Report to the President on Government Contracting for Research and Development

[vii] Executive Office of the President,
Bureau of the Budget,
Washington, D.C., April 30, 1962

Dear Mr. President: As requested by your letter of July 31, 1961,[1] we have reviewed the experience of the Government in using contracts with private institutions and enterprises to obtain research and development work needed for public purposes.

The attached report presents our findings and conclusions. Without attempting to summarize the complete report, we include in this letter a few of our most significant conclusions, as follows:

1. Federally financed research and development work has been increasing at a phenomenal rate—from $100 million per year in the late 1930's to over $10 billion per year at present, with the bulk of the increase coming since 1950. Over 80 percent of such work is conducted today through non-Federal institutions rather than through direct Federal operations. The growth and size of this work, and the heavy reliance on non-Federal organizations to carry it out, have had a striking impact on the Nation's universities and its industries, and have given rise to the establishment of new kinds of professional and technical organizations. At present, the system for conducting Federal research and development work can best be described as a highly complex partnership among various kinds of public and private agencies, related in large part by contractual arrangements.

While many improvements are needed in the conduct of research and development work, and in the contracting systems used, it is our fundamental conclusion that it is in the national interest for the Government to continue to rely heavily on contracts with non-Federal institutions to accomplish scientific and technical work needed for public purposes. A partnership among public and private agencies is the best way in our society to enlist the Nation's resources and achieve the most rapid progress.

2. The basic purposes to be served by Federal research and development programs are public purposes, considered by the President and the Congress to be of sufficient national importance to warrant the expenditure of public funds. The management and control of such programs must be firmly in the hands of full-time Government officials clearly responsible to the President and the Congress. With programs of the size and complexity now common, this requires that the Government have on its staff exceptionally strong and able executives, scientists, and engineers, fully qualified to weigh the views and advice of technical specialists, to make policy decisions concerning the types of work to be undertaken, when, by whom, and at what cost, to supervise the execution of work undertaken, and to evaluate the results.

[viii] At the present time we consider that one of the most serious obstacles to the recruitment and retention of first-class scientists, administrators, and engineers in the Government service is the serious disparity between governmental and private compensation for comparable work. We cannot stress too strongly the importance of rectifying this situation, through congressional enactment of civilian pay reform legislation as you have recommended.

3. Given proper arrangements to maintain management control in the hands of Government officials, federally financed research and development work can be accomplished through several different means: Direct governmental operations of laboratories and other installations; operation of Government-owned facilities by contractors; grants and contracts with universities; contracts with not-for-profit corporations or with profit corporations. Choices among these means should be made on the basis of relative efficiency and effectiveness in accomplishing the desired work, with due regard to the need to

1. Ed. note.-see Annex 1, p. 25, for complete text of letter.

maintain and enlarge the long-term strength of the Nation's scientific resources, both public and private.

In addition, the rapid expansion of the use of Government contracts, in a field where 25 years ago they were relatively rare, has brought to the fore a number of different types of possible conflicts of interests, and these should be avoided in assigning research and development work. Clear-cut standards exist with respect to some of these potential conflict-of-interest situations—as is the case with respect to persons in private life acting as advisers and consultants to Government, which was covered in your memorandum of February 9, 1962. Some other standards are now widely accepted—for example, the undesirability of permitting a firm which holds a contract for technical advisory services to seek a contract to develop or to supply any major item with respect to which the firm has advised the Government. Still other standards are needed, and we recommend that you request the head of each department and agency which does a significant amount of contracting for research and development to develop, in consultation with the Attorney General, clear-cut codes of conduct, to provide standards and criteria to guide the public officials and private persons and organizations engaged in research and development activities.

4. We have identified a number of ways in which the contracting system can and should be improved, including:

Providing more incentives for reducing costs and improving performance;

Improving our ability to evaluate the quality of research and development work;

Giving more attention to feasibility studies and the development of specifications prior to inviting private proposals for major systems development, thus reducing "brochuremanship" with its heavy waste of scarce talent.

We have carefully considered the question whether standards should be applied to salaries and related benefits paid by research and development contractors doing work for the Government. We believe it is desirable to do so in those cases in which the system of letting contracts does not result in cost control through competition. We believe the basic standard to be applied should be essentially the same as the standard you recently recommended to the Congress with [ix] respect to Federal employees—namely, comparability with salaries and related benefits paid to persons doing similar work in the private economy. Insofar as a comparability standard cannot be applied—as would be the case with respect to the very top jobs in an organization, for example—we would make it the personal responsibility of the head of the contracting agency to make sure that reasonable limits are applied.

5. Finally, we considered that in recent years there has been a serious trend toward eroding the competence of the Government's research and development establishments—in part owing to the keen competition for scarce talent which has come from Government contractors. We believe it to be highly important to improve this situation—not by setting artificial or arbitrary limits on Government contractors but by sharply improving the working environment within the Government, in order to attract and hold first-class scientists and technicians. In our judgment, the most important improvements that are needed within Government are:

To ensure that governmental research and development establishments are assigned significant and challenging work;

To simplify management controls, eliminate unnecessary echelons of review and supervision, and give to laboratory directors more authority to command resources and make administrative decisions; and

To raise salaries, particularly in higher grades, in order to provide greater comparability with salaries available in private activities.

Action is under way along the first two lines—some of it begun as the result of our review. Only the Congress can act on the third aspect of the problem, and we strongly hope it will do so promptly.

In preparing this report, we have benefited from comments and suggestions by the Attorney General, the Secretaries of Agriculture, Commerce, Labor, and Health, Education, and Welfare, and the Administrator, Federal Aviation Agency, and they concur in general with our findings and conclusions.

Robert S. McNamara,
Secretary of Defense.

James E. Webb,
Administrator, National
Aeronautics and
Space Administration.

John W. Macy, Jr.,
Chairman, Atomic Energy Commission.

Dr. Alan T. Waterman,
Director, National Science Foundation.

Jerome B. Wiesner,
Special Assistant to the President
for Science and Technology.

David E. Bell,
Director, Bureau of the Budget....

[xi] **FOREWORD**

This report has been prepared in response to the President's letter of July 31, 1961, to the Director of the Bureau of the Budget, asking for a review of the use of Government contracts with private institutions and enterprises to obtain scientific and technical work needed for public purposes.

Such contracts have been used extensively since the end of World War II to provide for the operation and management of research and development facilities and programs, for analytical studies and advisory services, and for technical supervision of complex systems, as well as for the conduct of research and development projects.

As the President noted in his letter, there is a consensus that the use of contracts is appropriate in many cases. At the same time, a number of important issues have been raised, including the appropriate extent of reliance on contractors, the comparative salaries paid by contractors and the Government, the effect of extensive contracting on the Government's own research and development capabilities, and the extent to which contracts may have been used to avoid limitations which exist on direct Federal operations.

Accordingly, the President asked that the review focus on-

Criteria that should be used in determining whether to perform a function through a contractor or through direct Federal operations;

Actions needed to increase the Government's ability to review contractor operations and to perform scientific and technical work; and

Policies which should be followed by the Government in obtaining maximum efficiency from contractor operations and in reviewing contractor performance and costs (including standards for salaries, fees, and other items).

The President requested the following officials to participate in the study: The Secretary of Defense, the Chairman of the Atomic Energy Commission, the Chairman of the Civil Service Commission, the Administrator of the National Aeronautics and Space Administration, and the Special Assistant to the President for Science and Technology. The Director of the National Science Foundation was also invited to participate.

In making the review requested by the President, a great deal of material was available from hearings and reports of the Senate and House Committees on Appropriations, Armed Services, Judiciary, and Government Operations, the House Committees on Post Office and Civil Service and on Science and Astronautics, the second Hoover Commission, and various governmental and private studies. In addition, information was obtained:

By questionnaires to which 10 Federal agencies and 71 Government field installations, universities, and contract establishments respond; and

[xii] By interviews conducted at 28 Government field installations and non-Federal establishments, and with a number of agency headquarters officials.

These data were obtained and analyzed with respect to major policy implications by an interdepartmental staff group, which included representatives of each of the officials whom the President asked to participate in the review.

This report presents a summary analysis and recommendations growing out of this review. . . .

[1] PART 1
STATEMENT OF MAJOR ISSUES

Policy questions relating to Government contracting for research and development[2] must be considered in the perspective of the phenomenal growth, diversity, and change in Federal activities in this field.

FEDERAL RESEARCH AND DEVELOPMENT ACTIVITIES AND THEIR IMPACT

Prior to World War II, the total Federal research and development program is estimated to have cost annually about $100 million. In the fiscal year 1950, total Federal research and development expenditures were about $1.1 billion. In the fiscal year 1963, the total is expected to reach $12.4 billion.

The fundamental reason for this growth in expenditures has been the importance of scientific and technical work to the achievement of major public purpose. Since World War II the national defense effort has rested more and more on the search for new technology. Our military posture has come to depend less on production capacity in being and more on the race for shorter lead times in the development and deployment of new weapons systems and of countermeasures against similar systems in the hands of potential enemies. The Defense Department alone is expected to spend $7.1 billion on research and development in fiscal 1963, and the Atomic Energy Commission another $1.4 billion.

Aside from the national defense, science and technology are of increasing significance to many other Federal programs. The Nation's effort in nonmilitary space exploration—which is virtually entirely a research and development effort—is growing extremely rapidly; the National Aeronautics and Space Administration is expected to spend $2.4 billion in fiscal 1963, and additional sums related to the national space program will be spent by the Department of Commerce and other agencies. Moreover, scientific and technological efforts are of major significance in agriculture, health, natural resources, and many other federal programs.

The end of this period of rapid growth is not in sight. Public purposes will continue to require larger and larger scientific and technological efforts for as far ahead as we can see.

The increase in Federal expenditures for research and development has had an enormous impact on the Nation's scientific and technical resources. It is not too much to say

2. Note on terminology: The term "research and development" is used in this report in the sense in which it is used in the Federal budget—that is, it means the conduct of activities intended to obtain new knowledge or to apply existing knowledge to new uses. The Department of Defense uses the term "research, development, test, and evaluation," which is a somewhat fuller but more cumbersome term for the same concept. In this report the shorter term is used for convenience. For a summary of all Federal activities of this type, see Annex 3. "Federal Research and Development Programs," reprinted from "The Budget of the U.S. Government for fiscal year 1963."

that the major initiative and responsibility for promoting and financing research and development have in many important areas been shifted from private enterprise (including academic as well as business institutions) to the Federal [2] Government. Prior to World War II, the great bulk of the Nation's research achievements occurred with little support from Federal funds, although there were notable exceptions, such as in the field of agriculture. Today it is estimated by the National Science Foundation that the Federal budget finances about 65 percent of the total national expenditure for research and development. Moreover, the Federal share is rising.

Federal financing, however, does not necessarily imply Federal operation. As the Federal research and development effort has risen, there has been a steady reduction in the proportion conducted through direct Federal operations. Today about 80 percent of Federal expenditures for research and development are made through non-Federal institutions. Furthermore, while a major finding of this report is that the Government's capabilities for direct operations in research and development need to be substantially strengthened, there is no doubt that the Government must continue to rely on the private sector for the major share of the scientific and technical work which it requires.[3]

The effects of the extraordinary increase in Federal expenditures for research and development, and the increasing reliance on the private sector to perform such work, have been very far reaching.

The impact on private industry has been striking. In the past, the Government utilized profitmaking industry mainly for production engineering and the manufacture of final products—not for research and development. Industries with which it dealt in securing the bulk of its equipment were primarily the traditional large manufacturers for the civilian economy—such as the automotive, machinery, shipbuilding, steel, and oil industries, which relied on the Government for only a portion, usually a minority, of their sales and revenues. In the current scientific age, the older industries have declined in prominence in the advanced equipment area and newer research and development-oriented industries have come to the fore—such as those dealing in aircraft, rockets, electronics, and atomic energy.

There are significant differences among these newer industries and others. While the older industries were organized along mass-production principles, and used large numbers of production workers, the newer ones show roughly a 1-to-1 ratio between production workers and scientist-engineers. Moreover, the proportion of production workers is steadily declining. Between 1954 and 1959, production workers in the aircraft industry declined 17 percent while engineers and scientists increased 96 percent. Also, while the average ratio of research and development expenditures to sales in all industry is about 3 percent, the advanced weapons industry averages about 20 percent and the aerospace industry averages about 31 percent.

But the most striking difference is the reliance of the newer industries almost entirely on Government sales for their business. In 1958, a reasonably representative year, in an older industry, the automotive industry, military sales ranged from 5 percent for General Motors to 15 percent for Chrysler. In the same year in the aircraft industry, military sales ranged from a low of 67 percent for Beech Aircraft to a high of 99.2 percent for the Martin Co.

[3] The present situation, therefore, is one in which a large group of economically significant and technologically advanced industries depend for their existence and growth not on the open competitive market of traditional economic theory, but on the sales only to the U.S. Government. And, moreover, companies in these industries have the strongest incentives to seek contracts for research and development work, which will give them both the know-how and the preferred position to seek later follow-on production contracts.

The rapid increase in Federal research and development expenditures has had

3. Annex 4 provides data, supplied by the National Science Foundation, on the sources of funds for the national research and development effort and on the distribution of work between the various types of performing installations-direct Federal operations, industry, universities, and not-for-profit establishments.

striking effects on other institutions in our society apart from private industry.

There has been a major impact on the universities. The Nation has always depended largely on the universities for carrying out fundamental research. As such work has become more important to Government and more expensive, an increasing share—particularly in the physical and life sciences and engineering—has been supported by Federal funds. The total impact on a university can be sizable. Well over half of the research budgets of such universities as Harvard, Brown, Columbia, Massachusetts Institute of Technology, Stanford, California Institute of Technology, University of Illinois, New York University, and Princeton, for illustration, is supported by Federal funds.

New institutional arrangements have been established in many cases, related to but organized separately from the universities, in order to respond to the needs of the Federal Government. Thus, the Lincoln Laboratory of the Massachusetts Institute of Technology was established by contract with the Air Force to supply research and development services and to establish systems concepts for the continental air defense, and similarly the Jet Propulsion Laboratory was established at the California Institute of Technology to conduct research on rocket propulsion for the Department of the Army and later to supply space craft design and systems engineering services to the National Aeronautics and Space Administration. In addition, other research institutions—such as the Stanford Research Institute—which were established to conduct research on contract for private or public customers, now do a major share of their business with the Federal Government.

In addition to altering the traditional patterns of organization of private industry and the universities, the rise in Federal research and development expenditures has resulted in the creation of entirely new kinds of organizations.

One kind of organization is typified by the Rand Corp., established immediately after World War II, to provide operations research and other analytical services by contract to the Air Force. A number of similar organizations have been established since, more or less modeled on Rand, to provide similar services to other governmental agencies.

A second new kind of organization is the private corporation, generally not-for-profit but sometimes profit, created to furnish the Government with "systems engineering and technical direction" and other professional services. The Aerospace Corp., the MITRE Corp., the Systems Development Corp., and the Planning Research Corporation are illustrations.

[4] A third new organizational arrangement was pioneered by the Office of Scientific Research and Development during World War II and used by the Atomic Energy Commission, which took over the wartime atomic energy laboratories and added others—all consisting of facilities and equipment owned by the Government but operated under contract by private organizations, either industrial companies or universities.

Apart from their impact on the institutions of our society, Federal needs in research and development are placing critical demands on the national pool of scientific and engineering talent. The National Science Foundation points out that the country's supply of scientists and engineers is increasing at the fairly stable rate of 6 percent annually, while the number engaged in research and development activities is growing at about 10 percent each year. Accordingly, the task of developing our manpower resources in sufficient quality and quantity to keep pace with the expanding research and development effort is a matter of great urgency. The competition for scientists and engineers is becoming keener all the time and requires urgent attention to the expansion of education and training, and to the efficient use of the scientific and technical personnel we have now.

QUESTION AND ISSUES CONSIDERED IN THIS REPORT

The dynamic character of the Nation's research and development efforts, as summarized in the preceding paragraphs, has given rise to a number of criticisms and points of concern. For example, concern has been expressed that the Government's ability to perform essential management functions has diminished because of an increasing dependence on contractors to determine policies of a technical nature and to exercise the type of management functions which Government itself should perform. Some have criticized the new not-for-profit contractors, performing systems engineering and technical direction work for the Government, on the grounds that they are intruding on traditional functions performed by competitive industry. Some concern has been expressed that universities are undertaking research and development programs of a nature and size which may interfere with their traditional educational functions. The cost-reimbursement type of contracts the Government uses, particularly with respect to research and development work on weapons and space systems, have been criticized as providing insufficient incentives to keep costs down and ensure effective performance. Criticism has been leveled against relying so heavily on contractors to perform research and development work as simply a device for circumventing civil service rules and regulations.

Finally, the developments of recent years have inevitably blurred the traditional dividing lines between the public and private sectors of our Nation. A number of profound questions affecting the structure of our society are raised by our inability to apply the classical distinctions between what is public and what is private. For example, should a corporation created to provide services to Government and receiving 100 percent of its financial support from Government be considered a "public" or a "private" agency? In what sense is a business corporation doing nearly 100 percent of its business with the Government engaged in "free enterprise"?

[5] In light of these criticisms and concerns, an appraisal of the experience in using contracts to accomplish the Government's research and development purposes is evidently timely. We have not, however, in the course of the present review attempted to treat the fundamental philosophical issues indicated in the preceding paragraph. We accept as desirable the present high degree of interdependence and collaboration between Government and private institutions. We believe the present intermingling of the public and private sectors is in the national interest because it affords the largest opportunity for initiative and the competition of ideas from all elements of the technical community. Consequently, it is our judgment that the present complex partnership between Government and private institutions should continue.

On these assumptions, the present report is intended to deal with the practical question: What should the Government do to make the partnership work better in the public interest and with maximum effectiveness and economy?

We deal principally with three aspects of this main question.

There is first the question, What aspects of the research and development effort should be contracted out? This question falls into two parts. One part relates to those crucial powers to manage and control governmental activities which must be retained in the hands of public officials directly answerable to the President and Congress. Are we in danger of contracting out such powers to private organizations? If so, what should be done about it?

The other part of this question relates to activities which do not have to be carried out by Government officials, but on which there is an option: they may be accomplished either by direct Government operations or by contract with non-Federal institutions. What are the criteria that should guide this choice? And if a private institution is chosen, what are the criteria for choice as among universities, not-for-profit corporations, profit corporations, or other possible contractors?

The second question we deal with is what standards and criteria should govern contract terms in cases where research and development is contracted out. For example, to what extent is competition effective in ensuring efficient performance at low cost, and when—if at all—must special rules be established to control fees, salaries paid, and other elements of contractor cost?

The third question we deal with is how we can maintain strong research and development institutions as direct Governments operations. How can we prevent the best of the Government's research scientists, engineering, and administrators from being drained off to private institutions as a result of higher private salaries and superior private working environments, and how can we attract an adequate number of the most talented new college graduates to a career in Government service?

These questions are treated in the sections which follow.

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[7] **PART 2**
CONSIDERATIONS IN DECIDING WHETHER TO CONTRACT OUT RESEARCH AND DEVELOPMENT WORK

Generalizations about criteria for contracting out research and development work must be reached with caution, in view of the wide variety of different circumstances which must be covered.

A great many Government agencies are involved. The Department of Defense, the National Aeronautics and Space Administration, and the Atomic Energy Commission provide the bulk of Federal financing, but a dozen or more agencies also play significant roles.

Most Federal research and development work is closely related to the specific purpose of the agency concerned—to the creation of new weapons systems for the Department of Defense, for example, or the exploration of new types of atomic power reactors for the Atomic Energy Commission. But a significant portion of the research financed by the Federal Government is aimed at more general targets: to enlarge the national supply of highly trained scientists, for example, as is the case with some programs of the National Science Foundation. And even the most "mission oriented" agencies have often found it desirable to make funds available for basic research to advance the fundamental state of knowledge in fields that are relevant to their missions. Both the Department of Defense and the AEC, for example, make substantial funds available for fundamental research, not related to any specific item of equipment or other end product.

A great many different kinds of activity are involved, which have been classified by some under five headings:

(1) Fundamental research.
(2) Supporting research or exploratory development.
(3) Feasibility studies, operations analysis, and technical advice.
(4) Development and engineering of products, processes, or systems.
(5) Test and evaluation activities.

The lines between many of the activities listed are necessarily uncertain. Nevertheless, it is clear that "research and development" is a phrase that covers a considerable number of different kinds of activity.

Finally, there have been distinct historical developments affecting the different Government agencies. Some agencies, for example, have a tradition of relying primarily on direct Government operations of laboratories—others have precisely the opposite tradition of relying primarily on contracting for the operation of such installations.

Against this background of diversity in several dimensions, we have asked, what criteria should be used in deciding whether or not to contract out any given research and development task? In outline, our judgment on this question runs as follows:

[8] There are certain functions which should under no circumstances be contracted out. The management and control of the Federal research and development effort must be firmly in the hands of full-time Government officials clearly responsible to the President and the Congress.

Subject to this principle, many kinds of arrangements—including both direct Federal operations and the various patterns of contracting now in use—can and should be used to mobilize the talent and facilities needed to carry out the Federal research and development effort. Not all arrangements, however, are equally suitable for all purposes and under all circumstances, and discriminating choices must be made among them by the Government agencies having research and development responsibilities. These choices should be based primarily on two considerations:

(1) Getting the job done effectively and efficiently, with due regard to the long-term strength of the Nation's scientific and technical resources; and

(2) Avoiding assignments of work which would create inherent conflicts of interest.

Each of these judgments is elaborated below:

STRENGTHENING THE ABILITY OF THE GOVERNMENT TO MANAGE AND CONTROL RESEARCH AND DEVELOPMENT PROGRAMS

We regard it as axiomatic that policy decisions respecting the Government's research and development programs—decisions concerning the types of work to be undertaken when, by whom, and what cost—must be made by full-time Government officials clearly responsible to the President and to the Congress. Furthermore, such officials must be in a position to supervise the execution of work undertaken, and to evaluate the results. These are basic functions of management which cannot be transferred to any contractor if we are to have proper accountability for the performance of public functions and for the use of public funds.

To say this does not imply that detailed administration of each research and development task must be kept in the hands of top public officials. Indeed, quite the contrary is true, and an appropriate delegation of responsibility—either to subordinate public officials or by contract to private persons or organizations—for the detailed administration of research and development work is essential to its efficient execution.

It is not always easy to draw the line distinguishing essential management and control responsibilities which should not be delegated to private contractors (or, indeed, to governmental research organizations such as laboratories) from those which can and should be so assigned. Recognizing this difficulty, it nevertheless seems to be the case that in recent years there have been instances—particularly in the Department of Defense—where we have come dangerously close to permitting contract employees to exercise functions which belong with top Government management officials. Insofar as this has been true, we believe it is being rectified. Government agencies are now keenly aware of this problem and have taken steps to retain functions essential to the performance of their responsibility under the law.

[9] It is not enough, of course, to recognize that governmental managers must retain top management functions and not contract them out. In order to perform those functions effectively, they must be themselves competent to make the required management decisions and, in addition, have access to all necessary technical advice. Three conclusions follow:

First, where management decisions are based substantially on technical judgments, qualified executives, who can properly utilize the advice of technical consultants, from both inside and outside the Government, are needed to perform them. There must be sufficient technical competence within the Government so that outside technical advice does not become de facto technical decisionmaking. In many instances the executives making the decisions can and should have strong scientific backgrounds. In others, it is possible to have nonscientists so long as they are capable of understanding the technical issues involved and have otherwise appropriate administrative experience.

By and large, we believe it is necessary for the agencies concerned to give increased stress to the need to bring into governmental service as administrators men with scientific or engineering understanding, and during the development of Government career executives, to give many of them the opportunity, through appropriate training and experience, to strengthen their appreciation and understanding of scientific and technical matters. Correspondingly, scientists and engineers should be encouraged and guided to obtain, through appropriate training and experience, a broader understanding of management and public policy matters. The average governmental administrator in the years to come will be dealing with issues having larger and larger scientific and technical content, and his training and experience, both before he enters Government service and after he has joined, should reflect this fact.

At the present time, we are strongly persuaded that one of the most serious obstacles to acquiring and maintaining the managerial competence which the Government needs for its research and development programs is the discrepancy between governmental and private compensation for comparable work. This obstacle has been growing increasingly serious in recent years as increases in Federal pay have been concentrated primarily at the lower end of the pay scale—resulting in the anomalous situation that many officials of Government responsible for administering major elements of Federal research and development programs are paid substantially smaller salaries than personnel of universities, or business corporations, or of not-for-profit organizations who carry out subordinate aspects of those research and development programs.[4] We cannot stress too strongly the importance of rectifying this situation, and hope the Congress will take at this session the action which the President has recommended to reform Federal civilian pay scales.

Second, it is necessary for even the best qualified governmental managers to obtain technical advice from specialists. Such technical advice can be obtained from men within the Government or those outside. When it is obtained from persons outside of Government, special problems of potential conflict of interest are raised which were [10] dealt with in the President's recent memorandum entitled "Preventing Conflicts of Interest on the Part of Advisers and Consultants to the Government."

We believe it highly important for the Government to be able to turn to technical advice from its own establishment as well as from outside sources. One major source of this technical knowledge is the Government-operated laboratory or research installation and, as is made clear later in this report, we believe major improvements are needed at the present time in the management and staffing of these installations. A strong base of technical knowledge should be continually maintained within the Government service and available for advice to top management.

Third, we need to be particularly sensitive to the cumulative effects of contracting out Government work. A series of actions to contract out important activities, each wholly justified when considered on its own merits, may when taken together begin to erode the Government's ability to manage its research and development programs. There must be a high degree of awareness of this danger on the part of all governmental officials concerned. Particular attention must be given to strengthening the Government's ability to provide effective technical supervision in the letting and carrying out of contracts, and to developing more adequate measures for performance evaluation.

DETERMINING THE ASSIGNMENT OF RESEARCH AND DEVELOPMENT WORK

As indicated above, we considered it necessary and desirable to use a variety of arrangements to obtain the scientific and technical services needed to accomplish public purposes. Such arrangements include: direct governmental operations through laboratories or other installations; operation of Government-owned facilities by contractors; grants and contracts with universities and entities associated with universities; contracts with not-for profit corporations wholly or largely devoted to performing work for Government; and contracts with private business corporations. We also feel that innovation is still needed in these matters, and each agency should be encourage to seek new and better arrangements to accomplish its purposes. Choices among available arrangements should be based primarily on two factors:

Relative effectiveness and efficiency, and

Avoidance of conflicts of interest.

Relative effectiveness and efficiency

In selecting recipients, whether public or private, for research and development assignments, the basic rule (apart from the conflict-of-interest problem) should be to assign the job where it can be done most effectively and efficiently, with due regard to the strengthening of institutional resources as well as to the immediate execution of projects. This

4. Annex 5 summarizes information obtained during the present review regarding salaries and related benefits.

criterion does not, in our judgment lead to a conclusion that certain kinds of work should be assigned only to certain kinds of institutions. Too much depends on individual competence, historical evolution, and other special circumstances to permit any such simple rule to hold. However, it seems clear that some types of facilities have natural advantages which should be made use of.

Thus:

[11] Direct Federal operations, such as the governmental laboratory, enjoy a close and continuing relationship to the agency they serve, which permits maximum responsiveness to the needs of that agency and a maximum sense of sharing the mission of the agency. Such operations accordingly have a natural advantage in conducting research, feasibility studies, developmental and analytical work, user tests, and evaluations which directly support the management functions of the agency. Furthermore, an agency-operated research and development installation may provide a useful source of technical management personnel for its sponsor.

At the present time, we consider that the laboratories and other facilities available to Government are operating under certain important handicaps which should be removed if these facilities are to support properly the Federal research and development effort. These matters are discussed at some length in part 4 of this report.

Colleges and universities have a long tradition in basic research. The processes of graduate education and basic research have long been closely associated, and reinforce each other in many ways. This unique intellectual environment has proven to be highly conducive to successful undirected and creative research by highly skilled specialists. Such research is not amenable to management control by adherence to firm schedules, well-defined objectives, or predetermined methods of work. In the colleges and universities, graduate education and basic research constitute an effective means of introducing future research workers to their fields in direct association with experienced people in those fields, and in an atmosphere of active research work. Applied research appropriate to the universities is that which broadly advances the state of the art.

University-associated research centers are well suited to basic or applied research for which the facilities are so large and expensive that the research acquires the character of a major program best carried out in an entity apart from the regular academic organization. Research in such centers often benefits from the active participation of university scientists. At the same time, the sponsoring university (and sometimes other, cooperating universities) benefits from increased opportunities for research by its faculties and graduate students.

Not-for-profit organizations (other than universities and contractor-operated Government facilities), if strongly led, can provide a degree of independence, both from Government and from the commercial market, which may make them particularly useful as a source of objective analytical advice and technical services. These organizations have on occasion provided an important means for establishing a competent research organization for a particular task more rapidly than could have been possible within the less flexible administrative requirements of the Government.

Contractor-operated Government facilities appear to be effective, in some instances, in securing competent scientific and technical personnel to perform research and development work where very complex and costly facilities are required and the Government desires to maintain control of these facilities. Under such arrangements, it has been possible for the Government to retain most of the controls inherent in direct Federal operations, while at the same time gaining many of the advantages of flexibility with respect to staffing, organization, and management, which are inherent in university and industrial operations.

[12] Operations in the profit sector of the economy have special advantages when large and complex arrays of resources needed for advanced development and preproduction work must be marshaled quickly. If the contracting system is such as to provide appropriate incentives, operations for profit can have advantages in spurring efficiency, reducing costs, and speeding accomplishments. (It is plain that not all operations in this sector have

resulted in low costs or rapid and efficient performance; we regard this as a major problem for the contracting system and discuss it further in pt. 3 of this report.) Contractors in the profit sector may have the advantage of drawing on resources developed to satisfy commercial as well as governmental customers, which adds to the flexibility of procurement, and may permit resources to be phased in and out of Government work on demand.

The preceding paragraphs have stressed the advantages of these different types of organization. There are disadvantages relating to each type, which must also be taken into account. Universities, for example, are not ordinarily qualified—nor would they wish—to undertake major systems engineering contracts.

We repeat that the advantages—and disadvantages—noted above do not mean that these different types of arrangements should be given areas of monopoly on different kinds of work. There are, by common agreement, considerable advantages derived from the present diversity of operations. It permits great flexibility in establishing and directing different kinds of facilities and units, and in meeting the need for managing different kinds of jobs. Comparison of operations among these various types of organizations helps provide yardsticks for evaluating performance.

Moreover, this diversity helps provide many sources of ideas and of the critical analysis of ideas, on which scientific and technical progress depends. Indeed, we believe that some research (in contrast to development) should be undertaken by most types of organizations. Basic and applied research activities related to the mission of the organization help to provide a better intellectual environment in which to carry out development work. They also assist greatly in recruiting high-quality research staff.

In addition to the desirability of making use of the natural areas of advantage within this diversity of arrangements, there is one additional point we would stress. Activities closely related to governmental managerial decisions (such as those in support of contractor selection), or to activities inherently governmental (such as regulatory functions, or technical activities directly bound up with military operations), are likely to call for a direct Federal capability and to be less successfully handled by contract.

Conflicts of interest

There are at least three aspects of the conflict-of-interest problem which arise in connection with governmental research and development work.

First, there are problems relating to private individuals who serve simultaneously as governmental consultants and as officers, directors, or employees of private organizations with which the Government has a contractual relationship. Many of these individuals are among the Nation's most capable people in the research and development field and can be of very great assistance to Government agencies.

[13] The problems arising in their case with respect to potential conflicts of interest have been dealt with in the President's memorandum of February 9, referred to earlier in this report. The essential standard set out in that memorandum was that no individual serving as an adviser or consultant should render advice on an issue whose outcome would have a direct and predictable effect on the interests of the private organization which he serves. To this end, the President asked that arrangements be made whereby each adviser and consultant would disclose the full extent of his private interests, and the responsible Government officials would undertake to make sure that conflict-of-interest situations are avoided.

Second, there is a significant tendency to have on the boards of trustees and directors of the major universities, not-for-profit and profit establishments engaged in Federal research and development work, representatives of other institutions involved in such work. Such interlocking directorships may serve to reinforce and strengthen the overall management of private organizations which are heavily financed by the Government. Certainly it is in the public interest that organizations on whom so much reliance is placed for accomplishing public purposes, should be controlled by the most responsible, mature, and knowledgeable men available in the Nation. However, we see the clear possibility of conflict-of-interest situations developing through such common directorships that might be harmful to the public interest. Members of governing boards of private business enterprises, universities, or other organizations which advise the Government with respect to research and development activities are often simultaneously members of governing boards or organizations which receive or may receive contracts or grants from the Government for research, development, or production work. Unless these board members also serve as consultants to the Government, present conflict-of-interest laws do not apply. The spirit, if not the letter, of the standards of conduct for Government advisers set forth in the President's memorandum, in our judgment, can and should provide guidance to boards and their members with respect to the interrelationships among universities, not-for-profit organizations, and business corporations where Government business is involved. Some boards of trustees and directors have already taken action along these lines.

Beyond this, however, there is a third type of problem which requires consideration: This might be described as potential conflicts of interest relating to organizations rather than to individuals. It arises in several forms—not all of which by any means are yet fully understood. Indeed, in this area of potential conflicts of interest relating to individuals and organizations in the research and development field, we are in an early stage of developing accepted standards for conduct—unlike other fields, such as the law or medicine, where there are long-established standards of conduct.

One form of organizational conflict of interest relates to the distinction between organizations providing professional services (e.g., technical advice) and those providing manufactured products. A conflict of interest could arise, for example, if a private corporation received a contract to provide technical advice and guidance with respect to a weapons system for which that same private corporation later sought a development or production contract, or for which it sought to develop or supply a key sub-system or component. It is [14] clear that such conflict-of-interest situations can arise whether or not the profit motive is present. The managers of the not-for-profit institutions have necessarily a strong interest in the continuation and success of such institutions, and it is part good management of Federal research and development programs to avoid placing any contractor—whether profit or nonprofit—in a position where a conflict of interest could clearly exist.

Another kind of issue is raised by the question whether an organization which has been established to provide services to a Government agency should be permitted to seek contracts with other Government agencies—or with non-Government customers. The question has arisen particularly with respect to not-for-profit organizations established to provide professional services.

There is not a clear consensus on this question among Government officials and officers of the organizations in question. We have considered the question far enough to have the following tentative views:

In the case of organizations in the area of operations and policy research (such, for example, as the Rand Corp.), the principal advantages they have to offer are the detached quality and objectivity of their work. Here, too close control by any Government agency may tend to limit objectivity. Organizations of this kind should not be discouraged from dealing with a variety of clients, both in and out of Government.

On the other hand, a number of the organizations which have been established to provide systems engineering and technical direction (such, for example, as Aerospace Corp.) are at least for the time being of value principally as they act as agents of a single client. In time, as programs change and new requirements arise, it may be possible and desirable for such organizations also to achieve a fully independent financial basis, resting on multiple clients, but this would seem more likely to be a later rather than an earlier development.

Enough has been said to indicate that this general area of conflict of interest with respect to research and development work is turning up new kinds of questions and all the answers have not yet been found. We believe it important to continue to work toward setting forth standards of conduct, as was done by the President in his February memorandum. We recommend that the President instruct each department and agency head, in consultation with the Attorney General, to proceed to develop as much of a code of conduct for individuals and organizations in the research and development field as circumstances now permit.

Finally, we would note that beyond any formal standards, we cannot escape the necessity of relying on the sensitive conscience of officials in the Government and in private organizations to make sure that appropriate standards are continually maintained.

[15] PART 3
PROPOSAL FOR IMPROVING POLICIES AND PRACTICES APPLYING TO RESEARCH AND DEVELOPMENT CONTRACTING

During the course of this review, a number of suggestions arose which we believe to indicate desirable improvements in the Government's policies and practices applying to research and development contracting.

IMPROVING THE GOVERNMENT'S COMPETENCE AS A "SOPHISTICATED BUYER"

In order for the contracting system to work effectively, the first requirement is for the Government to be a sophisticated buyer—that is, to know what it wants and how to get it. Mention has already been made of the requirements this placed on governmental management officials. At this point four additional suggestions are made.

1. In the case of many large systems development projects, it has been the practice to invite private corporations to submit proposals to undertake research and development work—relating to a new missile system, for example, or a new aircraft system. Such proposals are often invited before usable and realistic specifications of the system have been worked out in sufficient detail. As a consequence, highly elaborate, independent, and expensive studies are often undertaken by the would-be contractors in the course of submitting their proposals. This is a very costly method of obtaining competitive proposals, and it unnecessarily consumes large amounts of the best creative talent this country possesses, both on the preparation of the proposals and their evaluation. Delivery time pressures may necessitate inviting proposals before specifications are completed, but we believe that practice can and should be substantially curtailed.

This would mean, in many instances, improving the Government's ability to accomplish feasibility studies, or letting special contracts for that purpose, before inviting proposals. In either event, it would require the acceptance of a greater degree of responsibility by Government managers for making preliminary decisions prior to inviting private proposals. We believe the gains from such a change would be substantial in the avoidance of unnecessary and wasteful use of scarce scientific and technical personnel as well as heavy costs to the private contractors concerned—costs which in most cases are passed on to the Government.

2. We believe there is a great deal of work to be done to improve the Government's ability to supervise and to evaluate the conduct of research and development efforts—whether undertaken through public or private facilities. We do not have nearly enough understanding as yet of how to know whether we are getting a good product for our money, whether research and development work is being [16] competently managed, or how to select the more competent from the less competent as between research and development establishments.

When inadequate technical criteria exist, there is a tendency to substitute conformity with administrative and fiscal procedures for evaluation of substantive performance. What is required is more exchange of information between agencies on their practices in contractor evaluation and on their experience with these practices. A continuing forum should be provided for such exchange. It is possible also that some central and fairly formal means of reporting methods and experience and recording them permanently should be established. We recommend that the Director of the new Office of Science and Technology, when established, be asked to study the possibility of establishing such a forum and the best means for providing information regarding evaluation practices.

3. With the tremendous proliferation of research and development operations and associated facilities in recent years, it has become difficult for the Government officials who arrange for such work to be done to be aware of all the facilities and manpower that are available. To maintain a complete and continuous roster of manpower, equipment, and organizations, sensitive to month-by-month changes, would undoubtedly be too costly in terms of its value.

Nevertheless, we believe that an organized attempt should be made to improve the current inventory of information on the scientific and technical resources of the country. We recommend that the National Science Foundation consider ways and means of improving the availability of such information for use by all concerned in public and private activities.

4. In addition, the expansion of the Nations's research and development effort has multiplied the difficulties of communication among researchers engaged on related projects at separate facilities, both public and private. It is clear that additional steps should be taken to further efforts to improve the system for the exchange of information in the field of science and technology.

At present, a panel on scientific information of the President's Science Advisory Committee is at work on this subject. We expect that its report will be followed by full-scale planning for the establishment of a more effective technical information exchange system, to support the needs of the operating scientist and the engineer.

IMPROVING ARRANGEMENTS WITH THE PRIVATE SECTOR TYPES OF CONTRACTS

The principal type of contract for research and development work which is made with private industry is the cost-plus-fixed-fee contract. Such contracts have been used in this area because of the inherent difficulty of establishing precise objectives for the work to be done and of making costs estimates ahead of time.

At the same time, this type of contract has well-known disadvantages. It provides little or no incentive for private managers to reduce costs or otherwise increase efficiency. Indeed, the cost-plus-fixed-fee contract, in combination with strong pressures from governmental managers to accomplish work on a rapid time schedule, probably provides incentives for raising rather than for reducing costs. If a corporation is judged in terms of whether it accomplishes a result by [17] a given deadline rather than by whether it accomplishes that result at minimum cost, it will naturally pay less attention to costs and more attention to speed of accomplishment. On the other hand, where there is no given deadline, the cost-plus-fixed-fee contract may serve to prolong the research and development work and induce the contractor to delay completion.

Consequently, we believe it to be desirable to replace cost-plus-fixed-fee contracting with fixed-price contracting wherever that is feasible—as it should be in the procurement of some late-stage development, test work, and services. Where it is judged that cost reimbursement must be retained as the contracting principle, it should be possible in many instances to include an incentive arrangement under which the fee would not be fixed, but would vary according to a pre-determined standard which would relate larger fees to lower costs, superior performance, and shorter delivery times. There is ample evidence to prove that if adequate incentives are given by rewards for outstanding performance, both time and money can be saved. Where the nature of the task permits, it may be desirable to include in the contract penalty provisions for inadequate performance.

Finally, if neither fixed-price nor incentive-type contracts are possible, it is still necessary for Government managers to insist on consideration being given to lower cost, as well as better products and shorter delivery times—and to include previous performance as one element in evaluating different contractors and the desirability of awarding them subsequent contracts.

Contract administration

The written contract itself, however well done, is only one aspect of the situation. The administration of a contract requires as much care and effort as the preparation of the contract itself. This is particularly important with respect to changes in system characteristics, for these changes often become the mechanism for justifying cost overruns. Other factors of importance in contract administration are fixing authority and responsibility in both Government and industry, excessive reporting requirements, and all-too-frequent lack of prearranged milestones for auditing purposes.

Reimbursable costs

Concern has been expressed because of significant differences among the various agencies in policies regarding which costs are eligible for reimbursement—notably with respect to some of the indirect costs. These differences are now being reviewed by the Bureau of the Budget with the cooperation of the Department of Defense, the National Aeronautics and Space Administration, the Atomic Energy Commission, and the General Services Administration.

Arrangements with universities

With respect to universities, Government agencies share responsibility for seeing that research and development financed at universities does not weaken these institutions or distort their functions which are so vital to the national interest.

Government agencies use both grants and contracts in financing research at universities, but in our judgment the grant has proved to be a simpler and more desirable device for Federal financing of fundamental research, where it is in the interest of the Government [18] not to exercise close control over the objectives and direction of research. Since all relevant Government agencies are now empowered to use grants instead of contracts in supporting basic research, the wider use of this authority should be encouraged.

Apart from this matter, three others seem worthy of comment. One arises from the extensive use of contracts (or grants) for specific and precisely identified projects. Often there is a tendency to believe that in providing support for a single specific project the chance of finding a solution to a problem is being maximized. In reality, however, less specific support often would permit more effective research in broad areas of science, or in interdisciplinary fields, and provide greater freedom in drawing in more scientists to participate in the work that is undertaken. Universities, too, often find project support cumbersome and awkward. A particular professor may be working on several projects financed by several Government agencies and must make arbitrary decisions in allocating expenses to a particular project. It thus appears both possible and desirable to move in the direction of using grants to support broader programs, or to support the more general activities of an institution, rather than to tie each allocation of funds to a specific project. A number of Government agencies have been moving in this direction and it would be desirable to expand the use of such forms of support as experience warrants.

At the same time, it would not, in our judgment, be appropriate to place major reliance on the institutional grant, since the major purpose of making grants in most cases is to assure that the university personnel and facilities concerned will be devoted to pursuing specific courses of inquiry.

A second problem associated with the support of research at universities is whether the Government should pay all costs, including indirect expenses or "overhead," associated with work financed by the Government. We believe this matter involves two related but distinct questions, which should be separated in considering the appropriate policy to be followed.

1. We believe there is no question that, in those cases in which it is desirable for the Government to pay the entire cost of work done at a university, the Government should pay for allowable indirect as well as direct costs. To do otherwise would be discriminatory against universities in comparison with other kinds of institutions. For purposes of financial and accounting simplicity, in those cases where grants are used, and it is desirable for the Government to pay all allowable costs, it may be possible to work out a uniform or average percentage figure which could be regarded as covering indirect costs.

2. We believe there are many cases in which it is neither necessary nor desirable for the Government to pay all the costs of the work to be done. In many fields of research, a university may gain a great deal from having the research in question done on its campus, with the participation of its faculty and students, and may be able and willing to share in the costs, either through its regular funds or through raising additional funds from foundations, alumni, or by other means. The extent and degree of cost-sharing can and should vary among different agencies and programs, and we are not prepared at this time to suggest any uniform standards—except the negative one that it would be plainly illogical to require that the university uniformly provide its share through the payment of all or a part of the indirect [19] costs. Only in the exceptional case would this turn out to be the best basis for determining the appropriate sharing of costs.

A third problem relates to the means for furnishing major capital assets for research at universities (such as a major building or a major piece of equipment such as a linear accelerator, synchrotron, or large computer. In most cases, it will be preferable to finance such facilities by a separate grant (or contract), which will ensure that careful attention is given to the long-term value of the asset and to the establishment of appropriate arrangements for managing and maintaining it.

Arrangements with respect to not-for-profit organizations other than universities

It has been the practice in contracting for research and development work with such organizations to cover all allowable costs and, in addition, to provide what is commonly called a "fee." The reason for paying a "fee" to not-for-profit organizations is quite different from the reason for paying a fee to profit-making contractors and therefore the term "fee" is misleading. The profitmaking contractor is engaged in business for profit. His profit and the return to his shareholders or investors can only come from the fee. In the case of the not-for-profit organizations, there are no shareholders, but there are two sound reasons to justify payment of a "development" or "general support" allowance to such organizations.

One is that such allowances provide some degree of operational stability and flexibility to organizations which otherwise would be very tightly bound to the precise limitations of cost financing of specific tasks; the allowances can be used to even out variations in the income of the organization resulting from variations in the level of contract work. A second justification is that most not-for-profit organizations must conduct some independent, self-initiated research if they are to obtain and hold highly competent scientists and engineers. Such staff members, it is argued, will only be attracted if they can share, to some extent, in independently directed research efforts.

We considered that both of these arguments have merit and, in consequence, support the continuation of these payments. Both arguments represent incentives to maintain the cohesiveness and the quality of the organization, which is in the interest of the Government. They should underlie the thinking of the Government representatives who negotiate contracts with not-for-profit organizations. But the amount of the "fee" or allowance in each instance must still be determined by bargaining between Government and contractor, in accordance with the independent relationship that is essential to successful contracting.

An important question relating to not-for-profit organizations, other than universities, concerns facilities and equipment. In our judgment, the normal rule should be that where facilities and equipment are required to perform research and development work desired by the Government, the Government should either provide the facilities and equipment, or cover their cost as part of the contract. This is the rule relating to profit organizations and would hold in general for not-for-profit organizations—but there are two special problems with respect to the latter.

[20] First, we believe it is generally not desirable to furnish funds through "fees" for the purpose of enabling a contractor to acquire major capital assets. On the other hand, the Government should not attempt to dictate what a contractor does with his "fee," provided it has been established on a sound and equitable basis, and if a contractor chooses to use part of his "fee" to acquire facilities for use in his self-initiated research we would see

no objection.

Second, we would think it equitable, where the Government has provided facilities, funds to obtain facilities, substantial working capital, or other resources to a contractor, it should, upon dissolution of the organization, be entitled to a first claim upon such resources. This would seem to be a matter which should be governed, insofar as possible, by the term of the contract—or, in the case of any newly established organizations, should be provided in the provisions of its charter.

Salaries and related benefits

In addition to the question of fees and allowances, there has been a great deal of concern over the salaries and related benefits received by persons employed on federally financed research and development work in private institutions, particularly persons employed in not-for-profit establishments doing work exclusively for the Government. Controls have been suggested or urged by congressional committees and others to make sure that there is no excessive expenditure of public funds and to minimize the undesirable competitive effect on the Federal career service.

We agree that where the contracting system does not provide built-in controls (for example, through competitive bidding), attention should be paid to the reasonableness of contractors' salaries and related benefits, and contractors should be reimbursed only for reasonable compensation costs.

The key question is how to decide what is reasonable and appropriate compensation. We believe the basic standard for reimbursement of salaries and related benefits should be one of comparability to compensation of persons doing similar work in the private economy. The President recently proposed to the Congress that the pay for Federal civilian employees should be based on the concept of reasonable comparability with employees doing similar work in the private economy. We believe this to be a sound principle which can be applied in the present circumstances as well.

Application of this comparability principle may require some special compensation surveys (perhaps made by the Bureau of Labor Statistics), which can and should be arranged for as necessary. Furthermore, there will undoubtedly be cases in which comparable data are difficult to obtain—as, for example, with respect to top management jobs. In such cases the specific approval of the head of the Government contracting agency or his designee should be required.

In view of the inherent complexity and sensitivity of this subject, we suggest that special administrative arrangements should be established in each agency. Contract policies respecting salaries and related benefits in each contracting agency should be controlled by an official reporting directly to the head of the agency (in the Department of Defense, to assure uniformity of treatment, by an official reporting directly to the Secretary of Defense), and salaries above a certain level—say $25,000—should require the personal approval of that official.

[21] PART 4
PROPOSALS FOR IMPROVING THE GOVERNMENT'S ABILITY TO CARRY OUT RESEARCH AND DEVELOPMENT ACTIVITIES DIRECTLY

Based on the evidence acquired in the course of this review, we believe there is no doubt that the effects of the substantial increase in contracting out Federal research and development work on the Government's own ability to execute research and development work have been deleterious.

The effects of the sharp rise in contracting out have included the following. First, contractors have often been able to provide a superior working environment for their scientists and engineers—better salaries, better facilities, better administrative support—making contracting operations attractive alternatives to Federal work. Second, it has often seemed that contractors have been given the more significant and more interesting work assignments, leaving Government research and development establishments with routine missions and static programs which do not attract the best talent. Third, additional burdens have often been placed on Government research establishments to assist in evaluating the work of increasing numbers of contractors and to train and educate less skilled contractor personnel—without adding to the total staff and thus detracting from the direct research work which appeals to the most competent personnel. Fourth, scientists in contracting institutions have often had freedom to move "outside of channels" in the Government hierarchy and to participate in program determination and technical advice at the highest levels—freedom frequently not available to the Government's own scientists. Finally, one of the most serious aspects of the contracting out process has been that it has provided an alternative to correcting the deficiencies in the Government's own operations.

In consequence, for some time there has been a serious trend toward the reduction of the competence of Government research and development establishments. Recently a number of significant actions have been started which are intended to reverse this trend. We point particularly to the strong leadership being given within the Defense Department by the Director of Defense Research and Engineering, in striving to raise the capabilities of the Department's laboratories and other research and development facilities.

Nevertheless, we believe the situation is still serious and that major efforts are required.

We consider it a most important objective for the Government to maintain first-class facilities and equipment of its own to carry out research and development work. This observation applies not only to the newer research and development agencies but equally to the older agencies such as Commerce, Interior, and Agriculture.

No matter how heavily the Government relies on private contracting, it should never lose a strong internal competence in research and development. By maintaining such competence it can be sure of [22] being able to make the difficult but extraordinarily important program decisions which rest on scientific and technical judgments. Moreover, the Government's research facilities are a significant source of management personnel.

Major steps seem to us to be necessary in the following matters:

1. It is generally recognized that having significant and challenging work to do is the most important element in establishing a successful research and development organization. It is suggested that responsibility should be assigned in each department and agency to the Assistant Secretary for Research and Development or his equivalent to make sure that assignments to governmental research facilities are such as to attract and hold first-class men. Furthermore, arrangements should be made to call on Government laboratory and development center personnel to a larger extent for technical advice and participation in broad program and management decisions—in contrast to the predominant use of outside advisers.

2. The evidence is compelling that managerial arrangements for many Government-operated research and development facilities are cumbersome and awkward. Several improvements are needed in many instances, including—

Delegating to research laboratory directors more authority to make program and personnel decisions, to control funds, and otherwise to command the resources which are necessary to carry out the mission of the installation;

Providing the research laboratory director a discretionary allotment of funds, to be available for projects of his choosing, and for the results of which he is to be responsible;

Eliminating where possible excess layers of echelons of supervisory management and ensuring that technical, administrative, and fiscal reviews be conducted concurrently and in coordinated fashion; and

Making laboratory research assignments in the form of a few major items with a reasonable degree of continuity rather than a multiplicity of small narrowly specific tasks; this will put responsibility for detailed definition of the work to be done at the laboratory level where it belongs.

To carry out these improvements will require careful and detailed analysis of the different situations in different agencies. Above all, it will require the energetic direction of top officials in each agency.

Plans have already been developed for joint teams of Civil Service Commission and Department of Defense research and manpower personnel to visit nine defense laboratories during April and May 1962, in order to analyze precisely what administrative restrictions exist that hamper research effectiveness. In this fashion, those unwarranted limitations that can be eliminated by executive action can be identified as distinguished from those that may require legislative change.

3. Salary limitations, as already mentioned, in our opinion play a major role in preventing the Government from obtaining or retaining highly competent men and women. Largely because of the lack of comparable salaries, the Government is not now and has not for at least the past 10 years been able to attract or retain its share of such critically necessary people as: recently graduated, highly recommended Ph.D.'s in mathematics and physics, recent B.S.-M.S. scientific and [23] engineering graduates in the upper 25 percent of their classes at top-ranked universities; good, experienced weapons system engineers and missile, space, and electronic specialists at intermediate and senior levels; and senior-level laboratory directors, scientific managers, and administrators. This obstacle will be substantially overcome if the Congress approves the President's recommendation to establish a standard of comparability with private pay levels for higher professional and technical jobs in the Federal service.

4. A special problem in the Defense Department is the relationship between uniformed and civilian personnel. This is a difficult and sensitive problem of which the Department of Defense is well aware. We do not attempt in this report to propose detailed solutions, but we do suggest that certain principles are becoming evident as a result of the experience of recent years.

It seems clear, for example, that the military services will have increasing need for substantial numbers of officers who have extensive scientific and technical training and experience. Such officers bring firsthand knowledge of operational conditions and requirements to research and development installations and, in turn, learn about the state of the art and the feasible applications of technology to military operations. The military officer is needed to communicate the needs of the user, to prepare the operational forces for new equipment, to plan for the use of developing equipment, and later to install it and supervise its use.

All of the above roles suggest that when military personnel are used in research and development activities, they should perform as "technical men" rather than "military men" except when there is a need for their military skills. Military command and direction become important only as one moves from the research end of the spectrum into the area where operational considerations predominate. Both at middle management and policy levels, a well-balanced mixture of military and civilian personnel may be most advantageous in programs designed to meet military needs.

In research, there are many instances in which the existence of military supervision, and the decreased opportunities for advancement because of military occupancy of top jobs, are among the principal reasons why the Defense Department has had difficulty in attracting outstanding civilian scientists and engineers. On the other hand, there are examples within the Department of cause in which enlightened policies of civil-military relationships have drawn on the strengths of each and produced excellent results. In such instances, the military head of the laboratory has usually concentrated on administrative problems and the civilian technical director has had complete control of technical programs.

Military officers should not be substituted for civilians in the direction and management of research and development unless they are technically qualified and their military background is directly needed and applicable.

In the course of the next year, the Department of Defense intends to give consideration to the delineation of those research and development installations in which operational considerations are predominant and those installations in which scientific and technical considerations are predominant. Having done so, the assignment of military officers [24] to head the former type of installation, and civilians (or equally qualified military officers) to head the latter will be encouraged. Furthermore, when military personnel are assigned to work in civilian-directed installations on the basis of their technical abilities, it is intended that they should be free of the usual rotation-of-duty requirements and not have separate lines of reporting.

5. In addition to the recommendations above, we have given consideration to the possible establishment, which might be called a Government institute. Such an institute would provide a means for reproducing within the Government structure some of the more positive attributes of the nonprofit corporation. Each institute would be created pursuant to authority granted by the Congress and be subject to the supervision of a Cabinet officer or agency head. It would, however, as a separate corporate entity directly managed by its own board of regents, enjoy a considerable degree of independence in the conduct of its internal affairs. An institute would have authority to operate its own career merit system, as the Tennessee Valley Authority does, would be able to establish a compensation system based on the comparability principle, and would have broad authority to use funds and to acquire and dispose of property.

The objective of establishing such an instrumentality would be to achieve in the administration of certain research and development programs the kind of flexibility which has been obtained by Government corporations while retaining, as was done with the Government corporation, effective public accountability and control.

We regard this idea as promising and recommend that the Bureau of the Budget study it further, in cooperation with some of the agencies having major research and development programs. It may well prove to be a useful additional means for carrying out governmental research and development efforts.

6. It would seem, based on the results of this review, that it would be possible and desirable to make more use of existing governmental facilities and avoid the creation of duplicate facilities. This is not as easy a problem as it might seem. It is ordinarily necessary for a laboratory, if it is to provide strong and competent facilities, to have a major mission and a major source of funding. This will limit the extent to which it is possible to make such facilities available for the work of other agencies. Nevertheless, in some cases and to some extent it is clearly possible to do this, and a continuing scrutiny is necessary in order to make sure that the facilities which the Government has are used to their fullest extent.

7. Finally, together with the better use of existing facilities, the Government must also make better use of its existing scientific and engineering personnel. This implies not only a careful watch over work assignments, but also a continual upgrading of the capabilities of Federal personnel through education and training. At the present time, technology is changing so rapidly that on-the-job scientists and engineers find themselves out of date after a decade or so out of the university. To remedy this, the Government must strengthen its educational program for its own personnel, to the extent of sending them back to the university for about an academic year every decade. This program, necessary as it is, will only become attractive if the employee is ensured of job security on his return from school and if his parent organization is allowed to carry him on its personnel roster....

Document IV-10

Document title: Albert F. Siepert to James E. Webb, Administrator, "Length of Tours of Certain Military Detailees," February 8, 1963.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

From its inception NASA administrators made a practice of accomplishing goals by marshalling outside resources rather than reproducing them within the agency. Although NASA was a civilian agency, in its early days it made extensive use of military expertise. In fact, the number of military personnel working for NASA increased steadily between 1960 and 1968, and military officers played key roles in the Apollo program. This 1963 memorandum emphasized the need for NASA to obtain the services of military detailees for the extended time needed for them to carry out the responsibilities assigned to them by NASA.

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[1] Length of Tours of Certain Military Detailees

On April 13, 1959, the President approved an agreement between the Departments of Defense, Army, Navy, Air Force, and the National Aeronautics and Space Administration which provides for the detailing of military personnel for service with NASA. This agreement has made it possible for NASA to obtain from the military the services of many fine officers with skills and experience not obtainable from other sources. This cooperation on the part of the Department of Defense has contributed materially to the success of NASA's efforts.

The agreement provides that the normal tour of duty with NASA for military personnel on active duty will be three years. It also provides that NASA "... send a timely request to the military department concerned for any desired extension." Normally, the three-year tour is satisfactory. There are exceptions, however, and problems occasionally arise in obtaining extensions of more than one-year when NASA management happens to place a career officer with rather unique skills in a key program or management position. Even with the most careful planning, NASA's rapid growth has thus far made it impossible to plan ahead for an adequate understudy to take over these unusual assignments at the expiration of an automatic three- or four-year period. Jobs to which career officers have been assigned have in many instances grown considerably in terms of scope, responsibility, and urgency. Of greater significance, the ability of the officer himself to assume greater and greater responsibility and thereby become more critical to our needs makes it even more important for us to seek a more liberal interpretation of the provision in the basic agreement on extending tours of duty of career officers detailed to NASA when they occupy positions critical to our operations.

In two instances, by dealing with the military service concerned, we have been able to secure extensions greater than one year. The astronauts were granted a three-year extension because it was determined that such an extension was mutually beneficial to the officers, the military services, and NASA. Cdr. Albert J. Kelly was granted a three-year extension by the Navy because of his assignment as Director, Electronics and Control, Office of Advanced Research and Technology, a key executive position which was of considerable benefit to his career development. A one-year extension would not have provided sufficient time for NASA to secure and indoctrinate an acceptable replacement. Major Victor Hammond, Chief, National Range Support, Office of Tracking and Data Acquisition, is presently serving on a one year extension and no action has been taken to replace or to [2] obtain another extension. On the other hand, NASA has not attempted to obtain extended tours of duty of career officers when such an extension might stand in the way of the long-term career objectives of the officer. General Ostrander, General Roadman (returning to military assignment soon), Col. Heaton, and Col. Seaberg are good examples.

The Launch Operations Center at Cape Canaveral, more than any other NASA installation, has relied upon career officers of the military to staff key positions. Col. Asa Gibbs has occupied the position of liaison with the Atlantic Missile Range, thereby providing a focal point for all NASA range requirements. A request to extend his tour of duty of denied. Lt. Col. Ray Clark, presently serving as Special Assistant to Kurt Debus, has secured orders returning him to duty in a military assignment. A request for an extended tour of duty was disapproved. Major Rocco Petrone, presently serving as, Chief Heavy Space Vehicle Systems Office, is nearing the end of his three-year detail, and a request for extension of his tour of duty has been filed with the Department of the Army.

The loss of Lt. Col. Clark, and very possibly Major Petrone, will be a severe blow to the LOC organization. While the military objective of fulfilling the requirements of career development are recognized and understood, we feel we must do everything we can to obtain extended tours of duty for both Lt. Col. Clark and Major Petrone.

As background, the following table provides information on military details and extended tours of duty under terms of the agreement:

Career Military Officers Assigned to NASA

	Army	Navy	Air Force	Total
Presently Assigned	12	30	52	94
Previously Assigned	3	5	16	24
Assigned				118

Requests for Extended Tours of Duty

Requests	3	7	8	18
Approved	1	7 *	6 **	14
Disapproved	1	1	1	
Pending	1		1	

* 1 Navy + 2 Air Force extended for 2 years
** 4 Navy + 3 Air Force extended for 3 years

[3] The few times we have sought extensions of tours of duty clearly indicates that we have been most considerate of military objectives in furthering the career development of its officer personnel. Also, it is clearly evident that there is better cooperation on the part of the Navy and Air Force than there is by the Army.

Lt. Col. Clark and Major Petrone are key figures in the LOC organization which is now at the very beginning of a tremendous expansion. It is my opinion that every effort should be made to obtain two-year extensions of their tours of duty with NASA.

Document IV-11

Document title: U.S. Congress, House, Committee on Science and Astronautics, Subcommittee on NASA Oversight, Staff Study, "Apollo Program Management," 91st Cong., 1st sess. (Washington, DC: U.S. Government Printing Office, July 1969), pp. 59-74.

Olin ("Tiger") E. Teague (D-Texas), one of the space program's staunchest supporters in the House of Representatives and the Chairman of the Subcommittee on NASA Oversight of the House Committee on Science and Astronautics, struggled to protect NASA's budgets from cuts that began to occur after the agency's peak of $5.2 billion for FY 1965. In 1968 Teague wrote the presidents and chief executive officers of the Boeing Company, the McDonnell Douglas Astronautics Company, North American Rockwell Corporation, Grumman Aircraft Engineering Corporation, and the Space Division of the Chrysler Corporation, seeking their cooperation in a committee study of "those key management systems which have been adapted and developed in the Apollo program and which may have the potential for making a contribution to other large and complex technological programs." McDonnell Douglas, whose submission is reprinted here, designed and developed under contract to NASA the upper stage (S-IV) of the Saturn I launch vehicle and the third stage (S-IVB) of the Saturn IB and the Saturn V.

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[59] Apollo Program Management

PRESENTATION TO THE STAFF OF THE SUBCOMMITTEE ON NASA OVERSIGHT...

[61] INTRODUCTION

In May 1960 the McDonnell Douglas Astronautics Co.-Western Division (MDAC-WD) then known as the Douglas Aircraft Co., was awarded a NASA contract to design and develop the Saturn S-IV, the upper stage of the Saturn I launch vehicle, and the first of a family of three giant launch vehicles whose ultimate mission is manned exploration of the moon. In April 1962, this organization was also awarded a second NASA contract, to design and develop the Saturn S-IVB, the uppermost stage of the two other members of the launch vehicle family, the Saturn IB and Saturn V.

At the time of the first award, the organizational structure of that entity of the Company responsible for discharge of the newly contracted obligations was one which had been formed for the efficient and simultaneous development of various guided missile weapon systems for military forces. The advent of the Saturn/Apollo system, the greatest engineering task in history, required a much more intimate integration of Government and industry resources than had previously been the case. The necessity of this close integration of resources and effort was not immediately visible to either industry or Government, at least to the degree eventually required. Accordingly, over a period of time, the MDAC-WD found it necessary to realign its organizational structure and adjust its management techniques to accommodate the unique requirements of this great, joint, government-industry venture.

The report discusses how and why the MDAC-WD Saturn organization and management methods evolved to meet this challenge. It presents in chronological order how the organization configuration changed from an integrated functional form to a project form, to a divisional status, and then to a matrix form. It reviews the creation of new management tools to efficiently handle the requirements of precise configuration control, exacting quality standards, extensive contract change traffic, and even fundamental revision in the type of contract. The effectiveness of these management systems is then finally demonstrated by presenting the performances on cost control, schedule compliance, and flight program success.

SECTION 1
MANAGEMENT

1.1 Concepts

To manage the Saturn program, the Company devised a logical, systematic framework for the task with the ingredient of flexibility to accommodate program growth and change. Management concepts were influenced by the nature of the Company, Customer, work to be performed, and legal and regulatory requirements.

[62] 1.1.1 Company

The chain of events involving organization and reorganization of the Company's missile and space systems efforts, covered elsewhere in this report, has influenced the Saturn/Apollo program. Two management principles were used: (1) provide autonomy and freedom to Company personnel to interface directly with the Customer's managers, and (2) provide top management with the means to evaluate program status and support the program manager's needs for resources. (This was made possible by the projectized program organization placed in a matrixed division framework.)

1.1.2 Customer

Interfacing effectively and expeditiously with Customer program managers at all levels became an overriding necessity. To achieve this, appropriate parallels were established between key organizations such as in the structuring of the NASA Apollo Program Office and (then titled) Douglas Saturn/Apollo Program Office.

1.1.3 Work to be Performed

Large scientific and technical staffs were established during the design and development phases, and the results of their efforts implemented by manufacturing and test groups. Physical requirements imposed by geography and logistics had to be met. The stage was to be manufactured in Southern California, tested in Northern California (NASA test facilities are in Alabama), with checkout and launch taking place in Florida. Stages were to be transported between these areas and facilities managed at each.

1.1.4 Legal and Regulatory Requirements

Finally, NASA requirements had to be expressed in contractual terms. MDAC-WD had to conform to NASA's procurement regulations and other federal regulations.

Increasingly precise requirements were embodied in the contract, and they exerted powerful influences on the management philosophies.

1.2 Organization

For best control, MDAC-WD consists of organizations structured vertically according to function and horizontally by product line. Saturn/Apollo, one of the 13 subdivisions in this matrix framework, is projectized for single-point management control. Thus, the vital functions of Development Engineering, Financial Management, Reliability and Launch Operations (R. & L.O.), and Operations are made directly available to Saturn by organizational structure. . . .

Support given by these subdivisions to Saturn is (1) Huntington Beach Development Engineering–Engineering design and test, material research and production methods, standardization, etc., (2) Financial Management–Controller, contracts (including Work Order Authorizations), Operations Control (costs, pricing, budgets, schedules, program tracking, etc.), and financial forecasts and analysis, (3), R. & L.O.—Launch support services for Saturn/Apollo launches at KSC, including mission variation modifications, prelaunch preparations and stage testing, operating launch consoles, and participating in [63] countdown, and (4) Operations—Manufacturing Operations, Manufacturing Engineering, Reliability Assurance, Procurement, and Facilities.

1.3 Saturn/Apollo Program Subdivision

This subdivision manages the Company's Saturn/Apollo programs and coordinates support from other subdivisions. In certain areas cutting across the functional activities of several subdivisions, the Director, Assistant General Manager, MDAC—WD for the Saturn/Apollo program has established his own directorates, i.e., Director of Saturn Program Product Assurance, Director of Saturn Program Production, and others.

1.3.1 Director/Assistant General Manager

Mr. H. E. Bauer, Director/Assistant General Manager, has complete authority to plan, direct, and control the MDAC—WD resources applied to Saturn work. Mr. Bauer represents and acts for the Vice- President-General Manager of MDAC-WD in all matters concerning Saturn at all Division locations.

1.3.2 Directors and Staff

The directorates and staff elements . . . comprise the essential links of a project organization, autonomous but supportable through a matrix structure by other Subdivisions. No attempt is made to describe functions and responsibilities in this report. . . .

[64] In addition, support is given Saturn by the following subdivisions:

1.3.2.1 Information Systems

Developing and implementing integrated, management information system; the data from checkout, static firing, and flight operations for engineering analysis and evaluation, etc.

1.3.2.2 Advance Systems and Technology

Analysis of new product areas; conducting CRAD and IRAD programs, including the Saturn/Apollo.

1.4 Program Management Objectives

From its inception, the Saturn/Apollo effort was managed in a manner little recognized in textual theory on aerospace program management and management information control systems. Successes to date are attributable to the unique direct management techniques which were and are being used to meet program objectives.

1.4.1 Zero Flight Failures

The overriding objective was to avoid flight failures. MDAC-WD devised techniques and methods to produce articles of such quality and reliability that there would be no failures in flight. Administrative controls and requirements which had no direct bearing on flight success were subordinated to a secondary role, for later development in satisfying auditing agencies, internal and external.

1.4.2 Maximum Direct Communications

MDAC-WD and Customer personnel at middle management levels and higher were given freedom of direct communication for the sake of expediency and to avoid undue paperwork channels which might hinder progress on the day-by-day management of the program.

[65] **1.4.3 Flexibility With Short Reaction Time**

Built into the management systems was the flexibility to respond to Customer direction, redirection, and changes in the program. These techniques are covered in subsequent sections of this report.

1.4.4 Change Management, Not Change Inhibition

This objective was achieved.

1.4.5 Schedule Compliance Ahead of Schedule Capability

Early in the program, management struggled to move on time from engineering release, through first hardware test, and first article acceptance firing and delivery to the Cape. They resolved to first meet, then get ahead of the schedule.

1.4.6 Outstanding Technical Capability

The record of achievements attests to the success of this objective. The S-IV program established an outstanding technical capability, which bore fruits in the S-IVB and related efforts.

1.4.7 Avoid Cost Overruns

This very important objective and the techniques used to overcome an actual overrun will be explained later in the report. It is noteworthy that, in so doing, management implemented numerous cost reduction activities that resulted in an on-target or underrun condition.

SECTION 2
KEY MANAGEMENT EVENTS AND ACTIONS

2.1 Reorganization

In 1966, the program organization underwent several significant changes. The projectized Program Control was abandoned in favor of the Division concept. The Sacramento Test Center now reported to the program director, instead of Saturn Engineering. Also, an effective Configuration Change Control Board had been created. The success of being able to communicate the role and relationship of program managers to the remainder of the Division's organizations, and the providing of sound management systems with which he can carry out his responsibilities, has reduced the need for projectized organizations. The reduction in projectized organizations in favor of recentralization of functional resources contributes to flexibility in the shifting of resources between programs, with the inherent benefits of better utilization of manpower, improved performance, and lower costs.

2.2 All-Up Test Concept

The Marshall Space Flight Center set the tone for the space program. Their philosophy was to drive the first stage with dummy upper stages and fly the needed number of development rounds with two-stage vehicles. MDAC-WD history through such programs as Nike/Ajax Nike/Hercules, Nike/Zeus, also led to the concept of progressive developments. Since they were unmanned vehicles, the company employed an incremental development methodology. Upon entering the S-IV and S-IVB programs, we were ready to accept the all-up test concept.

[66] Flights occurred with near-to-operational configurations on the very first launch, as opposed to flying with partially complete or alternative configurations, such as programmers instead of full guidance. This meant a most comprehensive ground test program, which prevented the revelation of hardware weaknesses in flight.

This brought the S-IVB into the flight stage far ahead of schedule. Originally, several decisions were made to fly men on the Saturn I with the S-IV. Economics dictated against a decision to have a Saturn I, an IB, and a V all going at once. In 1962, the decision was made to cancel. The S-IV was actually canceled before it ever flew.

The obvious consequence of the all-up test concept was the imposition of configuration control disciplines on the program, on the technical staff, on suppliers, and on the entire community. Rigorous management of configuration changes avoided a near chaotic condition which would have resulted from the inclusion of results from various test analyses in the hardware. This would have caused much difficulty in establishing the proper configuration for each acceptance firing or launch.

Ground rules were laid down that connected the all-up philosophy with configuration control. It was considered a law that anything that flew on 205 had to be flown on 204, and anything on 503 had to be on 502. That the rules were well conceived is attested to by the program's degree of success.

2.3 Saturn I Performance and the LOR Decision

Performance of the Saturn I program and the Saturn S-IV stage was technically outstanding. All six vehicles were launched with complete success, providing MDAC-WD with the technical capability and the baseline necessary to proceed into the S-IVB. The lunar orbital rendezvous decision was then made, which led to the requirement of the S-IVB stage and the S-II Stage using the J-2 liquid-oxygen/liquid/hydrogen engine. With that decision the Company entered into the contract definition phase for the S-IVB. Successful development of hydrogen technology had a tremendous effect on Apollo. In 1961, Pratt & Whitney experienced several accidents with their RL-10 engine, and there followed a wave of adverse sentiment against hydrogen. If work had not progressed to show that hydrogen was an easy material to work with, and that multiengined capability was not impossible to achieve, the entire Saturn/Apollo program might have been shaped quite differently.

2.4 Controls

Management awareness and control of Saturn required a continuous monitoring analysis, and evaluation of all program aspects in terms of cost, schedule, and technical performance. This in-depth surveillance of the program was made feasible through the operation of four high-level action boards chartered to review program progress. These boards were not only to review, but also carry out a wide range of overall management functions. Their authority cut across all program activities, and they were the principal apparatus by which management formulated policy and provided program direction. By name they are: the Configuration Change Control Board, Change Analysis Board, Senior Management Action Board, and the Senior Financial Management Review Board. They are real-time, decisionmaking [67] boards with the capability to record and establish their findings and convert them to firm contract language in the form of change orders and program adjustments.

2.4.1 Configuration Change Control Board (CCCB)

In one sense, the management process often begins with this board, which was established to coordinate the activities of the Saturn program. It is here that proposed contractual changes in the program are formally brought to the attention of Saturn top management and the initial decisions made for putting them into effect. The board is chaired by the Program Director.

The Configuration Change Control Board meets three times a week. It examines all contract change orders, supplemental agreements, proposed ECP's that adjust the contract, and all work effort that requires responsiveness across the Division. A NASA representative also attends, and the products of the staff work are brought before all of the directors. This community of directorates, located at Huntington Beach, sits in that meeting as formal members of the team. The community expands, depending on the particulars of the agenda. Members acquire a thorough understanding of what is contemplated, and may object, agree, or propose a change. It is not, however, a voting board.

Saturn management is, perhaps, unique in the depth of detail into which it goes—the turning on of any change order or supplemental agreement, of board items down to very small items. The program director has all of his decisionmakers immediately available—often in one room—and they have an opportunity to look at every important piece of work to be authorized, including details that many would consider completely unnecessary when related to the stature of the board.

2.4.2 Change Analysis Board (CAB)

All Company-initialed requests for changes are first presented to this board before being sent to the CCCB. Those changes deemed advisable that do not require a formal change in the contract can be approved or rejected on the spot by this board. For those changes requiring formal contractual change, an Engineering Change Proposal is prepared and submitted to the CCCB. Authority for the operation of this board rests with its chairman, who reports directly to the program director.

2.4.3 Senior Management Action Board

This biweekly board is one of the principal tools by which Saturn management controls the progress of the program. The meeting, chaired by the program director, is attended by senior management and key supervisory personnel. Characterized by incisive question-and-answer sessions, the meetings have come to be known as the "Black Tuesday" reviews.

2.4.4 Senior Financial Management Review

This review is presented each month by the Financial Management Subdivision to the program director and his staff. Target costs and expenditures of each of the operating departments are examined in detail, with particular emphasis given to estimates for the future. Budget adjustments to correct deviations and resolve potential problems are made on the basis of much of the information coming from this financial review process.

[68] **2.4.5 Other Reviews**

Still other techniques used on the program embody the concept of review and re-review. The various levels of management or disciplines review the program progress. Communities are established to simply review the program on a short-term basis. In progress reviews with MSFC, however, the 30-45 review (meet for 30 minutes every 45 days) is presented only to division management.

In the launch mission reviews, any major tests may be reviewed, not only by the program but by an independent agency such as the Reliability and Launch Operations organization (R. & L.O.). These reviews are conducted by the Vehicle Flight Readiness Review Committee, which addresses itself to a specific test, such as an acceptance firing or a launch operation. They draw, from the division, appropriately skilled people to be the auditors. The program presents the status of the hardware, the configurations, significant failure and rejection reports, and open supplementary failure analysis documentation.

Another side benefit is the record of all of the examinations, findings, and actions taken to respond to those findings. These findings are presented to the director of the program. He must respond to all of those action items, in writing and to the satisfaction of the Reliability and Launch Operations organization—which is empowered to stop the test. It is then placed in the record for reference, should it become necessary.

The concept of review and re-review by different communities has been an important ingredient to ensure technical success.

2.5 Configuration Management Disciplines

Also in development during reorganization of the Saturn Program were the initial NASA/Contractor agreements involving application of the configuration management disciplines on program changes. These agreements were made contractual in early 1966 and represent a milestone in the achievement of program change control. Worthy of note is the fact that the agreement exceeded systems for control of the hardware only and provided methods by which all changes to the contract are defined and documented. Implementing these agreements significantly improved the control of the program.

2.6 Implementing Decisions

Given an organizational structure and an effective decisionmaking process, management decisions, once reached, still have to be put into effect. There are three such principal tools which have been adapted for use on the Saturn Program: a set of "management manuals" for issuing general operating directives; a work-management system for authorizing and implementing decisions; and a contract management procedure for identifying NASA requirements, negotiating contract provisions, and authorizing the work necessary to meet requirements.

2.7 Informal Communications

Superimposed upon the formal systems are the informal systems of communication through face-to-face contact. These are judged to be equally key to the success of the program. The management of the Saturn Program at MDAC-WD has not attempted to sit in an office examining status reports to reach significant management decisions. To the contrary, the program management's visibility is substantially [69] improved by daily personal contacts between Company and Customer personnel, and decisions are guided by information and facts which thus come to light.

2.8 Incentive Fees

NASA took positive steps to assure Apollo mission success by emphatically expressing to contractors the things most important to the Apollo Program. They did this in the way most meaningful to contractors: by increasing their profits for superlative performance and reducing profits for poor performance. The factors thus emphasized by NASA were: cost, schedule, and operational success.

At the time—in 1965 and early 1966—when the contract was converted from cost-plus-fixed-fee to cost-plus-incentive-fee, target costs and the cost-sharing incentive fees were agreed upon for the work then under contract. Provisional payment of incentive fees was to be made thereafter upon demonstration of specific evidences of superior performance.

The features have become a very important tool in controlling the technical performance, the schedules and the cost. It had been difficult to determine what would be paid for and what would not be paid for. Also, the many facets of the customer organization and MDAC-WD complicated contractual negotiations. Communications between MDAC-WD and the customer crystallized about these incentive features. The tradeoffs became crystal clear. Within 9 months to a year after signing, the confusion and difficulties in the program vanished because objectives were clearly defined. It now appears that the optimum time to incentivize is after the definition is well along.

Taken alone, a cost incentive could work to the detriment of other valuable considerations, but, combined with schedule and technical performance incentives, meaningful tradeoffs can be made to the benefit of the program. The greatest effect of these tradeoff considerations is to create in the whole organization—from top management right down to the man on the bench—an awareness of the importance for each of them to evaluate the effectiveness of every action that affects performance, cost, and schedule.

Meeting technical performance goals is the real make-or-break factor for an incentive contractor. Without this operational success, meeting cost and schedule goals is meaningless. So specific measures of technical excellence have been identified for comparing success, and fees are adjusted upward or downward in accordance with the results.

Performance is evaluated in terms of how flight missions are accomplished, the payload capability demonstrated, and telemetry responses shown. The performance requirements are based on technical requirements contained in CEI specifications. Flight-test plans are prepared for each flight by the Company and are followed afterward by final flight reports that set forth performance achievements. Certificates of performance achievement are submitted to NASA, and NASA's position is stated in return.

Schedule incentives are based on meeting three important milestones leading to delivery of completed S-IVB stages. The milestones here selected to provide NASA with the opportunity to review the effectiveness of the Company's work at regular, preplanned intervals. This is accomplished by the administrative technique of requiring from the [70] Company certificates stating the degree of completion of specific schedule-oriented actions and requiring from NASA prompt response—concurring or differing—so that program status is continually known by both parties.

In this way, the effect of all actions on delivery of contract end items becomes a part of total Saturn program activity, but is the special concern of the "Black Tuesday" reviews held biweekly and the primary concern of the Director for Saturn Program Production.

As a result of the incentive feature, MDAC-WD developed an improved reporting system in schedules and cost performance.

SECTION 3
ADDITIONAL MANAGEMENT ACTIONS

3.1 Introduction

The Saturn program introduced a new range of challenges for MDAC-WD. Management techniques geared to the production of aircraft in volume had to be slanted toward the complexity and state-of-the-art nature of the Saturn program. MDAC-WD relied heavily upon the quality and effectiveness of management practices that had been evolving steadily on prior programs but made them sufficiently flexible to be responsive to Saturn requirements. To do this, they established clear, detailed requirements, and provided for precise command and control through total program visibility. The success of this approach lies in the management record of the Saturn program.

3.2 Administrative

3.2.1 Interface

The number of agencies involved with Saturn, both within the Company and externally (Customer, associates, subcontractors, vendors and suppliers), is enormous. Communicating effectively with each, therefore, was a significant challenge. Both formal and informal lines of communication were established as were the means of transmitting information and documents to conduct daily business with NASA.

3.2.2 Evolution of the Role of the Program Manager

The role of the program manager in the newly formalized program office was not clearly understood by all levels of management. Further, a proper set of tools with which to carry out his responsibility was not available to the program manager. His capability to control his program depended somewhat upon his personal forcefulness and his success at inserting himself or members of his staff into the then existing Division's work authorization systems.

Customer organizations with responsibility to oversee the program were sympathetic to the frustrations of the program manager and began to express concern that their programs would not receive sufficient management attention.

To alleviate this situation, Division management responded with two courses of action: (1) Large programs were permitted significant projectization, especially in financial management and engineering; (2) A substantial effort was mounted to better define and publicize the responsibility and authority of the program manager. Position guides were carefully rewritten to assure that they carried a strong message [71] on that role. Division management directives were revised to define in operating directives the contribution and participation of the program manager. Probably the most significant change in the Division's management systems was the establishment of a Task Authorization Notice (TAN), the program manager's tool to authorize the release or cancellation of program plans and requirements to the Division's functional departments.

3.2.3 Company Standard Practice Bulletins

MDAC-WD sought to meet specific requirements of the Saturn program by expressly tailoring its Standard Practice Bulletins to the program and furnishing these documents to the Customer. This highly unusual amount of Customer orientation is somewhat reflected in that during 1964, over 507 SPB's were revised to improve MDAC-WD management systems. The Division sustains a concerted effort to continually revise, refine, and upgrade these management directives.

3.2.4 VIP Program

In 1964, a Value in Performance program (VIP) was implemented to produce superior product quality and personal excellence in work performance. The program emphasizes the importance of people, and enhances the feeling of each that he is a very important part of the Company. The program (1) motivates each person to take an increased interest in his job, (2) improves the quality of products and services, and (3) reduces costs and improves schedules.

The backbone of VIP accomplishment has been the establishment of meaningful measurable goals, and the subsequent attainment and improvement of these goals. Over 200 specific performance goals were established in 1967 of which 91 percent were achieved. This year Saturn/Apollo's VIP program has adopted the theme, "Management by Objectives." The objectives are goals which have become more specific and demand a high order of performance attainment. For MDAC-WD, the VIP program has been a factor in the dramatic increase in validated cost reductions, increasing from $16 million in 1964 to over $93 million in 1967.

In 1966 the Company received the U.S. Air Force's coveted Zero Defects honor, The Craftmanship Award. Of 3,500 competing companies, Douglas was one of the two to win this award. In October 1968, McDonnell Douglas was notified that they had achieved the Second or Sustained Craftsmanship Award for accomplishments in the field of motivation for the preceding year.

3.2.5 Supplier Motivation Program

NASA and MDAC-WD initiated a Supplier Motivation Program in early 1967. The intent was to advise MDAC-WD suppliers management of specific applications for the items they were manufacturing and thus motivate them to produce more reliable hardware.

The Company brought all suppliers of critical components to Huntington Beach to make them aware of the consequences of a failure in the critical component they were providing to the program. They were briefed thoroughly on failure-mode specification analysis of their individual piece of hardware, and the president of each Company completely understood what would happen should his component fail. They were shown their hardware on the stage, how it was handled, and [72] then asked to go back and examine the method by which they were providing this hardware. They were to determine whether they could detect anything that should be brought to MDAC-WD's attention, or anything they felt they should do internally in the preparation of their hardware. Sixty suppliers participated in 4 half-day sessions. A number of suppliers conducted awareness programs for employees and for their own suppliers. Their recommendations included design changes, and reverification of conformance to design requirements. The program benefited from these meetings before AS-5O1 was committed to launch at the Cape.

SECTION 4
SELECTED KEY PROBLEMS

4.1 Introduction

Managing Saturn has been almost as complicated and demanding a task as overcoming attendant technical difficulties. While geared to take on the management of this immense and complex program by valuable experience gained with Thor, Nike, and other families of missiles and space systems, no previous program compared with Saturn for scope, size and complexity. In retrospect, it can be seen that significant strides were made in learning how to control a major program of the size and magnitude of the Saturn project.

This section highlights some of the key management problems encountered by MDAC-WD with Saturn and how they were solved.

4.2 Effective Communication

On a program the size of Saturn/Apollo, the problem of communicating effectively impinges on all transactions, from the simplest, vis-a-vis, contact to major program negotiations. Throughout the program, at all levels, heavy emphasis was laid on the personal encounter. This basic philosophy was strengthened by firm and precisely defined requirements to document and record decisions made on the spot and under the duress of program schedules and requirements. The net effect of the decision to run the program on this basis, although intrinsically not measurable, was to expedite management and production decisions and raise morale.

A corollary of this decision lay in the necessity to so aline counterparts within the Company (as well as between those people and all external organizations) that each individual would be talking to others at precisely the right levels and in equally correct areas.

The Marshall Space Flight Center (MSFC) provided both in-depth technical and nontechnical control. Communications with the Industrial Operations Office, the Stage

Manager at MSFC, the laboratories at MSFC, and the technical communities within our Development Engineering organization, and supporting in-house technical activities had to be face to face. To realign the Saturn organization so that technical counterparts could be identified on a one-to-one basis, a technically oriented directorate was established, which could communicate to the Industrial Operations office, the Stage Manager at MSFC, and his corollary—the contracting officer. Saturn System Development supported that combination, so that the products that came out of technical interchanges and program requirements were crystallized into specific documents and became the contract end-item specifications.

[73] This was the beginning of effective control over the products of the technical working groups and the face-to-face interchange between technical counterparts. Real-time decisionmaking was implemented and authorized both by MSFC and Division management. The S-IVB, Stage Manager and the S-IVB Program Director made the principal program decisions, and all members of the program community accepted them.

Another area of communication, now formal, was the generation Change Orders that ultimately developed into contract requirements. To facilitate Change Order processing, the program director strengthened Saturn Systems Development and the manager of Saturn contracts. The Director of Development Engineering developed a supporting capability within his organization to assist in preparation of a formal response to Change Order direction. In concert, these organizations could quickly translate Change Order direction into work authorization.

4.3 Avoiding Cost Overruns

The number one priority was to achieve technical performance of the highest caliber. The second was to get the program on and ahead of schedule. The lowest priority was to avoid cost overruns (which should have been achieved had the program schedule remained intact). At present, the program is in an on-target position and in the process of realignment as a consequence of the schedule stretchout from the launch activity.

4.4 Program Schedule

The program is on schedule. Upon emerging from engineering release, and at the beginning of ground research programs, all contractors involved found themselves quite nervous about meeting schedule obligations. Several years ago, the goal was established of getting ahead and staying ahead of contract schedule. A vigorous program was initiated to obtain a complete set of hardware ahead of the contract schedule. This was probably the fundamental decision which permitted a get-ahead and stay-ahead-of-schedule capability. The procedure involved substantial risk, but resulted in avoidance of actual cost vulnerabilities inherent in major overtime panic situations generated in trying to meet contract schedules. Premium prices were sometimes paid to get these supplies into the system, but use of overtime and premium time was weighed very carefully by Saturn management and the NASA Resident Manager.

4.5 Information Retrieval

Saturn management does not maintain a program control room, with charts, graphs and schedule status on the walls. By themselves, such charts are considered out of date by anywhere from an hour to a month, depending on how responsive the system is. Instead, management developed a recording technique which retained the real-time decisions of those responsible and converted them properly to contract language. That was the essence of the unique feature of the Saturn/Apollo program management.

4.6 Capability Retention

A key consideration in the retention of a high-level of technical competence is that, for all practical purposes, Saturn has a fleet of S-IB, S-IVB's and Saturn V, S-IVB's. Five were launched on the IB program and two on the Saturn V Program, which means that [74] some 20-odd stages in inventory have yet to be flown. A technical and supporting staff must be maintained, capable of handling any problems which could come out relative to new mission assignments or anomalies.

4.7 Mission Failure Avoidance

To avoid mission failures, management went into a very comprehensive, in-depth, system, subsystem, and component development. The object was early exposure of weaknesses through repetitive forced exposures. The underlying and most fundamental activities are the ground test program, development tests, qualification tests, formal qualification tests, repeat qualification tests, and reliability verification tests, which are essentially component and subsystem oriented. In the system area are the factory checkout at Huntington Beach, the preacceptance firing checkout at Sacramento, the acceptance firings at Sacramento, and the postacceptance firing checkout at Sacramento. At KSC, prior to launch, there are a very elaborate set of validation, subsystem, and systems tests. Major opportunities for reducing costs on a program such as this (in area of debate) are to reduce or delete acceptance firings or repetitive subsystem and system tests at KSC.

The basic formal qualification activity on this program will soon diminish. A group of reliability verification tests will be eliminated entirely. Qualification tests on selective items will be repeated for some time to provide an opportunity for forced exposure to weaknesses inherent either in the design, in the manufacturing technique, or the production acceptance testing technique. Each one of these areas, although it is an opportunity to reduce costs on the program, also must be weighed as another opportunity of forcing an exposure of something that has escaped through the reliability assurance and quality programs. Large cost returns may be realized by deleting some of these activities. They may or may not be cost effective. The major tradeoff becomes nontechnical and political in nature, very rapidly.

SECTION 5
CONCLUSIONS

However economical their cost performance, however timely their schedule performance, the management systems described herein cannot be said to have justified the customer's investment unless the technical performance of the products assures him that his overall program objective can be achieved. In recognition of this, each management system element has actively participated in technical operations to assure success in technical performance. Unquestionably, the most significant technical operation assuring the customer of the effectiveness of these management systems is the performance of the product in acceptance testing and in-flight operations. Recapitulating, 23 flight vehicles have experienced successful acceptance testing. Thirteen flight vehicles have been successfully launched in either developmental or operational flight test configurations. While these acceptance and flight test programs have not been flawless (almost by definition developmental programs cannot be) the high incidence of success, MDAC-WD believes, bespeaks the effectiveness of the management systems it has devised and operated to control the S-IV and S-IVB programs. Its measure lies in the fact that current planning for the next flight is directed toward manned circumnavigation of the moon.

Document IV-12

Document title: George M. Low, Deputy Administrator, NASA, Memorandum for the Administrator, "NASA as a Technology Agency," May 25, 1971.

Source: James C. Fletcher Papers, Special Collections, Marriott Library, University of Utah, Salt Lake City.

The political consensus on the importance of space that produced the National Aeronautics and Space Act of 1958 and the Apollo program began to dissipate even before the first few Apollo missions were completed. As public support deteriorated, NASA executives found it more difficult to protect not just their programs, but their mission and institution as well. Maintaining NASA's infrastructure depended in part on the identification of marketable missions that the agency could pursue. A 1971 White House review of how government-funded technology could be applied to the nation's problems stimulated NASA's deputy administrator to reassess the agency's future role. His May 25, 1971, memorandum to the administrator printed here describes his position on the subject.

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[1] SUBJECT: NASA as a Technology Agency

These are some thoughts as to why it might make sense to assign to NASA the government-wide responsibility for the application of technology to national needs.

There are many national problems that require, at least in part, technology solutions and often, at the same time, require a systems management approach. These problems can be found, for example, in the areas of power and energy, pollution, transportation system, health care systems, productivity of services, education, and housing.

NASA has demonstrated a capability to solve difficult technological problems and to apply systems management and know-how in the solution of these problems. In these efforts, NASA has established a working relationship with the aerospace industry that would be difficult for other agencies to duplicate. At the same time, the aerospace community has a surplus of talent that could be applied to these problems, if properly controlled and managed. It, therefore, appears to be logical that NASA should be the agency to undertake the newly needed technological tasks.

There are two alternative ways in which this could be done. First, NASA could provide its services to other agencies; second, NASA could do these things in its own right as part of an expanded NASA mission.

If the first alternative were to be followed, NASA could apply some of its inhouse personnel resources (say, up to ten percent or 3,000) for any direct inhouse efforts and get [2] funding for out-of-house efforts by transfers of funds from other agencies. These other agencies would provide for the funds in their own budgets. This alternative could be done today without any change in existing laws.

Were we to take the second alternative (to do these tasks as part of an expanded NASA mission), then the job would be assigned directly to NASA and budgeted for by NASA. This, however, would require a change in the Space Act. The major disadvantage of the second alternative would be that other agencies would be reluctant to let go of jobs that they now consider to be their own. However, the second alternative, I believe, would be much more likely to succeed.

A word about the kinds of jobs that NASA could undertake. First, I believe that they should be in the general area of applied technology. It is in this area that NASA has the talent and the demonstrated capability. Also, the jobs must be doable, and they must be adequately supported. Finally, they should be tasks that are not now clearly assigned and capably carried out by other agencies.

If it were desired to change NASA's name, I would vote for something like "Aeronautics, Space and Applied Technology Administration."

Should we be asked to undertake a job like this, the first step would be to form a task team, reporting to NASA, to define the charter for the new agency, and to formulate the required government reorganization legislation.

George M. Low
Deputy Administrator

Document IV-13

Document title: George M. Low, Deputy Administrator, NASA, Memorandum to Addressees, "Space Vehicle Cost Improvement," May 16, 1972.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headuqarters, Washington, D.C.

NASA's dwindling budgets and its aspirations for an aggressive space program in early 1970s were incompatible. However, the NASA leadership did not perceive themselves as wholly at the mercy of the political environment in which the agency existed. Although politicians established spending levels, NASA's top administrators, as engineers and scientists, believed it was within the organization's ability to reduce the cost of doing business in space. Doing so would not only allow them to live within externally imposed budgets, but also to pursue aggressive institutional and programmatic goals as well. This memorandum of May 16, 1972, from George M. Low, the NASA Deputy Administrator, to several senior NASA officials emphasizes the importance of reducing costs and creating greater efficiencies inside the agency.

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[1] SUBJECT: Space Vehicle Cost Improvement

The high cost of doing business in space, coupled with limited and essentially fixed resources available for space exploration, places severe limitations on the amount of productive work that NASA can do, unless we can develop means to lower the unit cost of space operations. It therefore becomes an item of first-order business for each of us to find ways to drastically reduce the costs of all elements of space missions.

A fundamental reason for high costs has been the fact that most space systems are designed with great sophistication so as to operate acceptably with low allowable weight. However, as the cost of space transportation is decreased (especially with the shuttle, but even with some existing launch vehicles) a great many designs should be optimized for high reliability and low cost—in general with weight being a secondary consideration.

Another reason for high cost has been that most systems are individually tailored for their mission, used once or twice, and then never used again. Thus the economies of producing a number of like systems are never attained. Now that we have acquired a considerable background of experience as to the kinds and needs of space missions, we can better plan for multiple-use types of equipment.

I am convinced that major cost improvements can be realized, and that this matter should become a first order item of business for all of us. A basic approach to lowering the costs of space systems should include the following:

[2] 1. A detailed understanding of exactly where we spend our money. We need to identify those areas where a substantial cost improvement would be worthwhile in that it would have a major impact on the cost of the end product. In other words, we need to define the things with the greatest potential pay-off for cost improvement.

2. The determination of range of requirements (for the systems or subsystems with the highest potential payoff) for our spacecraft of the future. (So that we can develop a few "standard" systems, instead of individually tailored systems for each requirement.)

3. The development of "standard" systems or subsystems, designed for low cost and high reliability. (We need a catalog, ultimately, of available preferred parts.)

4. A method for assuring that as a rule only the "standard" systems are used.

I consider this effort of such high importance and priority that I am prepared to devote whatever resources are required, both in-house and on contract, to achieve significant results.

To begin with, I am hereby establishing a task force, chaired by Del Tischler, to carry out steps 1 and 2, above, and to develop a plan, goals and objectives for steps 3 and 4. I want each of the addressees to provide the necessary support to the task force, especially in terms of experienced people.

My plan is to have task force members named within one week, and to be in business in two weeks. Thereafter I intend to meet with the task force on a biweekly basis, and to have its final report in six months.

The task force is authorized to place requirements on the various line organizations to accomplish its objectives.

George M. Low

Document IV-14

Document title: E.S. Groo, Associate Administrator for Center Operations, NASA, to Center Directors, "Catalog of NASA Center Roles," April 16, 1976.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headuqarters, Washington, D.C.

The elaborate institutional machinery inherited by NASA from the National Advisory Committee for Aeronautics (NACA), supplemented by that developed to carry out Apollo, could not be easily disassembled, nor demobilized after the completion of the Apollo program, given the interlocking interests it had created among NASA's installations, contractors, and geographic regions and their representatives in Washington. By designating "roles and missions" for each of its field centers, NASA Headquarters attempted to avoid duplication, reduce intercenter rivalry, and assure each installation adequate work to utilize its special capabilities and facilities.

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[1] SUBJECT: Catalog of NASA Center Roles

Enclosed is a copy of the catalog of NASA Center Roles, dated April 1976, developed on the basis of decisions reached during the Institutional Assessment conducted earlier this year. The primary purposes of the catalog are to describe in a consistent way the programmatic responsibilities of the Centers and to serve as a guide in the assignment of work to the Centers.

The catalog has been reviewed by the Program Associate Administrators and reflects the changes they have proposed. As we discussed at the last Center Directors' meeting, the document is now forwarded to you for your comments. Dr. Naugle and I will entertain specific proposals which would further clarify the document within the context of the Institutional Assessment decisions.

While it is possible that refinements to the catalog should be made based upon your suggestions, we should, in the meantime, assume this document to be the definitive statement of the roles and missions of the Centers on which new program assignments will be based. There will, or course, be changes from time to time in the catalog as roles and missions evolve and all changes will be issued in writing and signed jointly by Dr. Naugle and me and, where appropriate, by Mr. Yardley.

We are now developing a procedure for the review and approval of major work assignments to the Centers. This [2] procedure, which we expect to issue in about one month, will recognize the catalog as the baseline document in the assignment of work.

E. S. Groo
Enclosure...

[1 of Enclosure]

CENTER ROLES

Introduction and Rationale

Assignment of specific responsibilities to NASA Field Centers is one of the keystones in the process by which the Nation's goals in Aeronautics and Space are met. Field Center responsibilities relate, in their broadest context, to these major goals. These goals are:

• gaining new fundamental knowledge about the earth, solar system and universe through maintaining a strong program in *space science and exploration*;

• bringing the benefits of space and space technology to bear for the direct and immediate benefit of man on earth through cooperation in *applications* oriented activities with a wide range of users and non-space mission oriented agencies;

• facilitating improvements in aircraft design and operations through the provision of an on-going *aeronautics research and technology* base;

• maintaining a strong base of *space research and technology* as a national resource which can serve to evolve and/or support new initiatives in space exploration or applications; and

• making space more accessible to both domestic and foreign users through development and operation of economical *space transportation* and the operation of efficient *tracking and data acquisition* systems.

These goals translate into a set of broad program areas to which the roles in this document are related.

Within these broad program areas, a Center is assigned and carries out both *principal* roles and *supporting* roles.

Principal: Roles of fundamental importance in supporting the Agency's overall goals. They serve as a basis for deploying resources to Centers over the longer term. They also represent areas of Center excellence and expertise that [2] is clearly discernible within NASA and recognized as a national capability.

Supporting: Roles of more limited scope or tentative nature supporting the Agency's overall goals. Such roles can also support principal roles for which other Centers or government agencies generally have the lead. They may also support a Center's own principal role or roles, or are discrete roles assigned to a Center because of a specific expertise a Center can provide in a particular discipline.*

Each NASA Field Center represents particular areas of special capability which, when considered on an Agency-wide basis, form the core of our national capability in aeronautics and space. The special capabilities highlighted herein consist of areas of technical excellence and facilities of superior merit – technical facilities which may be of unique or almost unique character and constitute, in themselves, a national resource. Consideration of such special capabilities is integral to the process of assigning Field Center responsibilities within the Agency's overall program.

Summarized on the following pages are highlights of Center capabilities and statements of role responsibilities current as of April 1976. Roles are grouped according to overall emergency goals by broad program areas – so that "Applications," for instance, has a broader context than just Office of Applications programs and includes Technology Utilization and Energy programs as well. The same can be said of "Space Research and Technology" vs. the Office of Aeronautics and Space Technology programs.

For supporting roles, any other Centers having related responsibilities – either principal or supporting – are noted in parentheses following each supporting role description. There are a few cases where a Center shares principal responsibility with another Center

* Many of these roles were previously identified in the institutional assessment as "limited roles." Others may have been identified as "broad roles" but are now judged to be supportive to principal roles assigned to the Center.

or acts as an alternate to another Center in the development of space hardware. Such roles are so identified where appropriate.

[3] **AMES RESEARCH CENTER**
Special Capabilities

- Areas of Technical Excellence
  - Biology
  - Human factors and man-machine interactions
  - Fluid dynamics and heat transfer
  - Aerodynamics and flight dynamics
  - Flight stability and control
  - Technical project management

- Facilities of Superior Merit
  - 40 X 80 ft. Wind Tunnel
  - Flight Simulator for Advanced Aircraft
  - Illiac IV
  - C-141 Airborne Infrared Observatory
  - High-Enthalpy Arc Jets
  - Unitary Wind Tunnel Complex
  - 3.5 ft. Hypersonic Wind Tunnel
  - Biological Containment Facility
  - Vertical Gun

[4] **AMES RESEARCH CENTER**

PROGRAM AREAS:
Aeronautics
Space Science and Exploration
Space Research and Technology
Applications
Space Transportation

Principal and Supporting Roles

- Aeronautics
- Principal

• **Short-haul aircraft technology** - developing a technology base for facilitating incorporation of short-haul aircraft into overall air transportation systems.

• **Helicopter technology*** - developing a technology base for improving efficiency and flexibility for both civil and military use.

• **Computational fluid mechanics** - furthering the state-of-the-art through the definition of new systems, both hardware and software, for application to aeronautical and other related areas such as weather and climate, etc.

• **Fluid simulation** - improving the state-of-the-art to permit more effective use of simulators in aircraft design and validation of flight simulation.

• **Human-vehicle interactions** - furthering the state-off-the-art through the study of man-machine and other human factor interactions and considerations involved in aircraft operations.

* Under study

• **Fundamental aerodynamics** - advancing the general state-of-the-art, both theoretical and experimental. (Shared principal responsibility with *LaRC;* supporting responsibilities: DFRC, JPL)

• **Fire resistant materials** - developing a technology base for internal application in aircraft. (Supporting responsibilities: JPL, JSC)

[5] - Supporting

• **Aviation system studies** - conducted to help define technical and system requirements. (Shared supporting responsibility with LaRC)

• **Aircraft structures** - improving predictive capability for structural lifetimes in degrading chemical environments, unsteady aerodynamic loads and aeroelasticity, and high temperature fuel tank sealants. (Principal responsibility: *LaRC;* supporting responsibility: DFRC)

• **Acoustics noise reduction** - using ARC unique fullscale low speed wind tunnel to study airframe noise and forward velocity effects. (Principal responsibility: *LaRC;* supporting responsibilities: DFRC, LeRC)

• **Aviation safety** - contributing to advances through joint efforts with the FAA and other appropriate agencies. Advanced tire materials, and wake vortex studies. (Supporting responsibilities: DFRC, JPL, LaRC, LeRC, MSFC, WFC)

• **Wind tunnel support** - provision of facility support to industry and other government agencies. (Other Centers having unique or outstanding facilities may provide similar support.)

• **Military support** - provision of military aviation systems technology support. (Other Centers providing military aeronautics support: DFRC, LaRC, LeRC)

• **General aviation aircraft technology** - developing a technology base for improving agricultural aircraft. (Principal responsibility: *LaRC*)

• Space Science and Exploration
- Principal

• **Extraterrestrial life detection** - developing and applying the analytical basis for life detection in space, including experiment design and management.

[6] • **Biological experiments** - developing and implementing experiments for determining effects of space flight environment on (non-human) living organisms.

• **Level IV life sciences integration** - developing, integrating and operating space flight hardware to conduct in-flight biomedical experiments and experiments on non-human living organisms.

• **Airborne research operations** - operating instrumented jet aircraft for the purpose of conducting airborne science experiments.

• **Planetary probes** - developing thermoprotection systems required for planetary atmosphere entry probes and managing probe development.

• **Pioneer** - completing the currently approved series, including associated flight operations. Phase out to be concluded after Pioneer Venus.*

- Supporting

• **Planetary science analysis techniques** - developing and applying techniques for analysis of planetary atmosphere and mass. To be completed in early 1980. (Principal responsibility: *JPL*; supporting responsibility: GSFC)

* Future pioneer spacecraft will be managed by JPL

• **Astronomical observation techniques** - focus on airborne science and the development of IR techniques and supporting systems for use in Spacelab payloads. (Principal responsibility: *GSFC;* alternate responsibility: JPL)

• **Upper atmospheric research** - providing aircraft based sampling and contributing to model development. (Principal responsibilities: *JPL, GSFC;* supporting responsibilities: LaRC, LeRC)

• **Spacelab bioresearch** - supporting development of Spacelab life science research capability through common operating research equipment development. (Principal responsibility: *JSC*)

• Space Research and Technology
- Principal

[7] • **Planetary entry technology*** - advancing thermal heat protection technology for planetary entry. (Supporting responsibility: LaRC)

• **Biomedical support systems** - developing advanced technology for development of long duration life support systems.

- Supporting

• **Fundamental research** - focus on quantum and surface states in solids. (Supporting responsibilities: JPL, LaRC, LeRC)

• **Space vehicle structures and materials technology** - focus on prediction of dynamic loading parameters related to space vehicles. (Principal responsibilities: *MSFC, LaRC;* supporting responsibilities: GSFC, JPL)

• **Space energy processes and systems technology** -furthering state-of-the-art in key areas such as heat pipes for thermal control and high power gas dynamic laser technology. (Principal responsibility: *LeRC;* supporting responsibilities: GSFC, JPL)

• **Technology experiments in space** - definition and development of experiments in areas consistent with ARC's other Space Research and Technology roles. (Principal responsibilities: *JSC, LaRC;* supporting responsibilities: DFRC, GSFC, JPL, LeRC, MSFC)

• **Shuttle technology** - Shuttle vehicle technology development and ground facility testing in the areas of thermal protection systems, dynamics and aeroelasticity. (Shared supporting activity with LaRC)

• **Space technology studies** - conducted to help define technology and systems requirements. (Supporting responsibilities: GSFC, JPL)

• **Medical research** - utilizing non-human specimens to derive information and develop countermeasures needed to solve space medicine problems. (Principal responsibility: *JSC*)

[8] • Applications
- Principal

• **Airborne instrumentation research** - providing aircraft platform support for applications oriented sensor research and development.

• **Technology transfer**

- **Technology utilization** - conducting projects to establish applicability of NASA technology in health care, participate in technology transfer to industry, identify and report new technology, and document results of secondary applications of NASA technology.

- **Specialized applications tasks** - draw upon unique Center capabilities included under other Center roles to advance the application of space related techniques. Current emphasis is on space processing and video compression techniques.

* Under study

- **Regional applications transfer** - current effort is a joint demonstration activity with USGS/EROS, the Pacific Northwest Regional Commission, and State agencies with Idaho, Washington and Oregon.

- Supporting

• **Energy technology** - conducting energy related materials investigations. (Principal responsibility: *LeRC*; supporting responsibilities: JPL, JSC, MSFC)

• Space Transportation
- Supporting

• **Passenger selection criteria** - establishment of medical criteria for non-crew passenger selection.

[9] **DRYDEN FLIGHT RESEARCH CENTER**
Special Capabilities

• Areas of Technical Excellence
  • Flight research instrumentation
  • Flight dynamics and controls
  • Flight research operations

• Facilities of Superior Merit
  • High Temperature Loads Facility
  • 600-Mile Instrumented Range
  • Remote Piloted Research Facility
  • Airborne Launch Aircraft
  • General Purpose Airborne Simulator

[10] **DRYDEN FLIGHT RESEARCH CENTER**

PROGRAM AREAS:
Aeronautics
Space Transportation
Applications
Space Research and Technology
Tracking and Data Acquisition*

Principal and Supporting Roles

• Aeronautics
- Principal

• **Aeronautical flight research** - providing a broad-based flight research and test capability including tracking and data acquisition for the Agency in support of aeronautics and other programs as required. (This principal role represents the composite of the supporting roles given below.)
• **Remotely piloted vehicle research** - development of research aircraft, and management/operation of flight experiments.

* Included within other program areas as indicated

- Supporting

• **Fundamental aerodynamics** - contributing to state- of-the-art advancement through flight testing of aerodynamics concepts. (Principal responsibilities: *ARC, LaRC*; supporting responsibility: JPL)

• **Aircraft structures** - contributing to technology base with focus on flight loads measurements. (Principal responsibility: *LaRC*; supporting responsibility: ARC)

• **Acoustics and aircraft noise reduction** - focus on flight measurements of airframe noise. (Principal responsibility: *LaRC*; supporting responsibilities: ARC, LeRC)

• **Short-haul aircraft technology** - support of *ARC* role through participation in flight testing of short-haul aircraft and systems.

• **Long-haul aircraft systems** - support of *LaRC* role through flight testing of long-haul aircraft and [11] systems, with focus on digital fly-by-wire experiments and active controls aircraft flight experiments.

• **Aviation safety** - contributing to advances through flight testing of devices/systems for wake vortex marking and minimization; definition of atmospheric conditions for supersonic acceleration and cruise. (Supporting responsibilities: ARC, JPL, LaRC, LeRC, MSFC, WFC)

• **Military support** - provide flight research support to the DOD. (Other Centers providing military aeronautics support: ARC, LaRC, LeRC)

• Space Transportation
- Supporting

• **Shuttle orbiter development** - conducting approach and landing tests in support of JSC. Provide landing and recovery capability during OFT and contingency recovery capability after OFT. (Principal responsibility: *JSC*)

• Applications
- Supporting

• **Technology transfer**

- **Technology transfer** - identify and report new technology, participate in technology transfer to public service and private organizations, and document results of secondary applications of NASA technology.

• Space Research and Technology
- Supporting

• **Space vehicle configurations technology** - analysis and study of the effect of operational considerations on the design and test program of manned research vehicles. (Principal responsibility: *LaRC*; supporting responsibility: MSFC)

• **Technology experiments in space** - definition and development of experiments consistent with DFRC's [12] other Space Research and Technology roles. (Principal responsibilities: *JSC, LaRC*; supporting responsibilities: ARC, GSFC, JPL, LeRC, MSFC)

[13] GODDARD SPACE FLIGHT CENTER
Special Capabilities

• Areas of Technical Excellence
  • Space and earth sciences
  • Data systems and analysis
  • Sensors and instrument systems
  • Flight systems - automated
  • Tracking and data acquisition and communications
  • Technical project management

- Space flight operations
- Mission operations control and information processing

- Facilities of Superior Merit
  - Spaceflight Tracking and Data Network
  - Spacecraft Magnetic Test Facility
  - Optical Systems Laboratories
  - Optical Tracking and Communications Facility
  - Thermal-Vacuum Simulation and Test Facilities
  - Dynamic Test Chamber
  - Remote Sensing Information Processing Facilities
  - Operations Communications Network
  - Mission Operations Control Centers

[14] **GODDARD SPACE FLIGHT CENTER**

PROGRAM AREAS:

Space Science and Exploration
Space Research and Technology
Applications
Tracking and Data Acquisition
Space Transportation

Principal and Supporting Roles

- Space Science and Exploration
- Principal

• **Earth orbit spacecraft development** - for science, including spacecraft propulsion systems. Emphasis on automated, standard spacecraft system and free flyers, including experiment integration.

• **Earth orbit flight operations** - planning and conducting flight operations for earth orbit science spacecraft.

• **Physics and astronomy** - developing the technical discipline base, developing and implementing flight experiments. (Includes planetary astronomy and the transfer of AMPS.)

• **Upper atmospheric research** - developing the technical discipline base, developing and implementing flight experiments.

• **Sounding rocket development, procurement and operations** - developing and procuring sounding rockets, and carrying out all phases of operations from mission/flight planning to landing and recovery. Payload carrier development, development and management of experiments, experiment management support to other institutions, launch operations and tracking and data acquisition are included. (Most GSFC sounding rocket activities involve the higher performance, more complex vehicle support systems. Most activities involving lower performance vehicle systems are assigned to WFC.)

[15] • **Spacelab payloads** - development, integration, and data processing for Spacelab payloads in astrophysics, solar terrestrial physics, and astronomy.

- Supporting

• **Planetary science** - developing and applying techniques for the analysis of planetary atmospheres. (Principal responsibility: *JPL*; supporting responsibility: ARC)

• **Lunar science** - phase out by FY 79. Continuation of unique computer programs for processing lunar and planetary remote sensing data currently being used for lunar and Venera data. Those unique computer programs that cannot be economically transferred will continue.

• Space Research and Technology
- Principal

• **Information systems technology** - developing and maintaining technical discipline base. (Supporting responsibilities: JPL, JSC, LaRC)

- Supporting

• **Space vehicle structures and materials technology** - contributing to technology base with focus on reducing cost of structural evaluation and reliability demonstration for space flight hardware. (Principal responsibilities: *LaRC, MSFC*; supporting responsibilities: ARC, JPL)

• **Guidance and control technology** - contributing to technology base with focus on magnetic suspension systems. (Principal responsibility: *JPL*; supporting responsibilities: LaRC, MSFC)

• **Space energy processes and systems technology** -contributing to space technology base - space power system component test and evaluation. (Principal responsibility: *LeRC*; supporting responsibilities: ARC, JPL)

• **Sensor and data acquisition technology** - focus on CCD astronomical sensor work for application in [16] space astronomy. (Principal responsibility: *LaRC*; supporting responsibilities: JPL, MSFC)

• **Space technology studies** - focus on earth applications spacecraft technology requirements. (Supporting responsibilities: ARC, JPL)

• **Technology experiments in space** - definition and development of experiments in areas consistent with GSFC's other Space Research and Technology roles. (Principal responsibilities: *JSC, LaRC*; supporting responsibilities: ARC, DFRC, JPL, LeRC, MSFC)

• Applications
- Principal

• **Earth orbital spacecraft development** - for applications, including spacecraft propulsion systems. Emphasis on automated, standard spacecraft system and free flyers, including experiment integration.

• **Earth orbit flight operations** - planning and conducting flight operations for earth orbit applications spacecraft.

• **Technology transfer**

- **Applications system verifications test** - acquire, process, and disseminate LANDSAT coverage to JSC.

- **Technology utilization** - conducting projects to establish applicability of NASA technology in public service activities, participate in technology transfer to industry, identify and report new technology, and document results of secondary applications of NASA technology.

• **Applications R&D** - developing the technical discipline base, developing and implementing experiments in the following Applications disciplines:

- **weather and climate**
- **earth and ocean dynamics** (JPL shares principal responsibility)
[17] - **communications**

- Supporting

• Contributing to the discipline base, developing and implementing experiments in:

- **environmental monitoring** (Principal responsibility: *LaRC*; supporting responsibility: JPL)
- **earth resources** (Principal responsibility: *JSC*)

- Tracking and Data Acquisition
- Principal

• **Tracking and data acquisition support operations** -planning and conducting support for earth orbit spacecraft. Includes flight control, tracking, data acquisition, communications, and information processing. (Tracking and data acquisition responsibilities include orbital phase of all mission types, such as manned, deep space, etc.)

• **Tracking and data acquisition systems** - planning, development, and implementation of network, data processing, communications, and mission control systems and facilities for earth orbit spacecraft.

- Space Transportation
- Principal

• **Launch vehicle procurement** - for science/applications oriented missions. Current focus on sounding rockets and Delta (includes procurement for Delta).

- Supporting

• **Flight operations** - network planning and implementation support for Shuttle including ALT and OFT.

[18] **JET PROPULSION LABORATORY**
Special Capabilities

- Areas of Technical Excellence
  - Space sciences
  - Space flight mechanics and flight systems
  - Space guidance and control
  - Tracking and data acquisition
  - Sensors and instrument systems
  - Technical project management
  - Deep space flight operations

- Facilities of Superior Merit
  - Space Flight Operations Facility
  - Deep Space Network
  - Rocket Propulsion Test Facilities
  - Solid Propellant Processing Laboratory
  - Table Mountain Solar Test Facilities
  - Electric Propulsion Laboratories
  - Radio Telescope Facility

[19] **JET PROPULSION LABORATORY**

PROGRAM AREAS:
Space Science and Exploration Applications
Space Research and Technology Aeronautics
Tracking and Data Acquisition

Principal and Supporting Roles

- Space Science and Exploration
- Principal

• **Planetary spacecraft development** - development of automated spacecraft for deep space exploration. Includes experiment integration and all aspects of spacecraft systems technology, with special emphasis on guidance and control, space power systems and the procurement of spacecraft propulsion systems.

• **Space flight operations** - conduct of flight operations for *deep space* missions involving automated spacecraft. Includes mission/flight planning, and flight command and control. (ARC retains flight control of current Pioneer series.)

• **Lunar/planetary science** - development of discipline base in lunar and planetary sciences, including developing and applying techniques for analysis of planetary characteristics (except *geosciences* for which *JSC* has principal responsibility, along with returned sample handling and analysis).

• **Upper atmospheric research** - developing and testing advanced instrumentation for atmospheric constituent analysis; conducting diffusion studies and contributing to model development. (Principal responsibility: *GSFC*; supporting responsibilities: ARC, LaRC, LeRC)

• **Science/Applications spacecraft development** - serves as alternate center to GSFC for earth orbital spacecraft development. Current focus is SEASAT. (Principal responsibility: *GSFC*)

[20] - Supporting

• **Space physics** - contributing to discipline base with focus on particles and fields; development of space physics experiments for planetary missions. Cometary physics work will continue under "planetary science" designation. (Principal responsibility: *GSFC*)

• **Space astronomy** - contributing to discipline base with focus on ground based radio astronomy, relatively and celestial mechanics, IR astronomy, laboratory and high-energy astrophysics. (Principal responsibility: *GSFC*; supporting responsibility: ARC)

• **Lunar/planetary geoscience** - conducting earth based observations, theoretical studies, analog studies, and developing science experiment concepts. (Principal responsibility: *JSC*)

• Applications
- Principal

• **Technology transfer**

- **Specialized applications tasks** - utilizing the unique capability associated with other roles to meet discrete needs. Current emphasis is on communications and space processing.

- **Technology utilization** - conducting projects to establish applicability of NASA technology in biomedicine and other fields, participate in technology transfer to industry, identify and report new technology, and document results of secondary applications of NASA technology.

• **Science/Applications spacecraft development** - serves as alternate center to GSFC for earth orbital spacecraft development. Current focus is SEASAT. (Principal responsibility: *GSFC*)

• **Earth and ocean dynamics** - focus on contributing to discipline base, data analysis and investigation management, and spacecraft payload/experiment development. Current emphasis on ocean sensor experiments related to SEASAT.

[21] - Supporting

• **Weather and climate** - focus on sensor development for solar radiation measurement, definition of weather and climate-related experiments. (Principal responsibility: *GSFC*; supporting responsibility: LaRC)

• **Environmental monitoring** - focus on development of advanced instrumentation. (Principal responsibility: *LaRC*; supporting responsibility: GSFC)

• **Energy technology** - conducting energy R&D, primarily on a reimbursable basis, with principal focus on photovoltaics and advanced coal energy extraction technology. (Principal responsibility: *LeRC*; supporting responsibilities: ARC, JSC, MSFC)

• Space Research and Technology
- Principal

• **Teleoperator technology** - focus on teleoperator/robot technology and communication delayed control techniques for exploration.

• **Guidance and control technology** - developing and maintaining a broad technology base in guidance and control systems. (Supporting responsibilities: GSFC, LaRC, MSFC)

- Supporting

• **Sensor and data acquisition technology** - focus on planetary imaging, failure modeling and prediction. (Principal responsibility: *LaRC*; supporting responsibilities: MSFC, GSFC)

• **Information systems technology** - focus on planetary data processing and transfer systems. (Principal responsibility: *GSFC*; supporting responsibilities: JSC, LaRC)

• **Space vehicle structures and materials technology** - focus on planetary expandable structures and dynamic response. (Principal responsibilities: *LaRC, MSFC*; supporting responsibilities: ARC, GSFC)

[22] • **Space propulsion systems technology** - focus on planetary spacecraft propulsion and low-cost solids. (Principal responsibility: *LeRC*; supporting responsibility: MSFC)

• **Energy processes and systems technology** - focus on long life, high energy density power systems for planetary spacecraft. (Principal responsibility: *LeRC*; supporting responsibilities: ARC, GSFC)

• **Space technology studies** - focus on planetary spacecraft technology requirements. (Supporting responsibilities: ARC, GSFC)

• **Fundamental research** - focus on photon-matter interactions and energy transformation research. (Supporting responsibilities: ARC, LaRC, LeRC)

• **Technology experiments in space** - definition and development of experiments in areas consistent with JPL's other Space Research and Technology roles. (Principal responsibilities: *JSC, LaRC*; supporting responsibilities: ARC, DFRC, GSFC, LeRC, MSFC)

• Aeronautics
- Supporting

• **Fire resistant materials** - focus on fire resistant polymers and anti-misting fuels. (Principal responsibility: *ARC*; supporting responsibility: JSC)

• **Propulsion systems** - focus on hydrogen enrichment of piston engine fuels and reducing oxides of nitrogen via unconventional combustor design. (Principal responsibility: *LeRC*; supporting responsibilities: DFRC, LaRC)

• **Fundamental aerodynamics** - focus on fundamental fluid mechanics, non-linear wave interactions. (Principal responsibilities: *ARC, LaRC*; supporting responsibility: DFRC)

• **Aviation safety** - focus on wake vortex marking techniques. (Supporting responsibilities: ARC, DFRC, LaRC, LeRC, MSFC, WFC)

[23] • Tracking and Data Acquisition
- Principal

• **Tracking and data acquisition support operations** - planning and conducting tracking, command, and data acquisition support for planetary spacecraft and radio science.

• **Tracking and data acquisition systems** -planning, development, and implementation of network systems and facilities for planetary spacecraft and radio science.

[24] **JOHNSON SPACE CENTER**
Special Capabilities

- Areas of Technical Excellence
  - Biotechnology and space medicine
  - Extraterrestrial materials analysis
  - Space flight mechanics - manned vehicles
  - Data systems and analysis
  - Sensors and instrument systems
  - Space flight systems - manned vehicles
  - Flight crew training and mission simulation
  - Mission operations - manned vehicles
  - Technical project management

- Facilities of Superior Merit
  - Space Environment Simulation Laboratories
  - Docking Test Facility

- Simulation and Training Facility
  - Mockup and Integration Laboratory
  - Mapping Sciences Laboratory
  - Geology and Geochemistry Laboratory
  - Test and Evaluation Laboratories for All Major Spacecraft Systems and Subsystems
  - Earth Resources Laboratory (Slidell, LA)
  - Mission Control Center
  - Lunar Curatorial Facility

[25] **JOHNSON SPACE CENTER**

PROGRAM AREAS:
Space Transportation
Space Science and Exploration Applications
Aeronautics
Space Research and Technology

Principal and Supporting Roles

• Space Transportation
- Principal

• **Manned vehicles** - development of manned space vehicles and
- **Shuttle** - development of the orbiter and lead Center for management of the Shuttle system.
- **Advanced missions** - focus is on space station, advanced transportation systems and construction of a satellite space power station-definition activities (MSFC and JSC have co-equal roles through definition, development responsibilities are not yet assigned).
- **Environmental and crew support systems** -develop and demonstrate EC/LSS and EVA systems suitable for the space transportation systems and other advanced needs.
- **Advanced developments** - development of prototypes, long lead time systems, and new procedures and software for advanced systems.

• **Operations** - operational planning, crew selection and training, space transportation system flight control, experiment/payload flight control for Spacelab and STS utilization planning/payload accommodation studies.

• **STS sustaining engineering** - providing sustaining engineering and logistical support for STS hardware. Includes Shuttle configuration management, Shuttle sustaining engineering and orbiter operational procurement. (To be phased over to KSC at a future point, yet to be identified.)

[26] • Space Science and Exploration
- Principal

• **Lunar and planetary geosciences** - developing and maintaining the technical discipline base for lunar/planetary geosciences and extraterrestrial sample handling techniques.

• **Space medicine** - defining and developing in-flight biomedical experiments to assess human physiological response to space flight environments. (Supporting responsibility: ARC)

• **Spacelab bioresearch** - development of Spacelab life science research capability through Common Operating Research Equipment development. (Supporting responsibility: ARC)

- Supporting

• **Physics and astronomy** - phase out by FY 79 of all science activity including payload definition activity.

• **Upper atmospheric research** - phase out by FY 79 of modeling and measurement activities.

• Applications
- Principal

• **Earth resources** - provide a discipline base for earth resources applications including airborne instrumentation research, data interpretative techniques, and space-based flight sensors.

• **Technology transfer**

- **Application systems verification tests** -conducting interagency operational tests to demonstrate automated natural resources inventory systems. Current emphasis includes the Large Area Crop Inventory Experiment and the Louisiana Environmental Information System.

- **Specialized applications tasks** - drawing on unique capabilities associated with other roles to meet discrete needs. Current emphasis involves life sciences space processing.

[27] - **Technology utilization** - conducting projects to establish applicability of NASA technology in health care, participate in technology transfer to industry, identify and report new technology, and document results of secondary applications of NASA technology.

- Supporting

• **Energy technology** - complete assigned energy efficient utility systems program. (Principal responsibility: *LeRC;* supporting responsibilities: ARC, JPL, MSFC)

• Aeronautics
- Supporting

• **Fire resistant materials** - performing evaluation tests of fire resistant materials for use in aircraft. (Principal responsibility: *ARC;* supporting responsibility: JPL)

• Space Research and Technology
- Principal

• **Technology experiments in space** - management of Orbiter Experiments program. Definition and development of experiments in areas consistent with JSC's other Space Research and Technology roles. (Principal responsibilities: *JSC, LaRC;* supporting responsibilities: ARC, DFRC, GSFC, JPL, LeRC, MSFC)

• **Medical research** - establishing human baseline data and developing countermeasures to solve space medicine problems.

• **Food systems technology** - developing nutritional requirements and food processing systems in support of human space flight.

[28] - Supporting

• **Information systems technology** - contributing to technical discipline base, with focus on advanced software for manned spacecraft data systems. (Principal responsibility: *GSFC;* supporting responsibilities: JPL, LaRC)

[29] **KENNEDY SPACE CENTER**
Special Capabilities

• Areas of Technical Excellence
  • Flight systems testing
  • Facility and equipment operations
  • Launch operations
  • Technical management

• Facilities of Superior Merit
  • Launch Complexes
  • Operations and Checkout Facilities
  • Central Instrumentation Facility
  • Fluid Test Area
  • Landing Strip for Shuttle

[30] **KENNEDY SPACE CENTER**

PROGRAM AREAS:
Space Transportation
Applications

Principal and Supporting Roles

• Space Transportation
- Principal

• **Launch systems development** - provide launch systems support for all Agency flight programs.

• **Unmanned launch operations** - includes launch preparations and checkout for current inventory of launch vehicles.

• **STS ground operations** - includes launch operations, STS turnaround, Levels I and II integration, Spacelab Level III integration, integrated logistics and transportation and post-landing operations, and flight line medical and biomedical support.

• **STS sustaining engineering** - includes configuration management, operational hardware accommodations and mods. (This responsibility will be phased over from JSC at a future point, yet to be identified.)

• Applications
- Principal

• **Technology transfer**
- **Regional applications transfer** - remote sensing applications involving studies of thermal pollution and methods of sensing crop freeze exposure over large areas.
- **Specialized applications tasks** - support to NSTL and studies of changes in requirements, procedures and techniques for processing space applications type payloads for Spacelab.
- **Technology utilization** - conducting projects to establish applicability of NASA technology in public safety and other fields, participate [31] in technology transfer to industry, identify and report new technology, and document results of secondary applications of NASA technology.

- Supporting

• **Bicentennial exhibition** - support major science and technology exhibition of national scope in conjunction with Bicentennial celebration.

[32] **LANGLEY RESEARCH CENTER**
Special Capabilities

- Areas of Technical Excellence
  - Structures and aerostructural dynamics
  - Flight mechanics and configurations
  - Flight stability, control, and performance
  - Sensors and instrument systems
  - Avionics
  - Flight acoustics
  - Aerothermodynamics
  - Technical project management

- Facilities of Superior Merit
  - 8 ft. Transonic Pressure Tunnel
  - Transonic Dynamics Tunnel
  - 16 ft. Transonic Tunnel
  - V/STOL Tunnel
  - Unitary Wind Tunnel
  - 8 ft. High Temperatures Structures Tunnel
  - Fatigue Laboratory
  - Aircraft Noise Reduction Facility
  - Scramjet Test Facility
  - Real Gas/Viscous Effects Entry Simulation Facilities
  - Differential Maneuvering Simulator

[33] **LANGLEY RESEARCH CENTER**

PROGRAM AREAS:
Aeronautics
Space Research and Technology
Applications
Space Transportation
Space Science and Exploration

Principal and Supporting Roles

- Aeronautics
- Principal

• **Long-haul aircraft technology** - developing a technology base for improving long-haul aircraft as cost effective, safe and environmentally compatible transportation modalities.

• **General aviation aircraft technology** - developing and maintaining an engineering technology base related to improving general aviation aircraft.

• **Acoustics and noise reduction** - conducting research and development of technology related to reducing aircraft noise.

• **Aircraft structures** - development of technology base for facilitating structural advances.

• **Helicopter technology*** - developing a technology base for improving efficiency and flexibility for both civil and military use.

• **Fundamental aerodynamics** - advancing the general state-of-the-art, both theoretical and experimental.

- Supporting

• **Avionics technology** - developing a technology base related to improving avionics.

• **Computational fluid mechanics** - contributing to technology base, with emphasis on the prediction of aerodynamic characteristics of 3-D aerodynamic configurations. (Principal responsibility: *ARC*)

[34] • **Propulsion systems** - contributing to technology base of air breathing propulsion systems by advancing the state-of-the-art hypersonic propulsion. (Principal responsibility: *LeRC*; supporting responsibilities: DFRC, JPL)

• **Remotely piloted vehicle research** - contributing to the technology base of highly maneuvering aircraft through analytical studies, experimental studies in wind tunnels and test evaluations on the differential maneuvering simulator. (Principal responsibility: *DFRC*)

• **Aviation safety** - contributing to safety advances with focus on wake vortex minimization. (Supporting responsibilities: ARC, DFRC, JPL, LeRC, MSFC, WFC)

• **Aviation systems studies** - with focus on foreign technology assessment. (Shared support responsibility with ARC)

• **Military support** - supporting military aviation advances through work for DOD. (ARC, DFRC and LeRC also provide military aeronautics support.)

• **Wind tunnel support** - provision of wind tunnel support to industry and other government agencies. (Other Centers having unique or outstanding facilities may provide similar support.)

- Space Research and Technology
- Principal

• **Space vehicle structures and materials** - developing technology base to facilitate advances.

• **Space vehicle configurations technology** - developing technology base related to advanced configuration including advanced space transportation concepts.

• **Technology experiments in space** - development and management of the Long Duration Exposure Facility and Advanced Technology Laboratory. Definition and development of experiments in areas consistent with LaRC's other Space Research and Technology roles.

* Under study

[35] • **Sensor and data acquisition technology** - contributing to the technology base of sensors and devices. (Supporting responsibilities: GSFC, JPL, MSFC)

- Supporting

• **Guidance and control technology** - contributing to technology base, with focus on multi-purpose stabilization systems. (Principal responsibility: *JPL*; supporting responsibilities: GSFC, MSFC)

• **Information systems technology** - contributing to technology base, with focus on solid state data storage. (Principal responsibility: *GSFC*; supporting responsibilities: JPL, JSC)

• **Fundamental research** - focus on high density plasma phenomena. (Supporting responsibilities: ARC, JPL, LeRC)

• **Planetary entry technology*** - provide planetary and earth entry aerothermodynamics experimental and analytical data. (Principal responsibility: *ARC*)

• **Shuttle technology** - Shuttle vehicle technology development and ground facility testing in the areas of thermal protection systems, dynamics and aeroelasticity. (Shared supporting role with ARC)

• Applications
- Principal

• **Environmental quality monitoring technology** - developing improved techniques for environmental monitoring. Includes maintenance of discipline base, experiment development/management, data analysis and investigator management and specialized ground/aircraft investigations. Also includes development of Shuttle payloads related to environmental monitoring.

• **Technology transfer**

- **Specialized applications tasks** - drawing on unique competence related to other roles to perform discrete tasks. Current emphasis [36] involves earth resources and space processing studies.

- **Technology utilization** - conducting projects to establish applicability of NASA technology in environmental fields, participate in technology transfer to industry, identify and report new technology, and document results of secondary applications of NASA technology.

- Supporting

• **Weather and climate** - contributing to discipline base. Emphasis on earth radiation budget. (Principal responsibility: *GSFC*; supporting responsibility: JPL)

• **Earth and ocean dynamics** - contributing to discipline base. Emphasis on wave modeling and ocean sensor experiments. (Principal responsibilities: *GSFC, JPL*)

• Space Transportation
- Supporting

• **Launch vehicle development** - development and procurement for science/applications missions, includes scout and meteorological sounding rockets. (Principal responsibilities: *GSFC, LeRC*)

• Space Science and Exploration
- Principal

* Under study

• **Viking** - completion of the Viking project including extended Viking mission management.

- Supporting

• **Physics and astronomy** - phase out of all physics and astronomy science and spacecraft development management.

• **Upper atmospheric research** - conduct stratospheric emissions research relative to Shuttle operations.

• **Planetary/lunar science** - phase out of all activities.

[37] **LEWIS RESEARCH CENTER**

- Areas of Technical Excellence
  - Acoustics
  - Materials
  - Space propulsion systems
  - Energy processes and systems
  - Internal flow dynamics
  - Heat transfer
  - Instrument and control systems
  - Technical project management

- Facilities of Superior Merit
  - Engine Research Building
  - Turbine Combustor Facility
  - Engine Fan and Jet Noise Facility
  - Zero Gravity Facility
  - Icing Research Tunnel
  - 8 x 6 and 10 x 10 ft. Wind Tunnels

[38] **LEWIS RESEARCH CENTER**

PROGRAM AREAS:
Aeronautics
Space Transportation
Space Research and Technology
Applications
Space Science and Exploration

Principal and Supporting Roles

• Aeronautics
- Principal

• **Propulsion systems** - development of advanced aeronautical propulsion systems (except hypersonic). Focus on efficiency and environmental compatibility.

- Supporting

• **Wind tunnel support** - testing and facility operations support to DOD, other government agencies and industry. (Other Centers having unique or outstanding facilities may provide similar support.)

• **Aviation safety** - contributing to advances, with focus on lightning hazards, rotor burst protection and high-energy brakes. (Supporting responsibilities: ARC, DFRC, JPL, LaRC, MSFC, WFC)

• **Acoustics and noise reduction** - focus on internal engine noise reduction. (Principal responsibility: *LaRC*; supporting responsibilities: ARC, DFRC)

• **Military support** - provision of propulsion systems technology support to DOD. (ARC, DFRC and LaRC also provide military aeronautics support.)

• Space Transportation
- Principal

• **Centaur** - development and procurement of Centaur launch vehicle system.

[39] • Space Research and Technology
- Principal

• **Space propulsion systems technology** - development and maintenance of space propulsion systems technology base.

• **Space energy processes and systems technology** - development and maintenance of technology base.

- Supporting

• **Fundamental research** - contributing to basic knowledge of metals and ceramics at atomic/molecular level. (Supporting responsibilities: ARC, JPL, LaRC)

• **Technology experiments in space** - definition and development of experiments in areas consistent with LeRC's other Space Research and Technology roles. (Principal responsibilities: *JSC, LaRC*; supporting responsibilities: ARC, DFRC, GSFC, JPL, MSFC)

• Applications
- Principal

• **Energy technology** - conducting energy related R&D, primarily on a reimbursable basis, with broad emphasis on solar, gas turbine, ground propulsion and other appropriate terrestrial energy systems.

• **Technology transfer**

- **Application systems verification tests** - demonstrate through exploratory tests the use of remote sensing techniques to improve current operational techniques. Current emphasis is on the use of satellite data to enhance ocean navigation, particularly shipping operations in Arctic areas.

[40] - **Regional applications transfer** - utilizing remote sensing techniques to monitor pollution, water quality, and land reclamation potential in cooperation with various neighboring governments.

- **Technology utilization** - conducting projects to establish applicability of NASA technology in public service activities, participate in technology transfer to industry, identify and report new technology, and document results of secondary applications of NASA technology.

- Supporting

• **Communications** - development of high-power communications technology oriented toward satellite-based applications. Includes experiment development and management. (Principal responsibility: *GSFC*)

• Space Science and Exploration
- Supporting

• **Upper atmospheric research** - contributing to discipline base, with emphasis on support of Global Atmospheric Sampling Program. (Principal responsibilities: *GSFC, JPL*; supporting responsibilities: ARC, LaRC)

[41] **MARSHALL SPACE FLIGHT CENTER**
Special Capabilities

- Areas of Technical Excellence
  - Launch vehicle flight mechanics and control
  - Structures and aerostructural dynamics
  - Materials
  - Propulsion systems
  - Space vehicle flight systems
  - Data systems and analysis
  - Technical project management

- Facilities of Superior Merit
  - Neutral Buoyancy Facility
  - X-Ray Telescope Facility
  - Acoustic Model Engineering Test Facility
  - External Tank Structural Test Facility
  - Dynamics Test Facility
  - Solid Rocket Booster Structural Test Facility
  - Structures and Materials Laboratory

[42] **MARSHALL SPACE FLIGHT CENTER**

PROGRAM AREAS:
Space Transportation
Space Science and Exploration
Applications
Space Research and Technology
Aeronautics

Principal and Supporting Roles

- Space Transportation
- Principal

• **Propulsion systems** - design, development and procurement of major propulsion-oriented systems and subsystems. Current focus on Shuttle-related systems, including Shuttle main engine, solid rocket booster, external tanks and interim upper stage in cooperation with the Air Force. Advanced development effort includes TUG and solar electric propulsion systems.

• **Manned vehicle** - design, development and procurement of manned vehicle systems on "as assigned" basis.

- **Spacelab** - focus on systems engineering management, development interface with European Space Agency and procurement.

- **Advanced missions** - focus is on space station, advanced transportation systems and construction of a satellite space power station - definition activities (MSFC and JSC have co-equal roles through definition; development responsibilities are not yet assigned).

- **Advanced development** - technology advances focused on advanced missions identified above within those disciplines assigned. Termination and transfer of all biotechnology efforts.

• **STS sustaining engineering** - providing sustaining engineering for assigned STS hardware.

[43] • Space Science and Exploration
- Principal

• **Spacelab mission management** - management of Spacelab I and II missions.

• **Specialized automated spacecraft** - design and development of large, complex and/or specialized automated spacecraft as assigned. Current focus on spacecraft and systems/experiment integration for STS, HEAO, and Gravity Probe B spacecraft development. (Principal responsibility: *GSFC*; alternate responsibility: JPL)

- Supporting

• **Physics and astronomy science** - phase out by FY 79 of science discipline base with retention of a minimal science capability to fulfill such scientific interfaces as are required to support space science mission and spacecraft management roles.

• Applications
- Principal

• **Space processing** - developing space processing discipline base, developing and managing space processing experiments for Spacelab.

• **Data management** - development of applications oriented data management discipline base. Contributing overall data management systems expertise in support of advanced high data rate systems development.

• **Technology transfer**

- **Regional applications transfer** - transfer of aerospace technology to State and local agencies in the Southeastern United States with particular emphasis on applications of earth resources data from satellites.

- **Specialized applications tasks** - drawing on capability related to other roles provides [44] discrete support in such as is related to laser applications in earth and ocean dynamics.

- **Technology utilization** - conducting projects to establish applicability of NASA technology in transportation, manufacturing, and other fields; participate in technology transfer to industry; identify and report new technology; and document results of secondary applications of NASA technology.

- Supporting

• **Spacelab payload definition** - definition of requirements for an Atmospheric Cloud Physics Laboratory for flight as a partial payload of the Spacelab. (Principal responsibility: *GSFC*; supporting responsibilities: JPL, LeRC)

• **Energy technology** - conducting energy related systems studies for reimbursable activity with primary focus on solar heating and cooling and advanced coal extraction technology. (Principal responsibility: *LeRC*; supporting responsibilities: ARC, JPL, JSC)

• Space Research and Technology
- Principal

• **Space vehicle structures and materials** - contributing to large complex space vehicle structures and materials technology base. (Shared responsibility with *LaRC*)

- Supporting

• **Space propulsion systems technology** - contributing to space propulsion systems technology base, with focus on launch vehicle propulsion, solar electric propulsion, system performance and technology assessment, and contamination control. (Principal responsibility: *LeRC*; supporting responsibility: JPL)

• **Space vehicle configuration technology** - contributing to technology base for advanced space vehicle configuration. (Principal responsibility: *LaRC*; supporting responsibility: DFRC)

[45] • **Guidance and control technology** - contributing to guidance and control technology base. Focus on inertial components. (Principal responsibility: *JPL*; supporting responsibilities: GSFC, LaRC)

• **Sensor and data acquisition technology** - contributing to fundamental electronics technology base, with focus on long-life reliable circuits. (Principal responsibility: *LaRC*; supporting responsibilities: GSFC, JPL)

• **Information systems technology** - contributing to technology base, with focus on high capacity data systems for applications use. (Principal responsibility: *GSFC*; supporting responsibilities: JPL, JSC, LaRC)

• **Technology experiments in space** - definition and development of experiments in areas consistent with MSFC's other Space Research and Technology roles. (Principal responsibilities: *JSC*, *LaRC*; supporting responsibilities: ARC, DFRC, GSFC, JPL, LeRC)

• Aeronautics
- Supporting

• **Aviation safety** - contributing to advances in aviation safety through improved understanding of turbulence phenomena. (Supporting responsibilities: ARC, DFRC, JPL, LaRC, LeRC, WFC)

[46] **WALLOPS FLIGHT CENTER**
Special Capabilities

• Areas of Technical Excellence
  • Operations support
  • Tracking and data acquisition
  • Small project management

• Facilities of Superior Merit
  • Sounding Rocket Range
  • World-Wide Mobile Launch Tracking and Telemetry Capability
  • Research Airport

[47] **WALLOPS FLIGHT CENTER**

PROGRAM AREAS:
Space Science and Exploration
Applications
Aeronautics
Tracking and Data Acquisition*

Principal and Supporting Roles

• Space Science and Exploration
- Principal

• **Sounding rocket development, procurement, and operations** - developing and procuring sounding rockets and carrying out all phases of operations, from mission/flight planning to landing and recovery. Payload carrier development, development and management of experiments, experiment management support to other institutions, launch operations and tracking and data acquisition are included. (Most WFC sounding rocket

* Included within other program areas

activities involve lower performance vehicle support systems. Most activities involving higher performance systems are assigned to GSFC.)

• **Balloon program** - Managing, Monitoring, scheduling, and technical analysis of OSS funded balloon activities conducted by other agencies (NRL and NSF at the present time).

• Applications
- Principal

• **Technology transfer**

- **Regional applications transfer** - identify, demonstrate and evaluate specific practical applications of remote sensing technology with emphasis on those of particular concern to the Chesapeake Bay regional resource managers.

[48] - **Specialized applications tasks** - undertaking desirable tasks in areas related to other roles. Current emphasis includes pollution monitoring and atmospheric measurement techniques.

- **Technology utilization** - identify and report new technology, participate in technology transfer to public service and private organizations, and document results of secondary applications of NASA technology.

- Supporting

• **Sounding rocket payload carrier development and experiment management support** - provided in the following applications disciplines:

- **Weather and climate** - (Principal responsibility: *GSFC*; supporting responsibilities: JPL, LaRC)

- **Space processing** - (Principal responsibility: *MSFC*)

- **Earth and ocean dynamics** - (Principal responsibilities: *GSFC, JPL*; supporting responsibility: LaRC)

• Aeronautics
- Supporting

• **Aviation safety** - contributing to advances in aviation operations through improved instrumentation and procedures in critical phases such as approach and landing. (Supporting responsibilities: ARC, DFRC, LaRC, LeRC, MSFC, JPL)

Document IV-15

Document title: James C. Fletcher, Administrator, NASA, Memorandum to Bob Frosch, "Problems and Opportunities at NASA," May 9, 1977.

Source: NASA Historical Reference Collection, NASA History Office, NASA Headquarters, Washington, D.C.

In the aftermath of the completion of the lunar landing phase of the Apollo program in December 1972, NASA as a post-Apollo, transitional institution was very much in an uncertain and potentially unstable situation. In this memorandum, James Fletcher, who headed NASA from May 1971 to March 1977, reflects for his successor Robert Frosch on the major institutional and programmatic issues facing the agency. Of particular interest are Fletcher's observations on keeping the NASA institutional base intact or at least ensuring a flow of new people into the agency. The "Al" referred to by Dr. Fletcher is Alan Lovelace, NASA Deputy Administrator under Frosch. The project called LACIE (Large

Area Crop Inventory Experiment) was an Earth observation project using Landsat satellites. The Jupiter Orbiter Project (JOP) was later renamed Galileo.

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[1] May 9, 1977
(Dictated May 6)

SUBJECT: Problems and Opportunities at NASA

Continuing our discussion in writing on some of the things that are less sensitive, let me raise some issues not in any particular order but simply for the record. Please feel free to share these with Al if you feel you would like to do so. He is already aware of most of them.

1. **Applications Program.** In my view, the Applications Program is the "wave of the future" as far as NASA's public image is concerned. It is the most popular program (other than aeronautics) in the Congress and as you begin to visit with community leaders, you will understand it is clearly the most popular program with them as well. The Application Program consists mainly of communications satellites, weather satellites, LACIE, and earthquake research. There are problems in each of these areas:

a. **Communication Satellites.** We temporarily phased out of this program in 1973 due to a severe budget cut. At the time, it seemed like industry was picking it up most rapidly and was something they could do without much help from NASA. I had serious misgivings when this decision was made since I realized that it was the part of the Applications Program which had the greatest public visibility and was the most obvious example of transfer to industry. We were able to keep a skeleton group aboard to support OTP and FCC and, to a limited extent, the existing ATS/CTS satellites. However, at this point in time, I believe we need to get back into the business one way or another. The search and rescue satellite was a small attempt in this direction. Also, the work we are doing with NOAA and the Coast Guard to monitor fishing vessels within the 200-mile limit (they install the transponders) is also a small step in that direction. The National Academy study prepared under the chairmanship of [2] Bill Davenport was a good one, and I think it is time we started following along the tracks that they recommended. I'm afraid, however, that OMB is going to give us problems.

b. **Weather Satellites.** To many, weather satellites are mostly talk and not much show. I had been at NASA four years before I realized that NOAA was not using weather satellites at all in their weather forecasting but rather used them as backup for their forecasters and occasionally for monitoring severe storms such as tornadoes and hurricanes. Weather satellites, however, have been used extensively by the Navy and by the Air Force for overseas forecasting, I think very effectively, and just recently NOAA's Numerical Weather Service in Suitland has begun making global weather forecasts for overseas construction and a variety of military uses.

The real potential, however, of weather satellites lies in the possibility of 5-day (possibly up to 2-week) forecasts and it has only been clear in the last year or two what the technical problems really are in making such forecasts. Bob Cooper is very much aware of the problem, as is Bob Jastrow of GISS, so I won't try to elaborate further on it except to say that what is really needed is some broad-gauge scientific talent to be involved rather than the specialized, narrow scope meteorologists who have been working the problem at NOAA (and for that matter at NASA also).

c. **LACIE.** The LACIE program is not going well and OMB is very much aware of this. If this program fails, it is going to reflect on NASA's credibility in the Applications area. What is needed here also is a new approach to the problem either organizationally or by using people of different technical background. The people now involved in the program at Houston are not the most talented, and they have been doing the same thing for too many years. It has not had high-level attention at Houston because, of course, the Shuttle is their main future. It may be that the program can be handled better by simply shifting the focus from Houston to Goddard. (I recommended this two years ago but got less than an enthusiastic reception from the Office of Applications.)

[3] d. **Earthquake Research.** I'm afraid we have no program in earthquake research, but we were able to get funds from the Congress and OMB by labeling some of our "tectonic plate motion" investigations improperly. As near as I can tell, what we are doing is scientific research only and this does not relate directly to predicting earthquakes, although admittedly it might add to the scientific base on which future earthquake prediction techniques might be predicated.

There are a lot of opportunities in Applications that we may be missing which may or may not be related directly to the programs in which we are now engaged. Electronic mail, wired suburbs, the Cooper/Augenstein Global Information System and, of course, a leadership responsibility for a national climate program are all things that Al is aware we could move into; however, it does take aggressive leadership to pursue these opportunities. We don't have that in the Applications Office itself. In fact, to pursue these new programs, it might be wisest to set up a separate office outside of Applications and leave the marketing of current programs (a, b, c, and d above) to the Applications Office.

In addition to opportunities and problems, we have personnel problems in the Office of Applications, which I'd be glad to discuss with you sometime.

2. **The MSFC Institutional Problem.** As I indicated to you in our discussion, NASA has an overall institutional problem which arises from the fact that we had to trim out civil service staff by almost a factor of two since its peak during the Apollo days. This has caused a number of problems that go with aging institutions generally, but our problems were accelerated because of the rapid RIFing that went on in the late 60's and early 70's. We still have a large number of competent people at NASA, but we are not bringing in new blood either at the younger age group or at the middle age level. There are three principal reasons for this. One is that some of the glamour has worn off from the Apollo days; second, there are other interesting fields in which scientists and engineers can become involved (in my judgment none of them compete with [4] what goes on at NASA but, of course, I'm prejudiced); and, third, new employees feel insecure knowing that the last ones hired are usually the first to leave in case of a RIF. This would be a dilemma for any agency in such a situation and even though we try diligently to protect our best people, we are still in danger of approaching mediocrity.

This is especially severe at Marshall where some of the largest cuts were made. Some time in the 1980-81 period, we face severe manpower cuts at this Center. An obvious solution would be to close the Center unless some new program came along that would keep the staff fully occupied. Because of the urgent need for the talent that Marshall has for the Space Shuttle development, we have tried to put new programs there (such as space telescope, HEAO, etc.) and have allowed them to do a considerable amount of in-house work on the Shuttle to make good use of their personnel. Closing Marshall has been on OMB's agenda ever since I came to NASA, although from time-to-time they have also suggested JPL, Ames, and Lewis. We have always resisted this very strongly on the basis that (a) the initial cost of replacing the facility would be very high, and (b) we couldn't afford to risk the Space Shuttle program. The real reason, however, is that there is no guarantee that by closing a Center we would be allowed to build back to the institutional base we had before the closing, and we might find ourselves in the same RIF situation but be one Center smaller. The only possible solution that I can see is to get a commitment from the President himself (the OMB Director's commitment can always be overturned) that if we do close the Center we will be allowed to build back substantially in order to bring in new personnel. Most people in Headquarters would laugh at this suggestion but I think that it is one that ought to be considered early on in your tenure. My own bias, of course, would be to try to find work to put into MSFC and use the Center as a national resource, which it indeed is, but so far efforts along these lines have not been successful.