increased greatly and frequency interference radically reduced.

There are at present a number of gaps in the state of the technology which, while they exist, will affect the relative advantages and disadvantages of each system for the various uses to which they might be applied. In particular the costs of operating either system are very dependent on the reliability required and available at a given state of development for all components of the system including the launching rockets and precision orbiting systems, as well as the satellites themselves. 5/

Another important technological gap has to do with the design and cost of receivers and transmitters. As indicated above, passive systems require costly satellite transmitters, receivers, antennas, and a relay system to carry the signal to private sets. While this may not be a great economic or organizational difficulty in areas already having good telecommunications systems, it clearly presents problems for the underdeveloped areas which could especially benefit from satellite communications. Direct reception from active satellites requires sets tuned to the ultra-high frequencies involved and, for TV reception, able to receive a higher number of scanning lines to the inch. Purchases of new sets would be required in any country; in underdeveloped areas the sets would also have to be highly reliable (because of the absence of service personnel) as well as able to work by means of a variety of electric power sources. 6/

An appreciation of the fact that these technological gaps do exist is important to an understanding of such factors as the following: (1) the time involved for development of either of the systems; (2) the possibility that either point-to-point relays or direct broadcast might be the reception method first used--and the different economic and utilization meaning thereof for various nations and regions; (3) the likelihood that the development of the technologies will be gradual and selective--a factor that would influence the social implications of the development as a whole.

Frequency utilization 7/

For satellite propagation, the higher frequencies have the advantage of lower power requirements (due to directional gains 8/), atmosphere penetration, and a signal-beaming capability, but the intensity of background noise limits the range of optimal frequency utilization within the "spectrum window" (which for space communications presently lies between 10 to 10,000 megacycles--the range between ionospheric penetration in the lower frequencies and poor signal-to-noise characteristics in the higher frequencies).

For both domestic and international broadcasting operations there has been for some years an ever-growing and urgent need to conserve and reallocate the limited radio-frequency resource; at the same time, world demand for commercial quality signal transmission has usually been ahead of the technical capacity to provide it, especially at the higher frequencies. Hence, to meet the expansion of needs which a satellite system will impose, complex national and international negotiations will be required for frequency allocation assignments. 9/ Allocation implies assignment review and inevitably some evaluation of priority based upon social as well as economic values. These values differ from society to society; therefore resolution of the conflicting demands will depend upon much more than the ease or difficulty of alternative technological approaches, though this too will certainly enter the picture. Since TV uses such large frequency band widths per channel compared to radio and since the costs of developing TV electronics will be high for the higher frequencies, the contest for preferred frequencies in the satellite "spectrum window" will be all the more intense.

The availability of spectrum space in the 1000 to 15,000 microwave range, is, after all, finite. The extent of the difficulty can be illustrated by the situation in the United States, where increasingly the radio waves have been wanted for various uses. Businesses have been built around land mobile telecommunications services; others have reduced costs by the use of mobile telephones: for example, an oil company has found that eight delivery trucks so equipped can cover an area that twelve trucks formerly were needed to service. To allocate frequencies to an increased demand, the Federal Communications Commission has had to tighten up on technical standards and to restrict band widths--to the point where some services are now required to operate on 25 per cent of previous band width allocations.

The FCC in 1960 extended hearings on allocations in the microwave bands to provide for space satellite needs. Two major bodies of testimony were submitted, one by American Telephone and Telegraph, which asked in effect that certain earth-bound frequencies be discontinued to make way for satellite communications. The Electronics Industries Association, arguing for its hundreds of constituents that now operate systems on microwave allocations, maintained that space satellites can share frequencies with earth-bound systems. (Signal quality was a major point of difference between the two viewpoints. Whereas American Telephone and Telegraph felt it necessary to provide a voice transmission with very limited background noise, EIA constituents could apparently tolerate a considerably higher noise level.) If the resolution of this difference should be on the basis of sharing frequencies with earth-bound systems, rather than displacing them, this must be done by further investment in advancing the technological state-of-the-art, rather than through sole use of choice frequencies.

The frequency allocation problem has notable international ramifications. At the Geneva Conference, August-December 1959, three nations among the eighty-five represented asked for frequency allocations for satellite communications--the United States, Great Britain, and Russia. The United States' request was for tracking and telemetry channels, not for any international commercial wave lengths. Six bands of frequencies totaling about 225 mc/s were allocated in the 890-16,000 mc range for experimental purposes, effective May 1, 1961. The issue of sharing earth-bound systems was postponed for future resolution. Even if the FCC were to allocate domestic bands for space communications, they would be of little or no value unless other countries were willing to accept that same allocation. 10/

Factors Affecting Application, Organization, and Control

Problems concerning the economics, technology, and utilization of satellite communications obviously cannot be resolved within the framework of the operating methods and values of the United States alone. The areas of utility of such a system would clearly be world wide, and therefore the implications must be examined in that light. If potential global needs are to be met, such problems as the following must be resolved: frequency allocation and/or sharing; equipment compatability; satellite use privileges and priorities and means of cost sharing; 11/receiver antenna control and sharing, and, in some cases, transmitter antenna; access to audience; control of program content--e.g., amount and type of propaganda or advertising, entertainment, and education.

Basically, a nation's philosophy concerning the purpose and proper use of radio and television defines the structure of its operational procedures and organization for telecommunications. 12/ The differences between national philosophies will have substantial implications for the way a satellite communication system might be used. Meshing the philosophies with each other and, further, with other competing national and international interests will involve a multitude of economic and organizational problems.

Economic, organization, and control problems for the United States

The implications of a satellite communication system have already raised many questions about government-industry cost sharing and control relationships. Involved are such problems as the need to use as boosters expensive government-owned rockets fired from government-operated installations; the high investment costs of research and development of reliable satellite components; the risk of rapid obsolescence, at least in the early period of development; and the potential costs of system maintenance, operation, and replacement.

How far should the government pursue programs to evolve equipment and a system for eventual commercial use? Industry has not yet been willing to carry alone the huge burden of research and development in satellite technology (including contingent developments in rocketry and electronics) to an operational stage. The issues have given a new urgency to the whole broad question of government-industry relations on multi-purpose, jointly-financed projects.[13/]

The government also must make vital decisions about frequency allocations between satellite systems and conventional systems. Even at the domestic level there are profound problems connected with assigning the control of or a share in desirable frequencies. Efficient and fair assignments will require detailed attention to the philosophical and political problems involved in recognizing and resolving not only the conflicts between competing private interests but also those between private and public interests. [14/]

The huge capital investments for initial research and later application might be undertaken through pooling or merging corporate entities, but this raises serious problems, given existing anti-trust provisions. On the other hand, if federal funds are used entirely or even in part, the government is faced with the consequences of subsidizing a form of communication which potentially threatens present private investments in wire, cable, microwave, and coaxial cable systems and which might reduce the amount of printed matter which presently helps to support various transportation organizations.

If taxpayers are to finance the major technological development of communication satellites, what provision is to be made for patent ownership and satellite utilization in a competitive economic system? There are two issues involved here: should public funds be expended to finance eventual private patent exploitation, and does the constitutional intent to advance science under the patent system apply to evolving government-industry relationships for technological development? [15/]

The entire question of public versus private interests will bear rethinking in terms of the political and economic consequences of alternative solutions to these problems. 16/

From the standpoint of private and public interests, all of the above problems take on especially complex aspects in relation to the following considerations:

1. Presently estimated requirements for a world-wide weather prediction system include communication satellites for transmitting the vast amount of data anticipated. The United States government is likely to continue to support major research on weather, and major developments in meteorological theory evidently require a global system for data collecting and processing. What then should or can be the respective roles of government and private industry in the development of communication satellites, given this special demand for them?

2. Many observers believe (for reasons which we will discuss subsequently) that a satellite communications system will eventually have to be controlled in whole or in part by an international or multinational agency. If, after study, it appears that this is likely to be the eventual disposition of such a system, what is the appropriate philosophy for government-industry financing and system ownership?

3. The USSR may also be planning a communication satellite system. The complications of adjusting the various systems involved in the shift in communication methods might possibly be fewer in countries where the presently utilized systems are publicly owned. Thus Russia, with its different economic and political philosophy, might be able to move ahead rapidly in meeting the technology requirements. If it becomes clearly evident that Russia is planning a communication satellite system, there will surely be additional pressures on the government to act quickly and decisively in forwarding the United States' efforts. Under such circumstances, government-industry cost and control relations may develop in ways unsatisfactory to one or both parties, unless the pertinent factors have been studied.

Overseas owners of satellites or transmitters (e.g., England, France, USSR) are likely to want to broadcast via their satellites or ours to the United States. Since the United States is known as espousing free speech, it would face philosophical and propaganda problems if it were reluctant to permit these broadcasts. Further questions in such a situation would be: who pays for the time, who sets the price, who arbitrates refusals concerning time and price, who chooses program content? The implications of the problems would probably vary still further, depending upon whether private enterprise or the government operated the channels.

Thus there are a number of complex problems involving economics, sociology, psychology, law, and the underlying, often contradictory values which govern our society and other societies. In summary, research on the following over-all problems is necessary to determine:

. . . The specific sources of demand for increased communications capability, and the assumptions on which these demands are premised. In particular, what are the assumptions -- of those claiming they would pay for the use of satellite services -- about the capabilities of the communication system for meeting their needs? **

. . . The relative cost and benefits of meeting by satellites and by alternate means specific types of demand discovered in the above research proposal. In particular it would be desirable to examine the costs and benefits involved for private enterprise and the nation in retiring, displacing, introducing, and maintaining equipment, personnel, and organizational operating, monitoring, and regulating procedures. 17/**

. . . Various means the United States government might use to fulfill its obligations to private enterprise, the nation as a whole, and special interest groups with regard to the support of satellite systems development, ownership, frequency assignments, allocation of profits and costs. How can the use of the product in the best interests of the nation be assured? What then are the appropriate and effective roles for government, private enterprise, and the two in combination in: financing, developing, owning, controlling, using, and negotiating for use of satellite communications domestically and internationally? **

. . . Alternative means of coping with a prior Russian satellite system development or a competing one. What would be the domestic and international costs and benefits of these alternatives?

. . . Both short-term and long-term cost and benefits for the nation in leasing, giving, or selling part or all of the functions of a communication satellite system to an international or multinational agency. For any combination of these arrangements, what would be the appropriate means for the government and private industry to share in the costs and control of development, if there appears to be merit in some part of international facility?

International and multinational economic, organization, and control problems

As noted earlier, underlying the operation of each national broadcasting system are institutions and philosophies which govern not only the kinds of programs but also the balance between program purposes -- information, education, and entertainment. Patterns of financing and control, derived from the public authority, are further determinants. 18/ Other major national variables include physical geography, audience geography, ownership, frequency allocations, equipment and transmission standards, cultural habits, and time-zone position. 19/ Such factors will necessarily have bearing on potential arrangements for multinational use of communication satellites and will also influence the direction emphasized by the United States in its further efforts to develop the technology.

Frequency Allocation. Central to the international aspects of a satellite communication system is frequency allocation, as discussed earlier. For many reasons there is urgent need for cooperation and agreement on the management and conservation of the band width spectrum 20/ -- and not least of the reasons is the possibility of interference with transmission. Since signals could be bounced off a passive satellite by any transmitter within visual range, two or more transmitters using the same frequency might overlap at least part of the reception area, opening the way to either accidental or willful interference. Solutions to the problems have implications for national sovereignty, and would need therefore to be sought in an international forum. At present, not all nations are members of the International Telecommunications Union, the current arbiter in frequency matters. 21/

As a preliminary to negotiation, research is necessary to:

. . . Compare existing national and multinational regulations for wave length allocation, control, and use with the regulations that would be necessary for effective transmission via communication satellites. The satellite requirements should be derived from the expected transmitting (or reflecting) properties of satellites, expected properties of the ground receivers and transmitters, and the anticipated specific national and multinational applications of the system.

Standardization of Technical Equipment and Transmission Standards. Satellite communications will be in the higher frequency ranges; most receiving sets now being manufactured are low frequency types. As for TV, there are at least four prevailing standards which are directly interchangeable for broadcasting and receiving. 22/ For international systems using wire or local broadcast networks to relay satellite signals, complex and compatible control centers and procedures are necessary.

Related to standardization is a matter which is both legal and technical -- a means for registering satellites and controlling their characteristics and numbers. A further serious question arises from the assumption that during the system-development period malfunctions are likely to make necessary rather frequent replacements. What should be done with dead satellites which later "come to life" or those in which the malfunction is such as to interfere with other communications? 23/ International inspection and registration, replacement or increase procedures, and launching site regulation will involve security problems that may have complex implications for sovereignty and national interests. Again, as a preliminary to negotiations, research is necessary to:

. . . Make explicit items, operations, and standards which must be compatible in multinational operations using particular types of communication satellites for specific tasks.

. . . Specify the problems involved in registering, controlling, and operating the satellites and the undesirable consequences which would arise if these problems were not solved in advance either through deliberate technological efforts or through organizational and legal arrangements.

Cultural Differences. Regional and national custom and culture have a great deal to do with the likes and dislikes of audiences and as such present complications when mass communications become international in scope. Language is the most obvious example of cultural differences: effective translation may require a full knowledge of local lore, including vernacular, humor, and proverbs. 24/ In visual media, the same picture evokes varied images and responses among different audiences; although it is common to refer to pictures as an international language, "actually, nothing could be further from the truth. The Anglo-Saxon, Latin, Scandinavian and Germanic races do not use pictures in the same way to communicate ideas. The subject is not divided up according to the same rhythmic patterns, nor is living matter tackled in the same way. Their tastes are not identical and they simply don't see the same thing when looking at the same picture." 25/

Some program topics -- e.g., space exploration and nuclear fission -- are susceptible to a single treatment suitable to all European audiences, whereas, anti-Semitism, as a topic, required such different treatment to fit the situations of audiences in various countries that it was impossible to present on the twelve national European networks participating in Euravision. Thus, as commercial, national, or international interests move into multinational fields, the application of anthropological methods to gain cultural insight will become very important. 26/

The increased opportunity for familiarization with other peoples which satellite-based TV may provide carries with it potentials for enhancing either tolerance, indifference, or antipathy. Thus, it will eventually be desirable to conduct research to:

> . . . Evaluate and apply, in the interests of effective multinational radio and television exchange, the substantial knowledge presently being accumulated by anthropologists, social psychologists, and other social scientists on culture differences and on the means for anticipating and reconciling them when it is desirable to do so.

Time Differences. One of the most frequently proffered arguments for the attractiveness and utility of international TV via satellite is the opportunity for live reception, as one sits comfortably in front of the home set, of entertainment from the far corners of the earth. It is, however, somewhat sobering to compare times around the world, using 8 p.m. in New York City as the take-off standard:

3 p.m.	Fairbanks Honolulu
4 p.m.	Juneau
5 p.m.	San Francisco
7 p.m.	Mexico City
8 p.m. ------	New York City

10 p.m. ...... Rio de Janeiro

1 a.m. ...... London

2 a.m. ...... Bremen
Brussels
Budapest
Danzig
Oslo
Paris

3 a.m. ...... Cape Town
Johannesburg

4 a.m. ...... Moscow

6:30 a.m. ...... Calcutta

8 a.m. ...... Bangkok

10 a.m. ...... Tokyo

11 a.m. ...... Melbourne

It is clear that prime listening time seldom matches the time at which the events to be seen are likely to occur. On the other hand, the time lags sometimes require radio transmissions when atmospheric interference degrades signal quality; the high frequencies used with satellites would obviate such interference. Presumably, a major value of the satellite is that it permits transmission to be live rather than prerecorded, but it remains to be shown that the cost and benefits would favor live transmission more than tape or film flown by jet to central ground transmitters. For the areas not in the range of central ground transmitters, study could perhaps discover whether world events would be of enough significance to the potential audience of these areas to make it profitable to reach this market, too, at the time of the happening rather than some days later. 27/ Research would help to determine:

. . . The cost and benefits of "live" transoceanic or transcontinental telecasts or radio transmissions compared to those of producing and distributing audio and video tapes or films. This study should be done for specific operational contexts -- for instance, markets and time -- and specified states of the technological art.

Conciliation of interests

Resolution of the potential problems and differences will, of course, depend upon knowledge about the problems involved as well as the auspices under which interested parties negotiate. As the situation now stands, there will be very few major sources of communication satellites for the foreseeable future -- possibly only the United States and Russia. Questions of satellite use and privileges, audience and user markets, reciprocity, program content, and the like would thus presumably be resolved between all other interested countries on the one hand and these two satellite sources on the other -- unless one or both were to turn over the capabilities to an international agency. In Russia, negotiations would be with the government; in the United States, it is not clear at this time whether negotiations would be with the government, private enterprise, or some combination thereof.

Receiver antennas and other receiving equipment (and possibly transmitters, too) might belong to the receiving country or to the U.S. or USSR transmitting agency, being built and operated by the USSR or the U.S. by agreement, in the receiving areas involved. Problems of the nationality and training of operating personnel would also have to be negotiated.

How successful these negotiations would be if conducted within the present perspectives of national telecommunication philosophies, legal constraints, and organizations is not clear. Perhaps there will have to be a willingness to try new approaches to the problems, if the potentialities of communication satellites are not to be thwarted. The world is full of examples of valuable technologies only partially used because of unresolved conflicts of political, social, and economic philosophies. There is no reason to assume that the same might not happen to communication satellite technology.

Especially delicate is the question of program censorship and control. In the first place, a program might inadvertently contain insulting or otherwise objectional material which would be deeply resented by the audience or the governments involved. (This is the more likely so long as the difficulties of programing for different cultures are ignored or little understood.) If local governments controlled reception, they could cut off the disapproved program. Protests to or from the United States would present different problems if the program were planned and broadcast by the government then if it were a private product free from government censorship. In the second place, while the first major applications of satellite communications would probably be in the fields of commercial telephone and data transmission, it is reasonable to expect that, eventually, government interests in propaganda and incitement will be served by radio and TV satellite communications. The international antipathies thus generated could be exacerbated by the active repeater system, which makes control of private receivers more difficult.

If all or part of satellite communications capability and control were internationalized, negotiation procedures would probably be different and, very likely, so would the emphasis on satellite uses, about which negotiations would be conducted. Another approach might involve a split in control of functions, with radio and TV legally the responsibility of, say, a special UN agency, and telephony, for example, left for national negotiations. Whether such an arrangement would permit easier resolution of national differences over program content and purpose remains to be determined. Preliminary to negotiations, studies should be undertaken to discover:

. . . What pertinent economic, cultural, and technological factors in each nation or region involved could complicate or facilitate the conciliation of interests in using and controlling satellite-based communications. What technological, economic, organizational, and legal arrangements could be developed to overcome specific major differences as detected in the above and to take advantage of specific major similarities. **

. . . The cost and benefits to the United States, compared with those to private enterprise, of private or public ownership of United States satellite facilities, in terms of the effects of ownership on areas of international agreement or disagreement on the use or sharing of United States facilities.

. . . Appropriate arrangements between the U.S. government and private U.S. organizations for control of and responsibility for program content, censorship.

. . . The costs and benefits of turning over to an international agency those communication functions which are either inherently unprofitable or which have the potential for stimulating international unrest. Under what conditions would such a transfer of function be in the interests of the United States? In the event these facilities were internationalized, what activities might be prohibited or subjected to international control and what should be the functions and powers of such an international body? **

Uses and Implications

The eventual uses of space communications systems via satellites fundamentally depend upon a willingness to undertake system development in the face of conflicting politics, social values and institutions, and standards of living. It is likely, too, that not all the uses will present themselves rapidly and that the existence of the satellite system itself will create new opportunities over time.

It is worth recalling here that the first truly large amounts of presently unavailable channel capacity will most probably occur in the radio and radio-telephony range rather than in the TV range. In view of possible major developments in cable and other forms of transmission not dependent on satellites, it is not clear how much actual need there will be for a massive, multichannel TV capability in a satellite system when the system finally exists.[28/] By that time, moreover, the major social implications may have already been introduced via other TV carriers.[29/] Nevertheless, since the problems related to the use of massive multichannel TV coverage have in general some of the most pressing aspects of all, attention will be here directed to their implications as well as to those of radio, facsimile, data processing, and telephony.

Telephony

It is often asserted that demands for overseas telephone circuits will greatly increase in the next few years and that satellites, at least for the present, appear to be the best means for meeting them as well as for providing service at reduced cost.[30/] However, it is not clear what the consequences are for a peaceful world, if these demands are or are not met.

For business and other far-flung organizations, the opportunity for frequent, extremely rapid, voice communications between various functional sectors implies possibilities for increased control and coordination -- with an amplification of the advantages and disadvantages for society which are presently matters of speculation and research.[31/] It may give the bigger, more complex organizations a further increment of capability over the small organization and thus hasten further the demise of the small organization. However, easy communication may increase the ability of the small organization to compete with the bigger ones. Whether savings or increased earnings accrue to users big and small, and if so to whom, remains to be studied.

An important part of the operations of world society could become dependent on the pace of the new system; the possibility is not too remote that a high-speed, high-capacity type of social organization heretofore unknown would develop. Interruptions in the communication system could therefore be costly -- and perhaps disastrous -- economically and socially.

Also deserving study are the implications of high-speed global telephone service for diplomacy and international relations. There are many in the diplomatic profession who feel that the pace is already too great for careful analysis and reaction, and that more input without corresponding capabilities to analyze and synthesize the information -- and without better informants -- would simply complicate an already vastly overtaxed situation. On the other hand, the availability of sufficient and immediate channels of communication might encourage a form of international relations wherein peers (at least at the middle executive levels) would work in continuous contact, thereby achieving an informal threshing-out of problems of mutual interest. Such a capability might be especially useful for widely dispersed international and multinational agencies. The long-term result in all cases might be a gradual lessening of identification with national interests and an enhancement of identification with the mission or goal. 32/

Research may be rewarding on the following questions:

. . . What appear to be the specific costs and benefits for the nation of the additional commercial telephone calls carried by a satellite system? What are the relative costs and benefits of alternative, if slower, means for enlarging this capacity? On the basis of such findings, what are appropriate bases for allocating costs and the rewards of investments in development and operation between the general public (as represented by the government) and private enterprise?

. . . What are likely to be the consequences for international relations and diplomacy of world-wide high-speed telephony? How can the advantages be exploited for the nation and the world, and how can the disadvantages be minimized?

. . . Are there consequences for society from substantially more phone calls for personal purposes, which might be of sufficient import to merit study?

Data search, retrieval, and processing.

An area large in potential implications for society, and one which needs only radio and telephony bandwidths, is that of data search, retrieval, and processing. Satellites might be used as the communication links; or the wire and coaxial cable circuits freed-up by shifting telephone and TV to satellites might be used instead. The search and processing requests would be handled automatically, through computers and other devices, actuated by coded signals and, in turn, transmitting the findings by coded signals. Organizations could thereby centralize their computer facilities and perhaps enlarge them with the savings gained. Special facilities otherwise not easily or economically available could be established around the world for the use of scholars, scientists, businesses, and governments. (As noted earlier, possibly one of the most immediate uses for a communication satellite system would be transmitting the vast amount of data anticipated from a world-wide weather data collecting and processing network.) In some situations, whole control systems might be operated and controlled by the feedback from remote computers and data-searching devices. It might also be possible to code the contents of major world libraries so that scholars could search them remotely.

While some organizations have begun data processing at a distance, the use of such techniques are not as extensive by any means as present technological capabilities would appear to make possible. 33/ Costs may be a factor. Possibly there is in most cases no clear evidence to those concerned that the competitive advantage is sufficient at present, to make economic and psychological investment in such systems worth while. Traditional perspectives and/or institutional inertia may also be deterrents. However, the growing emphasis on high-speed, far-flung, relatively inexpensive communications, which the satellites themselves will provide, may shift perspectives and competitive strategies sufficiently to make data search, retrieval, and processing at a distance an integral part of the coordination and control philosophy of business, government, and social enterprises of all sorts.

For full development, major contingent developments would also be necessary, including the production of sufficient numbers and types of computers for more routine purposes and the training of sufficient personnel to code data and interpret responses, and to build and maintain the computers. Agreement on international standards of component compatibility would be mandatory.

Success would in good part depend on the reliability of the various systems; redundant codes, check codes, etc., would need to be developed for the particular problems involved.

Whether or not codes could be developed which would permit nonquantitative scholarly research at a distance remains to be seen. The demand might not be great enough or the benefits to scholarship and the rest of the world sufficient to justify the immense coding effort involved. Scholars would need training in the use of codes for creative study, and funds would be necessary to support these activities. To the extent that the satellites provide the potential for this form of international scholarship they may also help to expand present efforts to develop machine translation and other codes for qualitative data.[34/]

As a direct and important consequence of the above, the long-needed tool and stimulus might finally be provided for a concerted attack on the tremendous problem of using the mountains of data, new information, and old information in new forms which presently threaten to overwhelm this civilization. Most observers believe that the major challenge lies, not in obtaining more information, but in using what we have efficiently.

Another likely area of profound implication for society may be the effect on the organizational pace of institutions produced by this high-speed interlocking of data, actions, and decisions. Whether this would put more or less strain on decision makers at all levels is not clear. While decisions may have to be more precise, more complicated, and more rapid, the computers, tied in via satellite, might ease the stresses by organizing and displaying complicated data in ways easier to grasp and act on. On the other hand, the pressure to outthink the competitor with his data processors may place more pressure on the decision maker. It is also not clear what the consequences would be, for society and specific users, of abrupt or partial stoppages due to faulty communication circuits.

If there are many TV channels available, they might be profitably used for on-the-spot surveillance of situations. In principle, all decisions which depend on visual impressions ought to be possible by using high-fidelity, three-dimensional TV instead of on-site inspections. Psychological and cultural habits may mitigate against this use, though research should be able to provide methods for overcoming these habits.

If such data processing systems develop, there are obvious implications for those activities which now depend on carrying printed information and people to and from the data users and the data processers. Economic readjustments would seem inevitable. The implications for the postal system, (especially as that system changes under the impact of other new technologies specifically intended to make it more efficient) would be worth studying.

Finally, large-scale organizations of men and machines tied together in a vast computer context probably have implications for attitudes and values toward man and his purposes held by those who live in such a society. (See Chapter 5 for further discussion of this.)

In summary, research might be undertaken to determine:

. . . What required changes in performance, function, and pace could be expected to face decision makers--given specific types of data, available to specific decision making sources, in a context using the actual time span expected to be involved for the sequences of decisions and the related data search? 35/ What changes in curriculum and training should be undertaken for specific types of decision makers? Are different selection criteria in order?

. . . In what ways would high-speed access to data repositories enhance the interpretation and use of specific existing data? What would be the specific cost and benefits involved in realizing this accessibility if preliminary study indicated that it appeared worth while in principle?

. . . What are the factors which determine satisfactory visual evaluation at a distance, compared to on-site evaluation? Under what circumstances is three dimensional vision necessary?

Education

Education and Culture Change in Underdeveloped Areas. The possibilities of teaching in underdeveloped areas via satellite-based radio and TV have been much commented on. Again, it is necessary to keep in mind that both the technical prerequisites for extensive satellite-based TV capacity and the reception requirements make it clear that the opportunities to use TV in underdeveloped areas on anything more than a demonstration basis are very probably some years distant. Auspices which did not require potential profits or national gain as prerequisites for technological investment might be able to accelerate the development. In addition to satellite development costs the costs of adequate local receivers, adequately distributed, would be involved. Requirements for reliability, maintenance, and replacement capabilities must also be met. (Obviously, the problems are of a different order for a one- or two-channel radio than for a facsimile printer or TV receiver.) Receivers could be provided by the local government or political party organizations, or under international auspices. How the costs are to be met and what the benefits are will of course determine who risks development costs and how much is risked.

If accelerated development appears likely, research is urgent on teaching in nonliterate societies via radio, TV, and possibly facsimile. The motivation to learn is not inherent in the human in any sense important here; rather, it depends upon culturally given attitudes toward learning per se, toward what is worth learning, and toward the pace of change which is acceptable in traditional terms.[36] Moreover, learning usually depends for its support on the source of the message, in particular on face-to-face experiences. This is especially true in underdeveloped or tradition-oriented societies.

In the complex relationship between demonstration, memory, and application that makes up a good share of the learning process, a variety of problems arise in connection with the translation of what is seen or heard into doing and behaving according to the standards conveyed by the communication. There is a large question of what can be learned through radio and TV unless there is sufficient physical contact with the world from whence the subject matter and the conveyed values arise. In fact, it is not at all clear to what extent, and for what kinds of material, literacy is a prerequisite for effective learning from radio and TV.[37]

In general, then, what is conveyed successfully (or what boomerangs) will be a function of the semantics and format of the message, and the extent to which it is meaningful within the values of the receiving culture. These problems are complex, but they are very familiar in principle to anthropologists and other social scientists who have studied other cultures and the processes of learning.[38]

When it is clear what societies or regions might benefit more from teaching introduced via satellite than from traditional or less costly forms, specific answers to the problems discussed above will have to be derived for the particular cultures involved. However, much preliminary fundamental research will be necessary to discover the general nature and dynamics of the relationships of radio and TV to learning and culture change in underdeveloped societies. For instance, research should:

. . . Determine what it is desirable to teach persons in underdeveloped areas. This requires a systematic study of the uses to which the teaching is to be put -- and importantly what local persons <u>want</u> to learn -- and the consequences if no such teaching is undertaken or if it fails.

. . . Determine what available knowledge is applicable to teaching and learning in different culture contexts by radio, facsimile, and/or TV.

. . . Apply and further develop knowledge and methods for understanding the values and behaviors in specific cultures which encourage or discourage the learning of specific types of ideas, attitudes, and behaviors (as distinct from the learning of traditional ones).

. . . Apply and further develop knowledge and methods for understanding the factors which affect the degree and type of learning from TV, radio, and possibly facsimile, as functions of literacy, subject matter, auspices, format, and opportunities to use what is learned. These studies must be aimed at meshing the content and purposes of telecommunications with other forms of communications from interested government groups, private organizations, and international agencies.**

. . . In the light of the findings from the above -- determine the cost and benefits of teaching and introducing culture change by more traditional means compared to those made possible by satellite communications. Then appropriate means need to be explored for stimulating, financing, and operating the required contingent developments under varying circumstances of private, government, or international ownership, or combinations thereof.

<u>Education in Advanced Countries</u>. Exactly how much and in what ways the exposure to ideas, processes, and world-wide, on-the-spot events that is made possible through radio and television affects the general educational level in advanced countries is simply not known -- despite the plethora of opinions on the matter.[39/] Careful and qualified observers are inclined to believe that children have acquired a good deal of factual knowledge from their TV experiences which they would probably not have acquired otherwise. The same thing is probably true of adults. But whether there have been any important gains in understanding or shifts in perspective because of this is another unknown; moreover our present information on the subject suggests that there is little basis for expecting that there might be.[40/]

One aspect of the question merits special mention. It is frequently asserted that access to extensive communication facilities will bring about better understanding between peoples and nations of the world -- on the assumption that exposure, per se, to values and attitudes other than those of the listener or viewer leads to greater tolerance. What evidence there is on the matter does not make it clear that the assumption is justified; in fact, there is some evidence that exposure to other values may reinforce the values of the viewer and thereby his intolerance or provincial-mindedness.[41/] It is possible, however, that when the effects of radio and TV on specific audiences and the factors involved in attitude change are better known, programing for the media could be geared to enhance international understanding.

In recent years various early-morning educational programs offered on TV by some of the major broadcasting stations have provided firm proof that some people are eager to be exposed to various areas of learning. This suggests that satellite-based communications, with their extensive capacity, could have great educational utility. However, expected developments in film, video-tape repository libraries, and air-borne TV might provide more efficient means of serving formal education sessions before satellite systems become a reality. Nevertheless, active repeater satellites would make possible "live" regional presentation of lectures and special events, which now must be taped and distributed singly to schools and local transmitters; such problems as schedules for viewing time and accommodation to time differences must be solved, and comparative costs studied. A further very probable utility of the new system could be its transmission (perhaps during low-traffic periods) of TV tape material from central repository libraries to schools. The expense of TV material might thus be kept low -- since the tapes could be erased and retranscribed -- and schools would have access to a much greater body of materials than they otherwise might be able to afford.

Research activities have been going forward for some time on the impacts of telecommunications and will undoubtedly continue. Since a major premise justifying the development of satellite communications is the enhancement of such impacts (and especially for educational purposes), research in this area should be supported and encouraged. Specific research useful for assessing the likely utility of satellites for education should determine:

. . . The extent to which TV tapes and live TV presentations are likely to be major teaching devices in the next ten to twenty years, and what sorts of subject matter can best be taught this way.

. . . The cost and benefits of transmission from central tape libraries to local schools, compared to those of a complete library for each school. Under what circumstances do the benefits of live programs exceed those of taped, and what are the comparative costs involved?

Implications for political manipulation

Since communication is necessary for developing and maintaining the identification of the individual with the group and of the group with other groups, repeater satellite systems could, in principle, assist in establishing or disrupting the political allegiances of person-to-group and group-to-group. Such a capacity might be especially useful in (1) areas that lack funds and personnel for building and operating a ground-based transmitter, and (2) areas where the society is highly decentralized and identification with a central political core is not traditional. It would also be of use to those who wished to disrupt existing allegiances through the communication of propaganda or inciting materials or by jamming the signals of the existing political core.

Successful use of the system for political purposes would depend on the selection of semantics, format, and subject matter. It would also be necessary to learn whether or not identification with a political core can be maintained in underdeveloped areas chiefly by radio, facsimile, or TV. Under some circumstances radio messages have helped alter patterns of authority, but how persistent and directive these communications can be is presumably a function of the level of literacy, salience of subject matter, and credibility of source, among other things.[42/]

The many evident opportunities there will be for using, and perhaps in the near future, the coverage of communication satellites for competing political propaganda and incitement has led many observers to conclude that the foreseen difficulties can only be avoided by internationalizing the system at its advent. On the positive side, it is felt that only international sponsorship can encourage identification with the world community, or would be considered by opposing blocs to have the requisite disinterest to handle the situation when encouragement of local, national, or regional identification would be helpful or necessary to maintain stability.

Research is thus in order to determine:

. . . The social and economic cost and benefits of permitting exploitation of satellite communications for partisan national political purposes relative to those of restricting use to nonpartisan international political purposes.

. . . Methods and means for implementing procedures for the alternatives above and for continually updating the procedures as satellite communications technology evolves.

Conferences

"The conference" has become a notable part of the twentieth-century as an exceedingly useful device for exchanging ideas and information and for solving problems. The opportunities for increased communication stimulated by satellite systems will probably increase the imperatives for sharing and synthesizing the consequent voluminous information. If sufficient TV channels became available to make closed circuit arrangements economically feasible, the satellite system could be especially useful for facilitating conferences.[43/]

Such conferences would, for instance, eliminate travel time and reduce the risks to life and limb of valued personnel. They would also permit easy access to and greater marshaling of resources located at each conferees home base. However, if the numbers of people conferring this way were great enough, the procedure would probably have adverse implications for the transportation industry and such supporting services as hotels.[44/]

Whether or not such procedures would become routine would depend on technological capabilities and social and psychological factors. To be effective the TV signal would probably have to provide both visual and aural high fidelity and private "side" circuits between various participants. The way the conference, as a conference, appears to each participan from his separate viewing position, is likely to be very important, and it is difficult to estimate in advance how such factors as side conferences via social activities, nonverbal "expressive" gestures, and attitudes toward conferences and "in-the-flesh" relationships would also affect the utility of this method. The procedure might be more suitable for certain purposes than for others -- more so, for instance, for briefing and problem-solving than for diplomatic maneuver.

The possibility of using closed circuit TV for this purpose seems to have many implications for the exchange of information and ideas and possibly for the control of organizations, but its realization is probably at least a decade away, given the technology necessary to permit many conferences via satellite or to free-up ground facilities through added satellite capacity. Research would eventually include:

. . . Specific studies of the various pertinent social and psychological factors, in the light of knowledge about conference technique and process. This should include laboratory research using various closed circuit TV arrangements, working situations, and personalities, including people from societies other than our own.[45]

. . . Studies intended to determine the factors which would enter into the decisions of typical participators as to whether they would prefer to attend the conference directly or participate via television. Obviously, the factors could change over time, and as values about face-to-face meetings change or are reinforced. The chief value of such studies would be the further insight they would provide for designing laboratory experiments of the sort recommended above.

4. IMPLICATIONS OF A SPACE-DERIVED WEATHER PREDICTING SYSTEM

Introduction

IT IS THE BELIEF of atmospheric scientists that advances in meteorological theory and practice will eventually permit world-wide, reliable, long-range forecasts at least a season in advance, as well as more precise short-range forecasts and easier identification and prediction of special phenomena such as hurricanes, typhoons, and tornadoes.[1/] Properly instrumented rockets, satellites, and perhaps other space probes will yield new kinds of atmospheric and solar data and can provide an extensive and constant reportage of phenomena that now are observed over relatively restricted areas of the globe. However, for the development of an advanced theory and its practical application, the information thus collected must be supplemented by and integrated on a world-wide basis with more conventional data now obtained through low atmosphere, oceanographic, and earth surface observation.[2/] In any case, when better weather predicting becomes possible, a variety of problems and opportunities will confront and profoundly affect many sectors of society around the world. The challenges are social, political, and cultural, as well as economic and legal, and much research is necessary to take advantage of the inherent opportunities and to minimize the problems intimately attached to them.

Estimates differ on the time required to develop a partially space-derived general weather theory that will be the basis of major improvements in long-range weather predicting. Some meteorologists believe that full development will take at least a decade and probably longer, given the major theoretical and practical data-collecting challenges faced, as well as the time necessary to accumulate the 80 to 100 temperate zone seasonal data by which a general weather theory can be tested;[3/] however, during this time gradual improvements are expected, though possibly not without reversals in accuracy as different hypotheses are tested. The longer the time, the more likely that, with appropriate research planned and applied, the transitions required to utilize better predictions can be made with a minimum of the disruption usually produced when traditional approaches are confronted with new imperatives.

Other meteorologists believe that significant results may be achieved much more quickly; if good correlation is found between ground-based and space-based measurements, the many years of available ground-based records may permit more rapid testing of general theory. Then too, certain kinds of short-range predicting -- for instance, forecasts of imminent weather disasters both in this country and in areas never before having access to weather predictions -- may become possible fairly soon by direct inspection, through the use of Tiros satellite-type data, without the development of elaborate theory. Also, once the required ground-based system is established, many nations will for the first time have access to regular forecasts, perhaps not as good as those regularly available in the United States today but far better than they presently have. Should this swifter timing prevail, it is essential that some of the suggested research be undertaken with maximum dispatch.

The time needed to develop a weather predicting system partially deriving from satellite observations affects speculations on the implications of that development in another important way. If more precise short-range and seasonal predictions are about two decades away, the activities which now might be seen as most affected by such predictions may themselves be changed in twenty years. Developments in farming technology, synthetic foods, and so on may radically reduce (in western nations at least) the dependency of crops on weather; nuclear power to pump desalinated sea water may alter the dependency of water utilities on rain; many other presently weather-dependent activities, among them tourism and travel, may be altered in significant ways. These matters will be discussed in more detail in the appropriate sections of this chapter. At this point it is sufficient to indicate that many activities for which weather predictions appear now to have great significance may not, in fact, be as weather-dependent by the time greater accuracy in predictions is available.

It is recognized, of course, that, even in the present, for many parts of the world and for many activities improvements in weather predicting (except under such circumstances as forecasts of imminent disasters) would not substantially alter behavior. In some cases the same activities can and would be carried on over a wide range of weather; in others, the weather range is not great enough to alter the pace of activities. This point has special significance in the face of claims that more precise day-to-day prediction would be a universal economic and social panacea. It is not at all clear that much can be done to help the fruit grower when temperatures hover just above freezing or to tell people which street a tornado will come down.[4/] Nor is it clear that, with the proliferation of air-conditioning, covered walkways, and so on, better daily predictions will help the consumer or hinder the seller, though seasonal predictions might have important effects.

Weather Control

Many of the matters to be discussed in this chapter would differ in substance and significance if weather control rather than weather prediction were to be realized on a large scale in the next twenty years. However, extensive weather control -- if possible at all -- will depend upon the development of the sophisticated weather theory discussed in this chapter. Therefore, although local fog dispersal or rain-making might be successfully practiced before that time, the period of applied weather control, on the scale frequently fantasied in recent years, is presumed to be more than two decades away and hence beyond the scope of this report.[5/]

The role of space activities in weather-control practices as conceived of now is not clear. As for local rain-making, legal problems are being explored as a result of some controversies already produced from the alleged effects of rain-making, even though the evidence that it has any effects at all is presently in dispute and under study.[6/] Certainly international legal problems would be substantial if rain-making became possible on a scale large enough to disrupt weather in neighboring countries, and thus it would be well to keep an eye on the progress of domestic legal decisions.

It is possible that efforts at disrupting hurricanes and typhoons in their formative stages may be attempted ahead of the presumed time table for a complete weather theory. Methods might include altering ozone levels in the upper atmosphere, possibly by nuclear explosions -- which would involve a number of international cooperation problems. Because the experimental requirements are still vague or unknown, not much rigorous research is possible.

Yet because of the importance of the potential problems, preliminary study is necessary to:

. . . Examine possible types of international cooperation and participation required to conduct specific weather control experiments.

In general, research in this area must probably wait until the physical requirements of the experiments and their possible undesirable by-products can be clarified. However, since the discovery of means for climate control or large-scale weather control would have profound consequences for international relations, this area of study should not be overlooked completely.

Probable Organizational Prerequisites for Applying Future Weather Observation Capabilities

A variety of organizational and personnel problems will be associated with the development of a system for utilization of weather theory and observations based on data collected world-wide and distributed for various forecast purposes on a similar scale. These will include questions in connection with acquiring, processing, and distributing data, as well as staffing installations with men and machines -- four areas of problems that are well known to present systems of weather study but which will be enormously intensified by the large scale of operations and the new wealth of data meteorological satellites are expected to provide. Yet according to a report of the Committee on Atmospheric Sciences of the National Academy of Sciences in September 1960:

"There exists at the moment no organization or group in the world that is prepared to exploit fully the new wealth of information that meteorological satellites will certainly provide....Thus, the huge expenditure of scientific effort, engineering, and finances in meteorological satellites may be largely wasted unless a proper organization is ready to exploit the informational output of the meteorological satellites for the increase of our knowledge and the construction of a sound, theoretical foundation upon which a new order of practical forecasting can be based."[7/]

Central to a sophisticated weather system would seem to be (1) a high speed world-wide communications system to receive and transmit data for short-time predictions, and (2) a further arrangement of communications that would allow for coordinate analysis of simultaneously occurring weather phenomena for long-range prediction. The latter requirement could be met by a large "real time" capacity to communicate data to central computer stations or by a large local data storage capacity with data being "read-out" to the central computer facilities at later times. In either case a communications satellite system appears to be necessary for transmitting the quantity and quality of weather data required, from all quarters of the globe as well as from space. Research on the communications requirements for the presentation of global, terrestrial, upper atmosphere, and space data remains substantially undone.

Problems associated with accumulation of data

Establishing and maintaining an international data collecting and reporting network through which terrestrial and satellite data alike can be communicated to a relatively few regional computer centers for correlation and analysis will more or less depend on the interplay of such factors as international law, prevailing modes of behaviour, economic considerations, and the availability of international organizations which can rise above the tensions between nations and make provisions for reaping the advantages of such developments.

Eventually, the opportunities for mutual benefit from world-wide weather forecasts might in themselves produce a greater sense of general social interdependence that might lessen international tensions. However, during the period of development and initial application of an improved weather theory the complexion of the international situation is likely to show the variations that have become so familiar in recent years, with the consequences for the evolving prediction capability also varying: tension could abate somewhat for a short or longer time, making possible cooperative arrangements between nations; the present level of tension could continue, involving the prediction efforts in a taxing alternation of competition and cooperation; or competition could be exaggerated to a point that would seriously restrict the flow of weather data and reduce international reporting of it to an informal and intermittent exchange calculated to have least relevance to military or economic effectiveness.

Motivations for supporting scientific investigations of the magnitude necessary to discover a comprehensive theory of the atmosphere will vary in kind and degree among nations. For instance, even in a world where tensions are minimized, the available capital of each nation will be a critical determinant of whether and to what degree each nation can afford to (1) support its own weather observation and reporting network, or (2) contribute toward the support of an internationally funded and/or administered organization.

Motivations of nations may also be influenced by past arrangements for gathering weather data. (In the Caribbean, for instance, the United States developed the weather observation network bilaterally, providing the necessary installations because most of the nations in that storm-incubating region could neither support nor perform the warning services that were vital to us. [8/]) Each nation's vulnerability to, and past experience with, weather extremes may be another critical factor. Important too may be the opportunities to enhance national prestige by making a special contribution to the development and organization of weather forecasting systems. The capacity of the social, political, and economic institutions of each nation to absorb and utilize weather forecasts to avoid injury and loss will undoubtedly play a role; in some circumstances both the leadership and the potential users may see better weather predicting as a threat to and a disrupter of the social, cultural, or political equilibrium.[9/]

Each nation, therefore, will probably have its own, self-assessed, many-factored formulae as the basis for its decision to cooperate or not to cooperate with the maintenance of and participation in a weather reporting network, or to set degrees to which it believes it to be beneficial or possible to contribute. As the requirements for the weather forecasting system clarify it will be appropriate to determine:

. . . What type of data collecting organization is necessary and what factors are most likely to influence each nation's willingness and ability to participate in the data collecting program.

. . . The role the United States can play in encouraging participation through its contribution to the development and application of new meteorology.

Although this report is examining the implications of peaceful uses of space activities this cannot be done realistically without noting here that the military implications of weather data will, in many countries, importantly influence decisions about participating in the system. Weather traditionally has been an important factor in conducting convential warfare.[10/]

If in the future there should be limited or conventional warfare among either the great powers or the lesser ones, both local and long-range weather predictions would appear to have such significance as to make decisions about the contribution of weather data a matter of major military consideration in each of the countries involved.[11/] Moreover, detailed knowledge of the weather in specific food-growing areas might permit more effective aggressive utilization of biological and chemical agents intended to destroy crops. Satellite observation of the density and color of growing areas could give advance information, when combined with foreknowledge of the weather pattern, which would be useful for conducting either military or economic warfare.

It follows that there are a number of military and military-economic factors which might affect the extent to which nations and blocs of nations would cooperate -- or permit international organizations to operate -- regularly or sporadically in providing ground-base weather data. Studies are thus necessary to:

. . . Determine methods of assessing the positive and negative military and economic consequences of participation in unrestricted weather data collecting and processing, as well as the consequences of varying amounts and frequency of participation.

. . . Determine the extent to which participation in weather data collecting and processing can be made unrelated to the military and economic warfare contingencies which may face various countries.

. . . Determine the extent to which weather-dependent requirements for nonmilitary activities are compatible or incompatible with military requirements. What would be the consequences for these nonmilitary systems of interruptions or limitations in weather data imposed by military requirements both during peacetime and wartime? Under what circumstances should priorities of continuity and completeness of information be assigned to military and when to civilian needs? What can be done to mesh and compromise potential differences? What are the costs and benefits to each of interruption and of compromise? (Some aspects of these matters will be discussed in the sections devoted to prediction utilization.)

Problems associated with data processing

It has been estimated that from six to ten well-staffed, intercommunicating weather data analysis centers would be required to correlate and interpret data pouring in from space and all quarters of the globe, although no thinking beyond speculation has yet been done on such requirements.

The United States, Canada, and the West European nations have by now generally incorporated computer methods into their respective national atmospheric research and meteorological services, with access to either multipurpose computer installations or special meteorological computer centers. The British, Germans, Japanese, and Russians, as of 1958, had such installations. In view of the close relationships of these national governmental meteorological installations to the respective military capabilities, it is unlikely that the weather facilities could be easily detached from their military relationship for incorporation into an international structure or authority in the foreseeable future, barring a major shift in military postures.

National centers, among them the U.S. Weather Bureau's Suitland installation, can and do make significant contributions to international data reporting by exchange of selected data with other nations under United Nations-World Meteorological Organization compacts. Costs of such international reporting are borne by the national weather organization originating the information.[12/] The exchange formula, however, has little relevance to the vast meteorological blanks -- those areas in which no computer centers exist and where even simple observations and reporting are minimal. In the great continental masses of Asia, South America, and Africa, indigenous forecast capabilities, especially for shorter-range forecasts, will depend directly on installations for assessing the continental weather factors -- as well as on the integration of local data. Such regional computer centers appear necessary to obtain forecasts equal to those now enjoyed in North America.

Research is necessary to determine:

. . . What type of data processing organization is necessary for the development and use of a more adequate weather theory and observation system, and how should this be distributed throughout the world? What alternative distributions are acceptable in the face of noncooperation or strong pressures for preferential involvement?

. . . What the motives for cooperation or noncooperation are in potentially involved nations. To what extent are these motives transient and to what extent likely to persist? To what extent are they compatible or incompatible with the required operating conditions established by the funding and/or initiating nations?[13/] What can be done economically, politically, etc., to encourage the participation of noncooperating countries whose cooperation is needed?

. . . What are the advantages and disadvantages of alternate schemes of financing the data processing installations?

Presumably, there will be prestige accruing to the nations which house the computers, and problems of balancing technical against political and economic feasibility and desirability of sites may present their own difficulties. Questions will arise concerning the funding and staffing of such facilities; ownership and the related question of assuring uninterrupted service in the face of political, military, and economic pressures must be resolved. The data processing centers may very likely also be the sources which produce regional predictions as well as data for incorporation in local predictions. Therefore, a study should be made to discover:

. . . How to develop means for minimizing the possibility of distorted regional and local predictions or data output by political, military, or private economic interests. International control, international membership in a "bureau of standards" organization, quid pro quo bilateral and multilateral arrangements, and fully automatic predictions should be examined as means of circumventing this difficulty.

Problems associated with data distribution

To the extent that the same facilities are used to collect weather data and to make and distribute weather predictions, the problems already posed in the previous two subsections are also pertinent here. An additional study area is evident at the local level, particularly for regions and areas which have not previously used precise weather predicting.

. . . Methods need to be developed for translating local long-range and short-range predictions into a meaningful form for those who can benefit from them. This is especially likely to be a challenge in areas unused to sophisticated weather predictions and to assessing their meaning in terms of the complex of factors to be considered in order to make maximum use of the prediction. (This matter will be considered in more detail, especially in the section on implications for farming.).

* * * * *

A number of research problems apply equally to data collecting, processing, and distribution. Moreover, there are special problems posed for the United States if it is to be the major contributor to the satellite-based aspects of the quest for an adequate weather theory. The following questions for investigation are applicable generally to many nations, as well as specifically to the United States and its national and international interests.

. . . To what extent can quality control problems at all phases of theory development and routine predictions be met by international, national, or private organizations?

. . . What will be the effects of faulty efforts at precision predictions on political and/or financial support during the theory development stage? What activities can be undertaken to minimize adverse consequences?

. . . What are the relative advantages and disadvantages economically, politically, culturally, and militarily of international, national, or private control of all or parts of the theory development system and, eventually, the weather predicting system? What problems need to be resolved regarding ownership, funding, and staffing of facilities in each of these cases? **

. . . What are the costs and benefits for a given nation of participating in these efforts? How dependent are these on the immediate or eventual participation of other nations? In particular, what are the domestic costs and benefits of participation and nonparticipation in relation to the possible consequences to a nation's international, military, and economic positions? [14/]

Problems associated with staffing a world-wide prediction system

There seems no doubt that a space-stimulated forecasting system will impose new and expanded demands for personnel, both to develop the system and the improved weather theory and to use them. Aspects of the problems thus involved can be illustrated by the present situation in the United States.

The United States' supply of meteorologists, especially those with a broad scientific background, is meager when measured against current demand; the U. S. Weather Bureau, for instance, is hard put to recruit an adequate number. Opinions differ on the reasons for the tightness of supply.[15/] Some of it can be ascribed to an absolute shortage, a certain amount of which is related to the very small teaching cadre.[16/] Although thousands of meteorologists were trained during World War II, all but 20 per cent left the field after the war. By 1959 the supply of new students was termed "inadequate to meet even the static needs of the science."[17/] In 1958 eleven major universities in the United States were offering advanced training (Ph.D.) in meteorology, such as may be required to complete the transformation of the technology into the basic science of the atmosphere.[18/] It is believed that about the same number of advanced training facilities exist outside the United States.

Whether satellite-based weather forecasting systems will require more or fewer highly trained meteorologists is not how known. There is a question too of what breadth of training in meteorology is required to develop and use weather satellite data and the world-wide communications and computer facilities associated therewith. If perfected forecasts are to be attained <u>and</u> effectively presented to the people to whom they can be of use, must training encompass physics, astronomy, chemistry, mathematics, oceanography, geography, and computer techniques -- as well as studies that would make clear the implications and relations of precision predicting to agronomy, entomology, hydrology, architecture, economic geography, finance, economics, sociology, and psychology?

For the countries presently with no weather predicting facilities the problem of recruiting and training personnel is even more intricate. Competing social needs more congruent with traditional perspectives may result in low priorities for the training of meteorologists in the number and at the level required for data accumulation and utilization. Participation may be encouraged, however, if a country perceives that weather predicitions and the prestige to be derived from contributing to this scientific program are national advantages, and that the technical training necessary for the weather program could stimulate interest in technology for other pressing areas.

In some localities, weather predicting is provided by the facilities associated with airlines and other commercial activities. There might be opportunities to use the facilities for training local personnel and to establish a local predicting capability, after resolving questions of funding and jurisdiction.

It may be that automatic equipment can be substituted for personnel in the data accumulation, processing, and distribution phases of theory development and application, although it is not yet clear how much of the predicting can be done automatically and how much will require the interpretive capacities of man. Local predictions now involve to a greater or lesser extent the familiarity of men with local weather vagaries. Whether or not machines can learn to consider these vagaries or whether it is worth while using machines even if they can do so is yet to be determined.[19] The alternative approaches must be considered, from the standpoints of actual costs and of the political and cultural advantages and disadvantages of both.

Finally, personnel will need to be trained to convey the meaning and utility of weather predictions to those who can benefit from them. Even in countries with a western scientific tradition, long-intrenched operating methods are frequently difficult to overcome; in non-western countries the difficulties are much greater. Since the effective use of long-range and short-range predictions will involve complex judgments of a variety of contingent factors, those personnel who do convey the information will have to have special training. Presumably, they must be intimately familiar with local customs and perspectives (especially those related to weather forecasting folklore) and with the complex of concepts and contingencies involved in the technology of prediction utilization.[20]

In view of all the foregoing problems, research would seem desirable to ascertain:

. . . How the required attributes and numbers of personnel may be designated sufficiently in advance to have them available when needed for utilizing satellite-based data.[21]

. . . What should be the curriculum content for those who will participate primarily as theory builders? As predictors? For those who will translate predictions meaningfully for various publics?

. . . What facilities, methods, and incentives need to be developed to train indigenous personnel, especially in the undeveloped areas? How can this training be used to advance the general social needs of the countries involved? What methods can be developed for selecting, training, and using "weather interpreters" appropriate for different culture contexts and utilization needs?

. . . What especially useful functions can be performed specifically under international, national, and commercial auspices in the recruiting, training, and utilization of personnel?

Weather Forecast Utilization Implications

To better appreciate the implications of an improved weather prediction system, it is worth discussing briefly what is meant by a "more accurate" forecast. For example, the accuracy of a forecast can be described objectively in statistical terms that are concerned with both the per cent of correct predictions and the precision of each prediction -- the latter factor drawing attention to the amount of deviation permitted before the prediction is defined as "wrong." The variability in wrong and right predictions becomes important in defining the criteria of forecast reliability.

For the individual forecast user, however, perception of "accuracy" is likely to be a subjective process that involves personality and culture, as well as a reaction to the practical consequences of a wrong or right prediction. In general, in an environment, such as the United States, of fairly reliable predictions, people will tend to term a weather bureau accurate when experience has demonstrated that its predictions more often than not could have been useful and important to act upon. Nevertheless, even in the United States and much more so in countries unaccustomed to an established predicting system, whether or not people will act in response to a forecast depends on what they perceive the consequences of action or nonaction to be, and this varies with the society, the individual personalities, the activities to which the prediction is applied, and the degree of exposure to predictions.

It is likely that only gradually will the predictions of an improved weather system -- and especially the long-range forecasts -- become highly reliable. Hence, there will probably be a period of considerable uncertainty as to whether it is worth the economic and social costs to gain the benefits. Leadership and user behavior can be expected to vacillate, especially in view of the attitudes touched on briefly in the foregoing paragraphs. Thus, realistic estimates of the costs compared to the returns from various levels of forecast accuracy will depend on a much deeper understanding than pertains at present of how specific potential user groups behave when given alternatives based on different levels of probability. Essentially, weather forecasts provide lead-time during which remedial or exploitive action can be taken when weather conditions are expected to require some departure from ordinary or average provision. Whether or not there is need or motivation to depart from ordinary practices depends on the efforts and rewards involved, and these in turn are related to available technological, social, and psychological alternatives on the one hand and to culture-bound perspectives and interests on the other. Therefore research is necessary to learn:

. . . How various groups of people and important individual decision makers decide at what subjective and objective probability levels to take action or refrain from it. What factors affect these estimates in different societies and in different institutions?

. . . To what extent are these factors compatible or incompatible with attainable weather forecast capabilities for given levels of cost and effort?

. . . What methods can be used to make subjective estimates more responsive to the "real" factors affecting payoff?

Before the implications of forecasting for specific activities are discussed a few speculations are apropos about some broader if more diffuse implications. If the time comes that long-range predictions based on a world-wide network of facilities and computers are realized, they might engender changed attitudes toward more than the weather. The demonstrated advantages of elaborate computer nets for making certain kinds of decisions (in contrast to private estimates of luck, odds, etc.), may encourage experiment with other types of world-wide decision making and planning based on computer facilities. Thus the implications of the weather satellite could include the assets and liabilities of the "computer society," with its potentials for making man both more and less than his machines.[22/]

The range of human undertakings that are presently weather-dependent or weather-sensitive is very broad. It includes directly dependent industries, such as agriculture, public utilities (especially water and water-generated electric power, which are doubly dependent), fuel manufacture and distribution, recreation and tourism, transportation, and storage facilities for commodities. Industries that are secondarily, but significantly, affected by weather variation include finance, insurance, farm machinery, marketing and distributive services, merchandising and advertising, etc. A number of other activities might become weather-dependent if predictions were to become more long-range and more precise. Medical needs and hospital emergency cases, for example, are to some extent correlated with weather; should the present shortages in hospital facilities and medical personnel persist, foreknowledge about the weather might permit more efficient utilization of resources.

In all these cases estimating the consequences of better forecasting will be a complex matter because of the interplay of many factors. The buyer's comfort may be the seller's discomfort, as weather bureau experience with the "Discomfort Index" illustrated.[23/] One industry's savings in overtime might be another's loss of extra purchases. And long-range predictions indicating persistently poor weather might stimulate confusing population shifts in farming and tourist areas.

If plans for the development of a world-wide forecast capability are to be related to the benefits to be expected from such a capability, research is clearly necessary to:

> . . . Determine the activities that will be most advantaged or disadvantaged by varying amounts of improved forecasts. Here it is necessary to consider the time at which improved forecasts are expected to be realized and the technological and social contingencies which may affect the degree of weather-dependence. In particular, legal, political, economic, and cultural factors must be considered for their influence on the advantages and disadvantages of long and short range forecasts.**

Implications for product raisers[24/]

To the extent that ground facilities are expanded in the quest for weather knowledge, areas not accustomed to good short-range forecasts may soon acquire them, along with the problems and opportunities they will present. However, as noted earlier, a world-wide, long-range, forecast capability may not be available for at least ten to twenty years, during which the face of problems seen now could change radically. In that interim, other technologies will be advancing, with profound consequences for agriculture, fishing, fiber raising, and herding -- and the world's population will be growing.

Population pressure may require that all available marginal food raising areas be exploited to the fullest; in this case, weather forecasts may help to indicate the advantages and disadvantages of planting a particular crop for a particular season. But population pressures could just as possibly stimulate the development of food manufacture by such techniques as synthetic photosynthesis or algae-growing. Harvesting of the sea may add substantially to the world's food supply. Economic desalination methods, aided and abetted by massive irrigation systems perhaps utilizing nuclear energy powered pumps, may eliminate the threat of drought in many food-growing areas. Techniques of growing crops under plastic (with or without hydroponic methods) may multiply the yield from areas with fairly stable weather, so that careful application of long-range forecasts for food production purposes could become unnecessary in these areas.[25/] In general, however, these are problematical developments, of uncertain time schemes. Even should they come about soon, improved weather information would still have meaning for many regions of the world.

To put the predictions to maximum use will require a shift from tradition-oriented methods of food raising and of assessing the meaning of forecasts. Among peoples living in essentially similar climates, traditional crop-growing rhythms may differ widely and specific groups might therefore respond very differently to suggestions that planting dates or the succession of crops be altered. Planting, even in a country with one commercial crop, is not an isolated activity; all kinds of plantings -- and other activities -- are bound together by the mesh of tradition.[26/]

Operational problems having to do with international crop planning and distribution will arise during and after the transition and will need solving if routine and efficient national and international food raising activities are to use the improved forecasts efficiently. The shift from transition to routine will most likely be an uneven process -- accelerated in countries which can make the most use of scientific forecasts and slower in those countries which may find the forecasts an added complication in their personal, national, and international activities.

In all of what follows in this chapter, it must be appreciated that inclination, ability, and direction of change are intimately related to the culture patterns of the society involved, and that what seems "reasonable" and "worth while" to one group may not seem so to another. Almost every private and government organization which has tried to introduce changes in ideas or behavior into cultures other than its own -- and indeed on occasion its own also -- has been faced with complex and often refractory problems.[27/] This is particularly true when the activities involve farmers, fishermen, and others "close to the land."[28/] The following discussion is based on the assumption that preliminary research is necessary to:

. . . Determine the extent to which the requirements for using science-based forecasts are compatible with the perspectives and behavior of those who will directly use the ideas or methods and of those at higher levels who must approve the ideas or methods for use. Among factors of special interest with regard to food raising methods and ideas are: the degree of acceptability of scientific statements as a basis for action; existing methods for making long-range forecasts; attitudes toward shifting the customary rhythms of crop-processing behavior, growing alternative crops, and eating alternative crops; how directions or advice are taken from higher echelons; and what the definition of "qualified authorities" is.29/**

. . . Develop and apply means for overcoming incompatibilites (as discovered in the above) with minimum conflict and disruption. Particular attention should be given to determining rates of introduction of innovation as well as what should be introduced. Worthy of special study are means and methods of introducing preparatory programs intended to encourage, before the day of accurate forecasts, states of mind and knowledge compatible with the opportunities provided by a forecast capability.30/

Long-Range Forecasts. If farmers, herders, fibergrowers, etc., know of the forecast and understand its implications for their farms and their crops, the following major sorts of responses could be expected and should be examined.31/

Depending upon such societal factors as population pressure to cultivate climatically marginal land and the capacity of the community to provide alternative uses for labor and capital, there could be significant additional commitment or withdrawal of acreage from cultivation in response to exceptionally good or bad seasonal forecasts. There could also be significant shifts in kinds of crops planted, in relation to forecast minimum or optimum climatic conditions. When a seasonal forecast is unfavorable, commitment to variable costs could be curtailed at the season's start to restrict losses.

Complete withdrawal of acreage (voluntarily or under state edict) would probably be a tactic limited to those lands originally put under cultivation against long climatic odds, and to those occasions in which forecasts indicate a high probability of lethal weather conditions at critical stages of crop development, such as a prolonged drought beginning at germination time.32/ The northern Canadian wheat periphery, the Russian "new lands," and the Iceland margins are examples of areas where forecasts of total disaster would not strain credulity, and where complete withdrawal of acreage might follow.33/

The consequences might well differ depending on the capabilities of the nation to utilize its farm population for other activities. The USSR, for instance, has opened up the Siberian lands, moved in population, made enormous social investment in schools, consumer distribution, hospitals, etc., against odds that only two crops out of five would yield successful harvests. With the recurrence of such odds the existence of accurate forecast capability might make it economic to develop a supplementary industry, in which the labor not employed in agriculture during forecast bad years could be utilized, thus keeping the major portion of the labor force on site and protecting the social investment in community facilities.

In areas where population pressures and traditional orientations in farm communities make it unlikely that alternative labor utilization would be feasible without extensive shifts in values and social organization, leadership would be faced with the problem of whether or not to use the weather forecast. With sufficient incentive a government could decide to keep the information from its farmers, although it would run the risk of having the information reach them in some roundabout and possibly internationally upsetting way.

The readiness with which the extreme decision, to plant or not to plant -- or even the less extreme decisions of what and when to plant -- might be taken would probably vary with the size and structure of the agricultural system and with the circumstances of the farmers. The farmer whose fixed investment in land and equipment represents a very high proportion of his total resources might be pushed to run longer risks with the weather in hopes of getting even a small return on his fixed costs, especially if there is no available alternative income source. A corporate farm with cash reserves might find it easier to shift capital, equipment, even labor to another more favorable forecast region, or to dip into reserves, rather than waste cash. Subsistence farming, the most prevalent form of agriculture in underdeveloped portions of the globe, would probably attempt to operate under any weather circumstances, as always, if left to itself -- which it may not be if better forecasts make better national planning for improved agriculture possible to governments.

The substitution of alternative crops and the use of additional techniques, such as irrigation, more intensive dry farming, etc., would probably be more widespread than the extreme measure of withdrawing land from cultivation. Such adjustments, however, are hardly less exacting in the social accommodations they require, among which might be the following:

(1) The motivation to use knowledge of possible alternative crops and their critical climatic and ecological limits, as well as of any specific husbandry involved and the equipment it requires.

(2) Access to capital to assist in shifting crops or to invest in major loss-preventers such as smudging equipment, the foddering and sheltering of cattle through snowy winters, installation of temporary irrigation equipment, temporary withdrawal of land to fallow, etc.

(3) A market structure receptive to crop substitutes.

(4) Flexible consumer tastes.

There are clearly many difficult and subtle alternatives and problems that need to be examined in detail. If nations and their farming populations are to benefit from scientific long-range forecasts and use them to the fullest agricultural advantage, answers are needed to such broad areas of questions as the following:

. . . Who will plan alternative strategies, for nations unfamiliar with these problems, to help them cope with the consequences of forecasts? What planning criteria will be used?

. . . How is the forecasting agency to insure, using whatever social apparatus is provided by the cultures of the various nations, that forecasts reach the agricultural decision makers, be they individual or corporate farmers, U. S. style, or peasants and landlords, Asian style?

. . . If the indicated response to unfavorable seasonal forecasts is withdrawal of acreage, what alternative uses for mobile factors, but especially for labor, would be available and known to the decision makers? If alternatives do not already exist, can they be economically created and accepted by the farm culture? In a predominantly subsistence farm system, what imports of food into the region would be necessary to carry over bad years? What food reserve system will be necessary to prevent acute hunger or famine, especially in areas where population increase ordinarily keeps the population at the margin of hunger?

. . . If shifts in kinds of crops and farming techniques are the course of action indicated, the following questions must be resolved by research and the findings absorbed by potential users: (1) What alternative crops would be successful under the weather conditions forecast? (2) What new and special methods would be involved in raising a successful crop? How can these methods be imparted to the farmers? (3) What equipment, or special support (irrigation, stock protection, etc.), would be involved in adjusting to the predicted weather conditions? (4) How can the alternative crop or crops be marketed and consumed indigenously, and in what quantitites and at what price? (5) If international, bilateral, and multilateral marketing operations are involved, what formally negotiated quantity and price limitations would govern? How can rigidities in consumption and in marketing arrangements -- such as quotas, price fixing, lack of storage facilities -- be adjusted to meet other production situations? (6) How can consumer habits be altered, especially if a traditional diet staple is involved?

In the United States and the developed economies of West Europe for more than a generation governmental action has been taken on behalf of agriculture. In the United States, the federal government has set production quotas, price supports, and special credit terms, has subsidized "conservation" practices, maintained "parity" of farm prices, and managed international market operations and surplus disposals and gifts abroad.[34/] In nations that are predominantly agricultural, international marketing aspects have become a major area of governmental intervention in the competitive scheme of things, with block selling and trade treaty arrangements negotiated with governments of buyer nations.

To the degree that governments thus enter into agricultural decision making, long-range weather forecasts will involve governmental as well as individual decisions. Governmental responses might include such policies as government-guaranteed, weather-related, credit provisions; farmer education in new husbandry; crop insurance to provide financial reserves for the withdrawal of land; storage schemes to carry over supplies in subsistence agricultural systems; renegotiation of international quotas, to allow international marketing and significant increases of production substitutes; international granary reserve schemes to provide for emergency supplies to areas with serious crop failures.

The possibility of the same bumper crops being produced by competing regions in seasons of most favorable weather forecasts requires attention. International arrangements devised to meet the complication should consider not only the economics of the situation but also the importance to the cultures of the involved regions of such matters as rivalry, delayed returns, substitute crops, and the like.

The effect of changes in agricultural production on commercial dealings in commodities is another potential problem area of concern to governments. Because of the many intangibles involved, this report has not attempted to speculate about what the specific impact might be, but the matter merits study.

The range of governmental responses touched on above ought to be further identified and assessed. Research efforts should include exploration of the following:

. . . The various mechanisms -- private, governmental, international -- for balancing agricultural production with demand which could act in relation to the overages or underages in supply that might result from long-range forecasts, taking into account factors that will influence the estimated demand (i.e., population, dietary habits, standards of living, etc.). Especially relevant here is the international stockpiling concept for those areas where the pressure of future population levels living at bare subsistence standards will result in famine, if unfavorable weather causes even relatively slight reductions of food supplies.[35]

. . . The effect of foreknowledge about weather on commerical dealings in agricultural commodities. This may involve a review of the whole history of trading in basic commodities.

. . . The degree to which an international food reserve fund might supplement or serve the purposes of commodity reserves, to achieve the stabilization and flow of agricultural commodities.

. . . The possible devising of interregional or international storage, with similar production patterns but located in areas likely to be subject to different weather patterns in a given year.

Almost any adaptation to the lead time provided by long-range weather forecasts will require rapid access to financial resources to implement preventive or exploitive action. It would appear then that financial institutions, public or private, would bear the first brunt of indicated adaptation. If so, the history of United States agricultural credit policy indicates that the credit structure to support rapid regrouping of agricultural forces will be a focal point for great economic and political pressure.[36] In the underdeveloped countries, where the financial resources of individual farmers or farm undertakings are least adequate, the stability of political systems might very well be threatened by a failure to make adequate credit arrangements to enable agriculture to respond to such forecasts -- if the farmers have access to the forecast and wish to take advantage of it. Research is necessary then on:

. . . Means for anticipating the need for and providing financial support in response to weather forecasts, both short and long range.

<u>Short-Range Forecasts</u>. The opportunity to use improved short-range forecasts -- deriving from a combination of Tiros satellite-type observations and local ground-based facilities similar to those in the United States today -- will very probably become reality long before the time table of long-range forecasts is achieved. Highly accurate, well-communicated, 7- to 30-day forecasts would allow farmers to take advantage of short-run weather phases (planting on days of the best temperatures for germination, just before rains, etc.) and reduce losses by offsetting unfavorable weather phases (short delays in planting to escape late frosts, rushed harvests to avoid severe storms, etc.),

thus contributing significantly to reduced risks and optimized yields.[37/] The highly specific uses of medium-range and short-range forecasts (decisions to spray or not to spray, to build levees or tornado shelters, or to evacuate) place great emphasis on communication and interpretation of forecasts to highly specific publics. Opportunities for improvements in food raising, for instance, will be relatively greater in precisely those areas which have had little experience with scientific prediction and therefore have the greatest adjustment to make to its interpretation. There is an obvious need for personnel -- part agronomist, part meteorologist -- who can translate the forecasts into the action terms of the farmer, fisherman, or herder.[38/]

If the individual user is to adapt quickly enough to the forecast, some type of flexible financial arrangement will probably be needed to provide capital resources. Corporate (or collective) agriculture with internal financing, for instance, would be likely to have the necessary financial ambidexterity.

Although many of the problems to be investigated in regard to long-range forecasts will also apply in some degree to the use of short-range data, other very specific research needs to be done for the latter's use. It will be necessary to:

. . . Provide training and utilization methods for personnel who will have the task of teaching and informing forecast users not familiar with the concepts for application of short-range forecasts. Among factors to be considered are the cost and benefits of using indigenous personnel.

. . . Develop a correlative indoctrination and training program for forecast users covering concepts, equipment, and procedures.

. . . Develop a program for supplying the equipment necessary to take advantage of the forecasts; questions of funding, ownership, accessibility, and the phasing of all of these in terms of the above must be studied.

Implications for tourism and related institutions

The degree of long-range forecast reliability required to influence the travel and recreation plans of vacationers would probably be significantly lower than for undertakings where responsiveness is limited by the necessity to cover fixed costs. In situations where the over-all supply of tourist facilities is in approximate equilibrium with demand, therefore, the tourist and recreation industries might well be among the sectors of the economy subject to the greatest forecast-inspired volatility in demand. The possible impact of seasonal forecasts of exceptionally good or bad weather would be especially important to those areas, regions, or nations in which seasonal tourism and recreation are major industries, such as Florida, the Riviera, and the ski regions in Canada, New England, Switzerland, Italy, and France.

Accurate short-range (weekly or monthly) predictions would probably have very noticeable effects on short-term tourism and recreation -- industries that have always been subject to the hazards of sporadic demand. If the effect of the forecasts was to concentrate demand on certain areas at certain periods of time, cooperative arrangements might be prompted among hotels, motels, resort area chambers of commerce, etc., to redirect and spread the foreseen demand over the widest possible range of establishments in good forecast areas. The effort might include rescheduling and even repricing of transport facilities.

Most tourists and vacationers have traditionally taken their chances with the weather. Whether or not they will continue to do so in significant numbers when predictions are more precise and forecasts are for a season ahead depends on a number of institutional factors which are altering now and may alter more in the future. If present leisure trends continue, along with population growth, the demand at all times on tourist facilities might be sufficient to make differences in demand as a function of weather forecasts economically trivial.[39/]

Research will be desirable to determine from the consumer's standpoint:

. . . What factors determine time and place of recreation and vacation decision making, and, in particular, how relatively important are weather and weather forecasts to the making and altering of recreation and tourism plans?

. . . If weather appears to be a major factor in such decisions, are there means for altering the institutional and personal context so that the adverse consequences of forecasts can be mitigated though greater flexibility at the consumer end of the tourist and recreation industry?

Under some conditions, owners and entrepreneurs of tourist facilities may seek ways to reduce losses resulting from forecasts. The extension of the principles of weather insurance needs to be explored. Undertakings with greater capital resources might select additional sites with markedly different climatic patterns, in order to assure their customers of finding good weather at one site or another. Special transportation rates and schedules might also be a device to attract customers to alternate facilities. Lead time from advanced forecasts could be used to advertise non-weather-sensitive attractions; the Edinburgh Festival, for example, provides an incentive to visit Scotland in August, regardless of the weather.

In summary, it seems probable that the industry will be threatened with even more instability than it is now subject to, if seasonal forecasts result in pyramiding of demand in good forecast areas during a given period of time and falling off of demand in poor forecast areas. How seriously the recreation entrepreneurs, especially those with high fixed costs, take weather forecasts, accurate or not, has been demonstrated by their general sensitivity to the summer "Discomfort Index" and, in the Florida resorts, to cold weather warnings.[40/]

The threat could be greatly reduced by planning based on study of the problems potentially involved. Research could be undertaken to determine:

. . . What would be the major modes of readjustment in the tourist industry required at local, regional, and national levels as a result of weekly, monthly, and seasonal forecasts? To be considered would be alternative uses for and the mobility of capital, managerial and other skills in the travel and recreation industry; applications of the insurance principle to redistribute weather risks concentrated on entrepreneurs by the extended forecast capability; organizational mechanisms which would permit a dispersal of over or under demand; and relationships with the transportation and communication industries to cope with local short-time peaks and drops as well as regional seasonal peaks and drops.

. . . What would be the effects of the above readjustments on service standards, and how could these be meshed with changing expectations in the consumer?

. . . What might be the role of public policy in ameliorating the difficulties and meeting the demands of both the consumer and the producer of tourism and recreation, given the government's role in providing the weather forecasts?

. . . What are the international implications associated with the impact of national forecasts on international tourism? How is this situation altered if forecast capability is under international rather than national auspices?

Implications for transportation

Within the next twenty years, certain transportation methods and facilities in the major industrial nations may have altered to an extent that will make them much less subject to the hazards of weather variation than at present.

For example, the application of advanced techniques -- perhaps based on navigation satellite and space-stimulated guidance devices -- could reduce the weather-dependency of aircraft, ships, and trains to the vanishing point under all but physically destructive weather circumstances. Similar changes in highway transportation methods are difficult to foresee -- short of the development of techniques so radically different as to push the old methods into obsolescence. In any case, motor and rail travel now appear to be more dependent on available resources to cope with the consequences of bad weather than on knowledge that bad weather is coming. (E.g., the number of snowplows in a given area or the design of snow-proof electric railroad engines is more often a matter of budgetary convenience than of weather experience.)

In less-developed regions and nations where large segments of the society and the economy have never been dependent on a complex, smooth-running, transportation system, the effects of tie-ups or slowdowns due to weather are more difficult to assess. However, these are the areas where the seasonal swings of weather have for generations stimulated some shifting of transportation loads to means less disrupted by the expected weather. Therefore the advent of highly accurate forecasting -- once it is accepted as such -- could without too much difficulty enhance custom into organized planning, with the further consequence of improvement of transportation schedules and methods.

Freight transportation systems of all varieties, in the highly advanced areas of the world as well as in the underdeveloped regions, should find it useful to estimate precisely and well in advance the hauling demands their clients will make. Foreknowledge of the probability of bumper crops, reduced coal demands, or a late ice break in inland shipping regions, for example, should permit better allocations of transportation, although cost and benefits consequences of better allocation are not immediately evident.

At the appropriate time in the development of local or regional weather forecasting capability, research will be desirable to:

. . . Discover appropriate methods by which cultures unfamiliar with utilizing scientific weather data might apply it to improve their transportation facilities and scheduling.

. . . Determine what kinds of transportation and what types of operating arrangements are likely to become especially dependent on better predictions. What would be the consequences of forecast interruptions (as might occur if military interests resulted in withholding of weather information)? How might the adverse consequences be overcome or compensated for?

. . . Develop the methods and data permitting cost and benefits analyses of better allocation of transportation resources, and, in the light of this, determine what ancillary facilities, resources, and organization would be needed to permit the transportation industry and its clients to take maximum advantage of the forecasts.[41/]

. . . Establish the nature of continuing methods and organization to supply this information to users, and to revise it in the light of changing factors in national and international operations.

Implications for water and fossil fuels and power utilization

Over the next twenty years conventional fuels -- coal, gas, oil, and dammed water -- will probably continue to be the main sources of power for industrial nations, although nuclear power may be possibly used in special circumstances, as in India, for example.[42/] Therefore, since weather will continue to play a large part in fuel stockpiling strategies as well as in consumption rates and patterns -- barring world-wide applications of major improvements in transforming fuel to power -- the implications of better forecasts for the management of power resources and related activities need careful examination.

Water Resources. Reliable long-range forecasts of 3 to 6 months could have significant impacts on water resource deployment, and thereby on public and private electric power production as well as flood control and irrigation services. The amount of fresh water immediately available at a given time for human consumption, agriculture, and manufacturing depends in general on arrangements for both storage and conduction to centers of population. Our lakes and river systems have become a proliferation of linked reservoirs and aqueducts, yet the ultimate water supply seems to be increasingly strained by population growth, although authorities in the field differ about the seriousness of the problem.[43/]

The water storage systems are engineered to withstand the highest peak loads likely to occur over the life of the installation. At present, however, a good deal of this capacity is not used, being kept in reserve against possible extreme weather-derived contingencies. This is particularly true of a multipurpose installation such as TVA, where extreme contingency requirements of reserve capacity for different purposes may conflict; thus, keeping reservoir capacity against floods may mean inadequate water storage against droughts.[44/]

The reliability of the improved weather forecasts would directly govern the degree to which these operationally conservative standards could be departed from. There is a question, then, of when forecasts would be considered sufficiently reliable to be a major programing factor. (Small-scale, violent disturbances such as local cloudbursts, the consequences of which are now absorbed in the safety margins of reserve capacities, should also be considered in estimating the costs in relation to the benefits of the application of forecast data.)

Possible efficiencies in water power storage operation would probably vary by area in relation to the variation in precipitation from season to season, or from rainy season to rainy season. Therefore, the utility of the forecasts might well vary for different climates, different terrains, and in relation to different sorts of water retention and utilization systems. Thus, to assess the impact of increased long-range forecasts and more perfected short-range forecasts, it will be necessary to discover:

> . . . What are critical forecast characteristics for programing flood control, water power, and multipurpose hydroelectric projects of various designs in regions with different weather patterns?

Using a multipurpose dammed river system as a model, some of the impacts of a reliable, three to six month forecast might be as follows. Run-offs from snows and rainfall could be forecast and calculated. From this, the reserve reservoir capacity required to prevent or buffer floods could be calculated over the season. If flood run-offs were not to occur, storage capacity could be fully utilized, and dam spills for electric power generation and irrigation could be maximized. Irrigation water could be parsimoniously or generously dispensed, depending on the adequacy of rainfall expected later throughout the season. Forecasts of extreme water shortages in areas that are not too extensive geographically might warrant relatively heavy expenditure to build temporary water conduits from adjacent drainage areas, if water could be spared from such regions. In preparation for a forecast flood season, levees could be reinforced, bottom land either left fallow or cover-cropped to retain soil, and preparations made for disaster relief. Water required for maintaining adequate channel depths on navigable streams could be calculated and spilled on forecast schedules. Seasonal demand schedules for electric power required for weather-sensitive producer and consumer uses (e.g., commercial freezing and commercial and domestic air conditioning) could be calculated and supplementary scheduling of thermal power planned and followed up with the optimum acquisition and stockpiling of thermal fuels (oil, coal, or gas).[45/] In the event that severe reductions of hydroelectric power capacity were forecast, hookups to power grids in adjacent power-surplus areas could be planned.

An efficiency increase of this magnitude might involve economies that would make otherwise marginal installations worth while to undertake. In an area such as the great arc of the Indian alluvial plain irrigated by the runoff from the Himalayas that flows down through flood-ravaged valleys, forecasts might result in great savings; however, in view of the general lack of historical weather data and loss calculation the possibility is highly speculative at present. Since several important river basin operations have already assumed international proportions (for example, the Niagara, Euphrates, Jordan, and Nile development projects), assessment and allocation of savings from long-range forecast programing would seem to be a matter for consideration and decision by an international organization, or at least by bilateral or multilateral negotiation between nations.

Decisions on the degree to which weather forecast data should be included in hydro-system planning and operations will require studies to:

. . . Determine the cost and benefits based on weather, geography, and water use.

. . . Develop methods, organization, and personnel to collect and process data necessary to explore the above sufficiently so that if long-range forecasts become possible they could be applied as soon as possible in previously determined high payoff areas.

To assess the potential economic impact of long-range forecasts, it will be necessary to study the following questions:

. . . If there are improvements in efficiencies, and therefore in economies, to whom should this saving accrue? If the research that will have produced the forecast capability has been done at public expense, who should benefit by the savings produced? In underdeveloped countries, where capital accumulation is a critical requirement for growth, to what extent should distribution of this saving be to consumers, or kept concentrated to serve as an incentive to capital development? Could the additional return to capital from these undertakings be used as an incentive to increase the flow of funds to projects that might have been considered marginal?

<u>Fossil Fuel Resources</u>. An improved prediction system could be expected to effect marked changes in the patterns of production, distribution, and consumption of fossil fuels.

At the point of production, whether it be oil well, gas well, or coal mine, foreknowledge about seasonal weather-based demands would permit seasonal extraction and production fluctuations to be evened out. At the present time, production is based on an unperfect estimate of what the heating or cooling season will be like; during excessively cold or hot periods, there may be sharp increases or decreases in production.[46/] Additional production, of course, usually means overtime work and overtime pay, which may affect the level of profitability for the firm -- but also increases the take-home pay of the worker.

In the transportation sector, sudden increases in the demand for the shipment of a bulk commodity such as coal requires an immediate rescheduling of rail cars and trucks. If the increase is sharp enough, there is usually a lag between the time of critical need for coal and the time required to move the coal from the source to the final consumption point. In the case of petroleum and gas, there is an analogous problem because the through-put in pipe lines can be increased only up to a fixed maximum. Excessive oil demand is also met by increased tanker service, but tankers can be made available only in the event that the extra capacity can be transferred from idle capacity or be shifted from another market area. This takes time; if the need is critical, extra shipping cannot always be assembled quickly enough.

At the point of consumption, as a result of factors described above, in the short run only limited additional supplies of oil, gas, and coal can be made available. This can result in a competition-based price increase, or if the cold snap is sudden and severe enough, the demand may be largely unrequited, with consequences such as power failures, curtailing of services, and personal hardship. To avoid such situations, consumers who cannot afford to run out of fuel stockpile large quantities of coal or petroleum products -- a power station, for example, may stockpile approximately a three-month supply during the winter. The problem of allocating fuels and having them on hand when needed will very likely become more pressing as world population grows and more people become dependent on urban utilities to protect them from weather. Thus there are implications for international planning of fuel production and allocation in conjunction with expected weather extremes. There would also seem to be implications for pricing and control.

The fossil fuel situation provides an unusually clear picture of the consequences of "weather guessing," and therefore research in this field to determine the effects of foreknowledge on the supply, distribution, and consumption points could be rewarding. Investigations should ascertain the circumstances under which better predicting would provide the basis for:

. . . Leveling-off of seasonal production variations, with consequent better production programing, greater ability to meet peak demands, and price decreases as a result of funds saved because stockpiling purchases need not be made at random.

. . . Overseas shipments of U. S. oil and coal when hardship winters have been predicted for other sections of the world. (There appear to be opportunities here to facilitate State Department programs to ease both price and human hardships in other areas of the world.)

. . . Feasible international arrangements for planning and allocating fuel in the light of expected weather extremes. Matters to be studied include the basis for organization for this task and means for negotiating prices and ownership arrangements of fuel production facilities; means for reconciling national policy and private interests in the face of foreknowledge about weather extremes and fuel shortages or overages would need study too.

In all of the foregoing discussion, no mention has been made of the highly complex costing, pricing, and production policies of the industry and the government (both state and federal). The activities of such groups as the Texas Railroad Commission and the Interstate Oil Compact Commission, as well as individual firm policies, would undoubtedly affect production scheduling and price changes. Indeed, research is necessary to:

. . . Determine the likely role which such potent political and economic agencies may play in the light of better weather predicting techniques.

Implications for weather disaster mitigation

It would seem obvious that more precise weather monitoring and prediction capabilities would greatly increase the capacity to foresee and thereby mitigate weather disasters. However, the possibilities of mitigation actually depend on a variety of complicated factors which need study.

In the first place a distinction must be made between predictions of imminent disasters such as hurricanes, typhoons, tornadoes, and flash floods, and predictions of long-range disasters such as droughts and sustained floods. And it must be remembered that the availability of information regarding a likely forthcoming disaster does not insure its use, since other physical factors of the situation may determine what can be done in the time available, and social and psychological factors may determine what people are willing to do in the time available.

These factors are especially inhibitory in the case of the imminent disasters. Moreover, it is not at all clear to what extent prediction of imminent disasters can be improved. In the United States, for instance, hurricanes are now detected well in advance, but how to chart their exact paths is still an unsolved weather mystery. So, too, for tornadoes, which are even more erratic in their paths.

A long-range disaster forecast could eliminate some of the crises-bred decisions and mistakes which occur when there is no foreknowledge, but other complex decisions, crises-bred by the atmosphere of the anticipated disaster, will offer their own set of difficulties. Societies and their governments might well be confronted with such problems as population shifts, labor force reallocations, stockpiling of disaster-compensating supplies, and the development of organizations for control, relocation, and recuperation.

Underlying all the above is the psychology and sociology of response to disaster predictions. There have been many studies in recent years, notably by the Committee on Disaster Studies of the National Research Council, which demonstrate conclusively that responses to disaster predictions are culture-bound as well as personality-bound.[47/] This is evident in the fatalistic or religious attitude of many societies toward disasters, and in the various types of reluctance to act displayed in the face of predictions. Groups and persons have different ways of preparing for or denying the threat of disaster, and about the only conclusion that can be reached at present is that in no sense can it be concluded that the availability of disaster warning information would necessarily result in the desired behavior and the desired saving of life and property.[48/]

Thus if weather disasters are to be mitigated by predictions and monitoring, research is necessary to determine:

that power bloc. Even in the absence of binding political allegiances, differences in predictions may sufficiently obscure the expected weather situation to produce, in some countries, a pattern of decisions regarding weather-dependent activities which may put one power bloc, represented by one forecast, in a better international position than the other.[51]

The opportunities for exploiting "tailored" weather predictions will depend in good part on who has control of the weather data accumulation and processing system, and who is the authority for the forecast. Research is desirable to explore:

. . . Opportunities and means for using forecasts -- if two or more sources should provide them -- to reinforce international cooperation between the competing capabilities.

. . . The opportunities for and costs of conducting international psychological, political, and economic warfare, and the means and costs of countering those activities antithetical to the United States and its allies.

. . . The relative costs and benefits (in the light of the above two suggestions) of international ownership and/or control of a forecasting system compared to national or multinational control and/or ownership.

5. THE IMPLICATIONS OF TECHNOLOGICAL BY-PRODUCTS

IN WHATEVER TERMS the technological by-products of space activities may be defined, there is one characteristic that marks their relationship to the space effort: they provoke controversy. It is, for instance, often asserted that these various derivatives, methods, and devices may constitute one of the most important aspects of the space effort.[1/] Almost as often it is argued that if a "by-product" is actually significant it could be produced in a more efficient way than as an incidental result of the space effort.

When these derivatives were being considered from the standpoint of this report -- i.e., their implications, as a part of the space effort, for society -- it appeared necessary to pose two test questions to determine whether a specific by-product should be regarded as within the report's province.

(1) Is the by-product unique to the activities, by being either a product of them exclusively or one so emphasized by space activities as to be in effect a product? For example, computer technology would have gone on developing regardless of the advent of space activities. The incentive for devising increasingly more complex computers and ever smaller and more reliable parts for them does not fundamentally depend on the space effort, although motivations for putting money and effort into computer developments have been importantly stimulated by it. But since general computer developments began long before "space" became a concept to be conjured with and have continued in a myriad of other fields not concerned with space, they are not herein considered as technological by-products of space activities.

In contrast, advances in telemetry have been vastly accelerated by and possibly almost completely dependent on the needs of space projects. No other on-going activity makes such demands on or provides so great an incentive to develop this technique -- wherein devices sense specific physical states of an object (e.g., temperature, accelaration, vibration), convert the sensing into electrical impulses that give a measure of the state of the object, and transmit these (usually via radio) to receivers which record or respond to the information. Thus telemetry is herein considered as a by-product.

(2) Does the introduction of the by-product confront society or parts of it with problems or opportunities different in degree or kind from those usually introduced by changing mass-production, consumer-oriented technology? In the process of seeking materials that would withstand re-entry temperatures, a product was developed that turned out to be an attractive and effective material for pots and pans, of which millions of dollars worth were sold in 1959. However, it is difficult to see social or economic implications in such an application of a space product beyond those routinely confronting competitors and the consumers of improvements for traditional artifacts. Neither the direction nor style of behavior, corporate or private, is changed significantly by such by-products. Similarly, it is difficult to foresee any special implications in the much-heralded television receiver that can hang like a picture on a wall. (Incidentally, apropos of the first criterion for inclusion in this chapter, this wall-TV will derive from the new electronics technology, which is frequently claimed as one of the most important by-products of space activities. Upon closer examination it is seen that space activities are only one of the many demands stimulating this expanding technology, but clearly not the cause of it.) On the other hand, some of the new plastic and metallo-plastic structural materials developed from the needs of space activities may make substantial inroads into the markets of natural metals and by so doing affect the livelihood of major sectors of the population and the trade posture of some nations. These are considered to be social implications.

Inherent in any technological development of course is the potential for unexpected and important effects on society, since no technology or object of technology operates by itself in generating its effects. In many cases utilization of the technology is almost totally dependent on other non-technological factors in the society.[2/] It is even difficult to identify the many factors which in the past contributed to the eventual place of any innovation, be it idea or artifact. Thus our selection of technological by-products to discuss for their presumed future implications is chiefly a reflection of the relative ease with which observers have been able to foresee or reject possible implications, as well as the relative ease of making a fairly distinct separation between these products and other which probably would have been achieved in any case.

If one of the major rationales for space activities is to be the serendipic effects for society, it is desirable to do research to determine:

. . . Criteria for detecting and evaluating the cost and benefits of specific by-products of space activities. Among other things, such a study will need to develop methods to distinguish the "distant cousin" claims of relationship to space from those activities actually dependent on space.3/

No claims are made for what follows beyond the belief that in themselves the examples demonstrate the complexity of the problem of predicting social impact of primary products, much less by-products, and that these examples demonstrate the need for research on:

. . . How to establish, maintain, and operate "watchdog" groups to alert and inform appropriate authorities and organizations to the foreseen or discovered applications and consequences of space technology by-products so that research or action can point the developments for the benefit of mankind.4/ **

By-Product Uses

Telemetry

The chief by-product application of telemetering techniques would seem to be in situations where information is desired about an object whose condition for some reason cannot otherwise be easily queried -- whether because wire communication is not feasible or because the object is mobile or isolated.5/ For example, the rapid transmission of biomedical information through very small devices to a receiver that processes and feeds back the reactions to the information has highly significant implications for the field of medicine.

Biomedical Applications. Experiments made some years ago notably demonstrated the utility of telemetered physiological information.6/ With the coming of space flight, the technology advanced rapidly, under the necessity of providing measuring techniques, channel capacity, and transmission codes to the effects of space environments on living organisms. The consequent new telemetering equipment, ground receivers, and data processing systems, including computers, have in combination become complex and elaborate systems for rapid collection and relatively speedy analysis of newly collected data and information. In principle, these methods permit (1) the recording of detailed physiological data, (2) the "real time" recording of it, (3) remote transcription and processing of it and, (4) automatic or pre-programed decision making on the basis of these steps.

Cardiac disorders will be used here to illustrate the possibilities, although obviously the applications and implications are far broader than those associated with this one disability. Medicine has made great progress in the therapeutic handling of many cardiac disorders, but a great deal of research is still needed to develop new diagnostic and therapeutic skills and techniques. It appears feasible in principle to implant surgically in the heart patient a microminiaturized telemetering device that can pick up specific inputs reflecting conditions of the heart and of other organs pertinent to it and transmit the information, along with an identification code, to a computer analysis facility. These signals could be processed by the computer; if serious changes were evident, warning signals could be sent back to the patient, indicating appropriate action. Undoubtedly there are physiologically detectable and measurable indications of impending difficulties which are not evident to the patient, to which the computer could respond.[7/] The computer could also signal the need for turning cases over to "live" doctors when incoming signals indicated the need for other than routine preprogramed responses.

These preventive techniques depend upon the discovery of pertinent physiological indicators, the development of appropriate telemetering devices for patients, including compact power sources (see section on new power sources below), and the attitudes of patients as well as doctors toward such an approach to medicine. Their use might free doctors for more specialized work, thus contributing substantially to the over-all physical welfare of society. However, allocations of decision making between doctors and machines would imply not only major revisions in the legal and moral aspects of the doctor-patient-society relationship but also substantial changes in the economics of medical care. Very probably the perceived nature of the problems would change during the intense discussion that would undoubtedly accompany the planning for such a transition.

If it appears technically feasible to meet the medical and engineering requirements for such a medical system in the next two decades, then research is desirable to:

. . . Ascertain the reactions, and the values and knowledge underlying them, among doctors and their patients and potential patients about this type of medical service, so that if deemed desirable, information programs could be developed to further the utility of such service.

. . . Plan for the appropriate changes in the supplementary education, training, and recruitment of doctors and related personnel.

. . . Determine the contingent social and technological prerequisites for implementing such a program. Specifically, what moral, legal, and economic problems must be solved and what social and technological methods can be used for solving them? Who has legal responsibility for machine decision that is in error? What facilities might be available for the person who does not trust computers for diagnosis but cannot afford a "live" doctor? At what point will machine diagnosis be considered accurate enough to replace the doctor? Who is legally liable for a malfunctioning piece of telemetering equipment?

. . . Determine the means and methods for establishing, operating, and funding the telemetering and computer facilities required.

Commercial Applications. It is obvious that telemetry has the potential of being useful in a number of commercial operations, but its application will depend upon the expansion of other related technologies, such as high-speed methods for data processing and data using, compact long-lived power sources (probably of the kinds discussed later in this chapter), and means for controlling frequency interference. In conjunction with such techniques, telemetry may contribute, for example, to more efficient coding operations, leading perhaps to a greater message capacity per channel per time and thereby permitting more communications of all sorts. In general, capabilities of all kinds for coordination and control could be extended.

Given the rapidly developing state of the art, research is desirable to:

. . . Examine the costs and benefits of specific potential uses of telemetry for commercial uses.

. . . Develop means for making these findings available to those who have incentives for applying them.

Telemetry of Individual Responses. Both the exploits of man in space and the possibilities of medical use of the new technologies, as discussed above, suggest that man may more and more become "plugged into" his environment as just one more piece of equipment in a complex system. The implications of this -- whether for good or evil -- must remain at present in the realm of speculation, because the situation is not enough definable to furnish measurable data. However, one idea that has been broached deserves special attention.

Given a more accurate knowledge of the physiological and behavioral correlates of physical and emotional stress (which will be discussed in the next section below), telemetry could in principle be used to monitor emotions.[8/] For psychological research and psychiatric therapy, the development could have great value. And on a large scale, such information could be most useful to any institution interested in appraising its behavior or that of its constituency -- but to democratic societies, at least, the idea would have unpalatable connotations. However, the prevailing attitudes (and which persons and groups hold them) as to whether a society so closely linking and organizing people and their activities (e.g., via telemetry, computers, and omnipresent communications) debased or enhanced the human condition would of course, profoundly affect the degree and direction of these developments. Thus, these by-products of space activities could produce attitudes either supportive or destructive of the society producing the products.

In general, any application of such devices would depend on the resolution of the profound, legal, ethical, moral, and organizational problems inherent in the development.[9/] It seems desirable, therefore, to begin at least to:

. . . Delineate systematically the specific economic, legal, social, and moral problems and opportunities implied in future society-machine relationships, so that opinion leaders and policy makers can be aware of what must be resolved and planned for prior to, during, and after major developments in this capability for communication and control.**

Stress research

Attempts to gather systematic knowledge about the capacities of the human being to cope with extreme physiological and psychological stress have encountered two major difficulties: (1) civilized societies do not approve of subjecting persons to the risks involved in situations of extreme stress simply to gather knowledge about the effects on the individual; (2) as behavioral scientists generally concede, it is hard (and perhaps impossible) to simulate deeply stressful situations -- if they are not perceived as "the real thing" by the participants the results are dubious. Thus, while we know that men can demonstrate almost incredible physical and mental stamina in real situations of stress, we have almost no systematic information on the matter.

Observations of man in space will provide a unique opportunity to expand our knowledge of stress reactions. Special methods, drugs and medicines, and equipment (including telemetry) will be developed for measuring stress, for coping with it, and possibly for using it positively. These all may have value for everyday health and perhaps provide mankind with radical insights into his make-up which will extend his presently "normal" facilities. The implications are of course moot at this time.

The process of acquiring this information may also have social consequences aside from the application of the medical and psychological knowledge gained. In the first place, it is likely that the systematic exploration of this problem will require further attention to the demonstrated abilities of other cultures (e.g., the yogis in India) to alter mental and physical states to cope with stress or to relate to their environment in ways different from or more effective than those used by western societies.[10/] The dissemination of knowledge about the philosophies and abilities of such other cultures will inevitably affect the philosophies of people in our society; in what ways, to what degree, and with what consequences are areas for later study. At present, the most that can be recommended is that sensitivity to these possibilities be maintained so that they can be studied and their implications assessed and prepared for as these changes develop.

In the second place, the deliberate subjecting of astronauts to stress in preparation for the conduct of space activities may alter attitudes toward such experiments on humans in general. The deliberate stressing of man may then be perceived and accepted as more "natural" than in the past, with possible implications both good and bad for ethics and morals.

Compact, long-lived, reliable power sources

A major technological requirement of all space vehicles is a compact electrical energy source operating reliably over long time periods. The power source must be able to energize equipment and to propel the vehicle. Of the sources being developed, for which space activities provide the main incentive, three may or may not have other implications for society: 1) plasmas and magnetohydrodynamic devices, 2) solar power, and 3) nuclear-powered thermionic converters.[11/]

The use of magnetohydrodynamic devices as an earth-based power source is still in the realm of speculation.[12/] Should it be possible to build large generating facilities using the principle, there seems no reason to presume that significant social changes would result, aside from those associated with any increase of the availability of electric power.

Solar cells in principle could supply isolated instrumentation with power for long periods of time and hence might contribute indirectly to the development of new aspects of knowledge, for example, about the weather, the oceans, and the like, for which information must be sought in isolated areas. However, the necessity of protecting the cell surfaces without interfering with their light collecting ability and providing storage facilities for night and cloudy day operation presents problems from the standpoint of practical and economic use.

Space-stimulated nuclear power research has produced the SNAP-type thermionic converter. It is not clear that it would be competitive with more bulky but probably less expensive and less dangerous thermionic converters operating from more traditional heat sources. The nuclear devices do have the advantage of requiring neither storage units nor heat sources, and appear more reliable than the usual forms of electrical generators; they may thus be of special value not only in isolated regions but also in localities where there are no facilities for electrical maintainance and repair but where the benefits of electricity are desired.

It has been suggested that the latter two power sources would be helpful in undeveloped regions. However, it is debatable whether the availability of electric power in relatively small quantities would significantly stimulate developments in such regions. Whether or not it is practical to introduce power to backward areas before the traditional indigenous patterns have been exposed to more easily understandable aspects of modern industrial cultures is a problem for study. Thus, to determine the potential usefulness of these devices, research is necessary to determine:

. . . For given cultures, the ancillary social and physical conditions that are necessary if the utilization of electrical power is going to make a significant contribution to the society.

. . . Whether the power sources and their associated environment would be culturally acceptable.

. . . Under what circumstances solar cells or SNAP devices would be economically feasible as power sources in comparison to other sources.

<u>New fabricating materials</u>

The development of new materials, including among them many synthetics and composites of synthetics and metals, reflects a concentrated effort to meet the special and unique requirements of space flight. Fabrics to be used must be light in weight, high in strength, resistant to temperature extremes -- especially very high temperatures -- noncorrosive, and tolerant of multiple accelerations.

Reinforced plastics are being considered for increasingly wide use in missiles and other space vehicles. Silicones, polyesters, epoxy resins, and phenolics reinforced with a variety of materials -- asbestos, quartz fibers, graphite cloth, glass fiber, etc. -- show mechanical strengths far exceeding most common construction materials. A filament-wound, glass-reinforced epoxy resin has been developed with the ultimate strength of 130,000 pounds per square inch and density of 0.072 pounds per cubic inch giving it a strength/weight ratio of 1,808,000 inches; to perform equally well, steel would have to have strength in the neighborhood of 500,000 psi. High-temperature inorganic polymers are also under investigation.

These materials may well have great utility for many more common fabricated items in which there is need for high strength, high temperature resistance, and long life, minimum wear, or light weight. Various plastics and new metal alloys could replace traditional fabricating metals, if the costs of the new materials should prove to be competitive with the costs of steel, aluminum, and the like -- especially if easily available sources of the older metals are consumed and as international competition for them grows. Should the change occur, not only might price levels be affected, but the total sequence of production -- mining the ore, producing the metallic sheets, bars, and forms, fabricating the final product -- would necessarily change. In particular, the availability of synthetics might mean the disruption of communities now existing at raw material extraction and processing sites.

The technological impact would also affect the skills and numerical distribution of labor. And the long life of products utilizing these new materials would substantially lower replacement requirements, with maintenance and service personnel correspondingly reduced. International trade patterns would alter if some nations no longer desired to import the traditional fabricating metals and if other nations found the demand for their exports of raw or refined metals reduced.

The above is supposition, of course, and it is by no means certain that the demand for metals will be reduced, since more and more nations seem to be developing needs for metals of all kinds. But the new fabricating materials seem likely to become eventually a part of the industrial scene. Research therefore would seem appropriate to determine:

. . . Which of the new space-stimulated fabricating materials have characteristics which make them functionally and economically competitive with traditional materials.

. . . What the readjustment problems may be for the personnel associated with possibly displaced operations.

. . . What implications for international trade may be.

. . . What should be the role of government in aiding both the development of new materials and the readjustment of industries and personnel possibly displaced.

High reliability components

Understandably, high reliability is overwhelmingly important to space activities. The space effort has greatly stimulated the development of methods for attaining high reliability in all parts and systems. To the extent that this results in new manufacturing, design, and/or utilization philosophies that can also be applied outside the space area, the implications may be of great importance for other sectors of society. (The implications of highly reliable radio and TV receivers are discussed in Chapter 3.)

Highly reliable components applied to products in general use have the potential for reducing the wear-out and break-down rate of commodities designed for a consumption-oriented society. Repair and service personnel would be less needed, and their skills could be applied to other technical fields. Products which could survive for many years would present major marketing problems for those manufacturers of consumer goods who depend on malfunctions, style changes, wear-out, and the costs of repairs to stimulate purchases of new products as replacements. However, the transition to ultra-reliable consumer goods could free resources for other than the replacement of worn-out or faulty equipment.

Whether or not the techniques for attaining the order of reliability magnitude required by space activities are applicable to consumer goods -- or would be applied to them or demanded for them if applicable -- remains to be seen. It is clear that a number of major economic and social considerations would be involved. Since coping with the possible changes in production and consumption would be a complex matter, the potential implications of these developments merit study. It would be well to examine:

. . . The role of equipment reliability in consumer consumption and replacement rates.

. . . The cost and benefits studies of increases in reliability at various steps in the production-consumption sequence.**

. . . Alternative uses for resources and types of personnel that might be freed by specific improvements in reliability.

. . . The implications of shifts in producer and consumer attitudes toward consumption of highly reliable products, especially in the light of other demands for national resources in the years ahead.

Closed ecological systems

Research on and application of closed ecological systems, which support man by reprocessing waste into food, water, and air, have been greatly accelerated by space activities. While this technology might be applied to society at large if defense considerations required living in sealed sites underground, and while the techniques could in principle be used to augment food and water supplies and serve at the same time as garbage disposal facilities, there would seem to be for the foreseeable future sufficiently easier and more effective ways to meet the food, water, and air needs of mankind on this planet. Thus, the social implications of this by-product are minimal.

Propulsion

While rocket propulsion is not uniquely a product of space activities, certainly most of the stimulus for it has come from that source. There have been many suggestions for non-space uses of rockets -- among them human and freight transportation, aircraft lifting and braking, and hoisting of construction materials in situations where high thrust for short time periods would be helpful.

Most of the suggestions have a certain implausibility about them. It seems to be assumed, for instance, that "getting there faster" will make rockets attractive as a means of transportation. However, even should the state of the art in principle permit such travel, it is doubtful that within twenty years rockets would be comfortable enough or their schedules maintained with sufficient precision to make them more attractive than jet transport.

High-speed shipment of freight would be worthwhile only if the time and cost required to prepare a package and transport it to the launching site (which would have to be well away from urban areas for safety as well as for reduction of the noise to a tolerable level), plus the time and cost required to unpackage and tranship to the place of use were less than the time and cost associated with more familiar forms of transportation. ("Packaging" includes "shaping" the item, through dismantling or initial design considerations, to fit the payload container, and protecting it from acceleration, vibration, sonic, and impact damage.) Further, except perhaps in certain emergency situations, routine commerical shipments would seem to have little need for transport at such speed. Even in emergency cases, it does not follow that the item would necessarily be designed for or be capable of quick packaging for rocket transport or that a stand-by rocket capability would be feasible.

Aircraft lifting and braking rockets seem to be plausible developments, especially if there are commercial incentives for using jets at airports with short runways and if vertical take-off and landing craft are not developed. It is not clear what the consequences for society would be of being able to move more rapidly to and from areas now restricted to non-jet transport. However, shorter runways might mean less acreage devoted to airports, with local consequences for land use and taxes.

The recent use of helicopters to hoist construction materials in crowded building areas has stimulated speculation of the similar use of small rockets. The requirements for noise control and safety have not been evaluated, however, and until they are the idea will remain in the realm of speculation.

It should be evident from the above discussion that the possible social payoffs of rocket propellants in the next two decades are by no means obvious at this time, chiefly because the state of the art, the criteria for commercial use, and the social need are all still insufficiently defined. However, when these factors clarify, studies might be undertaken to evaluate various speculations on application and contingent social contexts.

Guidance techniques

The extreme requirements for precision guidance demanded by space activities have profoundly accelerated developments in this field. There has been much correlative speculation about the applications of these techniques to more earthbound activities. The ideas broached have had to do with displacing the human as the guidance system in everything from automobiles to ocean liners.[13/] Aircraft planes and ships could in principle use precision inertial and radio guidance now. For the foreseeable future the only practical guidance for automobiles would be a method involving a system of electronized highways, but it would be well to solve some of the many ancillary problems first. Traffic control systems will be required, for example, as well as various legal adjustments.

Should the application of automatic controls be widespread, personnel displacement, if not planned for, could create serious economic and social problems.[14/] However, the practicality of using guidance devices in certain cases may be questionable. In the case of ships, those who guide them have other tasks to perform as well. Given the cost of the automatic equipment and of maintaining it, the economic advantage of eliminating only the guidance part of the human job is not clear. As for aircraft, if it were not socially or technically feasible to eliminate the pilot altogether, it might be more practical to use him as he is used now.

In general, as with propulsion, the present picture is ill defined, but it seems fairly certain that automation devices of this type will have future application in a number of areas -- and not solely because the human imagination finds itself fascinated by them. Therefore, some study of the contingent social requirements for ship or aircraft use of fully automatic guidance might be undertaken; thus as the state of the art and social need clarify, there would be background understanding of the factors which then need careful study from the standpoint of cost and benefits.

6. IMPLICATIONS FOR GOVERNMENT OPERATIONS AND PERSONNEL USE[1]

THE ORGANIZATION AND PERSONNEL requirements and problems of peaceful and scientific space activities differ in many aspects from those usually confronting a federal agency. An extraordinary number and variety of highly trained professional personnel are required. Very large funds are also required -- funds also coveted by other federal organizations and other programs in science and technology. The program organization of necessity obscures cherished distinctions between science and engineering, and between basic and applied research. The activities are important to both national and international goals, and as well to military, scientific, and commercial goals; therefore, they have significant implications for an unusual variety of other government agencies and may in turn be vitally affected by these agencies. In sum, an important consequence of the space effort is an imposing set of demands for efficient personnel utilization, for complex organizational arrangements, and for resolution of ambiguities in the relationship between space projects, science and technology, and policy making.

Of the sections of this chapter to follow, those on manpower and organization are presented largely from the standpoint of NASA's problems and opportunities. The section on science advisory activities has a more comprehensive context, because policy making is not the exclusive prerogative of NASA.

Manpower in Government Space Programs

The Second Hoover Commission report (1955), Personnel and Civil Service, pointed out with regard to the employment of scientists by the federal government that:

1. The personnel administration system of the federal government has serious defects when it is necessary to supply scientists.

2. The civil service system emphasizes positions rather than people, and these are classified, ranked, rated, and paid on the assumption that they can always be filled.

3. There is insufficient official recognition in laws, regulations, policies, and procedures that the government should meet the distinctive needs of this group.

4. New concepts, policies, and procedures are needed which are designed both to supply scientists to meet the needs of the federal government and to recognize the personalities and careers of such persons as individuals.

These admonitions are especially pertinent to space activities and to NASA as a major employer of scientific personnel. In what follows in this section, special attention will therefore be directed to research on possible "new concepts, policies, and procedures" for recruiting and maintaining the highly specialized personnel necessary to space programs.

Training and experience requirements

The scientific and engineering theory necessary for work in space activities can be provided by university courses, and certain developmental and basic research in materials, processes, and space research packages can be conducted in university laboratories. But for specific training in the unique aspects of space activity planning, development, and implementation, field experience and familiarity with the "hardware" are required. An understanding, for example, of the complex interrelations of the space vehicle, its mission, and its payload, as well as the processing and use of the obtained information, can be acquired adequately only at the plants, launching pads, and laboratories where research and development for future missions is going forward. The relatively few environments that at present can provide the necessary field training and the rapid rate of obsolescence of the experience thus acquired suggest that special methods of manpower utilization within the government framework are required.

It may be more desirable, for instance, to circulate professional personnel through the laboratories of government agencies performing functions and missions related to space activities, than to restrict them to the laboratories of the agency with which they are affiliated.[2/] And, since the space effort needs and capabilities of government, and those universities and other research organizations carrying on programs are intimately related to each other, there might be merit in developing means for circulating professional personnel between private and government laboratories, to facilitate exchange of perspectives as well as technological know-how.[3/] This exchange may be especially important in the light of the frequent reminder by observers that government personnel should be equal in competence to their nongovernmental counterparts in order to judge the quality and significance of the space activity proposals made by the latter to the government.[4/] (Such arrangements would generate conflict-of-interest problems that would need to be explored and resolved.[5/])

In the general interests of effective and efficient use of manpower, the whole concept of scientific and engineering careers in government space efforts might be explored from the standpoint of the special relationships existing now, and those that can be foreseen for the future, between government and its major private contractors in the space field.[6/]

Another potential problem to be faced by government is implicit both in the taxing demands made on the creativity and productive capacity of the typically young scientific personnel and in the rapid pace of developmental change and even obsolescence. What can be done with high-salaried personnel who are still capable but may have outlived their creative usefulness specifically for the productive purposes of space activity?

The problems set forth above illustrate the many that are involved in the effective use of personnel for the federal government's space programs. Research, then, is desirable to determine:

. . . The present and foreseeable experience and training required for scientific personnel affiliated with government space programs so that they will be (1) effectively incorporated into the space activity field, (2) capable of efficient coordination of technical operations, and (3) able to make highly competent judgments on pertinent programs submitted from outside the organization.

. . . The advantages and disadvantages for the program of varying time involvements of personnel in the government space program. If there are advantages to short or medium periods of involvement, at what stage of the person's career is there the greatest likely payoff for the program?

. . . Legal and procedural means for exposing personnel to the requisite experience and training in such ways as mutually to benefit them and the government's activities in the space field, including means for encouraging or discouraging turnover and circulation of personnel between and outside of government agencies appropriate to the findings of the studies proposed above.

Motivation

Various aspects of the motivations for recruitment into the space program, the length of involvement with it, and exodus from it suggest important research areas. The above-stated problems in manpower utilization could, of course, also be seen in this light.

The following statement indicates what NASA believes to be the main source of its turnover:

"During calendar year 1959, out of an average number of 2,355 research and development professional personnel, NASA had 171 leave the organization voluntarily. This is a turnover of 7.2 per cent. It is our belief that the large majority of research and development personnel left because of pay. Our studies in the past have shown that in only a few cases did the individual leave for less or the same salary, and those who went to industry usually received substantially higher pay."[7/]

At present there are few or no comparable and detailed data on the motivations to leave or join government science activities in general. In view of the many alternative opportunities open to scientists and engineers who might choose to work in the space field, it is especially important, if the government is to have its necessary share of high quality personnel, that insight into the motives and opportunities of those who leave or join its efforts be as clear as possible.[8/] (In this regard, Chapter 9's sections on the attitudes of such personnel are especially pertinent.)

Thus, research concerning motivation of NASA space scientists and engineers is necessary to determine:

. . . What are perceived by those working in government as the advantages and disadvantages of government employment in the space field? How does this compare with their perceptions of the advantages and disadvantages of industrial space employment? How are the perceptions related to professional interests, status, aspirations, competence, etc.? What are the corresponding images held by persons in industry and in non-profit institutions?**

. . . What are the perceived specific factors which now (and might in the future) cause professional people to leave or join NASA space activities?[9/]

. . . If working in NASA space activities were more or less attractive compared to working for (1) other space organizations in government or (2) other space organizations out of government, or (3) projects entirely outside of the space field, what would be, for the NASA program, the specific consequences of reductions or increases in the numbers of specific types and qualities of personnel and in the levels of competence under each of these three conditions of alternative employment?

. . . In what ways does NASA's favorable salary position affect other space programs? What are the feedback effects on NASA? What are the over-all effects on the national space program? What means can be developed and applied for arranging salary system realignments necessary to correct inequities in top salaries that have no flexibility with which to respond to general pay increases?[10/]

Research and development implications for manpower

There is abundant evidence that research and development activities require a different kind of organizational structure and managerial philosophy than that which is traditional for large-scale undertakings.[11/] The fact that research is a venture into the unknown, in contrast to such activities as production which involve efficient reproduction of the known, suggests the need for a different system of control and direction in research as opposed to manufacturing. The values and career aspirations of scientists and engineers -- as distinguished for example from those of manual workers or businessmen -- suggest that systems of reward and rules of conduct should be designed which would recognize those values and aspirations. The fact that the research manager's range of relevant knowledge and skill is usually different from that of the professional group he leads suggests the importance of finding alternatives to a command system for laboratory administration.[12/]

Research and development work related to space technology is marked by a degree of complexity unmatched in any other field. Particularly in respect to potential man-in-space or colonization projects, an enormous number of fields of knowledge and experimentation are required. Underestimation of the need for, or economies to be achieved by, a greater investment in research prior to costly engineering experiments, or of the need for integrating scientific and engineering experimentation can lead to delays, anomalies, and inefficiencies. Such occurrences can sometimes be traced to a discounting by the members of one technological field of the potential contribution of other fields, or to the inability of managerial personnel to create the conditions needed for adequate communication and collaboration among the groups involved in the creation of a complex system. It is not enough to recruit persons with appropriate scientific and engineering skills; arranging for the coordination and integration of their efforts is itself a complex and difficult undertaking. This is an area where there is a dearth of the experimental and observational knowledge which would ensure efficient utilization of the human resources and equipment involved in developing space technology.

Subgrouping of research and development personnel according to some principle is a necessity, but different principles appear to be optimal for different undertakings. Scientists and engineers may identify themselves with others in their own field (e.g., solid state physics or astronautical engineering), or with others working on the same large project, or with others interested in particular subject matters (e.g., propulsion systems or vehicles). The organizational structure and procedures of a research and development organization can produce such identification; they can also drive away scientists and engineers whose preferences conflict with them. For example, in one research location the most creative scientists were found to be spending much more time with persons in scientific fields other than their own than did their less creative colleagues.[13/] Again, the length of time members of a group have worked together appears to be related to the productivity and creativity of the group.[14/] Research to develop methods of determining optimal structures and procedures for the unique organizational problems confronting space technology could provide useful guides to persons charged with organizational administration.

Thus, to ensure that available scientific and engineering intelligence is mobilized most strategically for the tasks confronting space research and development activities within the government, research is needed:

. . . To develop means for assessing the present level of performance of organizations involved in space technology, and for estimating their potential for improvement.

. . . To develop methods for identifying obstacles to improved coordination, communication, and collaboration among the research groups involved, and to develop means for overcoming these obstacles.

. . . To locate and make use of opportunities for experimenting with novel organizational arrangements to gain the knowledge needed as a basis for establishing optimal conditions for creative collaboration among the scientists, engineers, and ancillary groups involved in space technology.

. . . To assess the effect of community settings on work in space technology. Does an R & D space community facilitate creative work, or does it produce conformity, squeezing out scientists whose standards are different from community standards? Does it stimulate promotion-by-friendship and preoccupation with status differences? Is a large metropolitan area better or worse as a community setting in regard to the above than a small isolated area?

Long-range manpower requirements

A report of the U. S. Department of Labor on population trends and their manpower implications indicates that, because of the low birth rate of the depression period, no significant change in the size of the 25 to 44 age group will have taken place during the decade ending in 1965. The age group of men and women between 18 and 24, which decreased in size from 16.8 to 15.1 million during the decade ending in 1955, was expected to increase by almost 5 million persons. The estimated gross national product by 1965 would amount to $560 billion -- as compared with $391 billion in 1955 -- and require a labor force of 74 million persons, representing an increase of 10 million. The report estimated that, in order to meet the needs of the nation's expanding economy in 1965, the professional and technical occupation groups would have to increase in size by more than a third.[15/] Thus, space activities will have to compete even more than at present with other professional attractions for the highly trained 25 to 44 age group; on the other hand, there will be available a potential work force under 25, well-educated but inexperienced.

In the light of these forecasts it seems obvious that in planning long-range space programs more thought must be given to the availability of skilled manpower to carry them out. Although significant over-all population increases are anticipated, the 25 - 44 skilled group will not increase and the skilled manpower requirements of numerous other sectors of the economy will compete for their share of the total supply. Therefore, the sufficiency of personnel to conduct in-house government space programs should be reckoned not only in numbers and types but also in terms of costs. If the desired personnel are in short supply, salary will be a major device, for both NASA and its contractors, to attract personnel and, as such, a major contributor to the costs of space programs. (NASA might thereby find itself in effect competing with itself.) However, through long-range planning of personnel recruitment and training the needed personnel might be provided in sufficient quantity to minimize the contribution of excessive competitive salary scales to over-all costs, thereby possibly permitting allocation of funds thus saved to other aspects of the effort.[16/] Future manpower requirements should be studied with the intention of reducing the chances that they will have a limiting effect on future operations.

Research is desirable, then, to determine:

. . . What will be the specific manpower needs of NASA by type and by competence for various future time periods and for specific programs?

. . . On the basis of the above and of the best estimates of career and utilization trends, what is the competitive situation likely to be with regard to these personnel at particular times, and what will be the estimated costs for NASA in competing for these personnel?

. . . What can be done to encourage and improve career selection by appropriate collegians, along lines compatible with NASA's interests, the welfare of the nation, and the interests of the potential recruits?

. . . What use can be made by NASA of the professionally inexperienced in the under-25-years age group in the years ahead? Are there space activity tasks which could be so organized that these people can be easily trained to do them?[17/] Through this training can they efficiently gain the needed experience for more sophisticated participation?

Information on scientific manpower

It is evident that planning for future personnel requirements, training, and costs depends on accurate and continuing knowledge of current national levels of competence and types of capabilities. Thus, information on scientific manpower is a logical prerequisite for personnel planning. However, according to the Commissioner of Labor Statistics, the problem of obtaining scientific manpower information is as follows:

"Part of the confusion surrounding the debate concerning the adequacy of our present and future supply of scientists, engineers, and other key manpower is a result of the lack of accurate current occupational information. It is a remarkable fact that we can pick up the Statistical Abstract of the United States and find out that, for example, on January 1, 1958, there were 22,357,000 milk cows in this country. Yet we do not know with the same exactitude, how many physicists we have and how much they earn."[18/]

The National Register of Scientific and Technical Personnel, an important responsibility of the National Science Foundation, is based upon a National Science Foundation Act directive "to maintain a register of scientific and technical personnel to serve as a central clearing house for information." Manpower data was to be provided on the supply, utilization, and professional characteristics of American scientists in the major fields. An appraisal of the Foundation's manpower studies and maintenance of the Register was made by a House committee during the First Session of the 86th Congress, and a subsequent report, critical of the Foundation for devoting only a very small per cent of its budget to their activities, urged that the program be strengthened, since "with the need for scientific manpower growing daily, the need for a superior manpower tabulation" was "likewise accelerating rapidly."[19/]

Research is necessary to determine:

. . . What information about the competence, distribution, and utilization of United States scientific and engineering personnel would be most useful to NASA in planning its personnel utilization requirements and costs now and in the future? To what extent would data from other countries be useful?[20/]

. . . How could up-to-date data best be obtained and maintained?

. . . What are the cost and benefits of more or less precision in the data?

. . . What are the most efficient ways to use the data for costing, planning, and recruiting purposes in regard to personnel?

. . . What other government organizations could assist in the accumulation, processing, and up-dating of the data? Who else would benefit from such data? Who has the best functional capability for obtaining and processing it?

. . . How can the required level of cooperation be obtained from the scientists and engineers who are queried for information?

Career aspirations in the younger generation

Because of their spectacular nature and the great amount of attention paid to them, space activities may represent for the younger generation the essence and direction of a variety of careers. It is possible that too many young people will aspire to careers in the space effort or in related scientific, engineering, and military fields, but there is also a kindred possibility that, with the palling of glamor after a time, indifference to space and related fields may direct first-class young minds into quite other careers.[21]

As of today, parents, their youngsters, teachers, and career advisers are responding to space activities career opportunities in a variety of ways. There is some evidence of a good deal of adolescent interest in current space projects.[22] Parental and school guidance attitudes toward military or civilian careers, as well as toward science and engineering, presumably will affect the numbers and types of students who choose space-oriented careers. Perceptions about the income and status levels involved in comparison to those of other fields may also contribute in favor of space-related fields.

It is important for NASA to consider, develop, and balance its role in stimulating youngsters to careers in space activities. In the first place, NASA will depend for its future personnel on some of those so stimulated, and their attitudes as future voters will also be important to space activities. Further, the space efforts of universities and industries, upon which NASA's program also depends, must obtain their future personnel from among those so stimulated. However, it is vital to the interests of the nation and its citizens that the number of youngsters aspiring to space careers should not be so great that other fields would suffer for want of talent.

For these reasons, then, it is most desirable that the effects of space activity products on career selection be understood and that efforts be made to insure plans for meeting personnel requirements in such a manner that NASA can fulfill its obligations toward space activities as well as toward society at large. Thus a series of studies with regard to career perceptions and aspirations is desirable, in order to determine:

. . . What, over time, are the evolving images in the minds of parents, teachers, career advisers, and young people of the space scientist and engineer, and how do these compare with the image of other possible career models.23/ In particular, what values (e.g., craftsmanship, dedication) are perceived as involved in particular careers? Are these seen as attractive or unattractive? What knowledge, ignorance, events, or experiences change or emphasize the nature of the images held?**

. . . What relationships are discoverable between adolescents' values and career commitments and their later adult attitudes toward life in general and space activities in particular.

. . . How space activities affect the interests and values of adolescent girls, with regard to their own career aspirations and to the career of the type of man they may wish to marry and the time at which they wish to marry.24/

. . . What the effects are of space activities on the knowledge, attitudes, and teaching interests of teachers -- particularly science teachers -- and how the effects in turn affect those taught.25/

. . . What methods could be developed for assessing early interests, aptitudes, and values that can be nurtured to provide the needed scientists and engineers for space activities.

. . . What curriculum requirements will provide the requisite training for space activity careers as well as a flexible intellectual and professional competence applicable to other socially useful activities in the event that the need for space personnel lessens.

Problems of Coordination, Cooperation, and Competition Between Government Agencies

Organizations, to work well, must be adapted to the special nature of their subject matter. Since space activities are unique in many aspects, formal or informal organizational procedures that are intended to meet the best interests of the space program and the nation should be based on an appreciation of the special implications that the space program has for government organization.

A new government agency such as NASA, with unusual activities that have wide-ranging needs and implications, must inevitably face problems of coordination, competition, and cooperation with other agencies which have, or would like to have, interests in the same activities. The problems arise out of both a communality of interest and the unique aspects of space activities. Thus organizational functions and procedures must take account of questions which are fundamentally new and at the same time partake of the immemorial conflicts of interest inherent in complex organizations of any kind.[26]

Another complicating factor is the heterogeneity of the various organizations involved. There are vast differences in size, political power, monetary resources, types of functions, and personnel composition; nevertheless, these agencies provide the common resource pools for many policy planning committees or specific crash-project tasks. An additional dimension is introduced when membership composition is examined. Members of one agency may be found to be associated with several other agencies, making it possible for one individual to have two or more different functions on the same project. And there may be common memberships in intergovernmental and nongovernmental agencies.[27]

Any research on interagency relationships should include:

. . . A rigorous inventory of the organizations involved, classified according to organizational characteristics, functions, techniques of operation, objectives, source of manpower, etc.

. . . A determination of the divisions of responsibility, the extent of authority, the role of competition, the way interrelationships are viewed internally, the degree of "extracurricular" cooperation, and the process of coordination for over-all planning.

. . . The methods used to maintain and facilitate interagency communications and the problems related thereto. For example, what methods are used -- scheduled coordinating meetings, *ad hoc* meetings as problems arise, hurried phone calls between old friends? What staff level or working groups are involved?[28] Are there operational differences between decision making and problem solving groups? What provisions are there for the circulation of reports, etc.? What is the extent and importance of prior individual acquaintanceships? Are there observable and meaningful patterns in the multiple-membership aspect?

The present and potential problems discussed in the rest of this section are typical of the problems that qualified observers think require careful and systematic study.

Salary conflicts

The salaries of the large majority of the government's scientific personnel are regulated by the Classification Act of 1949 (and amendments thereto), which provides for eighteen grades of positions based upon varying levels of difficulty as prescribed in Civil Service Commission grade-level position standards and qualification requirements. Under the National Aeronautics and Space Act, NASA is authorized to hire new government scientists and engineers two grades above normal entrance grades. NASA is also given authority under the Space Act (as distinct from P.L. 313): "(2) to appoint and fix the compensation of such officers and employees as may be necessary to carry out such functions. Such officers and employees shall be appointed in accordance with the civil-service laws and their compensation fixed in accordance with the Classification Act of 1949, except that (A) to the extent the Administrator deems such action necessary to the discharge of his responsibilities, he may appoint and fix the compensation (up to a limit of $19,000 a year, or up to the limit of $21,000 a year for a maximum of ten positions) of not more than two hundred and sixty of the scientific, engineering, and administrative personnel of the Administration without regard to such laws."[29/]

Under the Classification Act, the Civil Service Commission is authorized to raise entrance salary rates of professional scientific personnel from the normal base-level grade rate to higher within-grade rates as an aid in recruitment. A request to the Civil Service Commission by the NASA Administrator for authority to raise the minimum rates of pay, under this procedure, stated in part: "The National Aeronautics and Space Administration is faced with a serious problem in the recruitment of qualified scientific personnel for the Nation's space and aeronautical programs. In brief, the problem centers about our inability to meet staffing requirements because of low pay. In order that important programs such as Project Mercury may proceed without delay, authority is requested to raise the minimum rates of pay to the maximum scheduled rates of each grade."[30/] NASA's request for top-of-the-grade pay for aeronautical research scientists was subsequently withdrawn because of: "...substantial administrative difficulties in raising aeronautical research scientists to the top of the grade for a single agency, since similar positions exist in other agencies. The Defense Department, which has nearly all such positions outside of

NASA, does not support the increase because it does not at present face hiring needs for these skills to the extent NASA does."31/

Competition for space roles

Direct Agency Participation. The President's second annual report to the Congress on aeronautics and space activities "details the steps taken during 1959 to establish a firm foundation for a dynamic program of space exploration, and it summarizes the contributions of Federal agencies." Although the Congress established the National Aeronautics and Space Council and the Civilian-Military Liaison Committee in the Space Act to provide comprehensive coordination over the space programs, events indicate that the efforts of several space activities are not represented in either of these bodies. The CMLC is, in principle, concerned primarily with Department of Defense and NASA coordination, while the Space Council includes as members the Departments of State and Defense, NASA, the Atomic Energy Commission, and the National Science Foundation. However, the President's report also lists as participants in space activities the following additional agencies: the Department of Commerce, Smithsonian Astrophysical Observatory, Federal Communications Commission, and U.S. Information Agency.32/

It is not clear what the consequences are of such nonrecognition for the above agencies, but the experience of the Weather Bureau is perhaps indicative. The entire research and development budget for the Weather Bureau in fiscal year 1960 was about $5 million. In the fiscal year 1960, NASA's appropriation for meteorology alone was $7.9 million. The importance of the Weather Bureau for NASA's space program can be seen in one of the consequences of the Tiros I meteorological satellite launched on April 1, 1960: Bureau meteorologists received over 22,000 cloud cover photographs for interpretation. Faced with this additional workload for which inadequate funds were available, the Weather Bureau was forced to request an emergency appropriation from Congress for additional manpower.33/

Peaceful vs. Military Emphasis of the Space Program. Observers have speculated that the future direction of space activities is by no means clear and that, in spite of frequent declarations that the program (as represented by NASA) is primarily dedicated to peaceful and scientific space activities, it is not impossible that it may become subservient to the military space program -- which was originally conceived of as the proper responsibility of the Department of Defense. NASA's dependence on the military for many technical aspects of its program, the strong support of the military in some segments of Congress and the public, as well as persistent efforts by the military to remain self-sufficient in the space area are all taken as signs that the fight for control of the major space effort is by no means over.34/

Jurisdiction Over Related Science and Technology. Observers feel that inevitably there will be conflicts over which agency should control certain activities related to the space program. It is felt, for example, that the present jurisdictional arrangement may be temporary between AEC and NASA regarding nuclear space propulsion research and that the interests of the two organizations may become more vested as the project develops and as regulation becomes an important problem.35/

A recent staff report of the Senate Committee on Aeronautical and Space Sciences indicates that in the field of life sciences research there is an area of possible conflict and noncoordination. The Senate report is essentially a complete inventory of the more than $60 million worth of life science facilities existing in the Department of Defense. The central point of the report is not that NASA should not have a life sciences program in connection with its own activities, but rather that in proceeding with its program it should be aware that facilities already exist in this area and therefore its activities in the life sciences area should reflect the best utilization of these facilities.36/

Related jurisdictional problems may also arise. As space activities develop products having continuing effects for society, there may be problems of jurisdiction over equipment design and regulation. For example, how will control be allocated between NASA and the Weather Bureau regarding data processing by weather satellites and between NASA and the FCC for communication satellites?37/

Civilian-Military Coordination. The National Aeronautics and Space Act of 1958 authorizes a Civilian-Military Liaison Committee to coordinate space programs between NASA and the Department of Defense. Section 204 (b) of the Act states: "The Administration and the Department of Defense, through the Liaison Committee, shall advise and consult with each other on all matters within their respective jurisdictions relating to aeronautical and space activities and shall keep each other fully and currently informed with respect to such activities." But in the testimony before Congress, the chairman of the CMLC revealed, as follows, the plight of his organization and the reasons why its role as space program coordinator was essentially neglected by NASA and the Department of Defense:

"Since the passage of the Space Act on July 29, 1958, the Civilian-Military Committee has met 13 times....For the most part, the items of business brought before the Committee at the formal meetings are of the information type to keep the committee, as a whole, informed on the activities of NASA and DOD...the role of the Committee has been of relative minor importance. This status of the Committee, I might add, had caused some concern on the part of the members....

"This Committee, because of its composition, that is, a membership made up of representatives who are subject to a higher internal authority, is incapable of making firm decisions."[38/]

Further evidence of the neglect of CMLC is provided by the announcement by NASA and the Department of Defense on September 13, 1960, of the establishment of a joint Aeronautics Coordinating Board, unofficially to replace the Civilian-Military Liaison Committee. The agreement provided, as co-chairmen of the new board, the Deputy Administrator of NASA and the Director of Defense Research and Engineering. The announced objectives of the board, consisting of panels in various technical areas, were to: "(1) review planning to avoid duplication; (2) coordinate activities of common interest; (3) identify problems requiring solution by either NASA or DOD and insure a steady exchange of information."

To the extent that coordination of both competition and cooperation between agencies is ineffective or inadequate, there is, on the face of it, reason to suspect that scarce personnel and production and research resources, as well as money, are probably being used inefficiently. In view of the costs of space activities and the shortages of qualified personnel it would be in the interests of NASA and the nation to determine through detailed and continuing research:

. . . What would be the advantages and disadvantages of specific cooperative and coordinated arrangements for the use of manpower, money, and physical resources between specific agencies having interests in present and anticipated space research, developments, and applications?**

. . . To what extent do NASA and other space organizations compete for the same resources and facilities, and what are the costs and benefits of such competition?

. . . What are the foreseeable competitive and cooperative trends, and what are the estimated costs and benefits of continued cooperation and/or competition in these areas?

. . . In the light of the three above problems, what means can be devised and implemented for coordinating and utilizing effectively the interests and capabilities of other agencies for the advancement of space programs, either through selective cooperation or selective competition?

. . . What are the specific present and foreseeable jurisdictional problems, both administrative and regulatory, which will confront NASA? What studies can be undertaken now to anticipate future problems and lay the basis for efficacious resolution?

Science vs. Engineering, and Basic vs. Applied Research. There are indications, sometimes subtle, that competition is growing within the science hierarchy of the federal government between space activities and the more traditional science programs; manifestations include competition for funds, manpower, and space roles -- as well as the breakdown or neglect of coordination between agencies. While compelling needs sometimes dictate the urgency with which particular programs must progress, it is usually within a relatively static federal budget that such changes take place, sometimes at the expense of related programs. There is a well-documented history of the relationship and to some extent the rivalry between so-called basic and applied research.[39/] Other forms of competition between scientific fields are usually reflected in the private attitudes of scientists engaged in competing fields.[40/] Some organizations and their representatives appeal to Congress and the general public by emphasizing applied research and calling engineering "science"; others, appealing to other publics as well as their own self-images, try to keep the traditional distinction between science and engineering and basic and applied research. Space activities have been defined as any and all of these by various groups in and out of government with various vested interests at stake.[41/] But, at the same time, qualified observers have noted that in "big science," and especially in space activities, the lines between engineering and science and between basic and applied research are exceedingly difficult to maintain, given the intimate interdependence of engineering and science, the rapid pace of applying basic research, and the tendency to carry out what traditionally would have been basic research as a prerequisite for anticipated applications.[42/]

Organizational problems arise when who is to get what funds and privileges for conducting which programs depends -- or is perceived to depend --

on the semantics of the appeals made to fund sources and on which organizations are traditionally viewed as the proper ones for conducting science or engineering, basic research or applied. Since both the definitions and the interests are flexible, even though frequently perceived as rigid or "real," the problems of priorities and jurisdiction become vexing to the science and engineering communities in and out of government and to non-scientific administrators in government. (Other facets of this problem are discussed in the last section of this chapter.)

It is worth questioning, then, what would be the organizational advantages and disadvantages of updating the concepts of science, engineering, basic or pure, and applied research, within the scientific and engineering communities, Congress, the mass media, general public, and opinion leaders. Until this is done, many argue, competition for federal funds, priorities, and jurisdiction will be based on and will appeal to semantically invalid distinctions. This is believed to be especially so with regard to the many-faceted space programs.

Research is desirable, then, to determine:

. . . The extent to which competition for space funds and task jurisdiction is based on misperceptions, within the competing organizations and/or misperceptions in those appealed to, about the distinctions between science, engineering, basic and applied research.

. . . Means for clarifying the interrelationships between these distinctions in operationally meaningful ways -- or means for discarding these distinctions as criteria for assigning priorities, funds, and/or jurisdiction.

. . . Means for establishing in appropriate places a tolerance for and appreciation of the desirability of space research with no apparent payoff.

. . . Methods and means for establishing criteria for assigning priorities, jurisdictions, and funds to space research in concert with other scientific and engineering activities in the government.

Implications for federal-state relations

At present, civilian launching complexes are few, and for the most part are associated with military installations. It is not inconceivable that if the range and variety of civilian space activity increases, NASA will need its own sites. Some of these would be located in various states and might be subject to state regulations. NASA, as a civilian organization, cannot claim military necessity in order to expropriate land. State regulations regarding the siting and control of dangerous operations may require various adjudications and arrangements between NASA and state agencies, which may not be easily compatible. There may be foreseeable legal, health, and safety problems which make it worthwhile for NASA to study:

. . . Means for most effectively reconciling the possibly conflicting interests of the sites and the states in which they operate.

There may also be strong pressures on NASA to permit various types of state-promoted participation in the space effort such as already exists in the atomic field, for many states make intensive efforts to bring in organizations to enhance their economy or stature. Moreover, it is not inconceivable that groups of states would have an interest in launching special rockets for local weather tracking and detecting purposes. Groups of states also, as well as individual states, may find it worthwhile investing in training, testing, launching, and research facilities in the space field, as a device for retaining and attracting academic personnel to state universities, as a means of attracting high caliber students, and as an inducement to industry. With the development of solid propellants, some states, having safe launching and flight tracks out to sea or over uninhabited areas, may wish to promote actual rocket launchings.

There would appear to be both opportunities and problems in connection with state participation -- opportunities to expand interest in and contributions to the space program, and problems of regulation and control involving federal-state relationships. Therefore, research seems desirable to determine:

. . . Whether or not and, if so, in what ways states could be involved productively in space activities.

. . . If state participation is desirable, what incentives might encourage it and how might federal space programs provide the incentives? If undesirable, what restraints on space activities can the federal government impose effectively?

. . . If participation is desirable, what state-federal coordination and regulation problems need to be solved to permit participation, and what are the means for solving them?[43]

Science Advisory Activities and Government Policy

It is generally conceded that space activities and science in general have become inextricably intertwined at the governmental policy making level, so that policy about one must inevitably affect policy about the other. This intertwining of interests, while not new in degree to science or government, has clearly received special emphasis as a result of the special and spectacular role of space activities in government policies, both domestic and international. Probably more than any other scientific and engineering activity, the space program has emphasized and dramatized the intricate problems of assigning priorities to competing and cooperating scientific and technological efforts and of integrating new men, new ideas, and new technology effectively into the already conflicting and competing operations of a complex democratic government.

Inevitably, then, the significance and priorities of the many roles of the scientist as scientist, government adviser, special pleader, promoter, and everyday citizen have become exceedingly murky in his own perceptions; in the perceptions of the non-scientists, with whom he must work at the policy levels of the government; and in the perceptions of those outside of the government who report on and interpret the interrelated activities of government policy advisors and policy makers, both scientist and non-scientist. It follows that among the major on-going implications of space activities are their effects on the interrelations of scientist and engineer as advisers and administrators at high government levels to the non-scientist administrator and to government organization.

While much has been written from a philosophical point of view since World War II about this new role of science and scientists in government, there has been little evaluation of the operational aspects of the relationship. How, for example, is the relationship working out? Are scientific considerations being used adequately in policy formulation? Do scientists communicate effectively with political experts? What happens to the scientist when he steps into the political arena? And, perhaps more important, is there consensus among the people involved as to the role science and scientists are -- or should be -- playing at the governmental policy level?[44/] The recruitment of personnel to fulfill government space goals and the work of agencies in the pursuit of these goals cannot be done at the most effective level unless the role of the scientist and engineer as policy advisers with regard to the goals is clarified and formalized.

Interviews with qualified persons revealed two overlapping areas of controversy about the role of the scientist at the policy level of government. There were varying ideas (1) of what should be the function and organization of government scientific advisory groups in politics, and (2) of what should be the role of the scientific adviser. These ideas will be discussed in the subsections that follow.

What should be the function and organization of government scientific advisory groups?

Views Regarding the Office of Special Assistant to the President for Science and Technology. The respondents here included staff members of the Office of Special Assistant to the President for Science and Technology and members of executive agencies that use the services of the office. Some respondents felt very strongly that the responsibility of a presidential science advisory office was to advance science on a broad front and to integrate the interests of national science policy into public policy. Others felt, also very strongly, that on the contrary the office's function was to bring to bear on current special problems (including space activities) that segment of the scientific community most relevant to and informed on the situation, even if the broader interests of the scientific community suffered at the expense of a given program.[45]

Views Regarding Science Advisory Groups in General. Another set of issues had to do with organizational aspects of the advisory role: At what level of policy planning and policy making should the advisory group be introduced? Where should it be located? What working arrangements should be utilized?

Some felt that political agencies needed their own staff-connected technical personnel to act as translators for internal problems concerning technical matters, since it was believed that advice from technical people of other agencies was apt to be couched in the separate interests of that agency. An "objective" science agency was perceived by some to carry the danger of "scientific bias," and some respondents acknowledged that what they wanted were technical advisers with their own agency's bias. The contrary view was also expressed that in-house technical staffs in non-technical agencies should be minimized if not eliminated in the search for objective advice. There was little agreement on the level at which advice should be introducted or where the interaction should take place.46/

Concerning the problems of communication between the technical adviser and the nontechnical advisee views also differed. Among the respondents who saw and felt serious communication difficulties (a few saw this problem area as insignificant, if existing at all), some saw them stemming primarily from semantic differences involving the use of unfamiliar symbols. On the other hand, there were those who denied any semantic conflict whatsoever, seeing the problem as one of differences in basic frames of reference or broad points of view.47/

Some felt it imperative to include top-level personnel -- departmental secretaries and commissioners -- on science advisory committees if the various factors for a single policy were to be integrated effectively; others were strongly opposed to including such top-level people, on the grounds that it was impossible for them to do the necessary homework and that they were so involved with acting out their institutional roles that they could not get to the heart of other matters.

On the size of the committees, some thought that the twenty to thirty members frequently found in today's advisory committees are essential if all factors and viewpoints are to be taken into consideration. Others were fairly vehement about putting an upper limit of ten on the membership, as an absolute maximum for the type of interaction necessary for the integration of the various factors into policy advice.

The whole question of the ad hoc advisory panel versus the on-going advisory function (either individual or group) produced a variety of reasons, quite equally divided, why one type was better than the other. Only one respondent listed advantages and drawbacks to both sides, implying that different problems might call for different techniques.

These various conflicting attitudes about the proper role, purpose, degree of success, etc., of scientific advisory groups are important to examine because they indicate profound differences of perception and expectation about a very important and new phenomenon in our political system and in the value context of the scientific ideology. The materials presented indicate only enough of the nature of the problems and opportunities in the relationship of science to policy to demonstrate that far more systematic research is desirable if the nation, science in general, and space activities in particular are to benefit fully from this new arrangement.

The problems referred to are in an important sense not unique to this situation. They are characteristic of the problems facing new groups working out new answers to new questions in a not-so-new larger context of cross-interests, traditions, and goals. The wealth of knowledge acquired in recent years about factors affecting organizational structure, conference procedures, and small-group interaction deserves careful attention for its present utility and for the further research it suggests.[48/] Obviously, as basic research on these problems produces new knowledge, the opportunities of applying it to this particular situation will increase. But the situation in itself also provides many significant opportunities for basic research on these matters if the necessary cooperation is forthcoming.

Clearly the first step in a systematic examination of these problems would be more detailed interviews of the sort on which the above recounting is based. By combining the findings of such interviews with the extant knowledge about organizational structure, the operation of small groups and conferences, and the special factors contributed by the political context, alternative approaches to the resolution of differences could be developed and perhaps even tried. Whether or not they might be tried depends of course on the quality of the suggestions, but, importantly, it also depends on what in fact is and will be the attitude of non-scientists toward the application of scientific advice in a political context. It is by no means clear to what extent the use of scientists is based on (1) sincere commitment to the values of rational science, (2) ritualistic application of a "good thing;" or (3) the desire for an added political tactic. Nor, of course, is it clear under what conditions these different perspectives (and others) pertain.

As a first approach to research in this area more systematic attention should be given to:

. . . A detailed analysis (based on further interviews and observations) of the nature and relationship to each other of each of the differences of opinion regarding the matters discussed in the above paragraphs. Questions useful for this analysis would be, among others: What beliefs, expectations, and concrete experiences have led to and sustain the respondents' opinions on these various matters? What operating procedures and administrative organizations, under what specific circumstances, would the respondents recommend to best accomplish what they believe to be the functions of science advisers? What do respondents believe is wrong with the positions taken by those who disagree with their interpretations and recommendations and what adverse consequences do they perceive as following from implementation of those positions?

. . . An examination of the effects of scientific advice on policy making. Among the questions to be asked: How do antecedent advisory recommendations compare with actual policies? What are the factors which constitute pressures to accept or reject advisory recommendations? What are the effects on advisory group actions -- and on those they advise -- of membership in the group, of scientists who are also doing research under government sponsorship? What factors are involved, resolved, or remain as persistent sources of conflict for advisers and their clients when scientists are members of more than one advisory panel whose respective interests are in conflict or complementary?

. . . An attempt to discover the underlying values and goals of science advisory groups in their approaches to problems compared to those involved in the approaches of their clients. Under what specific circumstances (e.g., policy areas, types of decisions, technological problems) and in what ways are these compatible and incompatible?

. . . The direct and indirect consequences of the matters discussed above for the organization and conduct of space activities policy planning.

<u>What should be the role of the scientific adviser?</u>

The first set of issues here has to do with the dual aspects of the advisory role of the scientist -- dual in the sense that the two spheres of scientific and political activity are involved. There is also a strong tendency to confuse the adviser with the administrator, even though in more traditional governmental activities there are usually clear operational distinctions between these two mutually incompatible roles. In the case of scientific activity, however, confusion is justified, since the roles are sometimes fulfilled simultaneously by one man.

There was very little agreement among the interview respondents about the manner in which the scientist should or does adapt to his dual role as adviser. Some felt that the adviser himself should have competency in both scientific and political arenas, while others believed that it was important to have each arena represented separately, with an emphasis on liaison, through the use of a "middle-man translator" or other improvements in the means for communication. Some saw the desirability -- and inevitability -- of the emergence of a "new breed" that would incorporate both roles and establish its own norms of expertise; others saw undesirable consequences in this dual role in that it would centralize a function which should involve the blending of various points of view into a valid consensus.

The interviews referred to the importance of defining operational and organizational rules regarding the role of the "expert" (acting in the light of his scientific experience and knowledge) to facilitate the distinction between such an expert and the scientist who gets into the political arena "way over his head by making irresponsible statements." The potential usefulness of such a definition of rules is illustrated by the presently conflicting attitudes held about scientists who do have quite a bit to say about nontechnical matters. While most respondents agreed on the necessity of viewing such a man not as an expert but as a citizen, some felt that he could contribute a very fresh, creative and important outlook; others felt that he not only confused the issue, but caused great harm to the scientific community as well.

However, since such "expert" roles have not yet been institutionalized, individual factors play a very important part, not only in the effectiveness of operations during the interim but also in setting patterns for institutionalization, if and when it is established. Some respondents felt that when the government was fortunate enough to find that rare individual with the dual talent, actual operations did indeed "work like a charm," but the majority disagreed strongly on how this talent related to the adviser's effectiveness as a scientist.[49]

Similar differences of opinion were clearly reflected in responses concerning the utilization of the dual role. Some felt that the scientist should be only familiar enough with the political sphere to know what kinds of advice or scientific contributions will be both acceptable and useful to the scientific community. For others, the minimal requirements for competence in the advisory role involved not only an understanding of the bureaucratic hierarchy in Washington and its infighting techniques but also a working knowledge of the whole political process and a command of good management principles; in other words, the adviser should become an integral part of the policy making process itself. Some termed it naive to think that a technical adviser only advises and has no policy making power; others held the contrary view. In-house training for awareness and sophistication in the "other" fields was suggested by many as a stopgap measure; others talked of developing graduate programs for engineers and scientists in fields of government and policy.

It is a popularly held view that scientists get in trouble when they try to explain their "technical playthings" to political experts. However, these respondents frequently indicated that they had had very little trouble communicating technical points to political people; the <u>nontechnical</u> points were the ones that had produced great difficulty and frustration.[50/] (It may be that it is difficult to perceive the technical man in any nontechnical role. There is considerable evidence that people unconsciously as well as consciously tend to evaluate what a person tells them in terms of the role in which they perceive him.[51/])

Concerning the role of the scientific adviser in international negotiations, respondents ranged widely. Some limited him to quickly placing his scientific findings on the negotiating table, then leaving the room; others would have him sit behind the negotiator to answer technical questions; still others believed he should negotiate as far into the political arena as he could go. Most of the disagreement on this issue was related to confusion on the question "When does a technical issue become a political issue?" Some of the respondents had themselves felt "used" for political negotiations, while others had felt no "pressure" at all, defining their task as the normal function of the adviser -- to bring technical and political requirements together, within the limits of feasibility.[52/]

Most of the conflicts thus discussed were felt to stem, in part, directly from the fact that a clear, strong, institutionalized image of the modern science adviser is lacking. Regardless of the source of the conflicts, however, there was little doubt expressed about the adverse effect they can have on the functioning of the agencies the respondents represented.

It was more or less agreed that an initial conflict over whether or not to "get involved" in government advisory work may interfere with the recruiting of top-notch personnel for key positions. Nearly every respondent cited the recruiting problem as a serious one. Some respondents instanced the lack of stability in the range of possible prospects faced by the science adviser: his efforts may bring him anything from little or no recognition to very special Presidential treatment. Others spoke of the feeling of being in constant jeopardy in the advisory capacity; without institutional protection, an adviser is frequently attacked for causing problems in areas where he does not belong. One verbalized the situation as "accountability without responsibility."

The prefacing remarks for the research suggestions on the role of the science advisory group are also apropos for the suggestions that follow here. Deserving of considerable study, as well, is the changing role of the scientist in his own eyes. The conflicts and challenges discussed above appear to derive both from the demands made by policy and politics on the traditional values of the scientist and from the changing values of the scientist. A number of observers have remarked that Lord Acton's comments on the corrupting influence of power did not explicitly exclude the scientist.[53/] This observation may be especially pertinent in an area of scientific endeavor such as the space program, where activities are conducted in an atmosphere rich in circumstances and values not usually confronting the scientist when he is able to bring to bear his traditional value of the disinterested search for truth.

Research based on further and more detailed interviews should examine:

. . . The differences in viewpoint described above and the bases for them, in terms of values, beliefs, expectations, and experiences, so that these differences can be clearly understood and related to the role of scientific adviser.

. . . The operating relationships between the science adviser, the science administrator, and their respective users in the area of space policy. Precisely in what ways do the values and perspectives of the three groups complement or confound operating procedures, policy making, and administration in specific circumstances? **

. . . The consequences for policy making of a lack of consensus on the image of the technical adviser's function.

. . . The nature of the dual role. How important is identification with the scientific community? Must a technical adviser be perceived as a scientist to be effective? Are there limitations or restrictions in being viewed as a representative of the scientific community? Under what circumstances is it possible to remain closely identified in role as well as name with the scientific community after competence, skill, and leadership are demonstrated in political and administrative areas?

. . . The relationship between the advisory technique and the problem area. What are the limitations and advantages of in-house technical advisory personnel? Under what circumstances should an adviser have the "right bias" or "uncouched objectivity"? What are the significant differences in role acceptability between advising for planning compared to advising for operations at the policy level?

. . . The possibilities of distinguishing between scientific advice and personal biases, especially as the line between the values of the scientist and those of the political policy maker become more diffuse at some levels of organization and under some very pressing policy circumstances. What organizational means, training, and personal values can be used to keep the distinction clear when it is necessary that it be clear?

. . . What kind of training, curriculums, and selection techniques might be used to encourage and maintain the quality of politically sophisticated scientists and scientifically sophisticated non-scientists who must work toward the same policy goals?

7. IMPLICATIONS FOR SPACE INDUSTRIES

THE HIGH RATE OF CHANGE of space technology and the extent of government participation in stimulating, directing, and consuming this technology appear to have confronted the involved corporations (herein termed collectively "the space industry"), the federal government, and certain other sectors of society with a variety of problems -- economic, social, and organizational. Some of them appear to be new to our competitive economy; some are old problems made acute by the special demands of space activities; and some may be old problems made to look new, unique, or important by association with the novelty of space activities. The efforts being made to solve both the new and old problems may have significant implications for corporate organization and philosophy, for public policy affecting government-industry relationships, and for the use of important national resources.

The material to follow is chiefly a reflection of various opinions and viewpoints of qualified observers of the space industry regarding what they believe to be significant aspects of the involvement of private industry in the space program.[1/] When the opinions and viewpoints are summarized, it is evident that the issues that generated them are complex indeed, including as they do the special situation of the space industry, the intricacies of financing new enterprises whose end-results can at present only be surmised, and the role of government as both stimulator and regulator of a combination of technological and economic activity. Resolution of the issues would seem to require a thorough knowledge of each factor involved and the interrelationships of all factors. Much of this knowledge may need to be derived from intensive research -- which first of all should test the validity and pertinence of the issues themselves.

Two ambiguities that underlie many of the issues to be discussed here should be recognized:

1. It is unclear to what extent a specific corporate situation may be an examplar of the serious implications of space activities for corporate

strategies, government relations, and the consequences of these for society at large. In part this is because at least two types of situation may give rise, each in its own way, to problems for and protests from both government and industry: there are firms whose raison d'etre consists entirely of missilry and space projects; there are others which conduct or wish to conduct substantial activities in the space field but which probably are not dependent upon the development of the field for their corporate survival (many members of the electronics industry, for example, are in this category). The implications for each category are obviously different in kind and in degree.

2. The present situation confronting the space industry and government derives chiefly from a background of military rockets and missilry. The non-military space program has recently played a role, but the full impact of the program is yet to come -- as and if peaceful space activities expand greatly. Whether the problems will then be the same as they are now, or what the implications will be for possibly different combinations of problems remains to be seen and studied.

In the light of these ambiguities and of other preliminary considerations, research would be desirable to:

. . . Set criteria for defining and discovering the corporate situations which are being significantly affected by space activities.

. . . Determine which of the trends and problems described here (or otherwise known) do and will derive from peaceful space activities and do and will have significance for the general character of corporate organization and activity.

. . . Determine which of these trends and problems are the private business of private business, and which have consequences of sufficient public concern to merit further study.

. . . Examine the history of technological change in an environment of government participation to (1) discover possible tendencies and directions in corporate adjustment to such change and (2) discover whether the historical pattern (if any) can assist in understanding and anticipating present and future changes in the space industry. **

Corporate Response to Space Activities

Space technologies are evolving at a high rate of speed, and the responses of corporate strategies reflect the ferment and change. Conventional price mechanisms and market relationships are claimed to be inadequate for coping with the needs of both private industry and government in regard to the new technologies. The role of government as chief consumer and possibly chief stimulator of new products complicates the role of the producer operating in a profit-motivated economy. Yet the problems for industry, necessitating reorientation of many procedures, are in many respects traditional -- as are the solutions -- for corporations faced with the challenge of adjusting to and taking advantage of new technologies and new markets. Nevertheless, certain corporate responses to space activities may represent potentially important and socially significant changes in the way firms operate and perhaps in the way important sectors of the economy will operate.

Investments and risks in space enterprise

For some firms, space programs have forced a reappraisal of traditional precepts on profitable markets, long-term reinvestment or "plowback," and reasonable long-run risks or return on investment.[2/] The following characteristics of present space enterprise have affected outlooks in corporate philosophy: negotiated profits from limited production of custom-made space equipment; high precontract competition costs from company-sponsored research and development and contract preparation costs; the large proportion of professional personnel, and corresponding problems in personnel management and utilization; continual need to adjust capability to rapidly advancing technologies.[3/] ("Capability" is used here to mean a firm's ability to design and manufacture space components and its competence and skill in terms of facilities and manpower for industrial performance on space projects.)

Adjusting to the new conditions has meant for some firms changing their investment and risk outlook. Allocation of investment between short-term and long-term payoff from space contracts is apparently still a matter of trial in many cases. Decisions on what to do next depend in part on the prevailing optimism or pessimism about what the future holds for industry in the development and production of space activity components. Two opposing views have been cited here.

One view holds that two situations will pertain (and probably a mixture of them), both of which will tend to keep the industry broad-based and perhaps expanding: (1) once the government decides on particular components for a series of space efforts, there will be enough of them manufactured to permit some profit from a quasi-production-line run of items; (2) ambitious space efforts will require research and development on a variety of alternative solutions to each of an increasing number of problems, and this will support many companies working on new ideas to meet new challenges.

The counterview holds that it will be the natural evolution of the space industry to thin down to a very few companies, each producing very few products for one major client -- the United States Government. The argument is based on the assumption that the government cannot afford to carry second- and third-best proposals to insure the survival of the also-rans for a day when they might have the best proposal; this support pattern, standard in the days of airframe competitions, can no longer be sustained because of the huge development costs. Therefore, sooner or later in the development of space systems, the contract winners will have achieved the special expertise and plant which those who did not participate in the contract will not have and cannot gain. Thus, at a later stage of development, new contracts would tend to go to the same firms. The argument then bifurcates: either all system capabilities would be incorporated in one organization or there would be one or two contenders in each of the major fields -- propellants, engines, space frames, and so on.

It is generally conceded that neither the economics of these possible evolutions of the industry nor the factors affecting the development and application of technology have been examined closely enough to permit more than tentative appraisals. Therefore, research would be useful to:

> . . . Attempt to foresee and delineate the economic, technological, and organizational factors which might contribute to an eventual thinning down or expansion of the number and variety of organizations producing prime space activity products. **

Partially as an attempt to be prepared for either eventuality or, out of a belief in one eventuality rather than the other, some firms have chosen, as one major strategy for meeting the profit and risk problems facing them, to invest heavily in broad-ranging research and development facilities.[4/] These are intended to supply one means for generating methods and products permitting diversification into areas outside the traditional markets of the firms.[5/] It is also hoped that they will give rise to sufficiently interesting new possibilities in the space area to stimulate the government to invest in feasibility studies, prototype development and the like, thus initiating a technological wave which, by virtue of its original role, the corporation could ride for several years as an especially qualified contractor. At least three implications of this approach to long-range investments and payoff merit closer study:

1. Should the methods and technologies developed through government-financed space contract research and development be the property of the government or the firm? If the results are to be government property (subject to waiver by the government, as is now the case) how can the government be sure that it has control over the ideas and products, especially if the firm chooses not to patent them or to exclude from the patent crucial technological information central to utilization? There has been much concern over such questions. Industry argues that the derivative ideas should be its own to patent, since space research, which it conducts in part out of concern for the national interest, cannot provide profits sufficient to satisfy corporate interests. (This matter and recommended research are discussed further in the section of this chapter on patents.)

2. How much research should the government do in-house and how much should it contract out -- when each of a number of firms has a broad range of R & D capabilities and specializations to offer? Further, what is the best distribution (and from whose standpoint) of outside research capabilities: several across-the-board facilities, each competing with the others, or a number of facilities, each emphasizing one research and development area? Research is necessary here to:

> . . . Evaluate the advantages and disadvantages of various levels and kinds of apportionment of R & D between space firms and NASA's in-house facilities; and the advantages and disadvantages of various mixes of multipurpose R & D facilities and special purpose facilities. **

3. To establish and operate their research laboratories and to demonstrate a capability that could expand into the development stage if a contract were awarded, some firms have a strong tendency to "stockpile" scarce engineering and scientific personnel in order to maximize changes for gaining major contracts. Questions arise about the effective allocation and use of this national resource. (This matter will be discussed more fully later in this chapter.)

Small-firm participation

Some observers have expressed concern about the ability of small-scale enterprise to compete and survive -- even as subcontractors -- since the usual growth and stability problems are exacerbated by the risks in performing intermittent roles in space enterprise.[6/] Small firms can afford only limited staffs and facilities to compete for and engage in space projects; moreover, allowable profits on research contracts, with little or no production, seem to confront some small firms with special difficulties.[7/] In this regard, the implications of longer-term commitments to smaller enterprises -- unfeasible under current federal budget practice -- deserve careful examination. Research is recommended to:

. . . Delineate the unique problems and opportunities which confront small firms which participate in peaceful space activities. (Case studies on situations of the sort summarized in Note 7 would be most helpful in this respect.)

. . . On the basis of the above findings, discover, if possible, means for determining the conditions under which small-firm participation in space activities is desirable.

. . . On the basis of the above, develop legal and governmental facilities for assisting small-firm participation. In particular, determine the cost and benefits and other consequences of long-term funding of specific space activities compared to present governmental practices. The implications of such a funding approach for small firms as compared to large firms should be examined, too.

Negotiated contracts and the social value of space activities

The entire philosophy of government contracting may need re-examination in its implications for both small and large firms.[8/] There is a basic difficulty to be resolved concerning what is produced and at what price in the absence of the conventional market relationships that normally prevail between supplier and consumer. As the government has expanded its role, not only as a major consumer but as a stimulator of new products, negotiated decisions have emerged as a major economic arrangement alongside the conventional market and price mechanisms.[9/] These practices are also characteristic of weapon system procurement and of practices in atomic energy development, but the space effort, because of the special attention it claims, tends to draw particular attention to difficulties of arriving at price levels that are mutually acceptable to government and industry.

Widespread dissatisfaction has been expressed by space firms over the profit margins allowed in the negotiated price on research contracts. In the absence of a price mechanism, however, the "social value" of space systems becomes especially difficult to determine.[10/] The question then remains whether the criteria arrived at outside a market mechanism are either valid or satisfactory for determining what from the national standpoint is worth producing, at what price (and what profit) and with what apportionment of public and private funds for research.[11/] Moreover, the negotiated contracts for R & D can affect the ultimate price of new products derived from the research and thereby can influence the competitive position of firms and industries involved through the subsidy of particular technologies.

A prerequisite for better understanding of the intricacies of this situation is a concurrence between industry and government on the interpretation of industrial accounting as it relates to public finance. Needed are adequate measures of corporate costs and profits over the long run where public funds become involved.[12/] The complex problem of measuring performance efficiency on space contracts in the absence of a price mechanism is also pertinent here.[13/]

As indicated above, problems of costs, profits, and negotiated contracts are not unique to space activities and especially not to peaceful space activities. Much attention is being directed to the matter in general, including considerable research.[14/] Therefore this report will reserve its research recommendations to suggesting that:

> . . . A systematic effort be made to delineate the economic and social problems associated with the negotiated contract which are uniquely contributed to it by the goals or operating nature of peaceful and scientific space activities; and those aspects of the negotiated contract situation which present unique problems for the conduct and costing of peaceful space activities.

Such information should be useful to those deeply engrossed in the intricacies of the general problem, in their efforts to develop contract arrangements which meet both the economic goals of industry and the economic and social goals of government.

Manpower problems

Space enterprise presents some firms with new and complicated manpower needs and personnel procedures, related to the great increase in the number of professional personnel involved. Management personnel need special abilities to cope with the technical subject matter and also to coordinate an extraordinarily complex variety of men and tasks.[15/] Organizing creative space technology teams and retaining them is a persistent challenge to management: there seems always to be the possibility that scientific talent and engineering skill will disrupt a program by leaving, either to accept an attractive offer of better financial or working arrangements or to go into business for themselves.

The personnel practices usual to a firm do not always work well with these innovative personnel, who seem, if effective use is to be made of them, to require special working environments and other kid-glove treatment. Practices considered useful from the profit and risk outlook of the firm -- the "stockpiling" of skill, for example, or the transfer of a man hired for work in a specific R & D area to unrelated activities where his talents can be applied to more profitable developments -- have apparently had adverse effects on the motivations of some personnel.[16/] It is not clear under what circumstances the turnover in industry personnel may increase or decrease both the quality and cost of the space products finally invented and produced. However, to the extent that government funds and national policies support the space industry, it is in the public interest to have these personnel used as effectively as is possible.

Space enterprise requires technicians and craftsmen who have meticulous "watchmaker" standards. The emphasis is on custom-crafted skills -- to turn out a wide variety of prototypes in small quantities -- coupled with increased emphasis upon versatility, imagination, and adaptation -- qualities that were considered unnecessary or even undesirable in the days of mass-produced aircraft. There has been a corresponding upgrading in the maintenance skills required for the complex equipment supporting space activities; obtaining and maintaining very high quality work adds to the personnel problems of the industry.

Since, as noted above, it is very much in the economic and social interest of the nation, as well as of the organizations using them, to provide the most effective working environment for engineers, scientists, and craftsmen devoting their creative talents to the space industry effort, research is desirable to:

. . . Learn what personnel practices inhibit creativity and productivity in the space industry environment; discover managerial and operational methods that will yield a more effective working environment; develop means for encouraging industry to learn of and use such methods.

There are wider public aspects to the personnel recruitment problem which in the long run could have profound implications for both industry and other parts of society. If space firms want highly qualified managers, engineers, scientists, and craftsmen in the numbers necessary for the wide-ranging laboratories and production facilities, they can, with the support implicit in negotiated contracts, attract scarce personnel from other socially important activities -- and especially from the laboratories and lecture rooms of universities and nonprofit organizations. They are thereby doing nothing wrong or that differs from the tactics of other industries in bidding for scarce personnel. The point is that the space industry has become a major source of competition for a scarce national resource for which many industries, nonprofit organizations (including the government), and universities are also, and will be, bidding, especially in future years as society's demands in other areas increase.

The following questions then become of central importance: Are these scarce and valuable personnel being attracted to activities which use their creative abilities as effectively as possible? In the increasingly sharp competitive bidding for their skills, is the perspective of goals being lost -- by them and by the bidders? What interests have the greatest need to be served -- those of the private corporation, of the institution of learning, of the nation, of the creative individual himself? This is a complex problem involving conflicting values about the individual, free enterprise, and the nation's needs, and careful study of the implications of pursuing one approach to the use of creative manpower rather than another is merited.

. . . Clarify, as much as is possible (1) the ethical, economic, social, or political nature of the problems of how scarce talent can and/or should be distributed, as required by the pressing needs of society, and (2) the implications of such distribution for the rights of free occupational choice and the free-enterprise right of competing for these personnel. What are the special contributions of the space industry toward complicating or resolving these problems?

Two further problems in this area deserve special attention (again, by no means solely in relation to the space industry). In the first place, there has been much concern both within and outside the industry over the effects on the research environment in the universities of industry's essays into so-called basic research. It is argued that, by providing special incentives, the space industry (among others) has added substantially to an undermining of an important social resource (as well as their future personnel supply) by attracting away from the universities the teachers and researchers necessary to develop tomorrow's engineers and scientists. It is not clear to what extent this is true or, if it is true, what alternatives are available to industry and society to compensate for important imbalances. Research is needed to:

. . . Determine the extent and ways in which industrial recruitment of professional personnel is affecting the university research and teaching situation. To what extent have teachers and researchers left the universities specifically because of more attractive offers by industry? Are there demonstrable changes in the quality, interests, and commitment of those who choose to remain at the university? Are there significant consequences for the quality and quantity of teachers as a result of this situation? To what extent have consulting relationships between faculty and industry stimulated or degraded university teaching and research? To what extent has industrial activity in basic research affected research interests in the universities? To what extent has industry replaced the university as a teaching and research facility?

. . . On the basis of the above and other related questions are there reasons to believe that the teaching and research function of the university is seriously threatened and thereby the facilities for turning out new scientists and engineers? What is the role of the space industry in complicating or resolving the situation?

In the second place, industries (including the space industry) have been attracting engineers and scientists from countries where they are in even scarcer supply than here. As European and Asian scientists are drawn to work in the United States, we may be depriving their home countries of critical skills; our national posture may suffer thereby, as well as the development of the countries involved.[17/] If this demand for foreign science personnel persists, it is not clear under what conditions the results may be good or bad for society at large, since little is definitely known in general about manpower skills in the international labor market that may be interchangeably usable from one country to another. Research is recommended to:

. . . Determine the various good and bad consequences for the nations involved from the exodus of their scientists, engineers, and craftsmen who are attracted to work in the United States. What is the role of the space industry in complicating or resolving this situation?

The space industry may, however, be making a special contribution toward easing the professional personnel reservoir for science and knowledge in general. The quality of personnel it requires and the attitude toward craftsmanship engendered by its necessarily exacting standards might also contribute to changes in perspective and ambition that could carry over to other areas of endeavor now suffering from shoddy efforts and indifferent attitudes. The stimulation of space projects may motivate more careers in science, engineering, and precision craftsmanship; the inflow could also encourage improvements in curriculums and education standards. It would be desirable to know:

. . . In what ways the recruiting and promotional activities of the space industry may be affecting attitudes toward quality work and ambitions about science and engineering careers here and abroad? Is there evidence that these activities encourage or discourage realistic career aspirations and expectations? What is or can be the role of the space industry in stimulating work standards and providing motivation for education, so as to meet the anticipated needs of the industry as well of society?

Industry and Government Relations

The greatly accelerated pace and the increased scope and significance of peaceful space activity developments as well as the expansion and intensification of government involvement in the private-profit economy all emphasize the need for adaptation of the mechanisms that heretofore have maintained relations between industry and government. Research is needed to delineate the issues clearly and to suggest new models which could be examined for their desirability as substitutes for traditional patterns of relationships. Among the political and economic issues closely affecting governmental policy and business operations are those concerning pricing and the allocation of national product, the regulatory function, patent rights, antitrust policies, and space enterprise abroad.

Regulatory functions[18/]

Since the federal government is the near-exclusive purchaser of space components, certain regulatory functions are already implicit in contractual arrangements between it and industry. Complex technical problems in space activities rule out a static legalistic approach that would disregard the operational and functional demands of society.[19/] Since flexibility in adaptation to changing roles and operations for government and industry may be necessary to take advantage of potentialities in space activities, there would be benefits in examining the implications of a regulatory role defined in terms of an evolving public interest,[20/] with the function able to act as a positive and socially enhancing instrument, rather than as a negative force to inhibit or control. Such an approach would take into account market mechanisms, antitrust considerations, and the equitable criteria for issuing commercial franchises in space operations. An early recognition of the problems and issues in space development can benefit from the government's earlier supportive activities in economic development, thereby affording the opportunity to use the regulatory instrument judiciously. Political relationships between the regulatory agency and the space community as these influence space functions and roles will also have to be taken into account.

In addition to the economic implications, there are other technical operational aspects. Inquiries have already been received by NASA from private firms about commercial launching facilities for communication satellites. Some feel it is not too early to study the conditions and provisions under which a space authority may eventually wish to control or license either the launchings of rockets or subsequent operations of space systems. Already at issue is the question of whether the government will wish to undertake launchings for industry or license them under franchise. Public safety and noxious use are two apparent areas of police-power regulatory function, and further thought would be beneficial on the full range of licensing and control that may be necessary. Other factors may warrant the sharing of responsibilities among federal, state, and local authorities. (See Chapter 6.) National and international institutions will have to set safety standards and inspection systems for commercial space vehicles and space traffic, including launching and recovery areas, noise levels, and space vehicle radio frequencies. (See Chapters 3 and 8.) There are also problems related to indemnity liabilities of private firms here and abroad for accidents incurred at the launching pad or from re-entering space vehicles.21/ Whether the indemnity factor in space enterprise will loom as large as did safety considerations in nuclear energy radiation remains to be seen. Also to be considered will be assurance by public law (as under the Atomic Energy Act) of nondiversion of space activities to military purposes or other harmful uses.

An overlapping regulation area has to do with nuclear powered rocket motors. Radioactive particles could be spread by malfunctions at launching (if nuclear first stage engines are used or if upper stage nuclear engines are demolished on explosions of first stage chemical engines) or by impact on land or water if the nuclear engine fails to go into orbit or beyond. They could also be put into orbit if a nuclear powered engine or power reactor in a satellite were to be demolished. These last two possibilities would seem to imply international regulatory arrangements.

In the light of the foregoing problems and issues, research is recommended to clarify: 1) concepts and objectives of regulatory functions and roles, 2) economic and legal implications of government-industry enterprise, and 3) the role of interest groups as they affect the governmental authority. In particular:

. . . A continuing study should be done on the economic and political objectives of regulation of space activities. Among the major questions: which space activities are to be regulated and what are the contingent factors involved? **

. . . Case studies are also recommended on the economic and legal implications of mixed public-private enterprise. Pertinent material may be found in the history of hydroelectric power and atomic energy development. The experience of the Atomic Energy Commission and the Federal Aviation Agency is replete with what appear to be analogous problems and may be suggestive of certain lines of solution.22/

. . . So that any proposed space regulatory function will not be static and thwart further potentialities for growth in the pertinent space activity, preparatory research would be desirable to clarify and specify the processes and arrangements involved, congressional appropriations and powers granted, and the potential influence of space interest groups.

Patent policies

The conflict over patent policy in space enterprise ostensibly concerns the ownership of devices invented by private enterprise and developed with public funds, but much of the inconsistency in arguments and confusion of issues stems from attempts to evaluate an invention law devised in the time of Benjamin Franklin and applied in the age of Von Braun. Organizational research within a much more complex industrialized society poses intricate questions on the implications of the patent system.

The relative merits of the patent system in a free enterprise economy are not lightly resolved. A well-known political economist has concluded: "No economist, on the basis of present knowledge, could possibly state with certainty that the patent system, as it now operates, confers a new benefit or a net loss upon society."[23/] It bears noting that the incentive to innovate, originally encouraged by patent privileges, may now be paralleled or superceded by the encouragement of government support, especially in areas such as space activities. The issue over proprietary rights in invention is not limited to arguing the pros and cons of the patent system.[24/] Alternative means may have to be sought to encourage, for the national benefit, vigorous exploitation of new technologies, since under some circumstances patents are considered inadequate protection and firms, therefore, decide to restrict the dissemination of new findings entirely. The government's intentions, as expressed in present or revised patent policy, and industry's desire to retain title to technology that may be commercialized in the future must somehow be reconciled. Contractor equity is a matter that concerns efficient government operations, but the side effects upon our economy are of no lesser importance.[25/]

Aside from legal, institutional arrangements between government and industry, many scientists and engineers object to the kind of publication that is legally required under the patent system. They object to limiting the amount of scientific knowledge and the compromise in professional standards that institutional and legal considerations often demand in preparing a patent statement. Legally avoidable scientific and technological information is purposefully left out of commercial patents to protect competitive positions.[26/] As a result, there has been speculation about new systems that might exist alongside traditional patent practices, permitting alternative means of publication. Such new systems would be intended to fit much more closely to professional standards for scientific publication and would be designed to bring about an acceleration in the accumulation of knowledge.

Clearly, the patent question transcends space interests, even if they have helped to draw attention to the problem. Research requirements in terms of the space industry's interests center upon the need to clarify and understand the issues about (1) the effects of patents in helping or hindering creativity and enhancing or inhibiting the spread of innovation, (2) the effects of the patent system upon other economic aspects of our society, and (3) specific aspects related to federal government patent policy, as follows:

. . . Case studies are desirable on the way organizations may have used or avoided patents to enhance their own position in space activities, and if the patents were so used, what the good or bad effects upon competition and the spread of innovation and information have been. Aspects meriting examination:

Are there significant differences between profit and nonprofit organizations in the way patentable ideas are handled in the space area? If there are differences, what, if any, are the effects upon creative output and professional standards?

What is the contribution of government programs and purchases in stimulating industrial innovation? How does this compare with the contribution of the patent in stimulating industrial innovation? In the space industry in particular, under what conditions is government initiative and support considered a better path to profitable activities than that provided by patents? Under what conditions would investments in major developments have been likely if the possibility of patents were the major stimulus instead of government support?

Related to this, what are the prevailing attitudes in the space industry about the likelihood of getting patents on complex developments -- and of having them successfully contested or being able to contest a competitor's patent? Under what circumstances is it believed that patenting something will weaken the firm's competitive position by revealing too much about the product and its manufacture?

Are there specific types of delays and difficulties in dealing with contractors -- under the patent policy that retains waiverable government property rights, as compared with those agencies retaining only a "royalty-free, non-exclusive" license? If so, what are the specific adverse consequences? What means could be used to avoid these consequences?

. . . In the light of the findings from such case studies, research is necessary to determine the specific areas of compatibility and incompatibility between patent law and space technology research and development.[27]

. . . Research is needed to develop alternative ways to publish technological information and other claims on methods and products so as to retain proprietary rights without compromising the professional standards of the scientist and engineer.

. . . Under what circumstances would a uniform federal agency patent policy be useful or desirable, at least from the standpoint of developing space activity products?[28/] How does the patent policy of one agency affect that of another in dealing with contractors -- e.g., the Department of Defense and the National Aeronautics and Space Administration? Are there useful analogies in the histories of government-retained patents by the Atomic Energy Commission as compared to the National Aeronautics and Space Administration: have valuable ideas merely disappeared into the files, or have they in fact entered the public domain?

. . . How would patent arrangements with other nations affect the international aspects of space programs and our national posture?

. . . In the light of the findings of such studies as those enumerated above, how effective is the patent concept in meeting the intentions originally embodied in it? Can its present assets be enhanced and its liabilities eliminated in general or for specific situations (such as the space industry context), or are alternative or supplementary arrangements necessary in this area of organized invention and complexly interrelated and interdependent ideas and methods? If the latter is so, what are the conditions which a supplemental approach must meet?

Restraint of trade considerations

Space firms are proposing that the antitrust provisions be amended to permit large-scale cooperative enterprise.[29/] There appear to be good reasons for examining the legalistic concepts of competitive practice and "unreasonable restraint of trade" in the light of the functional requirements of developing space programs efficiently, as well as from the standpoint of general public policy for avoiding monopolistic practices contrary to the public interest.[30/]

Some observers argue that the great costs of space research and development and the interdependency of separate R & D organizations on the knowledge gained by each other imply that a more efficient arrangement for developing space activities would permit greater cooperation and integration between corporations than is now permitted by law. In particular, there is concern that, despite the growing need to pool information, some firms, in the light of the antitrust history, are very wary of exchanging information with one another because such exchanges might appear as collusion with intent to restrain trade. That such in fact might be the intent of the exchange worries other observers. This is a special problem for those firms which have a "mix of products" which include competitive commodities in the open market.

The prime contractor system is felt by some to have inherent in it possibilities for restraining trade, since the prime contractor has great power over what parts of the contract it will do and what parts will be subcontracted out. Whether or not the prime contract system is reinforcing economic concentration, and if so whether or not this tendency is contrary to the public interest, are subjects for study.[31/] Finally, if the number of corporations involved in space enterprise narrows down as described earlier, this economic concentration will itself involve monopoly issues.[32/]

There is a question of whether it is possible merely to bridge a gap between extant law and practice or whether these space-inspired interdependencies call for rethinking the entire approach to lawful arrangements appropriate to the scale and mode of space enterprise. In general, the question arises of how much reliance needs to be put on competition or regulations and how much can be accomplished through the government's own purchasing policies.

There are, of course, many aspects to restraint of trade which are not unique consequences of space activities but which have their influence on the space situation. (To be sure, weapons systems developers face these problems, too.) Those studies which have as their object an assessment of the implications of complex system development for antitrust policy could be aided by research intended to:

. . . Make clear the specific aspects of space activity research and development which are inhibited or stimulated by existing antitrust limitations on cooperation and data exchange. A case study approach should be of great value here. In the light of these studies, specify what arrangements would benefit the space program; in what ways these arrangements are incompatible with present antitrust laws; and what changes might be introduced into the laws which would benefit the space program and yet protect the public interest above and beyond the requirements for efficient space system development.

Space enterprise abroad

The $12 billion national defense budgets in West Europe, which include rockets and missiles, in part account for the establishment of American firms in Europe.[33/] One firm at least has expressed an interest in marketing disk antennas and other satellite tracking equipment to such countries as France, Japan, and Australia, and private firms now furnish a small number of rockets to foreign governments for scientific space probes.[34/] If present trends continue, many space components may be developed or manufactured overseas. Some overseas installations are already taking advantage of foreign technological capabilities in space programs.[35/] Lower costs in many cases also contribute to the move into foreign enterprise.

As space enterprise moves into foreign countries, it will be exporting techniques and industrial capability either in extending markets or in seeking technical support. In the field of atomic energy, the "Nth" country problem is concerned with the diffusion of nuclear capability among many nations. This diffusion of capability carries with it contingent political implications of strategic power and control.[36/] There may be analogous implications for the space duopoly between the United States and the USSR. Hence, the potential divergence or reinforcement of commercial and national objectives (and its expression in foreign policy) is a vital consideration in anticipating and planning for emerging space enterprise abroad.(The dealings between German and American firms during World War II over patents and markets is an indicative case where sharp divergencies developed between legitimate commercial criteria and the national interests of security.[37/]) On the other hand, the international competitive position of some aspects of space enterprise (such as global communications by satellites) may eventually become a question of national image, as was the case with our world maritime position and later with air power.

Research is recommended to determine:

. . . The social and economic costs and benefits of exchanges of information, methods, science, and technology, related to the development and/or use of space equipment, between United States corporations and foreign organizations. Detailed study is necessary to systematically explore the complex relationships between foreign policy and its several goals, and the stimulation or inhibition of free enterprise overseas in the space area. Worth special attention in this regard are:

The role of the government in supporting and stimulating the technology which may then be shared overseas for private and/or national reputation purposes.

The extent to which classified information and/or devices associated with space may help or hinder opportunities for industrial enterprise overseas.

The ways in which the exchange of information might have broader effects on the general competitive position of the United States by enhancing the comparative technological and production capabilities of this nation or other nations. Each of these studies should be done with particular space developments or products and particular foreign policy goals in mind. An examination of a variety of these hypothetical situations should help indicate common problems which require legal and political resolution to meet both national and private interests.

8. GENERAL IMPLICATIONS FOR INTERNATIONAL AFFAIRS AND FOREIGN POLICY

THIS CHAPTER IS CONCERNED with the interactive relationships of the planning, requirements, and achievements of space programs with the policies and organizational arrangements of nations and international bodies. Attention is especially directed to the international implications of space activity and of its control, regulation, inspection, and operation that are of broader aspect than those specifically pertinent to such potential space events as global communications and weather prediction discussed in earlier chapters.

Participation in space exploration for peaceful purposes may not give any one nation or group of nations many positive advantages over equally serious participants, but each nation or group would probably enhance its position relative to those nations which cannot participate or do not choose to do so. However, the consequence for a major power of participating fully, slightly, or not at all is still largely a matter of conjecture. Some informed observers believe that, should the major powers decide on all-out competition in their space programs, the social, economic, and military effects of the activities (aside from the effects that the operational status of intercontinental missiles with nuclear warheads is already judged to have had) would not significantly alter the existing relations among the powers, although, according to one observer, "the prestige effects may indeed turn out to be the major consequence of outer space activities in the international system."[1/] But it has also been surmised that "foreseeable technological developments will sharpen existing tensions between the United States and the Soviet Union and provide fruitful sources of new ones....Certainly the competitive exploitation of space opens a new arena for the conduct of cold, limited, and even hot warfare."[2/]

The findings of the research that will be suggested here may contribute to an understanding of how the impact of a nation's peaceful space program can be analyzed.[3/] The studies are primarily related, however, to the opportunities for positive advances in the United States policy of achieving a securely peaceful world through novel forms of international cooperation or unilateral operation in the space field. Although it is possible that space activity may eventually be totally internationalized, the assumption is made here that in the first instance the United States will have a major space program which will be substantially operated and financed domestically and matched in size and variety only by the Soviet program and possibly one or two others. (The implications of an exclusively internationalized or supranationalized program would call for studies similar to those suggested here, in that they should be designed to increase understanding of the ways in which space activities may contribute to a peaceful world politics.)

Space Policy and Its Implementation

The guidelines for space policy as laid down in 1958 by national and international groups implied these outstanding stipulations: (1) that outer space be used for nonmilitary purposes only, (2) that outer space should especially be used for genuine scientific exploration, (3) that the contributions of both domestic and foreign nongovernmental organizations to space activities should be encouraged, and (4) that international organizations and other forms of international cooperation should play a major role in the use of outer space.[4/]

For a variety of reasons, these four stipulations have not been fully heeded since 1958. The military interest in missiles was already well established at that time and has not yet been the subject of serious arms control negotiation;[5/] it has extended to some specific satellite systems and to an unspecifiable number of basic experiments employing rockets and satellites. The organization and implementation of the United States space program now emphasizes a duality: NASA and its rocket and satellite activities are dedicated to a policy of "openness" and essentially peaceful endeavor, whereas the experiments and satellite systems of the Department of Defense are kept secret -- to the extent that this is possible or militarily desirable -- and are intended to serve military purposes.[6/] The inherent difficulty of maintaining this duality in the international context is reflected in the occasional interpretations of scientific and technical feats as demonstrations of military prowess and of military testing and operations as innocent scientific inquiries. Scientific space exploration has been to some extent mixed with activities of two other types: those that primarily have military applications, and those that primarily are propaganda efforts designed to maintain a popular image of our national stature as impressive and forward-looking.[7/]

The opportunities for private initiative which existed during the IGY and which some competent observers regarded as an essential contribution to the distinctive success of the IGY and the organization of its early satellite and rocket programs are either no longer present to the same extent or are kept within stricter bounds by the interests of both national and international governmental agencies. Prior to the creation of NASA, the scientific aspects of our earth satellite programs were the responsibility of the U.S. National Committee for the IGY, operating under the nongovernmental National Academy of Sciences.[8/] NASA now has the responsibility for satellite and rocket programs, and the Space Science Board of the National Academy makes recommendations to NASA and otherwise acts in an important advisory capacity to operating agencies. There has thus been some shift of planning and operations from nongovernmental to governmental organizations.

The trend toward governmental responsibility is supplemented by a further trend toward national and bilateral activities as compared with the use of international organizations or multilateral mechanisms of international co-operation. The ad hoc committee which the United Nations established to consider the peaceful uses of space concluded that the United Nations should not play an active role in space operations. An early suggestion that the United States might launch complete scientific payloads that would be recommended by the Committee for Space Research (COSPAR) of the International Council of Scientific Unions (ICSU) appears to have been neglected in favor of bilateral arrangements, about which COSPAR is kept informed and its advice and comment sought.[9/] The plans of the International Astronautical Federation to establish an Academy of Astronautics and an Institute of Space Law have had no co-operation from Soviet and certain other participants, who stated that existing international arrangements in the space field were adequate.[10/]

It was the hope of many who were involved in the IGY and the early stages of our space program that important nongovernmental and international groups would play a significant part in furthering the United States' policy of espousing the peaceful and scientific use of space. That the hope has not been fulfilled to any large degree is undoubtedly owing in part to the sizable physical and economic requirements of many space activities and the rapid incorporation of space strategy into military strategy (compared to the rate of its incorporation into nonmilitary planning) as well as to the mutual suspicions of the United States and the Soviet Union. However, it is increasingly clear that the original publicly stated guidelines for space policy were incapable of being maintained undiluted -- because detailed knowledge of how to maintain them was lacking.[11/]

Good intentions alone cannot meet the challenges inherent in this complex field. They must be supported by a detailed working knowledge of the bearing of international affairs on the design and operation of experiments, equipment, and organization concerned with technical matters; on the drafting and negotiation of enforceable agreements about technical subjects; and on the accurate and timely assessment of social and material impacts of scientific and technological developments. The technological and social complexity of these problems will also require the systematic application of the findings of intensive research in the behavioral sciences, such as anthropology, social psychology, and sociology.

One of the science advisers to the President has stated the need for general research in respect to the whole of science in relation to foreign affairs: "Essential to these efforts is the development of an academic field of teaching and research in the interrelationship of science and foreign affairs, in order to provide education in and better understanding of the underlying significance and opportunities of this relationship."[12/]

Research on Potential International Aspects of Space Technology and Science

Sharing of costs

The equipment systems for a space program involve missiles, sounding rockets, earth satellites, deep space probes, and ground-based resources such as tracking, communications, launching, and recovery facilities, telescopes, and centers for data reduction and analysis. The cost of such systems is so large that few nations can support a major program, and at present only the United States and the Soviet Union do so, although there has been discussion of a multinational European program.[13/] The vast resources required for the United States' effort -- and those even more vast foreseen for the future -- have prompted suggestions that world-wide cooperation be sought.[14/] How the costs might be shared, however, or what the consequences might be for the control of policies and program has not been made clear.

The economic costs of any space program must ultimately be translated in terms of allocating specialized and therefore fairly limited materials and manpower. Thus, supplementary background research is desirable to determine:

. . . What are the size and nature of sharable costs of individual facilities or pieces of hardware and of separate units of world-wide networks associated with space activities. (Relevant estimates of the technical feasibility of having separate nations provide components for each system might be assisted by the experience of NASA and the Department of Defense with the system of prime contractors and subcontractors.) This general inquiry would provide one basis for assessing the significance of such sharing arrangements as those among NATO powers and the possibility that the domestic savings could be used effectively for other purposes.15/**

. . . Which nations are potential suppliers of personnel talents, special pieces of hardware, and the more routine "housekeeping" needs of a large enterprise. This inquiry could provide a basis for estimating the extent to which the U.S. program might be shared and also the viability of possible regional programs in Europe and Asia.16/

. . . Who would be the potential beneficiaries from the benefits gained by sharing costs. (From an international point of view, the potential users of specific direct and indirect products of a space program may well be more limited than the universe of potential specific contributors.)

Clear examples of intranational payment arrangements are furnished by the hourly rental use by NASA of the Jodrell Bank radio telescope in England and related equipment and the purchase by various European nations of the Asp and similar U.S. sounding rockets.17/ The experience of American scientists, government agencies, and businesses in hiring foreign personnel to carry on technical investigations or to process data in their own countries could also be informative. It would be appropriate to study:

. . . Existing arrangements for international payments for space science or related activities and the indicated opportunities for further specifying the costs and returns of international space activities on an economic basis.

The technical operations on which various nations cooperated during the IGY included many of special pertinence to space programs, among them the provision of satellite tracking devices and launching of sounding rockets. The total experience -- including the economic benefits that may have resulted directly from the space technology and activities of the IGY -- in this multinational cost sharing should provide useful insights into some of the problems of a shared space program.[18/] It would be appropriate to study:

. . . The costs and benefits of various IGY programs, and, in the light of those, the ability of different nations and their scientific groups to support such work on a continuing basis.

The imaginations of the engineers and scientists involved in space programs have demonstrated their capacity to strain the human resources and purse strings of even the mightiest nations. The enormous scale of the human and economic activities thus created has produced major administrative problems and a pressing need to establish mechanisms for coordinated and cooperative efforts. It is obvious that the international factors inherent in space operations magnify such problems; for example, the increase of science activities on an international scale prompted the inclusion of an arbitration clause for the first time in the charter of an ICSU special committee.[19/] The problems involved in sharing equipment and operations with friendly nations, let alone with suspicious political competitors, and in estimating the ultimate benefits and cost of such sharing cannot be efficiently defined or solved on an _ad hoc_ basis. Very carefully designed studies are necessary to determine:

. . . The economic, managerial, legal, and political aspects of specific (albeit hypothetical), economically motivated proposals for booster, data center, or tracking station sharing by, for instance, NATO nations, or other groups of nations, or the United States and the Soviet.[20/]

At the present time the United States is providing financial support in one form or another for a very large portion of the free world's space program. (The consequences of this for the United States are not entirely clear at present, but they apparently include the development of a unilateral space policy on our part and -- possibly -- a reluctance to give financial support to some other scientific or nonscientific projects which might also further our international objectives.) There are a variety of ways in which support is given to foreign space enterprises. For example, certain U.S. facilities abroad provide for local participation and free use of equipment when it is not otherwise needed. We also, as noted earlier, contract for the use by the hour of an existing laboratory installation.

To some extent the potentialities for new space discoveries by scientists in foreign laboratories thus depend on the breadth of the mandate of funding agencies such as NASA, the National Science Foundation, and the Department of Defense. Other consequences of the situation are not known, but should be known. Research is necessary to determine:

. . . The various ways in which financial support is now given to foreign space enterprises and possible means of broadening the range of available methods. The similarities and differences between the various domestic and foreign approaches to financing research should be examined. (A domestic equivalent of this same problem is the manner in which government agencies support academic and industrial research and development work.[21/])

. . . The ways in which foreign currencies resulting from the sale of U.S. surplus foods abroad, special tax provisions, other mechanisms for encouraging public or private expenditures and investments abroad might aid international cooperation on our space program.[22/]

. . . The influence U.S. economic support in its various forms can have on the character, quality, and quantity of scientific and technical work done abroad.

Although the direct cost of supporting leading space scientists and engineers and their intellectual exchanges of ideas and information is small compared with the over-all cost of a space program, the implications of such support in respect to the international aspects of a space program should not be overlooked. Scientists in every country are, for instance, dependent on modest but nevertheless tangible financial support merely to keep themselves and others informed of the current state of knowledge. It has been suggested by responsible persons that the rules of COSPAR and its parent organization, ICSU, governing the expenses for staff and travel might limit the usefulness of COSPAR as a representative body which can maintain and encourage interest in space research.[23/]

Relevant knowledge and understanding of the interplay of financing, administration, program planning, and operations in the context of international scientific and technical activities could be gained from case studies of:

. . . The International Atomic Energy Agency and the manner in which economic arrangements have influenced its policies and technical character.24/

. . . The administration and financing of the European Center for Nuclear Research (CERN). The Center has been discussed as the model for a European Space Research Organization.25/

. . . The arrangement whereby the federal government participated in the United States IGY program with especial attention to the satellite and rocket program as designed and carried out by the National Academy of Sciences. This arrangement deserves special study because of the novelty of this mechanism on the American scene, the approval which it appears to have had among a considerable number of scientists, and the direct bearing of the program on our subsequent space policies and programs.

. . . The proposals for public or private financial support of the activities of the World Meteorological Organization, The International Telecommunication Union, COSPAR, a NATO Space Science group, and the IAF Academy of Astronautics and Institute of Space Law. These should be examined to discover the likely roles of the financial supporters and the possible implications for internal controls over financing and financial decision making.26/

The need for special skills

The extraordinary variety of special skills, talents, and interests required for a space program may exhaust the specialized manpower reservoir of any one nation; the need suggests many opportunities for cooperation. NASA operates -- alone or jointly -- a number of overseas optical tracking and minitrack stations which employ other than American personnel in technical positions.27/ Although the tasks to be performed in such positions are quite clearly defined, there appears to be considerable room for resourcefulness -- for instance, where research stations may have opportunities for independent space research.28/

A space program imposes unusual demands for close coordination between scientists and engineers and the development of "teams" of participants. It may also demand the retraining of individuals and the introduction of new and exotic skills. In the international context these demands pose additional problems. Possible functional divisions of labor exist between basic design work, the preparation of necessary hardware (including instrumentation) for satellites or rocket-probe launchings, and the processes of recording, analyzing, or applying the resulting information.29/ If, as seems possible in terms of available manpower resources, few individuals and groups here or abroad will be able to make a balanced contribution covering all functions, it would be desirable to study the significant political and social factors having to do with the allocation of controls and responsibility and with the distribution of benefits and prestige associated with the final product.

Professional scientists, engineers, and other specially interested persons may participate in the United States' program directly rather than as representatives of the interests of other countries or of international organizations. Such participants could be of varying advantage or disadvantage for the program. It is possible that they would have differing ideas about the relationship of a space program to other competing endeavors. They may have conflicting national loyalties; be looked upon with special respect or suspicion by their countrymen; embarrass efforts at secrecy whether or not they are privy to secrets, since a well-trained mind can sometimes produce or analyze technical capabilities without benefit of confidential knowledge. Differing estimates of suitable proportions of emphasis within or between space sciences and space technologies could be a source of disagreement between professionals hailing from variously oriented regions. Such disagreements could easily lead to international friction and hence weakening of our international posture.

If participation of skilled individuals from different regions of the world becomes, as would seem likely, a prerequisite for a comprehensive space program or is desirable also for major policy reasons, research will be necessary concerning:

. . . The problem of standardizing terminology, procedures, and training.

. . . Incentives for special training, working conditions, and personal economic security appropriate to different societies. In this context special attention should be given to the tendency of some persons or groups contributing skills to exploit secrecy or gain priority rights over scientific data; ways to counteract this should be sought if the interests of science and the program could better be served by more complete sharing of data and skills.

. . . Appropriate means for instituting world-wide inventories of technical talents and for measuring interests as they might bear on a space program. Such a study might build upon general investigations already under way of scientific and technical resources and needs.[30]

The complex and costly supporting apparatus for most space science activity makes it particularly important that persons who might provide key ideas be discovered and drawn upon regardless of their country of origin. There is need for a more adequate knowledge of how to develop, use, and coordinate many different talents in many different countries.[31/] One useful approach to this problem would be to study:

> . . . Instances of collaborative international and supranational scientific undertakings, including comparative studies of: foreign trainee and research programs as developed by universities, the AEC, and the Defense Department; the operation of CERN; and various technical aid projects of the IGY program, including such situations as the integration of foreign scientists at IGY stations in the Antarctic that illustrate working relations between local and foreign-trained personnel.

The activities of COSPAR and the IAF contribute on the international level to the recruitment and training of persons with skills needed for space programs. These organizations and perhaps others which may come to surpass them in importance need to be studied to determine:

> . . . The opportunities that are offered by organizations with international scientific and engineering interests for the recruitment and training of scientists, and the political, economic or social factors that might facilitate or hinder these opportunities.

Since the end of World War II individuals from many parts of the world have come to the United States for training in nuclear physics and engineering, in relation to atomic energy programs. It has been pointed out by informed persons that these trainees have not always been able to use their new and very specialized talents effectively on returning to their native countries, and that this sometimes results in personal and official frustrations which can have serious consequences for the training programs and the enlargement of the specific technologies involved. In regard to NASA's offer to support foreign scientists on fellowships for training in space technology, it would be desirable, then, to examine the possible parallel in relation to the danger of overspecialization. Much basic information could be gained through study of:

. . . The positions now occupied by foreign scientists who have been trained in nuclear physics since World War II, and the prospective positions for those foreign students who might be encouraged to specialize in some aspect of space science or engineering.

In addition to utilizing already available skills, the opportunities for developing such skills in countries where persons having them are scarce or nonexistent are worth exploring. However, consideration should be given to the following questions. In the light of the specific values and ambitions of such countries, will training personnel in the skills pertinent to space activities be seen as the best way to use their scarce, talented manpower? Can technical participation in space-related activities provide means also of other training and participation that would be useful to these countries for reaching their own goals (e.g., operating hydroelectric installations)? Research is desirable to:

. . . Provide means for classifying United States space projects in terms of the contributions they might make to the economic or other development of specific nations.[32/]

. . . Design and use means for measuring long-run and short-run benefits which a nation might derive from the exploitation of its various capabilities in the sciences and technology.

. . . Determine the cost and benefits to the United States of encouraging the participation of other nations by training technologists for them in space activities.

The use of technological by-products abroad

The discussion in Chapter 5 of the possible by-products of the space program included several that might have use abroad. One special form of by-product which may have particularly important international implications is the equipment that has been outmoded by the rapid technological advances during the developmental phases of various space projects.

The innovations needed in some regions of the world may differ radically in kinds and degree from those needed in others. A technological device that has been rendered obsolescent for the needs of a demanding development program by the program's own rapid pace may very well meet a pressing need in another setting. The high degree of automation, miniaturization, and high reliability that is necessary in space technology suggests, for instance, that "surplus" devices with these characteristics might have special usefulness in regions where, due to present lack of technical knowledge, maintenance services are rudimentary. Thus it would be appropriate to examine:

. . . Prospects and problems in the distribution and peaceful use of surplus space equipment in technically "backward" parts of the world.

. . . Possible ways of identifying in advance specific surpluses of usable and adaptable first, second, and subsequent generation rockets, payload instruments, ground support equipment, and communications systems which could create a viable "foreign market."33/

. . . Possible analogies between the disposition of surplus space equipment and the disposition overseas of World War II and more recent surplus military and civilian equipment.

. . . The bearing of past experience on how both government agencies and private industry can and should arrange overseas disposal of such surpluses and utilize other by-products of the space program.

Geographical factors and their effects on space operations and national prerogatives

A country's location may lend it special importance with respect to one or another aspect of a space project. For example, to put satellites into special orbits -- such as equatorial or polar -- some locations are more advantageous for launchings than others.34/ Tracking and recovery requirements for various operations necessitate cooperation from nations whose sites and terrainal features make them important to these tasks. Rocket soundings of the atmosphere may also put a premium on the use of certain sites.

National efforts to be independent of international cooperation and coordination in relation to these considerations may not only add to the expense of a program, but also restrict it in various ways. The technological feasibility of some programs could depend on multinational cooperation.35/ And of course the extent of cooperation will affect both the opportunities for involvement of scientists and engineers from different countries and the kinds of scientific work undertaken in a given project.36/

Because each geographical location is typically under the control of only one nation if it is not part of the high seas, important international aspects are thus built into many space projects. These may possibly be anticipated with the aid of research concerned with:

. . . Problems and opportunities likely to arise from geographical assets or liabilities for particular space activities and the range of political and legal means available for suitable national responses.[37]

. . . Specific compilations and evaluations of the legal and political factors affecting the status of testing ranges in the oceans, globe-circling reconnaissance devices of all types, and similarly identifiable problems.[38]

. . . Retrospective examination of how international legal and political problems were posed and disposed of in connection with some of the IGY activities.

Contributions to science

Characteristically, major scientific discoveries and developments have ultimately transcended national boundaries, and there is no reason to suppose that those resulting from space programs will be exceptions. However, such a space discovery may also have short-term advantages for the one nation or another that can exploit it soonest. In such case, cooperation might then be effaced by a severe struggle, which the scientists themselves would either participate in or be helpless to modify, and which would disrupt the program development of the nations involved. It seems obvious that a well-established and firmly regulated plan for global data sharing is the preventive measure that might best guard against such situations. Thus the progress of science would benefit from studies that developed:

. . . Comparisons and evaluations, from the standpoints of scientific, national, and commercial concerns, of the relative utility and applicability to expected space-derived data of practices developed for international science data sharing. A study of the formal and actual arrangements for depositing data in the IGY World Data Centers, with special reference to the space sciences, might well reveal the particular problems and interests confronting scientific groups in different nations in their attempts to participate in the global scientific community.

Of special importance for the advance of space science is the possibility that some scientific discoveries or experiments may be temporarily or permanently impaired by unilateral national activities. Even assuming that an agreeable definition of purely peaceful scientific exploration could be arrived at, careful study will be required to determine:

. . . The suitability of possible controls over the launching and operation of scientific satellites and the means by which these satellites, or other space vehicles and activities, could be protected from interferences or destruction.

The danger that space discoveries might be impaired by indiscriminate activities has been foreseen. Some of the requirements for protecting radio astronomy and investigations of the existence of biological organisms in outer space have been delineated;[39/] other activities, however, which might effectively hinder future scientific inquiry must be expected. (The proposed orbiting of a belt of tiny wires as part of a communications system is a case in point; according to some scientists this could "block the passage of signals employed in other vital space projects."[40/])

Because of the global and all-encompassing nature of space science experiments, the actions of one nation or group could have an enduring detrimental effect on all scientific investigations of a certain sort. COSPAR has now assumed the obligation to protect the interests of science insofar as it can by alerting scientific communities to the possible consequences of rash space explorations and by stimulating voluntary agreements to take standardized precautionary measures. It cannot be assumed, however, that those scientists whose work would be most affected are necessarily in the best position to recognize the danger and effectively enforce the behavior which their science requires.[41/] There is a need to initiate research to determine:

. . . Appropriate means for identifying and weighing the consequences for science and for society of irrevocable acts related to space exploration and exploitation.

. . . Various means -- available and further required -- for international regulation of scientifically undesirable space activities.

The Status of Space Programs in International Affairs

Within the foreign affairs context, a space program accelerates the blurring of the well-developed administrative and diplomatic distinctions between private and official activities and between military and peaceful activities. In the United States the distinction between the private and official activities of any citizen has been an important one, but it may now have to be reinterpreted as the space program is developed and executed as an integral part of U.S. foreign policy.

Traditionally, the private aspects of a scientist's work have been emphasized, but as scientific research increasingly requires more cooperative effort and financial support and produces information of obvious and direct national importance it takes on public and even official aspects. There is a question of both the manner and extent to which scientists here and abroad have been "instructed" in the interests of their countries and the extent to which governments have preserved domains set aside for the exercise of private and unofficial initiative on scientific and technological matters having international implications. These intangibles need to be identified and studied.

Many international rules and regulations are based on clear distinctions between military and peaceful activities and equipment.[42/] The components of a full space program are not, however, inherently amenable to simple classification on this basis, as the following comment of a former leading scientific adviser to the government indicates: "I find it just as difficult to differentiate between military and nonmilitary science as I do between national and foreign policy in this contracting universe. The electronic-nuclear-micro-organic-astronautical age in which we live is only a military age if we choose to apply these scientific areas to military activities and becomes a peaceful age if we create peaceful applications for these scientific developments."[43/]

There are many potential international ramifications of this lack of clear separation of military and nonmilitary aspects of space exploitation, some of which pose problems while others offer opportunities. Overtly peaceful explorations of space may conceal military preparations or else serve as demonstrations of potential military might, whether or not this is intended;[44/] some military space activities may possess considerable inherent technical and scientific interest and receive assistance and approval on that basis. However, nations may have an increasing interest in demonstrating, with the aid of objective standards, the exclusively peaceful nature of particular space projects.[45/] If we plan to make major efforts to convince ourselves and the world of the distinction between our peaceful and military activities in space, it is desirable to understand the attitudes toward these two types of space activity held by those in other nations.[46/]

Popular and leadership attitudes in other countries toward United States reconnaissance satellites and toward statements concerning the orbiting of weapons merit careful evaluation. Although no definitive data have been collected on the matter, there is evidence of a widespread feeling that satellites can fall out of orbit, reach the ground, and do great damage. This feeling would not be eased by the realization that orbited weapons would be designed to return to earth in fully operative "combat" condition. Persistent research on and testing of military space systems may generate an attitude of hostility toward all space activities, no matter how much their scientific nature was proclaimed. There has been speculation that some nations will encourage the development of observation satellites, since their existence could reduce the incentive for surprise attack and therefore for pre-emptive nuclear warfare. Nevertheless, the same nations might well resent careful surveying of their own sovereign activities.

Claims of the legitimacy and peaceful value of navigation, communication, and weather satellites may be questioned, since the value of these to military operations is also obvious; the claims may be especially jeopardized if civilian and military users share satellites and ground facilities. It would seem to be most important to insure that activities undertaken in the process of developing precision satellites of all sorts and in planning for the international cooperation that will be necessary to their maintenance and use are not construed by world publics and their leaders as threats-in-disguise against security and sovereignty.

On these various matters, research is appropriate to:

. . . Ascertain now and over time the extent to which pertinent publics and persons in significant nations (including Eastern Bloc) subscribe to and believe in our distinction between military and peaceful space activities.

. . . Determine what characteristics of our space activities, under what circumstances, are perceived by them as within their definition of military or peaceful, and which are held to be ambiguous.

. . . Determine what effects specific military space activities can be expected to have on foreign inclinations to be supportive of scientific and peaceful space activities.

. . . Develop means for anticipating difficulties in this area and overcoming them if possible by adequate advanced explanations and plans for inspection and control arrangements in which the international community is encouraged to participate.

Although technological advances have injected many complexities into the wide range of foreign policy concerns of the United States, it is reasonable to assume that ad hoc solutions are not necessary (and might be harmful) and that optimum solutions can be arrived at. It seems certain, however, that the solutions will not be found without careful study directly concerned with international affairs and involving technical details of space programs.

International cooperation on organization and control

One pillar of United States foreign policy has been the support and encouragement of international cooperation and the control of aggression and armaments through the development of world-wide and regional international agreements and rule making, law enforcement, or operating organizations. An increasing number of expensive international scientific enterprises, including the IGY, the Antarctic and oceanic programs, and CERN, are being justified in part by their contributions to peaceful constructive cooperation. A space program might make unique contributions to this policy (1) because of the global nature of many of its activities, (2) because of world-wide interest in the exploration and exploitation of outer space even though only two nations now have major space programs, and (3) because of the most significant new role being played by private or quasi-private international and transnational scientific organizations.

Realistic emphasis upon the uses of outer space to further peaceful ends necessitates the recognition that the potential military and other aggressive uses of space may have to be actively controlled, by peaceful space means. Radio frequency interference, for instance, and the development and use of anti-satellite missiles can be forms of aggression in space, although they have little to do with direct military threats. On the other hand, satellite systems may contribute to arms control by helping to survey nuclear explosions in outer space or even those near the earth's surface.[47/]

Past experience with the development of international negotiations and organizations concerned with technical matters indicates that identification of the exact need and opportunity for control mechanisms of this sort requires considerable original study and accumulation of new knowledge. It has been suggested, for instance, that "long before any agreement becomes possible on regulating or eliminating the use of outer space for military purposes, a design for the management of this region, under the auspices of the United Nations, could be set before world opinion, with the psychological and ideological benefits inevitably redounding thereto."48/ It has also been asserted that "lawyers can contribute significantly to the solution of legal problems arising from known and predictable contingencies; they cannot sensibly recommend in detail rules to deal with contingencies wholly or largely unknown and beyond human experience. A viable Law of Space must be based on the facts of space."49/ On this matter there is much to be learned which would provide a needed background for interpreting more specific studies. Such a study would be concerned with:

. . . The circumstances under which international rules (1) anticipate or (2) wait upon technical developments and the accumulation of experience in respect to space matters.

Control over the undesirable uses of outer space would in any case have to be focused on known uses, likely kinds of uses, and effective use capability. There may be significant analogies for the space field in the arguments for and against international provisions for limiting or increasing membership in the "nuclear club." Of particular relevance would be studies of:

. . . The expected capabilities of major powers for the exploitation of outer space and the political implications of an increased number of "space powers."

. . . The kinds of activities that might be prohibited or subjected to international control or approval, and means for estimating the advantages and disadvantages to nations resulting therefrom.

. . . The existing or proposed international legal rules covering space activities, and the existing or proposed international machineries for continued promulgation or revision of rules.50/

. . . The ways in which the more technically oriented international organizations, including some of the specialized agencies of the UN, might be concerned with the development or management of various continuing space operations.51/

. . . New types of international and supranational organizations which might be created and the special problems which they may face as a result of the technical functions to be performed and the sizable budgets involved.

Control of non-space activities with the aid of space projects and the use of space programs for relieving world tensions and creating spheres of confidence may well require the kind of careful planning associated with control over undesirable uses of space. The difference between the two types of controls may be the greater need for inventiveness in the development of the latter, and advances in this area may depend on encouraging the study of:

. . . Familiar causes of international tensions which may be attenuated by the use of space technology or the findings of space science.

. . . The design requirements for space systems that are intended to demonstrate or otherwise prove their peaceful purpose. Such a study might explore the possible forms of inspection or multi-group control over facilities, equipment, personnel, operations, and results.

Among areas of revolutionary technical achievement, interest in space activities is probably rivaled in some parts of the world only by interest in atomic energy matters. Neither of these areas is now immune to disparagement, however, and other areas of scientific and technological development may come to rival them in capturing the attention of nations. Official national interest in them may well shift from time to time and may or may not parallel the interests of scientific communities.

In the context of human affairs, scientific activity is a means as much as an end in itself. It is not obvious that all nations are equally agreed on the importance of space science and it is not impossible that preoccupation with it by international science organizations or through other channels of foreign policy may alienate those who do not agree with this emphasis.52/ To better understand the usefulness of a space program in this context it is appropriate to conduct research on:

. . . The development of means for assessing the importance for nations of exploring and exploiting space as compared with the promotion of alternative technical development.53/

. . . The means by which interests in international cooperation can be reconciled with the concern of the sciences and of engineering for objective standards and uncompromised achievement.54/

Whether or not scientific activities attempt to divorce themselves entirely from international politics, economics, law, and public opinion, under present conditions they do have international implications beyond the natural science disciplines. International science organizations provide one means for fostering scientific activity or for restricting the spread of space capabilities. The lack of distinctions between private and official activities of scientists and between peaceful and military science activities in the context of a space program have suggested in the minds of some science statesmen a net increase of opportunities for complementary activities by a variety of official and quasi-private international organizations and rule making institutions and hence a greater choice of instruments for implementing the policy of national cooperation. Further understanding of any such unique contributions by a space program, or its planners and implementors, to the promotion of international cooperation could be aided by a study of:

. . . The distinctive, complementary, or competing space roles played by existing international groups including the United Nations, UNESCO, COSPAR, and IAF, and others in existence or proposed.**

Relations with allies, adversaries, and neutral nations

A nonmilitary space program might contribute to the objectives of (1) strengthening bonds with our allies, (2) gaining the respect, confidence, and friendship of the governments and leading groups of selected neutral nations, and (3) achieving direct advantages against hostile powers by non-violent means. The general foreign policy objective of helping certain nations to help themselves might also be furthered.

To developing nations, programs of aid may be more important than spectacular space events of no direct consequence for them.[55/] Major space exercises conducted by a rich and powerful nation may be resented if it is believed that the nation is at the same time skimping on the resources it allocates to the developing countries. On the other hand, participation in certain space activities of perceived value to such countries could enhance their self-images and/or their international prestige.

We must certainly ask whether or not those space activities which we believe offer many benefits and opportunities are perceived as doing so by persons in other countries. For example, the potential advantages of weather and communication satellites to the developing areas of the world appear to be substantial, yet there are many large problems and potential embarrassments also involved for the national leadership in these areas. As was suggested in the chapters on weather and communication satellites, programs of indoctrination and information will be needed well before the time of realization of a specific activity. These programs might assist materially in developing attitudes and institutions compatible with the benefits to be derived from the activity.[56/] It is recommended, then, that specific studies be undertaken to:

. . . Determine what activities need to be begun and routines established in various parts of the world to prepare regions and nations to take advantage -- with a minimum of undesirable consequences -- of the uses of space products.

. . . Develop means for instructing appropriate publics on the significance of contemplated space activities or on-going events to help them understand and use the socially important ideas and ideals implicit in particular products of space activities.

It has been argued, pro and con, that American prestige in the eyes of the rest of the world depends on the success of our space program, and particularly on matching or exceeding the Russian program.[57/] An assessment of the data available from public opinion polls overseas does not provide the basis for deciding to what extent our present and future prestige is indeed a function of our space effort.[58/] Nor is what is meant by prestige at all clear. Do we want people to like us, to emulate us, to send their students to our schools, to buy their heavy equipment and instruments from us, to feel we would win a war if a showdown came, or to turn their back on offers and blandishments from the Communist bloc? "Prestige" means many things and on the specific interpretation rests part of the basis for assessing the possible implications of space activities for enhancing that desired characteristic.[59/]

A foreigner's notions of how a country ought to behave vis-a-vis a country which has "prestige" may not coincide with our ideas of how it should behave, and the reasons why specific nationals regard us as a nation with or without prestige may not coincide with the reasons we think they should have for so regarding us. French reasons and responses may be quite different from British, Congolese, German, etc. Thus the role of space activities in forwarding our national image can only be clearly delineated after decisions are made about which aspects of prestige we wish to enhance, in what parts of the world, for what purposes. If the direction and effort of our space activities are to be partially a function of their prestige-generating consequences -- or at least are not supposed to adversely affect behavior and attitudes toward us -- it is necessary to conduct studies to learn:

. . . In various countries how do particular types of space activity influence specific people and institutions involved in the governmental decision making process?[60/] What other factors enter into the decision making process which may vitiate or amplify the contribution of particular space activities to our benefit or detriment?**

Because a space program, unlike many other programs in science and technology, includes a great many rather dramatic planned events, an unusual opportunity exists for understanding the consequences of these events for intergovernmental relations by comparing international conditions before and after the events. For this reason there is need for:

. . . Retrospective and prospective studies of the measurable beneficial and adverse effects, for United States and Soviet influence on other nations, of particular space events.

In addition to the matter of prestige, it would appear that there are qualitative as well as quantitative aspects to competition with Russia in the space area. Such factors as secrecy vs. publicity, feasible space programs, effective internal competitors for funds, relations with scientists in other nations, and access to other nations' territory may variously provide certain advantages or disadvantages to one side or the other. Without a serious research effort which considers the technical details of possible space projects, as well as their inherent merits, it is unlikely that the United States can understand, take full advantage of, or guard against the built-in imbalances or differences in U.S.-USSR postures.[61/]

Specific studies contributing to this understanding and the development of possible opportunities include:

. . . A systematic and comprehensive identification of significant political, legal, and other social, as well as technical, differences in the postures of the United States and the Soviet Union as they may affect the international implementation and effectiveness of possible space projects. Such a study should include historical and theoretical analyses of the concept of political parity between the Soviet Union and the United States, which appears to have particular significance in international programs for the peaceful uses of space.**

. . . An analysis of the geographic differences in the positions of the United States and the Soviet Union which may affect particular space projects. In this connection consideration might be given to the technical, and corresponding political or other social,significance, if any, of physical characteristics such as the equatorial belt; the poles of rotation; pairs of magnetic conjugate points; the relation of various land masses to the seas in terms of launching, landing, or surface station network requirements; and the general movement of weather from west to east or of daylight from east to west.

9. ATTITUDES AND VALUES

ACCEPTANCE OR REJECTION of technological innovation by a society is seldom exclusively a matter of rational assessment. A melange of personal and culturally defined values, as concepts of what is worth while, desirable, good, and ethically right, plays a large and often dominating role in generating the attitudes that in part determine an innovation's fate.[1/] Individual attitudes are further conditioned by the level of a person's ability to understand the use of the innovation and its pertinence to events and people within the context of the society in which he lives.

On the other hand, the impact of science and technology always has the potential for changing or reinforcing the attitudes and values that are fundamental to the direction and content of patterns of living.[2/] Therefore, if the consequences of space activities for living patterns are to be understood, so that they may be anticipated and planned for, it is desirable to know as much as possible about the intimate circularity of the relationship between attitudes and values and the processes of social change. Fortunately, one of the important implications of space efforts in this regard is the extraordinary opportunity they offer for studying these processes of change -- before, during, and after their occurrence.[3/]

The discussions of problem areas in earlier chapters have of course included to some extent the role of specific values in relation to the implications of a specific problem. However, attitudes and values themselves constitute a problem area, since one of the major products of the space effort has been a variety of stated opinions about the present and future impact of space activities on them. The extent to which these opinions are personal expressions of an assumed "fact" and the extent to which they are based on empirical data needs to be known, so that their validity as a basis for policy can be assessed.[4/] Such assessment is always important to the workings of a democratic society in which policies are, ideally if not always in fact, the result of an interacting relationship between policy planners, decision makers, and the people, who may be either hostile or supportive to the plans and decisions. By the same token, assessment would appear to be especially important in regard to space activities, which, if present plans and accomplishment hopes materialize, will unavoidably have global consequences for human affairs.

Yet exact empirical data are few, both about opinions on attitudes and about the interworkings of attitudes with the events of social change. Since the space effort may well be a most radical instrument for social change, it is appropriate that agencies charged with its conduct should assist in pursuing research that may enlarge the still slender store of knowledge in this problem area.

Implications of Space Activities for National Goals and Tomorrow's World

Many of the knowledgeable persons who were interviewed during the preparation of this report -- or whose statements made elsewhere were read -- expressed deep concern and often strong opinions regarding the proper role of space activities in a democracy and in the world into which we are moving. The substance of their concern included both the special and complex problems that space activities may pose and the changes already under way in traditional values -- changes in part related to the recent history of high rates of technological change and the pressures for social adjustment produced by innovation.[5/] That the present speculations -- and often firm convictions -- of these serious students of space and society demonstrated a variety of conclusions about the role of space in relation to society suggests that research would be helpful to clarify the assumptions associated with the arguments to be discussed here.

The role of space in the world ahead of us

Many observers of the present scene believe that eventually the cold war of weapons must either become hot or be replaced by economic warfare between East and West. Given the latter alternative, some of the observers argue that the vast expenditures consequent on the rivalry in social and economic development would probably seriously reduce resources and ambitions for space activities, aside from an occasional scientific probe, because positive humanitarian results of earth-based challenges could be realized relatively quickly and without the interim frustrations that are at present characteristic of complicated space developments. It is assumed that, in an all-out competition between East and West for economic dominance, the East would probably place its major propaganda investments in devices less remote than space projects, and thereby reduce the incentive for all-out space activities in the United States to the point where the program would be simply a useful technological adjunct to certain areas of scientific research. Others, however, assert that, despite the demands made on resources and creativity by all-out economic warfare and the associated rivalry to improve the standards of living in underdeveloped areas, the United States and Russia would continue to place major emphasis on their space programs as outstanding devices for scoring propaganda victories and for demonstrating the relative technological and scientific prowess of the two ideologies.

Some informed students of the matter are unshakeable in their belief that the search for knowledge in space will encourage a large program to support and supplement the search and to make use of its findings, although they acknowledge that at present there is no good reason to believe that the government and the "public" are prepared to pursue space-derived knowledge, primarily for its own sake, at the level of resource and financial investment presently going into these activities.

Another point of view contends that space activities will continue because they are a form of circus not only for the man on the street but for his leadership, providing a sense of escape from the profound frustrations and complexities of life on earth.[6/]

A good many people are convinced that internationalizing space is the only way to insure its utilization for peaceful activities and to meet the eventual magnitude of the cost and effort it involves. Some of those who hold this opinion feel that great new opportunities would be open to an internationalized program and new creative resources brought to bear; they point to such an international research effort as CERN, the European nuclear accelerator project. Others feel that it would eliminate what they consider to be the chief basis for space activities -- East-West competition -- and without such competition, there would be little or no pressure for expending resources at the level held necessary for future large-scale space projects. In other words, if it no longer mattered who "gets there first," the incentive for getting there at all would be radically reduced.

The relation of space strategy to national strategy and needs

With regard to our needs as a nation, two general problems are posed. First, what is the appropriate priority for space activities? In view of the always increasing demands on manpower and money for routine national needs and of the many social and technological areas in which manpower and money might be expended to produce other important results for mankind, to what extent are we justified in spending vast sums on space activities?[7/] Few suggest that they know the answer, and many argue that research on the problem of priority assignment itself deserves the highest priority, from the standpoint of the utility of the advancement of science for mankind.[8/] Even among the scientists in the space community -- who might seem to have the most to gain from space activities -- there is some concern as to whether an "all-out space effort" is in the best interests of science and the nation. While this concern is related in part to the anticipated costs of space activities, there is also a feeling that continued excessive attention to space may blind the policy makers to the compelling needs and opportunities in other physical and social sciences.

The second problem involves the proper integration and articulation of the space effort's role with other national goals. If international competition is a major reason for space activities, it is argued that they should be much more closely coordinated with other national policies: if, for example, we insist that our space program is for peaceful purposes, every effort must be made to insure that this image is not embarrassed.

Each of the arguments and concerns discussed above has a number of important implications. As a whole they suggest that, if the space effort has potentials for benefiting mankind under various broad sets of circumstances, the potentials and circumstances need to be explicated in the interest of better planning of space activities in concert with other worth while and expensive public service activities. This is especially important in a nation such as the United States, where policy is sensitive to the attitudes of the various publics. For some of the questions posed, systematic study can perhaps at the most indicate that opinions on a subject are, in fact, only opinions; thus space projects based on them should be undertaken with the full understanding that neither history nor psychology guarantees the outcome prophesied, no matter how high the source of the opinions. Background research useful for such an evaluation would determine:

. . . The general nature of the diffusion of new ideas and artifacts through society and the reasons why an idea will be accepted, forwarded, and incorporated by some groups under some circumstances and rejected by others.

. . . An especially worthy aspect of this problem entails such questions as these: What factors historically have entered into support or rejection of new ideas or technologies? What was and wasn't appreciated about the potentialities or lack of them in the innovation and under what personal and social circumstances did this occur? (For example, what were the roles of factors such as physical environment, politics, personalities, limited systems analysis capabilities, insufficient communications to decision makers, and national goals?) In what ways are previous innovations and the social context in which they developed or were rejected comparable with present space innovations and their social contexts?**

In addition, systematic examination of the arguments summarized above should be undertaken to:

. . . Set out the conditions under which specific lines of argument would seem reasonably valid and those under which they are not likely to pertain.

The broad problems posed imply that research is also necessary to:

. . . Attempt to develop systematic methods for assigning priorities between competing scientific and social efforts (where competition may be long term and involve personnel, money, public support, and conflicting attitudes and values).**

. . . Examine the nature of decision making needed at appropriate levels to develop methods for coordinating space policy and national policy for the benefit of both (See Chapter 8 for more detailed research recommendations on this problem).

Special Publics

In estimating public attitudes, it is necessary to take into account the possibly differing values of various specific groups in the society.[9/] The emphases and perspectives of the "military," for instance, tend to differ from those of the "scientists" and the "politicians," which in turn differ from each other. Not all values held by a group are unique to it, and within a group are subgroups and individuals whose attitudes differ in some degree from the general position; nevertheless, there is likely to be sufficient cohesiveness that identifies the group as a group. Thus it is reasonable to expect that space activities differently affect and are differently affected by such "special publics."10/ There is also evidence that both the leadership which makes decisions and that which influences decisions tend at times to separate specific groups from the "general public" and act as if certain values and attitudes were associated with them.11/

To the extent that planning and policies for space activities or their implications actually consider the attitudes of special publics, informal estimates of the constitution of such groups and of their opinions should be supplemented by research intended:

> . . . To discover the role of space activities within the context of the functions and goals which are the distinguishing characteristics of specific groups, and to learn the significance of the group attitude toward space activities.

The special publics discussed below are among those presently believed to have special significance for various aspects of the space program.

<u>The space community</u>

As might be expected, many of the scientists and engineers associated with government and private space activities are enthusiastic about them. There are others, however, whose disillusionment and cynicism have impressed observers; personally and professionally preoccupied with their work, they nevertheless feel alienated from the world they are creating -- because they believe it will be used "as politicians and promoters see fit," whether or not the use is appropriate to what they believe to be its significance.12/

No systematic study has been made of such factors, but the frequency with which the subject has occurred in informal conversations between observers and members of the space community indicates that negative attitudes are not rare. It should be known how widespread such attitudes may be, at what levels of decision making and creativity they occur most often, and what other factors may be involved. It should also be learned to what extent these attitudes might be known to or shared by students planning careers in space fields; if they were found to be prevalent yet not deterring, this might indicate that the new recruits for space activities have a different set of values than those typical of the engineers and scientists heretofore involved.

The more intensely reacting members of the present engineering and scientific personnel, perhaps including some of the more imaginative, might very well leave the field for other more satisfying areas; already there is evidence in many areas of science of the arrival of the "gentleman scientist."[13/] Whether or not the loss of these dissatisfied personnel or the influx of changed values with new personnel would change the quality of space activities needs careful study.[14/]

Many studies show that people filling particular roles have different ideas of their roles and the roles of others than do people filling other roles.[15/] Thus there is every reason to believe that, among other pertinent space community people, as well as outsiders, there is ignorance of or confusion about the attitude situation described here; similarly there is every reason to believe that the dissatisfied scientists and engineers within the community are not fully aware of the purposes and roles of those they disparage. So long as the situation is left formally unexamined and not brought to the attention of all concerned it will be difficult for all individuals and groups involved to base their actions and understanding on valid assessments of the attitudes and values of each other. It appears worth while then to conduct studies to determine:

. . . The nature and extent of positive and negative attitudes and values among members of the space science and engineering community over the application of their efforts. To what extent are similar attitudes conveyed to or already incipient among potential space activity candidates and what kinds of influence do they have on recruitment? (This type of study should be repeated every few years.)

. . . What is the relationship between specific aspirations and motivations on the one hand and job satisfaction or dissatisfaction on the other? Is there a relationship between satisfaction or dissatisfaction and quality of creativity, as well as the rate of personnel turnover?

. . . In the light of the above, if alterations in perspective are appropriate for those in the space community who are dissatisfied and/or for those who act in ways presently contributing to this dissatisfaction, what means can be discovered to encourage insights, understanding, and changed perspectives?

Present and future astronauts

The attitudes of the men now training as astronauts in the Mercury program and their perception of the attitudes held toward them and their efforts will have important implications for their training, their ultimate performance capabilities, and thereby for the selection and training of future astronauts. (The public's reactions to "man in space" are discussed later in this chapter.) Further information is much needed on the relation of attitudes and values to aspirations and fulfillment of performance requirements in this very special situation. The kind of understanding that would be derived from studying the values and attitudes of the first group of astronauts over time as they move through and beyond the Mercury program will also be of use to future astronaut programs. Thus it is important to study:

. . . The attitudes of the astronauts toward themselves, each other, their families, other space community associates, former associates, and the world at large and changes in these attitudes, and the values on which they are based, over time and in the face of particular events in connection with space activities both nationally and internationally.

. . . The attitudes of their families and associates toward the astronauts' efforts, and the effects of time and events on these.

. . . The attitudes believed by the astronauts to be held by various publics about them, their families, and their mission.

. . . The interrelationship of the above as they affect astronaut performance and motivation through time and in the face of specific events.

. . . Historical parallels (if they exist) of the "hero's" perception of his role and the effects of this perception on his behavior.

The non-space science community

Conversations with natural and social scientists and science administrators indicate a range of reactions to space activities: some scientists are delighted with them as tools for and areas of research, some are indifferent, some are hostile. Future space activities will be partly dependent on scientists in universities and other institutions for ideas as well as for the kind of supporting approval that will encourage competent men to contribute to the space effort.[16/] It will thus be important to discover how to use most effectively the existing enthusiasms among non-space scientists, but there appears to be an even more pressing need to discover and assess the reasons for the expressed indifference and hostility.[17/]

At present, it is not clear how extensively these attitudes are held and under what personal and operating circumstances they predominate. Nor is it clear what could be done to make space activities more compatible with the values and attitudes of those reluctant to participate in them -- or whether efforts should be made to reduce this reluctance to participate in space until the nature and extent of the reluctance, and thereby its significance, are better understood. Thus, it is most desirable that studies be undertaken to determine:

. . . The nature and extent of positive and negative attitudes and values in the non-space science community toward space activities. (This kind of study should be repeated every few years.)

. . . The nature and extent of participation desired now and in the foreseeable future from the type of scientist and student who presently is reluctant to participate.

. . . How, in the light of the above, to increase, when appropriate, the compatibility of interests of those preoccupied with space activities and the rest of the science community.

. . . How to bring to the attention of nonhostile and potentially enthusiastic social and natural scientists the unique opportunities for applied and theoretical research offered by space activities.

(The last recommendation refers to that important implication of space activities noted earlier in this chapter -- the opportunity they afford social scientists for research on the effects of spectacular yet continuing events on the attitudes, values, and behavior of members of various societies -- both before the events and after them.[18/] The fact that space events can be anticipated by informed personnel before they become known to the general public enhances possibilities for (1) the sort of controlled experiments usually not available to the historian or social scientist, (2) base line studies, and (3) judging value and attitude changes in the light of the base line studies and the larger context of events. There is an excellent chance that theoretical insights into the processes of social change can thus be increased substantially. Since such insights would be invaluable for anticipating the implications of space activities for mankind, it would be desirable for the NASA social science research facility to bring these special opportunities for fundamental and applied research on social change to the attention of the social science community as soon as possible.)

Business executives

The attitudes of business executives as influenced by space activities may well have important implications for the direction and intensity of space activities and, to some extent, for business philosophy and practice. Information about these attitudes and the values underlying them is found in a survey directed by Raymond A. Bauer of the Harvard Graduate School of Business Administration for the Harvard Business Review.[19/] The study is also valuable for showing where further research is necessary in this area. Only a brief summary of the findings is provided here, but a detailed report on the survey, its findings, and the recommended research is given in Appendix A (to be found at the end of the Footnote Volume).

According to the survey, the impact of recent technological advances appears to have made executives extremely reluctant to conclude that anything is impossible, and they questioned only the most speculative of the possible benefits from space exploration. The majority felt that projects such as long-range weather forecasting, improved communications, and tangible by-products of research were very likely to "pay off." However, the responses gave very little indication of either the significance or stability of attitudes, and since the approving support evinced could have been based on generalized impressions rather than specific knowledge, it might wither if project results were slow in coming. Older executives, particularly, seemed less caught up by the romance and adventure of space and more reluctant to spend money on space programs.

The respondents were able to distinguish between civilian and military space objectives, but did not do as well in specifying which existing programs were civilian and which military. What distinctions were made probably did not reflect detailed knowledge of the actual differences between the two objectives, for not many of even the most enthusiastic executives were completely informed on this subject.

Five possible reasons for or advantages of supporting the space program were ranked in this order: (1) pure science research and gaining of knowledge; (2) control of outer space for military and political reasons; (3) tangible economic payoff and research results for everyday life on earth; (4) meeting the challenge and adventure of new horizons; (5) winning the prestige race with the Soviet Union. However, there did not seem to be a clear distinction in the minds of the respondents between "pure science" and "control of outer space."

Considerable willingness was indicated to grant the civilian space program more funds than the amount it was assumed to be already getting. A preponderant majority of the executives gave space research priority over a cut in taxes, though expenditures for health and education took precedence over space expenditures. Many thought that the program needed to be stepped up and, in general, that more could be done with the resources already committed. It was evident that respondents hoped that private industry would have a role in the space program, but many of the comments about this were more wistful than confident.

The generally favorable attitude revealed toward a civilian, rather than a military, space effort needs additional scrutiny. Is the attitude based on an evaluation of the relative potency or efficiency of the two programs, or does it indicate a preference for nonmilitary space research? The optimism about space activities also needs examination. Is it the product of an unbounded faith in science, of past experience with R & D payoffs, or what? Will practical R & D benefits be needed to reinforce the optimism and the implied support? These questions are typical of others that need to be answered before the implications of business executives' opinions become clear. Research, then, would be desirable to determine, for example:

. . . The meaning of executives' estimates as to the speed with which the civilian space agency (as opposed to the military) will achieve given objectives.

. . . The factors behind the optimism expressed about the benefits of space research.

. . . The tenacity of the opinions about and commitment to space research, especially in the light of possible future events.

. . . To what extent and under what circumstances do executives' attitudes, when the approach is made to them as individuals, differ from those when approached as members of a group?[20]

Children

Children born the year of Sputnik I will vote within the twenty-year period encompassed by this study; those born a few years before that will, within this time period, be launching on careers. Their childhood impressions of space and its implications may have strong effects on their career choices and adult attitudes toward space activities.

For the adult, the perception and interpretation of new events, objects and ideas is filtered through a residue of values, beliefs, and experiences representing a lifetime of familiarity with the old. For children, the new is more real, since there is less interpretive background to help define initial and spontaneous perceptions. Thus children are the major carriers of change; what they "see" or remember will be remolded over time, but nothing can remove the underpinnings of initially more literal perceptions.[21/] Even the four-year-old, however, is already a "socialized animal," reflecting many characteristic adult attitudes, and the freedom to see a given subject area through fresh eyes operates less and less as the child grows older. Therefore, since the attitudes of children toward space ought to provide much insight, especially if they can be rechecked at various periods of the child's growth, it would be wise to begin studies on very young children as soon as possible. Since values start young and in primitive enough form to be readily observable to research, such studies are practicable.[22/] A special purpose of the research would be to detect both the inner and outer factors that contribute to the eventual adult's attitudes and behavior in support or non-support of space activities and to his perception of the world as influenced by space activities.[23/]

Research, then, would be desirable to determine:

> . . . The prevailing attitudes toward and knowledge of space events in youngsters of varied ages and the changes in attitudes and knowledge through the years ahead under the combined influence of new events in and adult attitudes toward space activities and exposure to the other alternatives and experiences which come with physical and mental growth. For each annual group of four-year-olds, six-year-olds, and so on, how important is space in relation to other world events and societal commitments and how do they define this importance?

Possible Implications for the General Public

Exactly when and how the divergencies in opinion and attitude that mark off one special public from another decrease to the extent that the members of a large number of such groups can then be referred to as the "general public" is indeterminable -- and probably never does happen in fact. Nevertheless, there are many situations in which a fair degree of unanimity rather than divergence at least seems observable, and while the concept of a general public may be only a semantic myth, it is certainly a convenient one, and especially so to spokesmen, planners, and decision makers. This section, then, discusses implications and attitudes that have been assumed by spokesmen concerning space activities to have applicability to wide groupings of special publics.

Public interest in and commitment to space activities

Many strong statements have been made about the degree of public knowledge of, interest in, and commitment to space activities for peaceful uses, but there is good reason to believe the situation is much more complicated than many of the statements imply.[24/] In the first place, questionnaires and surveys of public attitudes about space programs show that various parts of the public tend to be selective in their attention to the subject and seem to be variously affected by the perceived military implications and the public relations releases of military, industrial, and other special interest groups, as well as by specific events.[25/] Base line data are very much needed . state of present public knowledge of space activities and the associated attitudes. Thus research is recommended to explore:

. . . The state of public knowledge about space activities, both on-going and contemplated, and the assumptions, expectations, and values that underlie the attitudes toward and interpretations of this knowledge. Also needing study are the effects over time of new knowledge and events on attitudes toward space activities, and the effects of the sources of information on the acceptability of the information. **

Related to this general matter is the widespread tendency to assume that the direction and intensity of mass media reporting have attributable affects on attitudes. There is also the assumption that the media reflect, in the amount of attention they give to a subject, the interests of their audiences. However, the precise effects of the mass media on attitudes and values and the extent to which they reflect or generate interest are still not well understood, despite the amount of research conducted on these problems.[26/] (This lack of understanding results in part from a dearth of the before-and-after studies on important events that foreknowledge about space activities make possible.) Because it is important that decision makers, policy planners, and pertinent attentive publics have more precise information about the role of the mass media in regard to space activities, further study is recommended on:

. . . The complex relationships between events, media translation of them, media presentation of them, audience attention to them, audience values, attitudes, and perceptions in related areas, and changes in values, attitudes, and behavior as a result of exposure to media content.[27/]

Moreover, careful study is indicated of the proper and effective role for the public in regard to policy on a subject as complicated as space; given the many alternative needs on which public funds might be expended, this question is of particular interest. Thus, it would be desirable to examine:

. . . The ways in which the public can contribute to the setting and supporting of space activity policy. In what ways is it limited (e.g., lack of education, lack of accurate information, lack of channels to communicate its opinion?) in its ability to contribute constructively and with the level of sophistication required?

Optimism and overoptimism

Spokesmen for space activities often try to generate optimism in their audiences by dwelling on the imminence of vast space efforts and the abundant rewards to be expected from them. There has also been an unceasing stream of public relations releases and promotional statements (often translated by the mass media as news) about the glamorous and fantastic events that will happen in space in the near future, and what these will mean for the public.

Public optimism is assumed to be desirable, in that it should generate support for the space program in general. However, should promotion efforts lead to overoptimism, support attitudes might easily not be lasting if the difficulties inherent in space efforts have not at the same time been appreciated enough to make the failure of specific projects understandable. As space efforts become more grandiose and the potential consequences of payoff more exciting, failure will have even more possibility of creating general disillusionment. If enough glamorous projects are not successful at the time they are supposed to be, earlier efforts to imply their ease and imminence may boomerang: the public state of mind may well make it difficult to obtain future funds for the more expensive efforts, which must compete in one way or another with other public programs for money, manpower, and ideas.[28/]

On the other hand, it may be that a certain degree of overoptimism is necessary to sustain public interest in and support of space activities in the face of project frustrations and failures. However, these discussed effects are mere conjecture, since exact knowledge simply does not at present exist of whether the public is optimistic, pessimistic, or indifferent about the future of the space effort. Thus, to anticipate and ameliorate adverse consequences of overoptimism and to make effective use of optimism, the following questions need systematic study:

. . . How important are expectations of imminent and glamorous space activities to public support of the effort and the allocation of funds and resources to it?

. . . Under what circumstances do authoritative statements about the assured success of costly projects, which do not eventuate as predicted, result in indifference or resentment and withdrawal of support or in continued support? What, in terms of the individual's attitudes and values, defines the success or failure of an event or sequence of events?

. . . To what extent are people sophisticated or naive about the competition for attention between the many institutional and organizational rivals in the space field, and in what ways do the level of knowledge about and the attitudes toward the competition affect expectations and interest in and support of space activities?

. . . To what extent are people sophisticated or naive regarding optimism as to the future, to progress, and the limits and potentialities of science? How do these general values and attitudes relate to attitudes toward space possibilities?[29/]

Broadened horizons

It is said that man has an insatiable will to progress, to climb the mountain "because it is there," and therefore to explore space to the utmost because he is driven by the nature of his being to do so. As he thus explores, his social and psychological horizons will necessarily be broadened by the magnitude and challenges of the universe in contrast to his former earth-bound preoccupations; herein, it is claimed, lies one of the great implications of space activities for attitudes and values.

In assessing these claims it should be recalled that there are many societies in which the traditional way of doing things is the proper way of life; even in our own society, with its emphases on change and on progress, it is common for potentially useful innovations to be blocked by traditional perspectives.[30/] Not all people here or abroad will be or are committed to space exploration because it is "challenging" or represents "progress"; among those who are interested in meeting challenges, a good number will no doubt decide that they prefer to expend money and effort on challenges more immediately and intimately related to their own needs and those of the earth-bound human community.[31/]

However, certain ideas related to space activities may even now be contributing in some quarters to changing horizons. For example, under the impetus of the new but frequent claims that space exploration is a fine example of man's most worthy aspiration -- the accumulation of knowledge per se -- a public attitude favorable to scholarship in general may be generated. Acceptance of long planning periods for space activities and the possiblity of international space programs may stimulate attitudes favorable to multinational cooperation and systematic planning in other areas as well. And perhaps the belief that space activities must inevitably result in broadened horizons and perspectives will encourage a pattern of responses which will produce a "self-fulfilling prophecy."[32/] In any case, it would be desirable to anticipate the effect of possible new perspectives or the lack of them as a prelude to planning for the effective meshing of space activities and programs with other socially important activities. This will require research:

. . . To develop appropriate methods for measuring personal perspectives and changes in them.

. . . To determine over time (aided by the measuring methods indicated above) the extent to which space activities are perceived as complementary or contradictory to the needs and aspirations of various significant portions of world society and especially to those of the opinion makers and pressure groups.

The implications of a discovery of extraterrestrial life

Recent publicity given to efforts to detect extraterrestrial messages via radio telescope has popularized -- and legitimized -- speculations about the impact of such a discovery on human values.[33/] It is conceivable that there is semi-intelligent life in some part of our solar system or highly intelligent life which is not technologically oriented, and many cosmologists and astronomers think it very likely that there is intelligent life in many other solar systems. While face-to-face meetings with it will not occur within the next twenty years (unless its technology is more advanced than ours, qualifying it to visit earth), artifacts left at some point in time by these life forms might possibly be discovered through our space activities on the Moon, Mars, or Venus. If there is any contact to be made during the next twenty years it would most likely be by radio -- which would indicate that these beings had at least equaled our own technological level.

An individual's reactions to such a radio contact would in part depend on his cultural, religious, and social background, as well as on the actions of those he considered authorities and leaders, and their behavior, in turn, would in part depend on their cultural, social, and religious environment.34/ The discovery would certainly be front-page news everywhere; the degree of political or social repercussion would probably depend on leadership's interpretation of (1) its own role, (2) threats to that role, and (3) national and personal opportunities to take advantage of the disruption or reinforcement of the attitudes and values of others. Since leadership itself might have great need to gauge the direction and intensity of public attitudes, to strengthen its own morale and for decision making purposes, it would be most advantageous to have more to go on than personal opinions about the opinions of the public and other leadership groups.

The knowledge that life existed in other parts of the universe might lead to a greater unity of men on earth, based on the "oneness" of man or on the age-old assumption that any stranger is threatening. Much would depend on what, if anything, was communicated between man and the other beings: since after the discovery there will be years of silence (because even the closest stars are several light years away, an exchange of radio communication would take twice the number of light years separating our sun from theirs), the fact that such beings existed might become simply one of the facts of life but probably not one calling for action.35/ Whether earthmen would be inspired to all-out space efforts by such a discovery is a moot question. Anthropological files contain many examples of societies, sure of their place in the universe, which have disintegrated when they have had to associate with previously unfamiliar societies espousing different ideas and different life ways; others that survived such an experience usually did so by paying the price of changes in values and attitudes and behavior.

Since intelligent life might be discovered at any time via the radio telescope research presently under way, and since the consequences of such a discovery are presently unpredictable because of our limited knowledge of behavior under even an approximation of such dramatic circumstances, two research areas can be recommended:

. . . Continuing studies to determine emotional and intellectual understanding and attitudes -- and successive alterations of them if any -- regarding the possibility and consequences of discovering intelligent extraterrestrial life.[36/]**

. . . Historical and empirical studies of the behavior of peoples and their leaders when confronted with dramatic and unfamiliar events or social pressures.[37/] Such studies might help to provide programs for meeting and adjusting to the implications of such a discovery. Questions one might wish to answer by such studies would include: How might such information, under what circumstances, be presented to or withheld from the public for what ends? What might be the role of the discovering scientists and other decision makers regarding release of the fact of discovery?

Implications of man in space

The evolving man-in-space program may already be having its impact on values and attitudes. Given the people involved and the necessary risks in the program, it is likely that there will continue to be value conflicts in various parts of the general public as well as in the groups which must make decisions about the direction and extent of future activities in this area.

The Mercury man-in-space program has already received much comment in the media, which illustrates the kind of conflicts that can be expected. There have been favorable reports, as typified by the articles on the astronauts, their families, and their training.[38/] There have been unfavorable statements about the "stunt" characteristics of the program and about its apparent tendency to emphasize the glamorous astronauts rather than the scientific and engineering aspects and problems of the project.[39/] Many commentators have remarked that wives and children are assets to astronauts, who can thus still be considered "normal" Americans; at the same time, their military status permits them to take risks which large portions of the general public might not otherwise consider appropriate for family men. A leading anthropologist who has studied this problem says the astronauts "are not models for other women's husbands -- not one little bit....Part of the feeling about space, which spreads right through the country, is women's objection to men's going there."[40/] The actual astronaut launching may highlight the question of a man's responsibility to family versus his willingness to risk death in space. This and similar questions will be resolved, probably not without emotional conflict, according to the particular personal and institutional values held by those involved in various aspects of the controversies.

Here again is an opportunity to conduct before-and-after research on the implications of innovations for attitudes and values. Studies preceding the launching can also provide a basis for better informing the public so that it can realistically appreciate both the accomplishments and difficulties of the program. It is recommended, then, that base line studies be begun as soon as possible to:

> . . . Determine the present knowledge of, beliefs and expectations about, and the values that underlie attitudes toward the Mercury program and the astronauts. These should be continuing studies so that the impact of events can be anticipated, evaluated, and planned for.**

If the Mercury program is successful it will be only a prelude to attempts to put man on the moon and some of the planets. Thus the implications of astronautic efforts, subsequent to Mercury, for attitudes and values should also be studied. Social observers have speculated that manned flight to the moon or Mars might restimulate the American frontier spirit, thereby supplying a new form of vicarious living for a large part of the public and perhaps inspiring some to participate in more challenging activities here on earth.[41/]

Although the physical requirements for an astronaut probably will be compatible with the preferred American image of masculinity, the psychological characteristics appropriate for long flights through space, alone or in compact quarters with others, may be quite incompatible. Indeed, the very rigors which the astronaut may have to withstand and the special techniques that may be used to make it possible for him to withstand them (such as hibernation or some form of drug treatment) may produce a great gap in the earth-bound man's identification with the astronaut. To the average man who is increasingly embedded in the security and organization of urban life, the physical threat and the physical and psychic isolation implied in manned space activities may seem unpalatable and at a great emotional distance from the daily problems he finds challenging and interesting. Thus, the personalities of astronauts, the esoteric technical problems they solve, and the challenges they accept might become matters of indifference to the public, or, in one way or another, represent aspirations and ways of life that are undesirable.[42/] This may be especially so for other nations whose values about "pioneering," "frontiers," and "conquest" may be different from ours. Since truly large man-in-space efforts will probably require international support, the states of mind in other nations will become important to the planning of programs for which we will need their contributions.

The possibility must be considered that, except for short trips -- and even these perhaps biologically or genetically suicidal -- man will not, after all, be able to go very far into space in the foreseeable future. The weight of shielding necessary to protect him from heavy cosmic ray particles and the intense blasts of energy from solar flares (which are presently unpredictable) may make more than an occasional foray so expensive and unrewarding as to cancel out the advantages of studying space through man's first-hand experiences with it.[43/] This situation could lead to extraordinary efforts to find a way to put man in space -- efforts not necessarily of optimum social use. It could also bring about an intensive development of robot equipment that could do man's exploring for him. Application of the robot technology to other endeavors might be extensive and carry with it all the moral, social, ethical, and economic problems and opportunities which have been explored by the more thoughtful science fiction writers.

If it should become necessary to accept the impossibility of first-hand experience in space, there may be important consequences for American values and aspirations. As a nation, we have come to believe ourselves conquerors of nature and equal to any task if we apply "science." In recent years this confidence has appeared to be spectacularly justified. The discovery that man cannot for the foreseeable future go into space by any of the glamorous means so regularly predicted might so disrupt our self-confidence as to set off a chain of revisions in values which could either hinder or improve our capacity to deal maturely with our other problems.

Whether or not man will be able to study space at first hand in the next two decades depends on information not now available. Since the outcome might go either way, the effects of later man-in-space efforts on values and attitudes in general, as well as with regard to such space activities in particular, require research to:

. . . Develop base line data on present attitudes toward and expectations about post-Mercury man-in-space efforts. These data should include indications of attitudes toward supporting or not supporting such activities and the reasons pertaining thereto.

. . . Assess changes in attitudes and expectations in the light of subsequent events and statements intended to inform, to encourage, or to discourage support of the program.

. . . Discover what symbols and ideas regarding man in space would be stimulating in cultures whose support is desired, but whose aspirations and ideals may not be similar to ours.