DESIGN FOR DECLINE:

Executive Management and the Eclipse of NASA

by

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ABSTRACT

Title of Dissertation: Design for Decline: Executive Management and the Eclipse of NASA

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This study examines the organizational development of the National Aeronautics and Space Administration from the creation of its parent organization in 1915 through the 1960s. It focuses especially on the relationships which the organization's leadership established with external groups and individuals, as well as with its own employees.

The dissertation intends to: provide a more adequate explanation of NASA's decline than currently exists; gain some insight into the management of research and development organizations within the federal government; and determine the utility of using different theoretical perspectives for exploring how organizations change. The findings from the case study are related to existing theories of organizations, and different explanations of NASA's decline are evaluated.

Among the various reasons identified for NASA's decline, management's maladroit handling of several potentially conflicting organizational goals figures prominently. Steady decline in agency appropriation levels after 1965, coupled with the lack of widely agreed upon criteria to evaluate its technical and management decisions, produced in NASA a striking example of an organization unable to successfully adapt to changes in its external and internal environment.

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GLOSSARY

BOB	Bureau of the Budget
CSC	Civil Service Commission
GAO	General Accounting Office
JPL	Jet Propulsion Laboratory
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
OART	Office of Advanced Research and Technology
OMSF	Office of Manned Space Flight
OSSA	Office of Space Science and Applications
OTDA	Office of Tracking and Data Acquisition
PAD	Project Approval Document
PERT	Program Evaluation and Review Technique
RIF	Reductions-in-Force
RTOP	Research and Technology Objective and Plan Document

Chapter I

INTRODUCTION

In 1958 the National Aeronautics and Space Administration was created to assure the nation's superiority in space.[1] The support this organization received in its early years was unparalleled for a federal organization. By 1965 its annual appropriation had passed five billion dollars and over 400,000 individuals (contract and civil service) worked on NASA-sponsored projects. Its technological achievements were recognized throughout the world, and the nation's superiority in space was spectacularly made known to the world in 1969 when a NASA astronaut became the first man to walk on the moon.

But if its achievements were impressive, equally impressive was its decline. Since 1965 NASA's appropriation level and personnel complement have steadily declined. Its 1977 appropriation was about half the 1966 appropriation in constant dollars, and the total civil service and contract employment had shrunk to 124,000. Congressional and Executive personnel ceilings have resulted in the resignation of some of NASA's top personnel and morale problems at all levels.[2] New field installations were closed to offset the impact of the budget cuts on NASA's total program, and a 1975 internal institutional assessment brought into question the continued existence of some of its major field installations.[3]

Equally distressing to NASA's leadership is the continued growth in the Department of Defense's space budget. In 1981 for the first time NASA's share of the United States' space budget was less than the Department of Defense's.[4] Perhaps more ominous to NASA's future survival is Congress's requirement that NASA submit all requests for major program changes to the National Academy of Sciences before submission for approval to Congress.[5]

Why did NASA change from a thriving, highly supported organization to one which has lost even the authority to propose major program changes? Was this decline caused by internal management problems, some performance failure on its part, or might the decline better be interpreted as simply the inevitable result of allocative decisions made by Congress after losing interest in space?

This study attempts to provide some insight into NASA's decline by examining the historical development of the agency from its creation as the National Advisory Committee for Aeronautics in 1915 through its metamorphosis as NASA. It was undertaken for three reasons: to provide a more adequate explanation of NASA's decline than currently exists; to gain some insight into the management of research and development organizations within the federal government; and to determine the utility of using different theoretical perspectives for explaining how organizations change or in this case fail to change. The findings from the historical study are related to existing theories of organizations, and the weaknesses and strengths of different explanations of NASA's decline are discussed.

INTERPRETATIONS OF NASA'S DECLINE

NASA's decline has been attributed by some authors to its Administrator, James Webb's, unwillingness to challenge the Executive Branch's decision in 1965 to lower NASA's budget despite repeated requests from Congress that NASA's leaders propose programs which they could support with additional funding.[6]

Others, while agreeing that NASA's decline began and continued because it was unable to come up with long-term objectives, argued that this failure was the result of an imbalance in the structure of power within NASA.[7] The group responsible for the manned space flight programs was able to virtually control the objectives of NASA because of its size, share of the organization's resources, and the dependence of the agency on the success of the Apollo program. Since the objective of the manned space flight program was to produce a technical capability, not a product which could be used to justify future appropriations, NASA was never able to establish adequate justification for its continued existence or high level of funding when competition for resources became high in the mid and late 1960s.

Bauer and Meyer argued in a similar manner that NASA's leaders were never able to integrate the competing groups within NASA in any fashion adequate enough to engage in long-term planning.[8] NASA, according to these theorists, was not one, but a number of competing bureaucracies whose objectives were never integrated into agency-wide objectives. This lack of coordination and cooperation extended to the performance of the agency's research and development activities, with one group letting contracts for work which another NASA group was already accomplishing. The result was an unwillingness on anyone's part to support another group's programs.

Chapman, in contrast to other analysts, concluded that the extensive bureaucratic apparatus which NASA set up for approving and monitoring its programs, stifled research innovation and made it difficult for NASA to retain and attract highly qualified scientists and engineers.[9] But Chapman also argued that NASA never established the informal structure of relationships necessary to assure organizational continuity. Informal relationships developed within project groups and individual field installations and ended with the completion of the project.

NASA's Interpretation of Its Decline

Although it is difficult to assess what the leadership of NASA felt with regard to the above evaluations, written records of their attempts to manage the decline show individuals very frustrated by the lack of alternatives available to them.[10] Its leaders attributed many of its morale problems to the "Reductions-in-Force" required by the Bureau of the Budget after 1965 and criticized the Civil Service Commission's regulations which NASA's leaders felt made reducing personnel unnecessarily difficult and resulted in the retention of poor performers, while highly qualified scientists and engineers who could obtain employment elsewhere simply left because of the problems created by these regulations.

They also felt that Congress and the Executive Branch played a role in many of NASA's problems. The increase in monitoring, which Chapman gives as one of the reasons for NASA's decline, was described by its leaders as necessary in light of the extensive investigations by Congress which followed any technical failure. Its inability to produce new ideas was said to have occurred because the Executive Branch and Congress felt that research studies were only a bureaucratic mechanism for starting high cost projects. This prevented the accomplishment of the studies which could have produced new ideas and the basic research necessary to generate new technology. They argued that those individuals whose proposals for research studies were turned down simply left the organization in frustration. Cancellation of scientific programs which had been supported for many years by some scientists was said to have resulted in the withdrawal of the support of the scientific community--the only other mechanism for obtaining new ideas.

NASA's leaders did not disagree with the conclusion that the manned space flight group had enormous power within NASA, but they pointed out that the alternative of not providing the greatest amount of its resources to the manned space flight program never existed. It was the reason for the agency's existence and one accomplishment which all observers could understand and support, whatever the long-term consequences of accepting the manned space flight group's objectives.

The Importance of NASA's Decline

While the above explanations offer a great deal of insight into NASA's current situation, they raise as many questions as they answer. Competing groups exist in all organizations, and yet these organizations have found ways to resolve the conflicts and obtain adequate funds. All federal agencies have been required to adopt bureaucratic structures similar to NASA's, and yet most have managed to generate adequate support to ensure their continual funding. The decline in resources and manpower undoubtedly affected NASA's management's ability to manage the organization, but other organizations have gone through periods of decline and not only survived, but even prospered.[11] What, then, made NASA unique among these organizations? Perhaps most important, the explanations of NASA's decline, with the exception of that given by its leaders, ignore the role other groups played in NASA's downfall. Congress not only approved NASA's funding, it also evaluated its performance, and placed constraints on its ability to respond to the drop in funding. As NASA's leaders pointed out, various agencies in the Executive Branch eliminated many of the alternatives available to them after the cuts began.

Leaving these questions unanswered seems unacceptable. If, as some of the above theorists argued, NASA's decline was partially related to its structure, then some effort should be made to find out why NASA's structure developed in the manner that it did. If NASA's decline is interpreted as a political decision which reflected a loss of interest in the achievement of major space advancements, then determining what the consequences of these decisions are remains important in making future policy decisions. The build-up of teams of scientists and engineers during the early 1960s was not only costly in terms of monetary resources but also in terms of the loss of these individuals' skills for other research and development projects. The breakup of these teams with little consideration of the impact on these individuals or our future capabilities is perhaps the most serious consequence of NASA's decline, and it appears to have been done with little understanding of the costs to the nation. If, as NASA's leaders argued, the decline could have been accomplished with less damage to the organization as a whole, as well as to individual scientists and engineers, understanding why this was not accomplished so that future budget cuts can be more meaningfully managed seems important to anyone interested in organizations, but particularly to those interested in the management of research and development organizations.

AN ALTERNATIVE APPROACH

The study differs from the above in a number of important ways. It focuses on the relationships established both internally and with external actors with the assumption that an organization's internal management cannot be separated from its external relationships and the requirements that external actors place on the organization. It also differs in that it presents a historical study rather than looking at NASA during one period of time or only after 1965 with the assumption that a more adequate explanation of NASA's decline could be given if there were a greater understanding of the factors leading to its decline. Finally, it not only examines other explanations of NASA's decline in light of the findings from the case study, it also attempts to look at NASA from a number of different theoretical perspectives. Each of these differences is discussed in turn below.

The Executive Function

Rather than limiting the study to such factors as the number of competing groups or methods of controlling subordinates, the study focuses on the performance of the executive function. To justify this focus, it is necessary first to explain how the term 'executive function' is used.[12] The executive function is defined as the responsibility of executives to maintain an equilibrium between demands being made upon them by external actors and those being made by their subordinates in a manner which will ensure the organization's survival. In general this involves providing the organization's clientele with some type of product which will satisfy the clients and ensure that its suppliers, whether they be a political body such as Congress or the clients themselves as in the case of most private organizations, will provide adequate funds to meet the needs of the organization. To accomplish this, executives must either through negative or positive inducements convince their employees to produce at the level necessary to ensure that they receive adequate funds. Consequently, there is a very direct link between an organization's external environment and its internal management which cannot be ignored. Public organizations present a special case because the link is more formal in that other organizations, such as the Civil Service Commission, can require it to meet certain demands which have little to do with the actual objective of the organization. Personnel regulations are only one of the many examples of these types of demands. An executive in a public organization is thus not only faced with finding some equilibrium between the demands from external and internal actors, but also establishing this equilibrium within a set of rules and regulations which might make doing so even more difficult.

I assume that adequate performance of this function requires that an organization's leaders establish an authority structure and objective which are accepted as legitimate by subordinates. Authority structures are divided into two types--those based on expertise and those based on position, but most organizations are assumed to have a mixture of the two. This is true particularly for research organizations in which scientists and engineers may accept the authority of non-technical superiors to make decisions about administrative matters, but not about their research.

The term 'objective' or 'goal' is used rather broadly to refer to what Barnard calls the purpose of the organization. It is the end toward which the activities of the organization are directed. For example, the National Advisory Committee for Aeronautics, the organization which was re-created as National Aeronautics and Space Administration in 1958, had as its purpose the advancement of aviation. Its members believed that the best method of accomplishing this was through basic and applied research. The specific projects in which it engaged changed through the forty-four years of its existence; but this underlying purpose remained the same.

I argue that an organization's purpose plays an important role in its survival because it is the criterion which is used to make decisions about the organization's activities. Without a legitimized purpose, executive leaders have no way of evaluating the importance of any activity to the organization's future survival, nor do they have any way of justifying their decisions to either subordinates or external actors responsible for their funding.

I will argue that NASA's decline can most adequately be explained as a failure of the executive function. To be more specific, I will argue that NASA's leaders for various reasons failed to establish either an authority structure or purpose which was accepted as legitimate by their subordinates. They failed to understand both the importance of expertise as a source of authority to scientists and engineers and the importance of basic and applied research to obtaining their objectives. The result was that these individuals were unwilling to accept their authority and either left the organization or stopped presenting their ideas to NASA's leaders. NASA's leaders were in the end left without a mechanism for providing the organization with ideas about new technologies. They had, either because of their own unwillingness to accept the ideas of scientists and engineers or because the researchers themselves had given up trying to convince their superiors, no group which could provide the stimulus for the change in research activities necessary to maintain Congress's support. It was the executive function failure which led to the decline in the first place, as well as made the impact of the cuts in appropriations and personnel so devastating to the organization.

The Case Study

The study presents a historical study of the development of NASA from the creation of its parent organization, the National Advisory Committee for Aeronautics (NACA), in 1915 through NACA's re-creation as NASA in 1958. It ends in the late 1960s shortly after the resignation of NASA's second administrator, James Webb.

NACA was included in the examination of NASA both because it was difficult to ignore the enormous role it played in NASA's development and because it could be used to show how another research organization coped with changes in its environment. Since I was interested in understanding the relationship of the external environment to the management of organizations, the fact that NACA's period of existence spanned a time frame during which there were major changes in the management of federal organizations makes it very useful for understanding the changes which occurred, as well as showing how another research organization copied with the changes. The fact that NACA was for many years successful in coping with the changes makes it particularly useful for understanding where NASA's leaders failed. NACA also went through a period in which its survival came into question, but in contrast to NASA it was able to respond in a manner which ensured its survival. Its reaction to this crisis period will be used to show the differences between two organizations' method of searching for solutions to a threatening environment. I will argue that NACA's leaders had established an authority structure and purpose which was acceptable by their subordinates and were thus able to avoid the decline which faced NASA. Finally, NACA will be used to explain why it was so difficult for NASA's scientists and engineers to accept the authority structure based on position which NASA's leaders attempted to establish. NACA's scientists and engineers, as were many of the other researchers brought into NASA, were used to an authority structure based on expertise. Their superiors before joining NASA were scientists and engineers, most of whom were well respected in their fields. The origins of many of NASA's problems can be traced to this fact.

The decision to end the study in the late 1960s was made for the simple reason that NASA's history after this period has only been one of continued decline. In 1969 this observation could obviously not have been made with as much certainty as today, but even at this early stage, NASA was displaying most of the symptoms of a declining organization. As I will discuss in the case study, it was, by the end of the 1960s, plagued with morale problems; having difficulty attracting and retaining highly qualified scientists and engineers, as well as promoting them; suffering from a high level of competition over remaining resources with dissatisfaction displayed about the level of resources allocated to the manned space flight program; rapidly losing external sources of support; committing a high level of its resources to coordinating and monitoring its work activities; and continually raising the organizational level at which final decisions were made.[13]

The choice of 1965 as the starting date of this decline was somewhat arbitrary and based primarily on the fact that this was the year when the cuts in appropriations and personnel levels began. This is said with some caution since, as will be discussed in the case study, NASA's scientists and engineers were indicating their dissatisfaction with the situation within NASA prior to 1965.

Finally, some note should be made of some problems created by using the case study approach. As with other case studies, it is difficult to generalize its conclusions to other organizations. This seems particularly to be the case with regard to NASA, which is unique in a number of ways. As a research and development organization, it faced many problems which other government organizations do not face. The changes in federal management policies made it necessary for many research and development organizations to change their methods of accomplishing their activities, if for no other reason than the fact that many scientists and engineers were unwilling to accept the authority structure necessitated by the changes. The changes, as will be discussed in the analytical section, had less of an impact on organizations with staffs who were more amenable to structures based on position. NASA was also unique among research and development organizations. It was composed of a number of organizations which before their inclusion in NASA were used to an authority structure based on expertise, and which had primarily been small in-house research groups. This presented it with many difficulties which most leaders of other government organizations do not face. For this reason, any conclusions from the study are only tentative and require additional studies of other organizations before they can be confirmed.

The Analytical Section

The third difference between this study and others is that I will examine not only other explanations of NASA's decline and relate them to my findings, but also attempt to look at NASA from a number of different perspectives.

I will conclude from my examination of other explanations (e.g., interference from external actors, competing groups) that neither my argument or the findings from the case study preclude accepting these explanations. NASA's decline can probably best be explained as the end result of a number of interacting factors. I argue, though, that the failure of the executive function provides a more complete explanation of why it began to decline and the enormous impact that the cuts in appropriations and personnel levels had on the organization.

In addition, I will examine my findings from the case study using a number of different theoretical perspectives. This was undertaken to see if a more adequate explanation of NASA's decline could be given if I was not limited by one theoretical framework. I will use the executive function perspective to focus my examination and to explain how NASA's leaders failed. Cyert and March's problemistic search theory will be used as a mechanism for understanding how organizations change and to link the executive function failure to the actual decline.[14] The structuralist approach or those set of theories which examine organizations and their relationships with external actors over time will be used to show how NASA differed from other organizations which existed during the 1960s.[15]

METHODOLOGY

The primary source of data for the analysis was the official records of NACA and NASA.[16] These records are extensive and particularly in the case of NACA go down to the level of handwritten notes among staff members. Although the sheer volume of data prevented reviewing all the records, an attempt was made to selectively review those materials which might provide some insight into the structure of the organization. In addition, minutes of committee meetings, NACA Annual Reports, Congressional Hearings, and reports of oversight agencies (e.g., General Accounting Office) were reviewed. Public accounts (books, articles, and newspaper clippings) were used to supplement this review. In the case of NASA, these sources were supplemented by reports of NASA contractors on the organization. Many of these reports, since they evaluated some aspect of NASA's performance, were found to be fruitful sources of information on the organization.

Since NASA also keeps copies of interview notes, both those done in-house and by individuals under contract, these were also examined with the hope that some insight could be gained on the perceptions of organization members about NASA.[17]

Some note should be made of the problems associated with the data. First, not all records were reviewed nor were these records complete. NACA's records alone comprise 5,232 cubic feet at the National Archives and Records Service.[18] They are also recognized as incomplete and do not include the records of many of the NACA laboratories nor records on the organization kept by other archival sources (e.g., Smithsonian, Johns Hopkins University) or even those remaining in the NASA History Office. NASA records present even more difficulty. NASA is required by law to make its operations open to the public.[19] This makes it a fascinating organization to study, but also leaves one immersed in so much detail that it is difficult to understand the organization at all. Numerous histories of its ventures have been published, but they are primarily descriptive narratives largely devoid of attempts at analytic inquiry. It is easy to find out the name of a chimpanzee sent into space, but very difficult to determine the organizational arrangements which surrounded the ascent. This problem is compounded by the fact that any organization can destroy those records which it does not want reviewed or can at least make them difficult to find.

Written records also do not contain those numerous verbal agreements which play such an important role in the development of any organization. This problem was somewhat alleviated by a review of the personal accounts of the NACA and NASA's staff, but these accounts obviously introduce their own biases.

Personnel and appropriation data were reviewed, but their validity is questionable. This is particularly true in the case of NACA's records. Its leadership refused to classify their employees according to federal guidelines. This refusal was based on a belief that classification of their employees was the first step toward taking away their researchers' autonomy. This problem was exacerbated by the fact that the laboratories had a great deal of discretion with regard to personnel management, and no two laboratories operated exactly the same way. Administrative and personnel matters were considered secondary to the research work, and attempts to track employees took valuable time away from the real work of the laboratories. This attitude continued through the creation of NASA. As late as 1966, an in-house report on personnel management found that

NASA leadership was unable to track personnel and relate them to research and development needs for the simple reason that each field installation had its own personnel management system. Civil Service Evaluations continually found their personnel classification system inadequate with little uniformity among the NASA field installations, least of all with Civil Service regulations.[20]

Notwithstanding these problems, I felt that relying on these records was the only way that a historical study of this nature could be accomplished. Interviews and personal observations not only have their own particular problems, but also are more suited to one point in time.[21]

Although some thought was given to using interviews to obtain data on NASA's current situation, I felt that, if properly interpreted and in adequate quantity, written records would provide as much information on the organization as interviews.[22]

ORGANIZATION OF THE STUDY

The study is divided into descriptive and analytical sections. The first section presents a case study of the historical development of NACA and NASA and is largely descriptive in nature. It is divided into three chapters, each of which discusses a period in which the organization has been through a major change in its management or research activities. Decisions about which periods to examine were based on a review of the history of NASA and NACA, other authors' conclusions about important periods in the history of the two organizations, and my own judgment. In general the organizations were examined approximately ten years after there was a major change in their external relationships in order to determine the impact of these changes on the organization. To avoid discussing temporary reactions to these changes, the organizations were not examined immediately after the change.

Rather than presenting the story of NACA and NASA as a strict historical chronology, I have chosen to discuss the organizations' external and internal management during one period of time and to follow this by an examination of those factors which I felt played a role in the establishment of new external and internal relationships. This was done to avoid immersing the reader in details which had no relationship to the central argument and in recognition of the fact that a complete organizational history of NACA and NASA would require two or three volumes.

The first chapter discusses the research activities, external relations, and internal management of NACA in the late 1920s. NACA, which was created in 1915, had by this time formalized its relationships and settled on those research activities in which it was to engage until World War II. The period prior to this time was one in which NACA was continually changing these relationships and research activities.

The second chapter describes the organization as it existed in the mid-1950s or shortly before Sputnik was launched and the transformation into NASA. This period was selected for two reasons. NACA had gone through a period after World War II when its continued existence as an independent organization was at stake. By the 1950s it had resolved this problem and re-established new relationships with external actors. In contrast to NASA's leaders, NACA's leaders were able to cope with a threatening environment and adopt new research activities which Congress and the Executive Branch were able to support. NACA, during this period, also was faced with requirements from external actors for changes in its internal management. Its staff's response to these demands provides some indication of the problems which faced NASA in the years following its creation.

The third chapter discusses NASA during the late 1960s. NASA by this time had shown the world that the nation's technical capabilities in space were greater than the Russians' and thus achieved its major objective. It was already suffering from the impact of personnel ceilings and budget cuts which had started in 1965. In contrast to NACA, it had after ten years of existence not been able to establish stable internal and external relationships.

In the second section I present my interpretation of NASA's decline in light of the findings from the case study and existing theories of organizations. The fifth chapter is devoted to the development of my argument in light of the findings. The sixth and seventh chapters discuss how my argument is related to other explanations of NASA's decline and existing theories of organization. The final chapter reviews the findings and their management and policy implications.

The limitations of the data, as well as the exploratory nature of the study, imply that any conclusions I present are highly tentative in nature. I am primarily interested in raising some questions about the management of research and development organizations and the public policies which are adopted to guide them.

I might also note that the study does not address the problem of what specific research and development policies there should be or even if there should be public support of research and development projects. I accept such decisions as the one to go to the moon as a given.

1 Public Law 85-568, 85th Cong., H.R. 12575, July 29, 1958. 72 Stat. 426. The appropriations and personnel statistics presented in this section were obtained from U.S. Congress, House, Committee on Science and Technology, Subcommittee on Space Science and Applications, United States Civilian Space Programs: 1958-1978, Committee Print, 97th Cong., 1st sess., January 1981 (Washington, D.C.: Government Printing Office, 1981); and Jane van Nimmen and Leonard C. Bruno, with Robert L. Rosholt, NASA Historical Data Book 1958-1968, Vol. 1; NASA Resources, NASA Publication #SP 4012 (Springfield, Va.: National Technical Information Service, 1976). Appendix A contains a breakdown of NASA's personnel and appropriations.

2 NASA's morale problems have been the subject of numerous internal investigations and other studies. See U.S. Civil Service Commission, "Evaluation of Personnel Management NASA Nationwide, August 1967, and the numerous Memoranda for the Record made in response to this evaluation; NASA, "Consideration in the Management of Manpower in NASA, September 8, 1966," Report of the ad hoc NASA Manpower Utilization Committee (Hjovnivik Report); 1975 Institutional Assessment; "Shuttle Program Mangement Assessment," September 12, 1979, Submitted by Special Staff of Individual Consultants, Marked "For Official Use Only." The results and details of the investigations are stored in the NASA History Office files. NASA is currently in the process of preparing an assessment of their management problems for Congress.

3 Ames, the Jet Propulsion Laboratory and Lewis have been under threat of closure or transfer to another organization for some time. See Appendix B for location and name of all NASA centers.

4 John Noble Wilford, "Space and the American Vision," The New York Times Magazine, April 5, 1981, pp. 53ff.

5 See "Science Academy Voted Role in NASA Projects," Aviation Week and Space Technology, December 1, 1980, p. 20. The justifications for this transfer were cost overruns and technical problems on most of NASA's projects. The irony is that one million dollars of NASA's research and program management fund was designated for the review of its programs by the National Academy of Sciences.

[6] See U.S. House, Toward the Endless Frontier: History of the Committee on Sciences and Technology, 1959-1979 (Washington, D.C.: U.S. Government Printing Office, 1980); Raymond A. Bauer, et al., NASA Planning and Decision Making, Final Report, 2 vols. Contract NGR 22-007-163, Harvard Graduate School of Business Administration, 1970; Transcript of Proceedings, National Aeronautics and Space Administration, "Management Advisory Panel Meeting," April 19, 1968, Washington, D.C. NASA History Office Files. The latter presents some of Webb's views on management. Before being appointed as Administrator of NASA, Webb was the Director of the Bureau of the Budget. This appointment was felt to have influenced his refusal to challenge the executive branch's decision on NASA's budget and objectives. Whatever his beliefs, his departure in 1968 resulted from a confrontation with President Johnson over the continual cuts in NASA's budget. His concern about NASA's future is probably best presented in "Address by James E. Webb, Administrator NASA," John Diebold Lecture on Technological Change and Management, Harvard University Graduate School of Business Administration, Boston, Mass., September 30, 1968, in which he argues that the U.S. through its expenditure policies was accepting a "second-rate position in space"; p. 4.

[7] Emmette S. Redford and Orion F. White, "What Manned Space Flight Program after Reaching the Moon? Government Attempts to Decide: 1962-1968." NASA Research Grant NGL 33-022-090. Syracuse / NASA Program, December, 1971. NASA History Office Files.

[8] Bauer, loc. cit.

[9] Richard L. Chapman, Project Management in NASA: The System and the Men (Wash., D.C.: NASA, 1973). Chapman bases these observations on interviews with NASA staff members. Many critics of NASA have also focused on the bureaucratic structure of NASA as a reson for its continued decline. See Richard Goody, Michael McElroy, and Philip Morrison, "Human Issues in Space Exploration," Bulletin of the American Academy of Arts and Sciences, Vol. XXXIII, No. 8 (May 1980), pp. 10-13.

[10] The following description of the reactions of NASA's leadership to its decline was based on numerous documents in NASA's History Office Files. Specific examples will be cited in the case study.

Also see National Academy of Public Administration Foundation, "Report of the Ad Hoc Panel on Attracting New Staff and Retaining Capability during a Period of Declining Manpower Ceilings," June 1973, NASA History Office Files, Washington, D.C.

11 See particularly Alfred D. Chandler, Jr., Giant Enterprise, Ford, General Motors, and the Automobile Industry (New York: Harcourt, Brace & World, Inc., 1964). The National Advisory Committee for Aeronautics which will be discussed in the case study went through a period of decline following World War II and made those changes necessary to ensure its survival.

12 The explanation given of executive function relies heavily on Chester Barnard, Functions of the Executive (Cambridge: Harvard University Press, 1938). Also see James G. March and Herbert A. Simon, Organizations (New York: John Wiley & Sons, 1958), for a discussion of the various propositions of what is generally known as the inducements / contributions theory.

13 These characteristics are a composite of other authors' observations with regard to declining organizations. See Anthony Downs, Inside Bureaucracy (Boston: Little, Brown and Company, 1967); Arthur L. Stinchcombe, "Social Structure and Organizations," Handbook of Organizations, ed. James G. March (Chicago: Rand McNally College Publishing Co., 1965), pp. 142-193; William H. Starbuck, "Organizational Growth and Development," Handbook of Organizations, ed. James G. March (Chicago: Rand McNally College Publishing Co., 1965), pp. 451-553; John Freeman and Michael T. Hannan, "Growth and Decline Processes in Organizations," American Sociological Review 40 (1975), pp. 215-228; Richard M. Cyert, "The Management of Universities of Constant or Decreasing Size," Public Administration Review, Vol. 38, No. 4 (July / August 1978), pp. 344-350; Irene Rubin, "Politics and Retrenchment in the City: A Case Study," paper presented at the Mid West Political Science Meetings, April 1979; Albert O. Hirschman, Exit, Voice and Loyalty: Responses to Decline in Firms, Organizations, and States (Cambridge, Mass: Harvard University Press, 1970).

14 Richard M. Cyert and James G. March, A Behavioral Theory of the Firm (Englewood Cliffs, N.J.: Prentice Hall, Inc., 1963).

15 See Stinchcombe, loc. cit.; Howard E. Aldrich and Jeffrey Pfiffer, "Environments of Organizations," Annual Reviews Inc., 1976, pp. 79-105; and Michael T. Hannan and John H. Freeman, "The Population Ecology of Organizations," Environments and Organizations, eds. Marshall W. Meyer and Associates (San Francisco: Jossey-Bass Publishers, 1978). The perspective will be discussed in greater detail in Chapter 7.

[16] Staff members of the NASA Headquarters History Office have prepared extensive reports on the availability and integrity of NASA records and data. These can be obtained by contacting this office. Of particular interest are the bibliographical essay of Alex Roland, Research by Committee, A History of the National Advisory Committee for Aeronautics: 1915-1958, Comment Edition, April 1980; and by the same author, A Guide to Research in NASA History, 4th ed. (Washington, D.C.: NASA, September 1979).

[17] Interviews with NASA staff members are recorded and kept on file in the History Office. These are in most cases of two types: (1) interviews which contractors have undertaken, and (2) what NASA calls exit interviews. The latter interviews are those which NASA staff give shortly before they leave the organization.

[18] See Roland, op. cit., for a discussion of the problems and the location of these data.

[19] Public Law 85-568, 85th Cong., H.R. 12575. July 29, 1958, 72 Stat. 426. 42 U.S.C. 2454. For a compilation of the texts of all public laws relating to aeronautical and space research, see U.S. Senate, Committee on Commerce, Science and Transportation, National Aeronautics and Space Administration Act of 1958, as amended, and related legislation, Committee Print, 95th Cong., 2d sess., Washington, D.C.: U.S. Govt. Printing Office, 1978.

[20] NASA has gone through a number of evaluations by the Civil Service Commission because of its personnel management system. See particularly, "Evaluation of Personnel Management System," op. cit. NASA's response and Headquarters evaluations of the field installations are contained in the files for 1967-1968, but similar reports exist for most years.

[21] I might note here that I was employed by the Goddard Space Flight Center, NASA, in the mid-1970s. The observations I made while employed there were not made part of the current study, but were used to evaluate some of the more recent data I reviewed.

[22] There is some precedent for this approach. See Alfred D. Chandler, Jr., The Visible Hand: The Managerial Revolution in American Business (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1977); Leslie H. Gelb with Richard K. Betts, The Irony of Vietnam: The System Worked (Washington, D.C.: The Brookings Institution, 1979); A. Hunter Dupree, Science in the Federal Government (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1957); James C. Thompson, Rolling Thunder (North Carolina: University of North Carolina, 1979).

Section I

NACA and NASA: 1915-1970

NASA's organizational history started in 1915 with the creation of the National Advisory Committee for Aeronautics. This section, which contains the case study, traces NACA's development from 1915 until its transformation into NASA in 1958 and NASA's development until the end of the 1960s. It is divided into three chapters, the first of which describes NACA as it existed in 1927. This is followed by a chapter which discusses NACA's development up to 1958. The final chapter describes NASA as it existed in the late 1960s.

Chapter 2

NACA IN 1927

INTRODUCTION

On March 3, 1915, the National Advisory Committee for Aeronautics was established through a rider attached to the Naval Appropriations Act.[1] The rather ambiguous one-page legislation established a committee composed of twelve unsalaried members appointed by the President from both the public and private sectors and appropriated five thousand dollars for its needs. Although the legislation did not specifically order the establishment of research laboratories, it did state that,

> In the event of a laboratory or laboratories, either in whole or in part, being placed under the direction of the committee, the committee may direct and conduct research and experiment in aeronautics in such laboratory or laboratories...[2]

What Congress expected of this new Committee was equally broad and vague. It was to determine the aeronautical problems requiring solution, discuss their solution, and supervise the scientific research required to solve the problems of flight.

Whatever their mandate, the members of the Advisory Committee acted like they knew exactly what was expected of them. In their first meeting on April 23, 1915, they formulated the rules and regulations for the conduct of their new organization as specified in NACA's legislation. Between 1915 and 1927 they proposed eighteen amendments to these rules and regulations, but these amendments were minor or primarily involved the new research laboratory. No additional amendments were proposed until 1944.

Within six months the Advisory Committee requested funds for a laboratory in Hampton, Virginia. By 1927 this laboratory was engaged in those research activities which it was to perform with little change until after World War II and with an organizational structure which allowed the laboratory to perform its technical activities to the satisfaction of its researchers and the Committee members.[3] The twelve-member committee by 1927 was assisted by a research agency employing 165 individuals and numerous committees which reviewed and disseminated aeronautical research not only in the United States but also in Europe. Its five thousand dollar appropriation had increased to an annual appropriation of over five hundred thousand dollars.

It is hard though to argue that NACA's development was the result of any systematic plan on anybody's part. NACA in the beginning performed a number of technical research activities which it later dropped when external actors found for some reason that NACA's performance of these activities was unacceptable. The Advisory Committee also attempted to establish a different structure from the one which existed in 1927, but this attempt also failed. Rather than a planned development, NACA appeared to develop rather haphazardly in response to each situation it encountered. The individuals who made up NACA did not choose a specific technical activity or type of structure from all the alternatives available. Rather they settled on the task which met three criteria. It needed to be accomplished to advance aviation. It was not being accomplished adequately, if at all, by others, and its performance brought no criticism which NACA's leaders felt could seriously hurt the organization. The structure, on the other hand, was influenced by the nature of NACA's work, the philosophies of the leaders and staff members and the constraints presented by the environment.

The purpose of this chapter is to show how and why NACA developed in the manner it did. The first part of the chapter describes NACA as it existed in 1927. The second is devoted to a discussion of those events and factors which played a role in the formation of the 1927 organization.

NACA IN 1927

INTRODUCTION

In contrast to the vertical hierarchical structure administered by a single individual appointed by the President existing in most government agencies today, NACA in 1927 and throughout its history had what amounted to a two-tier structure. As Figure 1 shows, the first tier consisted of the Advisory Committee, the Executive Committee, and the various technical committees and subcommittees. The second tier consisted of the Langley Research Laboratory under the direction of Henry J. E. Reid. What tied the two groups together was the relationship which developed between Joseph S. Ames, the Chairman of the Executive and Advisory Committees, George W. Lewis, the Director of Aeronautical Research, and John F. Victory, the Secretary for NACA. These three individuals formed a triumvirate which ruled NACA until World War II.

Dr. Ames, a physicist, while not engaged in the day-to-day operating matters of the research laboratory, worked with Lewis in establishing the policies and research programs of NACA. The Advisory Committee with the assistance of the technical committees and subcommittees was responsible for general policy decisions, supervision of the agency's research activities, and NACA's relationships with other organizations, but as Chairman, Ames was able to guide the various committees in the direction he desired.

Lewis, an engineer, was responsible for executing and directing NACA's activities and any research conducted at Langley or at other laboratories under contract to NACA for specific research projects. He

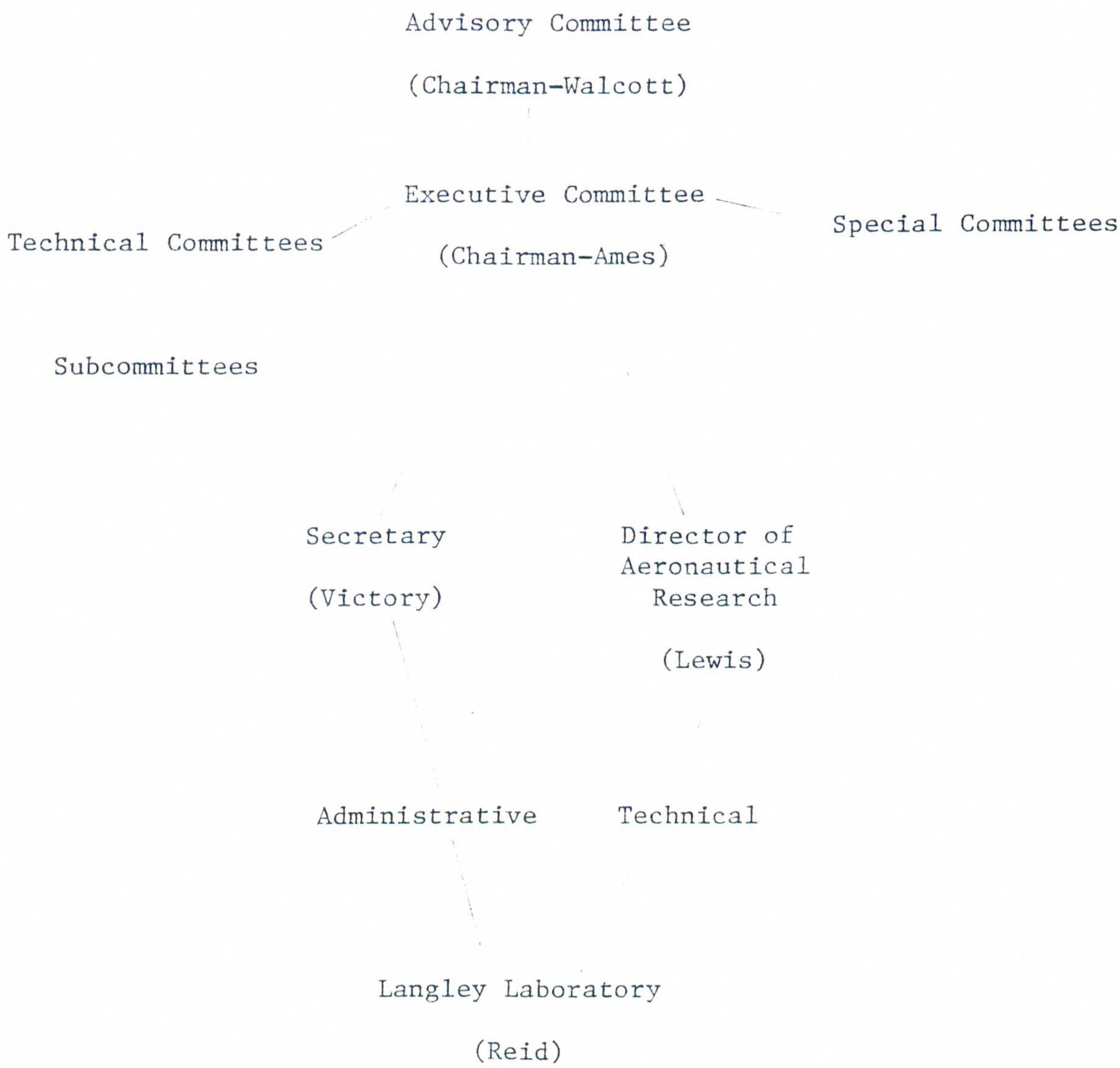

Figure 1

NACA's 1927 Organization Chart

reported directly to Ames and was an *ex officio* member of all technical committees. He prepared NACA's Annual Report and performed those activities related to Congress and the Executive Branch, as well as acted as the Committee's liaison with the military services, other government agencies, private industry, and universities when necessary.

Victory served as Secretary of the Executive Committee and as general administrator for the Langley Research Laboratory. He directed the administrative work of NACA and supervised its expenditures and personnel employment.

The various committees and subcommittees provided technical and administrative assistance to the Advisory Committee. They had no formal or legal control over the Research Laboratory, but made recommendations about Langley's research proposals to the Advisory Committee.

NACA performed two types of activities: in-house aeronautical research and the coordination of external aeronautical research. The first was performed at the Langley Laboratory and primarily consisted of applied aerodynamical research. The latter function was performed by the Advisory Committee with the support of the various committees and the headquarters unit under the direction of Lewis and Victory.

NACA worked for and with a small group of organizations and was largely unknown outside of the aeronautical research community. Its leadership had established good relationships with a number of Congressmen, and its requests for funds were generally approved with few comments. It had from the beginning maintained strong ties to the military services who were the major users of its services.

GENERAL MANAGEMENT

NACA developed a rather unique committee structure to fulfill its Congressional mandate. The Advisory Committee was the main committee responsible for exercising all the functions authorized by NACA's legislation, but it was the Executive Committee, composed of seven of the original twelve Advisory Committee members which actually performed the executive functions of the organization. Lewis and Victory with the assistance of Ames were responsible for the day-to-day general management of the organization. Reid, the Director of Langley, reported directly to Lewis and was responsible for the direction and coordination of the research activities at Langley.

The Advisory / Executive Committees

The Advisory Committee was composed of twelve unsalaried representatives of the aeronautical research community. Seven of the members were government representatives and five were representatives from the private aeronautical research community.[4] Since the Advisory Committee met only twice a year, the Executive Committee which met monthly handled most of the work required to maintain NACA.

The Advisory Committee and its Executive Committee established general policies for NACA, approved a broad research program based on recommendations from the technical committees, other government agencies engaged in aeronautical research, and Ames and Lewis. The Committees were also responsible for the performance of such administrative functions as approving NACA's budget requests and expenditures. Final decisions about NACA's Annual Report to Congress, its technical research reports and what aeronautical research information would be collected and disseminated to other organizations were made by these two committees.

The Leadership

Although the Advisory Committee had legal authority and responsibility for all of the activities of NACA, it was Ames, Lewis, and Victory who virtually controlled the operations of the organization, the specific research projects which the organization funded, and the formation of NACA's general policies. Victory had full responsibility for the administrative and personnel direction of the agency, as well as the disbursement of funds. He reported directly to the Executive Committee secretary, and his direction of the administrative affairs of NACA was accepted by both the technical staff and the Advisory Committee.

Lewis and Ames exercised their control over the research program and general direction of the organization through their control of the research authorization process and their knowledge of the day-to-day operations of both the Committee and the Laboratory.

Research Authorization Process

Requests for research came from three sources: (1) the staff at Langley; (2) other government agencies (primarily the military services); and (3) the private sector (primarily industry representatives). In theory all requests once received were sent to the technical committees and subcommittees. The technical committees were responsible for making specific recommendations to the Executive Committee on broad problems and developments in research in the field for which they were responsible. They met twice a year and based their recommendations on their knowledge of the problem and the advice received from the technical subcommittees under their jurisdiction. The subcommittees were generally responsible for a specialized problem. Although some remained in existence only for a short period of time, others were appointed to handle problems which took many years to solve. There were five subcommittees and seven committes in 1927.[5] The Executive Committee then selected those programs which NACA would support from the recommendations submitted by the technical committees.

The purpose of this general review was to provide the organization with a research program which reflected the decisions of the various aeronautical experts on the technical committees and subcommittees. The problem was that the system did not work exactly as NACA's leaders' envisioned it. Requests from the Laboratory staff went directly to Reid, and from Reid to Lewis.[6] No staff member was allowed to present any new material to the subcommittees if it had not been approved by Lewis. The requests from government agencies went directly to the Executive Committee, chaired by Ames and staffed by Lewis. They were approved automatically unless research was already in progress on the requests. Requests from the private sector did go directly to the technical subcommittees, but there were a number of factors which mitigated how much influence these subcommittees had even on the approval of these requests. First, NACA's leaders were very wary of approving requests submitted directly by industry--the major source of these requests. For this reason, many industry requests were funneled through the military services and then back to Lewis and Ames.[7] Second, even those which were approved were then sent to the Executive Committee where they again had to be approved by Ames. The ineffectiveness of the technical subcommittees is probably best attested to by the continual lobbying by industry to obtain representation on the Advisory Committee from which they would have an opportunity to join the Executive Committee.[8]

Lewis and Ames also had a great deal of control over the agenda of all the committees. Lewis was an *ex officio* member of all the committees, and many staff members attended the meetings in their respective field of interest. The staff's responsibility for the day-to-day administrative affairs of the committees also played a role in what would occur at any meeting. Perhaps the major factor in the role they played in setting the agenda was the fact that they were able to limit what the members of all the committees reviewed. If Lewis and Ames turned down a research request from a Laboratory staff member, the subcommittee never even reviewed it.[9] This situation was exacerbated by the fact that both Lewis and Ames approved some requests without even notifying the Advisory Committee.

In addition, Lewis instructed his staff to present all research authorization requests to the technical subcommittees in a non-technical manner which could be understood by any layman. The reasons for this instruction are evident in a memo from Lewis to the staff.

> Dr. Ames and I both realize the importance of interesting the Committee as a whole in the scientific research that the Committee is carrying on, but feel that the matter must be presented to the members in such form that it will demand their immediate interest, and not be read to them in the form of a report. This will be in line with the functions of the Committee, and I feel that will also be of an educational value, as most of the members of the Committee, with the possible exception of Admiral Taylor, do not fully appreciate the necessity of their hearty support of scientific research.[10]

Although the reason given for this instruction was the lack of technical competence of the members, it also meant that: (1) their approval of any research authorization was less than knowledgeable and probably done with a great deal of guidance from the staff and Lewis; (2) the staff was given a very broad mandate when their research proposals were approved; and (3) the committee members would have difficulty tracking what the staff was doing.

Day-to-Day Operations

While NACA's leaders argued in just about all its reports that the part-time, unpaid status of its committee members was the key to its success, as well as saved the organization money, it also had the dysfunctional aspect of almost ensuring that the full-time paid staff would develop into the major determiners of NACA's policies and programs.[11] The full-time staff was there when problems and questions arose. They defined these problems and questions for the various committees. They had first-hand knowledge of possible solutions and could implement them when the committees were not available. The situation was exacerbated in the case of government committee members. Their membership on the Advisory Committee was linked to their government positions. Consequently, they did not have the knowledge of NACA's activities which the full-time staff had nor the knowledge of a member from the private sector whose tenure was not based on position.[12] Ames, who was willing to commit his time to NACA's activities for many years, had the advantage over all those individuals unwilling to do so.

Management of the Agency

The control of the Advisory Committee over the activities of the organization was further undermined by the amount of discretion given the agency and its staff with regard to technical and administrative matters. If the committee tier of NACA is ignored, the headquarters / research laboratory section of NACA looked at least on paper very similar to a normal bureaucracy. Lewis and Victory directed and coordinated the technical and administrative activities of the organization in much the same manner as any contemporary administrator would. As suggested above, Reid, the Director of the Langley Research Laboratory, reported directly to Lewis and Victory. The laboratory itself was organized into research and administrative divisions which were directly under the control of Reid.

This formal structure though did not provide an accurate picture of the actual relationships which existed within NACA. This is best evidenced by examining the process by which the agency accomplished its research activities. The research authorizations approved by the Advisory Committee only provided general guidelines for the laboratory staff. The Director of the Laboratory, Reid, had some control over the priority given the project and allowed his staff to select the means of completing the project.[13] Changes in the research plan, if they were felt to be necessary, could generally be made at the laboratory. Lewis not only condoned interpreting the research authorizations very broadly, but at times allowed research under one research authorization that even Reid felt required a new authorization.[14] Perhaps the best example of the discretion both the laboratory and Lewis felt they had, involved one of the wind tunnels. On April 28, 1925, the laboratory started work on the wind tunnel. Formal committee approval was not given until June, 1925.[15]

The research staff also played a role in this process. Although some projects obviously had to be accomplished, the researchers were allowed to engage in the research which interested them. Whether a particular project was accomplished was heavily dependent upon some staff member taking an interest in it. Those projects without an interested researcher were given to new staff members who might or might not stay interested. One research authorization had a twenty-year history and numerous individuals working under it before the results obtained from the work were substantial enough to produce a report.

Changes or extensions in the Research Authorizations could be made by attaching an appendix to the original Research Authorization unless the changes exceeded a certain amount or their cost was more than the cost of the original Research Authorization.[16] These required a new Research Authorization. There was also no attempt to separate the costs of the extensions from the costs of the work performed under the original Research Authorization. No formal procedures were required if the research was felt to be going nowhere. As Abbot pointed out,

> Under the method of control of research used by the NACA which amounts to audit after the fact, it was relatively easy for the laboratory staffs to fail to progress on the problem in which they lacked interest, and to proceed vigorously on those they wanted to pursue. Staff had far more research freedom than in any other government agency, and management insisted on keeping it this way.[17]

The Research Authorizations were only required for major programs. Job orders were used for such work as the development and modification of instruments, equipment, and facilities.[18] This type of work was generally not reported or broken down into separate categories in the budget. The use of job orders, coupled with the fact that Lewis's approval was assumed unless Reid heard otherwise, meant that work could be started on a project without a long wait for approval. It also implied that the researchers could start some projects and in the case of short-term projects complete them before individuals outside of the laboratory were even aware of the project's existence.

The result of this discretion was that what any of the Committee members wanted and what they received or at least the time period in which they received it were two different things. Even if they had controlled the authorization process, their inability or unwillingness to control the actual research limited the amount of control they exercised. It does not imply that the committee had no control over the Laboratory, Lewis, or Ames. They had the legal power to control the organization in any manner they desired within certain parameters and certainly more than they did, but they appeared to be content to leave things as they were.

THE COORDINATION AND DIRECTION OF RESEARCH

The discussion above leaves the impression that NACA's leadership was exercising little, if any, control over the research activities of the organization. This conclusion though ignores the very effective mechanisms used by NACA's leaders to coordinate and direct the activities of the researchers toward the agency's objectives. In contrast to many of today's government organizations, the researchers' activities were controlled not through rules and regulations which specified exactly what they were to accomplish or continual tracking of their activities, but through the use of incentives and control devices which are more characteristic of an academic environment than a public organization.[19]

Internalization of NACA's Values

From the beginning of their employment at NACA the researchers were subject to an environment which was conducive to the internalization of NACA's values and methods of accomplishing its objectives. This process started prior to the actual employment of any researcher in that NACA's leaders were recruited directly from highly rated colleges rather than other private or public organizations. Letters of recommendation from the department heads of the applicable University and the quality of the applicant's thesis were the primary criteria used to select recruits. Although the applicants did have to go through the Civil Service process, NACA's leaders were known for their ability to circumvent Civil Service regulations, which were not particularly burdensome during this period in any case.

Once recruited, the new staff members were trained into the NACA way of doing things. This was primarily accomplished by placing the new engineers under older engineers who had already achieved some recognition for their work. Since the Langley Laboratory was fairly small, the new recruit was in an environment in which exposure to new ideas was a continual process. Becker describes one of the methods through which this socialization and training was accomplished.

> The entire professional staff and some of the shop people except for a few "brown-baggers" assembled here [the laboratory cafeteria] everyday for a simple but excellent plate lunch. ... There were no formal personnel development or training programs in those days, but I realize now that these daily lunchroom contacts provided not only an intimate view of a fascinating variety of live career models, but also an unsurpassed source of stimulation, advice, ideas and amusement. An interesting consequence of these daily exchanges and discussions was that often no one originator of an important new research undertaking could be identified.[20]

This socialization process was facilitated by the sense of community which developed within the Langley Laboratory. The fact that Hampton, Virginia, the location of the Laboratory, was at least a day's trip from Washington, D.C., the location of the headquarters unit, gave the researchers a feeling of isolation from other aeronautical research groups. The sense of community was strengthened by the early animosity of the surrounding residents and the Department of War; the relatively young age of the group; and the fact that their research activities generally required more than one division.[21] There appeared to be little internal strife or discontent, and many of the researchers became close friends.

The feeling of closeness among the researchers was sharpened by Lewis's policy of making all promotions from within the organization, as well as the stability of the leadership and staff. Many of the engineers stayed with the organization through their entire career.[22]

The early introduction into NACA's way of accomplishing its activities and the establishment of an environment in which the researchers were made to feel that they were part of a unique group set the stage for the internalization of NACA's method of accomplishing its research activities. The staff, as its reputation grew, developed a strong feeling that their research methods were the "best way" of accomplishing scientific research. This feeling was encouraged by the leadership's emphasis on in-house research and their active discouragement of letting contracts for research. Most of NACA's funds were spent on in-house research at the Langley Laboratory.

The Research Environment

This socialization was only part of the process by which NACA's leaders were able to persuade the staff to produce as they desired. They also established an environment in which innovation and creativity were fostered. The staff was provided with research facilities which were considered to be some of the "best in the world."[23] They were actively encouraged to request new facilities and make suggestions regarding improvements in existing facilities which might aid in the advancement of their research activities.

Although the researchers were supposed to obtain approval for all research projects, Reid and Lewis encouraged innovation and the suggestions about new research projects. The smallness of the laboratory meant that Reid was available for conferences about new projects or changes in existing projects at any time. Lewis made frequent trips to the laboratory to encourage the exchange of ideas.

There was also an active effort on the part of the NACA's leaders to provide the staff with contacts with outsiders. In 1926 they established the practice of holding Annual Industrial Conferences to which industry representatives and other individuals interested in aviation were invited to review the research activities of Langley's staff. This not only provided the staff with contacts with individuals who were also engaged in aeronautical research, but also provided them with a forum for presenting their research accomplishments.

The meetings of the technical committees were another mechanism which was used to provide the staff with valuable contacts with individuals outside of NACA. Although Lewis's directive that the staff's research results be presented in layman's terms probably meant that the meetings only served to reinforce the staff's loyalty to NACA's way of accomplishing its work, the contacts did have the potential for introducing the staff to new ideas.

NACA's leaders encouraged their staff to focus on high quality research by allowing them to publish their research results in technical reports published in NACA's Annual Report under their own names. Since the NACA technical reports had a reputation for high quality research, this privilege provided the researchers with a way of obtaining recognition in the aeronautical research community outside of the organization, as well as within NACA.

Control of Output

The socialization process and the provision of a research environment conducive to research were in some ways only auxiliary control mechanisms; the primary reason that NACA's researchers directed their activities toward the organization's objectives was that they accepted the authority of the individuals in positions above them to make decisions about their research and its relationship to the organization's objective of promoting aviation. This is not as easily explained as the other mechanisms primarily because it was an accepted part of the organization's operations and thus not as easily observed, but it was the major reason that NACA's leaders could allow the researchers so much discretion while at the same time exercise a great deal of control over the output of the organization. NACA's method of controlling its researchers involved the use of the members of its committees to legitimize NACA's leaders' decisions and the use of a promotion system based on expertise.

Committee members were drawn from the major aeronautical research interests in the United States. These interest groups were of two types: those who were interested in NACA's solution to problems which were preventing the advancement of aviation; and those who were experts in aeronautical research because of their own research accomplishments.[24] The first group was for the most part either from other government agencies or private industry. The latter was largely drawn from major Universities. Their decisions were accepted both by NACA's staff and Congress because between the two groups was an understanding of what the major aeronautical problems were, what solutions to these problems already existed, and which problems were being addressed by individuals engaged in aeronautical research. The committees provided NACA's leaders with a built-in mechanism for evaluating the performance of their researchers and relating their work to the needs of aviation during any period in time. The researchers accepted their leaders' decisions because they were legitimized by individuals who both knew the needs of the aeronautical research community and the existing state of the art.

The use of experts to legitimize the decisions of the leaders of NACA was duplicated within the organization itself. Promotion decisions were based on research accomplishments, not tenure or positions in the organization. This allowed the organization to establish superior / subordinate relationships which were based on expertise in the researchers' field rather than on position.

It was the technical report system which brought NACA's method of controlling its researchers in line with its objective of advancing aviation. A final report was expected for every Research Authorization which was approved, and all researchers were required to publish their research results as a NACA report before submitting it for publication to any other journal. Whether and how rapidly the researchers advanced was based on their research accomplishments, and this was evaluated by the response of the aeronautical research community to their published reports. The Annual Report containing these reports was the most visible evidence of the entire organization's performance, and the quality of the reports was perceived by both the staff and the aeronautical research community as a measure of the success (or failure) of the entire organization. The technical reports served a dual purpose. The researchers' positions in the organization were tied to their ability to publish results which individuals outside of the organization considered to be important to the advancement of aviation. They were also a mechanism through which NACA's leaders demonstrated to other individuals that they were indeed producing high quality research.

Rules and Regulations

NACA's method of controlling its researchers and directing their output toward the agency's goals provided NACA with a staff who had "an overall *esprit de corps*" and enabled its leaders to direct the laboratory with very few negative incentives. The staff internalized NACA's values and methods of accomplishing their work. They accepted the decisions of NACA's leaders as legitimate and saw it as in their best interest to produce as the leaders desired. This is not to say that there were no constraints on the staff's freedom. NACA, as any other organization, had formal and informal rules and regulations which had to be followed by the staff.

Beyond those already stated, such as the requirement that all research projects be approved by Lewis, the researchers also had to conform to what were accepted methods of operating. One of the most important of these was the requirement that all researchers be willing to work as team members. Lewis's idea of a well run laboratory did not include individuals working completely as independent units. This he made quite clear in a memo to Reid.

> A research organization is a body of scientists that are combined through system and regulation into a coordinated whole. Every successful research laboratory director is an organizationist, a believer in the smoothly operating machine of management. All of his research men work together for a common end.
>
> The value of direct cooperation, or concerted teamwork, among the members of a research laboratory cannot be overemphasized. There should be no tendency toward purely individualistic work; an appreciation of the importance of mass action in achieving results should be firmly established from the start...
>
> No research man is a complete unit of himself. He requires the contact, the stimulus, and the driving power that are generated by his association

> with other research men, in his own organization, as well as at meetings of professional societies.[25]

Individuals who were unwilling or unable to work in this team effort could either leave voluntarily or involuntarily. As with the relationship between the Committees and the full-time staff, Lewis had the authority to ensure that the desired teamwork occurred.

The researchers also faced two additional constraints on their autonomy. Their reports had to meet NACA's standards both in content and form. NACA was known for its "solid, dependable, careful report[s]..."[26] All reports went through extensive editing at the laboratory before they were sent to headquarters where they were subject to additional editing.[27]

Victory also placed strict requirements on the laboratory's administrative and procedural mechanisms. Even non-technical reports had to be up to some minimal standard with regard to format and form. Memos written to Victory, Lewis, or the Executive Committee had to follow certain specified guidelines and were returned to the laboratory if they did not meet these guidelines.[28]

THE PERFORMANCE OF NACA

NACA's unique committee structure, while interesting in view of today's single administrator bureaucratic structure, is only worth investigating if it worked, as its creators argued it did, to produce the output desired by the users of its research and Congress. Although there is a great deal of evidence that it did accomplish its mandated objective and certainly NACA was well respected throughout the aeronautical research community, its performance was not faultless nor all that its creators desired.[29]

According to NACA's legislative mandate, it was supposed to: (1) supervise and direct "...the scientific study of the problems of flight with a view to their practical solution, and (2) ...determine the problems which should be experimentally attacked, and (3) ...discuss their solution and their application to practical questions."[30] NACA's leaders argued that the determination and discussion of problems and their possible solution were accomplished through their committee structure and that scientific research was accomplished by their in-house staff, other government agencies, and under contract, but this claim is not completely substantiated by the evidence.[31]

Determination of Research Needs and Their Solution

The committee structure was supposed to provide a mechanism through which NACA's leaders could determine the nation's research needs and review the research which was being or should be accomplished to meet these needs. Thus, they argued, that

> Coordination of experimental and research work is provided for by the subcommittees of the NACA. The organization of NACA provides for subcommittees of power plants, for aircraft materials, and for aircraft aerodynamics. Each department of the government as well as the different branches of aircraft industry are represented in the membership of the various subcommittees. The proposed and active research and experimental development of each government department is reported to the subcommittee, thus preventing unnecessary duplication. The subcommittees further provide means of exchange of information and ideas which permits the industry and the various departments to familiarize themselves with the research that is in progress.[32]

Theoretically, then, NACA's committee / subcommittee system was supposed to allow for the determination and solution of all research needs, because it provided representation of those individuals who knew the needs and had possible solutions. Together the various subcommittees could develop a research program which would lead to the solution of those problems stopping the advancement of aviation. The problem was that the system did not work exactly as portrayed in the NACA Annual Reports or as its leaders argued that it did. Not all individuals interested or engaged in aeronautical research were represented on the committees, nor was the product of the process a research program.

NACA provided representation for individuals interested in the advancement of aviation, but not for those involved in radical departures from the existing state of the art. This was particularly true in the case of such individuals as Dr. Robert Goddard, who in 1926 had already launched his first rocket.[33] Even those individuals who were invited to join NACA's technical committees and subcommittees did not have equal access to membership on the Advisory Committee. Industry representatives were not allowed on this Committee until after World War II, and universities were not represented at any significant level during NACA's history.[34] Since the Advisory Committee members were the final decision makers of NACA, these groups, particularly industry interests, voiced numerous complaints about their inability to gain this membership. The impact of the above was that all research problems and ideas simply were not submitted to the Committee.

The second discrepancy with the Committee's portrayal of its work involved the term "research program." The technical committees and subcommittees reviewed the problems brought to their attention by the Langley Laboratory staff, other government agencies, and private industry. They focused on "those areas where lack of knowledge hindered aviation progress...," not on developing or testing specific theories.[35] The product of the process of review which the various committees went through was not a research program, but a list of problems which required solution. NACA was in the business of providing aid to the Departments of War and Navy, other government organizations, and private industry. It was not in the business of developing entirely new theories, testing these theories, and laying the groundwork for an entirely new airplane. Whether the projects the organization sponsored added up to any significant research program was not its concern.[36]

Scientific Research

NACA's leaders' claim that their staff was engaged in scientific research was also questionable. The researchers were engineers, not scientists, and their objective was to improve the speed, safety, and reliability of the existing airplane, not make radical changes in it. They did not have set research programs which defined various theories or concepts that they wanted to test. The testing they did was in response to problems which arose and came to their attention. The laboratory engaged in applied aeronautical research. It primarily focused on aerodynamics, but did engage in structural and propulsion research at times. Its research was accomplished through both model and full scale flight tests. Wind tunnels were developed and used to obtain test results from models. These results were then correlated with data from flight tests. For example, by obtaining data in wind tunnel tests, they showed that airplane speed could be increased substantially simply by retracting the landing gear after take-off. Before they produced these data, landing gears on airplanes were fixed, despite the fact that many people thought that retractable landing gears would substantially reduce drag.[37] In the process, they invented and standardized many of the instruments used in today's airplanes.[38] The researchers, as many of their critics pointed out, were essentially problem solvers using a hit or miss method of solving problems. As Becker argued, most of their work involved the collection of data, not any systematic analysis of these data.

> Underlying theme for all of our work in the first few years of the 8-foot high speed tunnel was 'to provide accurate component data for designers...' Our Chief of Aerodynamics... encouraged this conservative philosophy, telling the staff at one of the monthly department meetings, 'Our aim is to produce good sound research data--nothing spectacular, just good sound data...Dr. Lewis, fortunately, had a broader outlook, and a willingness to invest occasionally in speculative new ideas.[39]

NACA's creators had hoped that they could promote aviation by establishing an organization whose primary objective was scientific research. That they did not accomplish this objective is perhaps best evidenced by the words of Dr. Ames, one of the major supporters of scientific research within the Laboratory.

> What we would like to do would be to give free scope to [competent mathematical physicists familiar with aerodynamics], and to conduct the laboratory tests under their direction, so that theory and knowledge of acts could make progress together. But that is not possible in an establishment whose primary purpose is to give advice to other governmental services, especially advice concerning questions raised by these services. It is true that we can often inspire these questions, and we can always, in the process of obtaining answers, learn more than is required for the specific purpose. It follows, that while we are conducting practical tests we are also doing fundamental scientific work continuously, exactly as a justice of a high court expresses his deepest thoughts as *obiter dicta*.[40]

Its Accomplishments

This is not to say that NACA's researchers and committees were not in 1927 accomplishing what was their primary objective, the advancement of aviation. They just were not accomplishing it in exactly the manner they said they were. The committees may not have brought all aerodynamical research groups together, but they did bring those individuals together who were interested in making the new airplane economical, stable, and safe, and this in itself was a very significant accomplishment. The airplane in 1915 when NACA was created was an uneconomical, unstable mechanism whose potential was recognized during World War I by many observant individuals, but whose actual contribution to the war effort was minimal. The first government order for an airplane did not occur until 1907, and in 1914 the United States had only 23 planes. NACA's committee system brought government agencies and private industry representatives together for the first time and provided a forum in which the government could communicate what it wanted and industry could communicate what it could provide. NACA acted as a clearing house for research and as an intermediary between the military services and industry. It helped the military services obtain basic research by providing funds to private institutions without requiring detailed proposals or specifications, but only the production of a final report.[41]

NACA's researchers played a major role in the change of the airplane from what was essentially a stunt man's machine to an economically and technically feasible machine. They provided aid to the services when they were preparing specifications for experimental airplanes. When private manufacturers encountered design problems, they received assistance from NACA's researchers. The results from their research had a major impact on the design of the airplane. As Anderton pointed out,

> The availability of the NACA cowling, propellers of increased efficiency, more efficient airfoils, wing fillets, and knowledge of the mechanism of drag led directly to the change in design from the strutted biplane to the sleek monoplane. No longer could a designer argue that it wasn't worth the weight and complexity to retract the landing gear for those few miles per hour. The aerodynamicists could tell him that those miles per hour weren't few, and that retracting the gear could mean the difference between winning and losing a contract.[42]

By 1929 NACA had received the Collier Trophy, awarded annually for the greatest achievement in aviation in the United States, for the NACA cowling. It was the recognized leader in wind tunnel research and had standardized many of the instruments used on airplanes during the period.

NACA AND ITS RELATIONSHIPS WITH OTHER GROUPS

NACA's world was a relatively small one compared to that which faces most government agencies today. The aeronautical research community consisted of a small number of organizations, none of whom were very powerful or well established. Oversight agencies were few in number and largely ineffectual. Its relationships with both the individuals who used its services and those who evaluated its performance were on the whole very good.

NACA and Its Clientele

NACA worked with both public and private organizations. In 1927 the aeronautical organization of the government consisted of the Army Air Corps, the Navy Bureau of Aeronautics and Air Organization, the Department of Commerce, the Air Mail Service, the Weather Bureau, the Patents and Design Board, and the aeronautical laboratories of the Army and Navy air organizations. Research was also conducted by private industry and at some universities. It was a small group of organizations and NACA was able to have members of most of them on its committees. By 1927 the various organizations had developed a division of labor which was to last until World War II. The Bureau of Standards was responsible for structural research. NACA focused on aerodynamics, and private industry took care of propulsion research as well as the development and production of aircraft. The universities were responsible for the basic research for all the other organizations. The military services provided justification and funds for the research.

It was the military services, though, who were NACA's most important customer and major supporter. NACA had been established on the recommendation of the Acting Secretary of the Navy. Its legislation was a rider on the Naval Appropriations Act, and its first chairman was General Schriven of the Department of War. The Langley Laboratory was built on land purchased by the Department of War, and its first facilities were built by the military. The planes used for testing as well as the pilots who flew them were provided by one of the services. The Department of War's facilities were used for offices for the headquarters staff. NACA acted as a research unit of the military services, despite the fact that it was legally an independent organization. NACA's leaders deliberately cultivated the relationship with the military services to protect themselves from any take-over attempts by other organizations, but particularly attempts from either one of the services. As Hartman argued,

> Lewis and Victory aimed to be of such value to each service that neither would allow the other to take over NACA. Dr. Lewis, in councils with his staff, declared that NACA must be so alert that it would anticipate the needs of the military even before the military became aware of those needs.[43]

When it was in trouble, NACA's leaders made deliberate attempts to emphasize its strong ties to the military. It was the services which provided the justification for its existence.

NACA deliberately kept a low profile and few individuals outside of the above organizations knew of its existence. There was no group which competed with it for funds before Congress and none which was able to provide the specific services it did for the military services. It met needs (e.g., wind tunnel testing) which no other group was able or willing to meet in 1927.

Oversight Organization

The only other groups of any significance in NACA's environment were the Bureau of the Budget and Congress. Most Congressmen had little knowledge of or interest in the affairs or activities of NACA. This situation was cultivated by its leaders because it allowed them to influence a few members of Congress without having to worry about the entire body. Since NACA's budget never reached a level at which it was a major concern to Congress or the Executive Branch, it was for the most part left to its own devices. Lewis and Victory were personal friends of a number of key Congressmen who could ensure that NACA's requests were handled expeditiously without worrying about other members of Congress.[44] The staff worked with the Bureau of the Budget before presenting their budget requests to the Bureau, and this eliminated any potential conflict between the two organizations.

Perhaps more important, NACA's leaders simply did not have the restrictions on their activities which most government organizations have today. It was not required to go through an annual authorization process, and its budget requests and reporting of expenditures were written on one page. They were divided into funds for salaries and construction and unless NACA requested a large amount of funds for construction, no further information was given. Its leaders allocated the total funds it received among the various projects as they desired and hired and promoted individuals as they deemed necessary. The oversight agencies which did exist were small and ineffectual, and

NACA's only potential source of problems with its performance was Congress. Since its budget was small and considered with the military services' requests, there was generally no problem in obtaining its requests.

THE DEVELOPMENT OF NACA
THE YEARS BEFORE 1927

NACA in the years between 1915 and 1927 had formalized its relationships with groups outside of the organization as well as within the organization. General policies and research programs were established either at the Committee or headquarters level, but three individuals--Ames, Lewis, and Victory--actually ruled the organization. The Laboratory had a great deal of influence over the selection of the research projects necessary to carry out these policies and research programs and was responsible in many cases for the priority given the projects, but final approval of the output of the research laboratory was the responsibility of the headquarters office and the Advisory Committee.

The leaders of NACA primarily used tacit incentives to influence the behavior of the research staff. Their researchers were given a great deal of discretion, but NACA's leaders exercised control of the output by providing an environment in which the researchers internalized the values of the organization and innovation and creativity were fostered. The researchers accepted what controls did exist and the decisions of their superiors both because of this environment and their belief that those individuals making decisions about their projects had the expertise to act in their best interest. This is not to say there weren't some constraints on their behavior. If the researchers were unwilling to act as team members or did not produce the desired output, they were forced to leave the organization.

By 1927 NACA's place in the aeronautical research community was established and its work was accepted as important to the development of the airplane. The committee tier was used as a communication mechanism for individuals interested in the advancement of aviation and provided a group of individuals whose expertise could be used to convince both Congress and the agency's researchers that NACA's decisions about the relationship between their work and the development of the airplane were correct. The Laboratory's work was of a technical nature. The staff carried out the directives of the Advisory Committee, acted as a technical link between the military services and private industry, and produced the applied research necessary to make the airplane more efficient, safe, and economical.

What the above does not show is why NACA developed as it did. The original Advisory Committee could have let contracts for all their research needs. The Laboratory could have engaged primarily in scientific propulsion research. The researchers could have been given very little discretion. The Committees could have played an active role in the day-to-day operations of the Laboratory. Obviously no definitive answers to these questions can be provided, but some understanding can be gained by examining NACA's development prior to 1927.

THE CREATION OF NACA

The creation of the National Advisory Committee for Aeronautics was preceded by four years of extensive lobbying by scientists, the military services and businessmen for the establishment of a government aeronautical laboratory.[45] The lobbying started in 1911 with the announcement by the Aeronautical Society of a plan for the establishment of a research laboratory administered by the Smithsonian Institution and located within the National Bureau of Standards. The failure of this plan was followed in 1912 by a similar proposal by Captain W. Irving Chambers, the Secretary of the Navy's special Advisor on Aviation Matters, who had been the author of the first proposal, and Alfred H. Zalm, an Aerodynamics Professor at Catholic University. Their activities resulted in the establishment of the Woodward Commission in 1912. It was to make recommendations concerning the establishment of the laboratory to President Taft. Although the committee recommended establishment of a research laboratory, President Taft's failure to obtain the "advice and consent of Congress" before making appointments to it, as well as disagreements over the Commission's recommendations, resulted in its disbandment and burial of its recommendations in Congress.[46]

Leadership of the fight for an aeronautical laboratory passed into the hands of Charles D. Walcott, a geologist and Secretary of the Smithsonian.[47] Walcott, who had been actively involved in the establishment of other scientific bureaus in the federal government, was recognized not only for his research efforts but also his ability to communicate the advantages of scientific research to laymen and in particular Congressmen. Although he failed in his first attempt to open a laboratory, his second attempt was more successful. In late 1914, Walcott, with the approval of the Smithsonian Regents, established a committee to prepare a memorandum to submit to Congress for the approval of an Advisory Committee of Aeronautics. This proposal was endorsed by Acting Secretary of the Navy, Franklin D. Roosevelt, in a letter to the Chairman of the House Committee on Naval Affairs. His only objection was that the proposal did not emphasize the interests of the government adequately. This objection was overcome by changing the membership of the committee from seven private members to five. Since the original proposal had recommended that seven government members also be on the Advisory Committee, this change left the proposed Committee with a majority of government members.[48] Attached as a rider to the Naval Appropriations Act of 1915, the one-page NACA mandate passed virtually unnoticed with the passage of the Naval Appropriations Act.[49]

What is interesting for our purposes are the conflicts which occurred during the four-year period preceding NACA's establishment. That the parties agreed on the need for the establishment of an aeronautical laboratory was evidenced by the fact that all the proposals, except for the one which actually established NACA, focused on the establishment of this laboratory, not an Advisory Committee. The 1912 proposal by Chambers and all succeeding proposals specifically stated that this laboratory should engage in research in aerodynamics.[50] The only other significant area of agreement was that the laboratory's objective should be the promotion of aviation in the United States. The participants in the fight for an aeronautical research laboratory agreed on little else.

Control of the Laboratory

From the start, the participants argued, sometimes bitterly, over the placement of the laboratory in the federal bureaucratic structure. Although its strongest proponents (i.e., Walcott, Chambers, and Zalm) felt it should be placed under the auspices of the Smithsonian, a number of individuals wanted it placed under the Bureau of Standards or the Departments of War or Navy. David W. Taylor, Director of the Navy's Bureau of Construction and Repair's Model Basin; Richard Maclaurin, President of the Massachusetts Institute of Technology and an engineer; and Samuel W. Stratton, Director of the National Bureau of Standards, who was also an engineer, as well as others, opposed this proposal, but could not agree among themselves on an alternative placement. In the end the only acceptable compromise was to make NACA an independent organization--a solution which none of the participants found particularly satisfactory.[51]

Scientific vs Applied Research

On the surface this fight appeared to be simply an example of bureaucratic "squabbling," but basic philosophical differences separated the combatants, and these differences played an enormous role in the inability of the participants to compromise. The Smithsonian advocates believed that the laboratory should engage in the "systematic, thorough, and precise investigation of new ideas, or of old ideas with new applications, with the specific intention of discovering laws and formulas for advancing the progress of aerial navigation."[52] Since the Smithsonian was a scientific organization, it could provide the proper environment for this scientific research. In contrast to this, those individuals who opposed this placement felt that "the problems of aeronautics are engineering problems, and a national aeronautical laboratory should be developed under the stimulus of engineers."[53] The engineering proponents argued that placing the new laboratory under the Smithsonian, a scientific organization, would not provide the necessary environment and would result in duplication of engineering research efforts already in progress in the military services' laboratories and at the Bureau of Standards.

The Proper Environment

This disagreement extended to the structure of the proposed organization. The Smithsonian group wanted to establish an organization similar to those which had existed in various foreign nations since 1903.[54] These countries had established advisory committees composed of distinguished scientists and engineers from both the private and public sectors. The committees were responsible for the supervision of the research laboratories under their direction, protected the laboratories from the politics and commercialism so often associated with aviation, provided technical advice to the laboratories, and ensured the laboratories' scientific credibility. The Smithsonian group argued that the success of this arrangement was evident in the scientific advances made by the laboratories and the growing superiority in aviation development of the nations in which the laboratories existed, over the Americans' development.[55] More important, they argued, was the fact that this structure would provide the proper environment for scientific research. The Smithsonian group made an argument which scientists had made for many years and continue to make today.

> Science 'must be controlled by the fact discovered from year to year, and from month to month, and from day to day.' Operations must be led by the men who are actually performing the work, involving constant consultation and changes of plan. The director largely selects men 'who have a genius for research' and lets the plans come up from them. 'It will thus be seen that it is impossible to directly restrict or control these scientific operations by law. The general purpose of the work may be formulated in the statutes, and the operations may be limited by the appropriations.' A statute could go no further because 'if the operations themselves could be formulated by law, the facts would already be known and the investigations would be unnecessary.' Hence the bureau 'should be left free to prosecute research in all its details without dictation from superior authority in respect to the methods to be used.'[56]

The opponents of the Smithsonian proposals argued that the type of research (i.e., engineering) necessary for the advancement of aviation did not require these arrangements. They envisioned individuals working in a team effort toward specified research objectives (e.g., increasing the safety and speed of aircraft) and under the direction of a bureau chief. Although these researchers had to have the flexibility necessary to change research approaches when one method failed, they did not have to have the freedom the scientists were advocating. The engineering proponents argued that the proposed laboratory could be placed under the direction of an administrator, who was appointed by the President, and not necessarily a scientist or engineer. They felt that one of the problems with scientific bureaus was that they lacked adequate administrative supervision. "As a result the bureaus [were] neither 'managed on sound business principles' nor [had] 'the proper scientific criticism and control.'"[57]

The final legislation did little to resolve these basic differences. Although the language of the rider, as well as the basic structure of the Advisory Committee, was taken almost verbatim from the legislation which created the British Advisory Committee for Aeronautics, the vagueness of the document provided little indication of the intentions of Congress with respect to the structure of the laboratory.[58] What the legislation did produce was a small advisory committee whose existence threatened none of the parties and was thus an acceptable compromise for all the participants.

Congressional Intent

Finally, while not spelled out in NACA's legislation, Congress traditionally had not supported scientific research either by government agencies or private parties.[59] During the period in which NACA was created, though, it had supported the establishment of organizations such as NACA when private industry was not willing or able to engage in the applied research necessary to make advancements in the particular area of interest. The assumption underlying this support was that there was a relationship between the technical advancement of commercial aircraft and military aviation. The commercial aviation interests would thus be responsible for developing and testing an aeronautical innovation and if successful the military would adopt the innovation with the minor design changes necessitated by its new military application.[60] Congress had generally opposed any government activity which could be accomplished in the private sector, but the laboratory's proponents argued that an organization such as NACA was necessary since the aviation industry was unable to support the construction of wind tunnels and other expensive equipment necessary to the development of aviation.

THE EARLY YEARS

All participants in the fight for NACA agreed that there was a need for an aerodynamical research laboratory and that the purpose of NACA should be the promotion of aviation. What they disagreed about was the nature (i.e., engineering or scientific) of how to reach this objective and the type of structure under which the researchers should work. Congress provided little aid to the new organization with regard to its structure or work activities. The establishment of a research laboratory (least of all any administrative arrangements) was only indirectly mentioned in NACA's legislation. Its mandate directed the Committee to "supervise and direct the scientific study of the problems of flight," but the solutions and questions were to be of a practical nature.[61] What the above does not show is the link between the organization of 1927 and the organization which was created in 1915. NACA was only an idea in the minds of its creators in 1915. By 1927 it was a living organization which had worked out the details of its ambiguous mandate.

The Development of the Langley Laboratory

The Advisory Committee requested funds from Congress for an aeronautical research laboratory within six months of its creation, but this request cannot be interpreted as a direct implementation of its creators' ideas. NACA's leaders took this step only after they had been notified by George P. Shriven, the Army's representative on the Advisory Committee, of an attempt by the Department of the Navy to establish an aeronautical research laboratory.[62] After receiving

Congressional approval, a committee was appointed to oversee the construction and hiring of staff at the laboratory. John Victory was hired to handle the administrative work of the committee in 1916. John H. DeKlyn, an engineer from Curtiss Aeroplane and Motor Corporation and NACA's first technical employee, was hired to oversee the construction of the new Langley Laboratory. He was appointed Engineer-in-Charge in 1917. By 1918 NACA had a full-time staff of 40.[63]

The problem, as Leigh M. Griffith, one of the Laboratory's engineers pointed out, was that NACA's leaders hadn't told the staff what they were supposed to do nor had they established anything resembling a research policy.[64] Until these decisions were made, the Laboratory could not organize itself in any efficient manner. Griffith not only complained about the lack of direction, absence of a formal chain of command, poor morale, and the high turnover of employees, he also proposed that there be a central director and the division of the Laboratory into work areas (e.g., wind tunnels, aerodynamics, etc.). In short, he suggested the establishment of a formal structure more in tune with present-day administrative organizations and the end of the Committee's practice of just placing researchers at Langley and expecting that somehow some research results would be produced.

Griffith's complaints had little impact on the Executive Committee in the beginning, but a number of additional factors precipitated some changes. At the Laboratory, conflicts between DeKlyn and Victory over the management of the administrative details of the Laboratory, coupled with conflicts between the Laboratory's staff and the Army, as well as with local residents, reached a critical level which no one was willing to continue to accept, least of all Victory, who fired DeKlyn. Victory found the lack of administrative and procedural mechanisms disastrous at the Laboratory. He argued that the research laboratory had been set up to do research, and while the research could be carried out in any manner the staff desired, correspondence should follow certain procedures with respect to format and neatness. Victory complained about the lack of an adequate filing system and argued that the laboratory staff might require autonomy to perform their research, but such administrative matters as budgeting, personnel records, and correspondence did not.

More importantly for the organization's future, the Executive Committee hired George W. Lewis, a mechanical engineer from Cornell University and a member of the NACA subcommittee on Power Plants. Lewis was charged with "general responsibility for execution of programs and policies approved by the executive committee...and the immediate charge of scientific and technical work of the committee."[65] Victory was to continue as the assistant secretary and was placed in charge of the agency's administrative and personnel activities. Responsibility for the agency was divided between the two individuals. These changes were accompanied by the appointment of Joseph S. Ames to the chairmanship of the Executive Committee.

Resolution of the Laboratory's problems still did not occur. Lewis's decision to remain in the Washington, D.C. office resulted in control of the Laboratory passing to three individuals--Griffith, who had made the original complaints; Edward P. Warner, an aeronautical engineer from MIT and the Laboratory's chief physicist; and a clerk who reported directly to Victory. An organizational structure was nonexistent, the relationship with the headquarters office had not been formalized, and as Griffith pointed out, there was "some inevitable conflict between the interests of the three heads."[66] Griffith was appointed Engineer-in-Charge on November 1, 1922, but some clerical and financial functions were still left under the control of the Laboratory's head clerk who reported directly to headquarters. Griffith's appointment, it might be noted, occurred primarily by default. Warner, who also came into conflict with Victory, resigned in 1920 and the Chief Clerk resigned in 1922.

Griffith remained as the Engineer-in-Charge until 1925. Although he established a working relationship with Lewis, continual conflicts with Victory resulted in his resignation. Before he left he did bring some order into the situation at the Laboratory. The Laboratory was organized into the work sections (Flight Test Division, Wind Tunnels, Power Plants, and Property and Clerical Divisions) it was to keep for the next twenty years. He also was able to establish good relations with both the Army and the Hampton residents. Griffith's own comments about the situation at Langley in 1925 are probably the best indication that it was still having major problems. In his final report, he noted that turnover was high, both the flight test and wind tunnel division chief posts were unfilled, and that positions were being filled by headquarters without his knowledge or consent.[67] Ames was equally critical. He was not satisfied with the research accomplishments of the Laboratory and the departure of a number of what Ames felt were promising young scientists only added to his dissatisfaction with the management of the Laboratory.[68]

Resolution of the Problem

Although it was evident that the Laboratory by 1925 was finally beginning to rationalize some of its formal structures, there was also a great deal of evidence that a relationship hadn't been worked out with headquarters that was acceptable to both the Laboratory and headquarters. This is best indicated by Griffith's inability to get along with Victory and requests from him and others for clarification of their relationship with Victory.[69]

The Laboratory's problem was solved by the promotion of Henry J. E. Reid, a 30-year old aeronautical engineer and head of the Instrument Section, to the position of Engineer-in-Charge of Langley. In 1926, after sharing responsibility for the Laboratory with a fellow staff member for a short period of time, Reid took over complete responsibility for it. His tenure lasted as long as NACA existed and was due not only to his ability to establish an acceptable relationship with Victory, but also his ability to keep his staff working without undue interference from headquarters. The first he accomplished by accepting the administrative constraints placed on him by Victory, and the second by accepting Lewis's control over the research policies of the Langley Laboratory. In return for this, he was given a great deal of autonomy with respect to the implementation of these research policies.

SCIENTISTS AND ENGINEERS

The search for a solution to the second problem--whether it should be an organization of scientists or engineers--occurred in the same fashion as the rationalization of the formal structure. NACA's development into an engineering organization whose research was directed more by aeronautical problems than a desire to explore new horizons occurred primarily because of (1) its inability in the first few years to attract and retain scientists with the requisite skills to develop a scientific program; (2) its leaders' perception that its survival was linked to satisfying the demands of the military services and other government agencies; and (3) the fact that promotion of aviation--NACA's objective--required making the existing airplane into an economical and safe machine, not major theoretical advancements.

Recruitment Problems

The Advisory Committee in its early years was composed of many of the individuals who had lobbied for NACA's creation as a scientific organization.[70] These individuals took two specific steps directed toward achieving this objective. They attempted to hire a scientific director for the laboratory and to place individuals who they felt could develop a research program and perform scientific research at the laboratory.[71] Lewis's recruitment was in a way representative of the failure of these attempts. After a number of attempts to hire a scientist to take this position, the Committee settled on an engineer. NACA had neither the facilities nor reputation during this period to attract scientists. Although Lewis's appointment was only meant to be temporary and only as an engineer, not a scientific director, his success in administering the Laboratory and NACA's other affairs made him an ideal candidate for Director, which he became in 1924.

Lewis's appointment as the Director of the agency changed not only the type of research in which the organization would engage, but also its structure. The philosophies of the two groups of protagonists for the creation of NACA were held by Ames and Lewis. Ames, the Executive Committee chairman and a scientist, believed that scientific research required giving the researcher the maximum amount of freedom in the "selection and formulation of the investigations he was to conduct," as well as in the pursuit of this research.[72] Lewis, an engineer and Director of Research, while believing that his staff should generate ideas, also believed that those ideas could be pursued only with his and the Committee's approval. While Ames might believe that NACA could produce research results by simply hiring scientists and placing them in a well equipped laboratory, Lewis's idea of a well run laboratory was slightly different. As discussed above, he believed it should be composed of individuals working together as a team toward a specified end. There was no room for individualistic research.

Ames, as Executive Committee chairman, may have been able to implement his ideas of what type of research the staff should engage in and the amount of control which should be exercised over it, if he had succeeded in his attempt to hire scientists for the Laboratory, but this attempt failed also. The conflict betewen these two views of the nature of the Laboratory's work and structure came to a head in the form of Max Munk, whom Ames and another committee member had hired to provide a research program for the Laboratory. Munk in their view was to provide the theoretical framework from which the engineers could perform their work. No longer would the staff just enumerate questions and test results. Hired in 1921, he spent six years with the Laboratory and provided much of the theoretical work which established the reputation of NACA, but he was not a team player, and team player was what Lewis and Reid wanted. Disagreements between Munk and other Langley staff came to the attention of one of the technical subcommittees in 1926. From Lewis's perspective, the conflict challenged his authority over the Laboratory, and he directed the Laboratory to submit all research requests to him prior to submission to any outsider or committee member. He also informed the Laboratory that all future presentations to the committees or any outsider would be broad in nature and not contain any work which had not been authorized by himself.[73]

Munk's contention that he was only responsible to the Advisory Committee, not to Reid or Lewis, resulted in the centralization of authority for all staff members. Although Lewis generally demanded only that he be given a broad outline of the research proposal and was willing to accept a broad interpretation of what fell under each research authorization, the order itself changed the nature of the control structure at Langley. The independence which many scientists demanded was no longer available at Langley. Those individuals not willing to work as part of a team and accept Lewis's directives were not welcome at the Laboratory.

It also ended all basic research at Langley. Although other scientists were hired, they made few notable contributions. The impact of this was enormous. It precluded major scientific research if for no other reason than the fact that the staff didn't have the skills to engage in it. Since the committee members themselves were unwilling or unable to establish a research program or question thoroughly what the staff was doing, there was no incentive for the staff to develop the skills to accomplish scientific research unless some outside event showed that they were not performing satisfactorily. Any scientist hired by the Executive Committee would be at a distinct disadvantage for the simple reason that any lack of concern for practical results would bring him into conflict with those whose primary objective was to achieve practical results.

NACA and the Military Services

The dominance of engineers and the difficulty of recruiting scientists would not have played the strong role which it did, if NACA's leaders had not decided that they must meet the needs of the military services. This decision stemmed partially from the lessons many of the members learnt while NACA was being created, but it became solidified during NACA's early years after a number of attempts by its critics to transfer it to other government agencies.[74] NACA's leaders strongly believed that the survival of their small independent organization depended on their meeting the needs of all the organizations who wanted to assimilate them. This belief was based on the assumption that none of the participants would be willing to compromise enough to allow NACA's take-over by any individual participant. As when it was created, the only compromise would be NACA's continued independence. Since the military services were the strongest and the most interested in taking over NACA, their needs were met first.

This decision had two impacts on NACA. First, it was forced, when the military services required it, to work on individual planes, rather than on airplanes in general. Attempts were made to avoid this by trying to apply a solution to a specific design problem to a wider class of airplanes, but these attempts were not always successful. As long as NACA had adequate resources to meet these needs, as well as the demands of its own researchers, this was not a problem, but NACA throughout its history continued to have problems meeting both needs, and they always placed the military needs first.

The second impact of the decision to support the military services was that it virtually limited NACA's staff to applied research. Neither the military services nor the industrial firms who produced the airplanes the services ordered were interested in major scientific breakthroughs. Scientific breakthroughs meant major changes in the design of the airplane, and that was a cost neither the military nor the infant aircraft industry was willing or able to bear. Hunsaker adverts to this problem in his discussion of the problems surrounding dependence on industry for basic research.

> A competitive engine firm must concentrate on what its customers want. The firm improves its engine with small changes based on experience. It seeks the minimum risk of interruption of production. The military services, its principal customers, conduct competitive trials based on standard performance specifications. After quantity orders are placed, no major changes are possible. The services, of course, welcome small changes based on experience, if the risk of trouble be slight. As a result, engine development tends to adhere to a definite pattern and progresses slowly.[75]

What the services did want was incremental improvements which would lead to an airplane which was more airworthy and economical--engineering refinements, not scientific advancements.[76]

NACA's leaders could not have afforded to ignore these needs even if they had wanted to. The organization was judged by the research results it produced, and these results were evaluated with respect to their value to the development of aviation. Thus, the Langley staff had an incentive to improve, not radicalize, the design of the airplane.

THE DEVELOPMENT OF THE ADVISORY COMMITTEE

The years preceding 1927 were also years of disarray for the Advisory Committee. The development of its rather unique committee structure, its use of these committees to coordinate the research activities of the nation, the relationship it established with the Laboratory, and its acceptance of its inability to engage in scientific research occurred both because of its successes and failures during this period.

The Committee Structure

The Advisory Committee in its initial formulation of NACA's rules and regulations had decided that membership on any NACA committee would be limited to individuals appointed to the Advisory Committee.[77] Walcott, who had been absent when the rules were written, wrote directly to the President suggesting a revision in this rule. Following the British example, as he had from the beginning, he suggested that non-Advisory Committee members be allowed to serve on the NACA subcommittees. The President concurred, and NACA established a policy of inviting all aviation interests to serve on their subcommittees.

The problem was that it created a new committee each time a problem arose. By the end of the war, this practice had led to the creation of thirty-two committees whose product was being criticized by outsiders as more administrative than technical and of very low quality.[78] The result was a total reorganization into the committee / subcommittee structure of the 1927 organization. Rather interestingly, Griffith's influence was again felt. In a memo to the

Executive Committee, he suggested the elimination of the numerous committees and the establishment of a small number of committees with salaried staff and limited membership.[79] Whether his memo had any impact on the Executive Committee is difficult to assess, but his description of how the committee structure should be organized was the final structure which was adopted.

Coordination of Research

The Department of the Navy immediately took advantage of NACA's committee system. The same law which had stopped NACA's creators from forming a committee without the consent of Congress, as well as the numerous procurement regulations which made communication difficult between engine manufacturers and the Navy, had resulted in a growing conflict between the two which was preventing the development of new engines. NACA established a Motive Power Committee which provided a forum in which the services could communicate what they wanted and industry could communicate what they could provide. NACA's first attempt at coordinating research was so successful that it continued to fill this role for many years.

Aviation Policy

It was its failure in aviation policy making which had a major impact on the role it would fill in the aeronautical research community and undoubtedly on its acceptance of itself as an engineering organization. NACA prior to 1926 had played a strong role in decisions about aviation policy in the United States. In 1926 it withdrew completely from any active role in aviation policy making and became what many of its creators had wanted it to be, primarily an aeronautical research organization. Three of its experiences are particularly indicative of the reasons for its withdrawal.

NACA's first experience with the problems surrounding aviation policy making occurred when Ames in 1918 commented privately to a friend that his attempts to convince the Aircraft Production Board (the military services' major mechanism for procurement) of the sorry state of the United States' aircraft production had failed. This communication was reported to the news media and resulted in enormous criticism of Ames not only by the Board but also by his fellow Advisory Committee members. The affair ended with the passage of a resolution stating that Advisory Committee members should not "express comment for publication without having copy of such matter as it is intended to publish submitted and approved before publication."[80]

This episode was followed by the patent controversy. After NACA's success with the engine problem, the Navy asked it to intervene in the patent disputes which were obstructing the production of airplanes. Two aircraft producers were claiming that all airplane manufacturers had to pay them a royalty for each airplane produced if they used their inventions. Since all were, these demands essentially halted the production of airplanes because of the low profit margin which resulted. NACA's intervention was successful. A Manufacturers Aircraft Association to which each member paid two hundred dollars for each airplane produced was set up, and the Association decided whether and how much royalties would be paid. The end result was that the United States aircraft industry operated virtually without patents. NACA's problems occurred because not all aviation interests were satisfied with the solution. The Aeronautical Society of America argued that NACA had acted outside of its Congressional mandated power, and numerous small inventors and manufacturers suggested that NACA had simply created an aviation trust.[81]

Although these reactions disturbed NACA's leaders, it was its involvement in the passage of the Air Commerce Act of 1926 which ended its participation in aviation politics. In 1918 the Aircraft Manufacturers Association asked NACA to examine the problem of regulating civil aviation. As with NACA's creation, most aviation interests agreed that passage of this legislation was necessary. The dispute occurred over who should be responsible for the regulation. NACA's leaders initially recommended the Department of Commerce and this was where the responsibility finally ended, but not until NACA had faced accusations of trying to take over the responsibility itself.[82] The problem, as far as NACA was concerned, was that those opposing NACA's recommendations also proposed NACA's transfer to the Department of Commerce. From 1922 to 1926, with the exception of the final bill, all Air commerce drafts contained a provision for this transfer. This situation was exacerbated by the recommendations of the Joint Committee on Reorganization of the Administrative Branch of the Government. Although this committee had no connection with the disputes occuring over the civil regulation of aircraft, it also recommended the transfer of NACA to the Department of Commerce.[83] By 1924, NACA's leaders began to withdraw from the drive to establish an agency in the Department of Commerce, and in 1926 they ended their unofficial role of coordinating civil aviation policy.[84]

NACA's Leaders' Acceptance of Engineering and Lewis's Controls

NACA's leaders' acceptance of its development into an engineering organization and the controls demanded by Lewis is more understandable in light of these difficulties. Its continued existence as an independent organization was in question from 1922 through 1926. To ignore the demands of the military services for practical research results was simply not possible without endangering its own independent existence. Scientific research was important, but applied engineering research was equally important to the advancement of aviation. Since their experiences with Munk provided ample evidence of the difficulty of conducting both scientific and applied research in the same organization, they were forced to compromise by giving up scientific research.

The same type of reasoning may be used to explain their acceptance of Lewis's controls. The belief that the researchers could be hired and placed in a laboratory with little or no supervision did not work in practice for various reasons. The wind tunnel testing required large and expensive pieces of equipment whose very existence implied the need for a group of individuals with different skills (both administrative and technical). Someone had to be responsible for determining how and when the researchers would use the equipment. Some minimum level of controls was thus necessitated by the nature of the organization's research activities.

This requirement may not have been as important in the development of control, though, as NACA's leaders' unwillingness to place the organization in the position of being criticized more than it already was. Munk's disagreements with other staff members came to the attention of one of the technical subcommittees at the same time the organization was experiencing difficulties with the Air Commerce Bill. The members of these subcommittees, while theoretically members of NACA, were not part of the organization in the same manner as either the Advisory Committee members or the paid staff. If one of them informed Congress or the news media that NACA was having difficulties within the Laboratory, its situation with regard to its independent existence would have been even worse. Lewis's desire to adopt more controls can be partially explained by the nature of the Laboratory's research activities, but it was also a response to problems in NACA's environment.

This is not to say that Ames and the other scientists who fought for the creation of a scientific Laboratory did not have an enormous impact on the structure of the agency. The Laboratory was initially established with total research autonomy. No controls were placed on the original researchers who were supposed to plan and carry out their own research efforts. Lewis made changes from this original total autonomy but these changes were few in number. Such practices as publishing under one's own name, promotions based on quality of work rather than tenure or position, and the 1927 recruitment methods were all established before Lewis began to restrict the autonomy of the Laboratory. Lewis placed restrictions on the researchers' freedom; he did not change the underlying character of the structure. NACA maintained most of the methods of controlling its researchers that its scientific creators believed in. The Laboratory was under the direction of an engineer, not an administrator. Its staff had the discretion to follow interesting leads and work on those projects which they felt would advance aviation. The committees, composed as they were of scientists and engineers, had the final authority over the Laboratory and ensured that the researchers' work would be protected from interference of individuals without a technical background.

CONCLUSIONS

NACA in 1927 was an amalgamation of its creators' ideas of what its structure and research activities should be and what individuals in its environment allowed it to be. It was the staff who acted as the major stimulators of change. They were the ones who first brought problems to the attention of NACA's leaders and it was their proposals for new structural arrangements which were finally adopted, but it was not until external groups took notice of the problems that the changes were made. The creators' idea of what the organization's objective should be (promotion of aviation) and how this objective should be achieved (through an aeronautical research laboratory) were the guidelines by which decisions were made. If either was brought into question, changes or compromises were made. Thus was NACA molded by its environment.

NOTES

[1] Naval Appropriations Act, 1916 (3 March 1915), Public Law 271, 63d Cong., 3d sess., passed 3 March 1915 (38 Stat. 930). The rider tactic was used to assure passage in light of a possible veto by President Wilson of whose support its creators were unsure and the fact that it was late in the session. It was a common tactic during this period because congressional support of science was not adequate to assure passage of any legislation promoting science. For a discussion of these tactics, see A. Hunter Dupree, Science in the Federal Government (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1957).

[2] The NACA published its rules and regulations and all amendments in its Annual Reports. They can also be reviewed in Appendix A of Alex Roland, Research by Committee: A History of the National Advisory Committee for Aeronautics: 1915-1958, Comment Edition, April, 1980.

[3] A more detailed description of these developments is provided below. I might note that I am using 'structure' rather broadly here to refer to the relationships established by organizations to accomplish their work. It includes the formal written organizational chart, the methods of controlling output, such as the incentives offered, rules and regulations, etc. Appendix A contains a complete breakdown of NACA's and NASA's personnel and appropriations.

[4] The formal structure of the NACA is discussed in its Annual Reports, as well as many of the NACA histories. See Jerome C. Hunsaker, "Forty Years of Aeronautical Research," in Annual Report of the Board of Regents of the Smithsonian Institution, 1955 (Washington: GPO, 1956), pp. 241-270; Arthur L. Levine, "United States Aeronautical Policy, 1915-1958: A Study of the Major Policy Decisions of the National Advisory Commitee for Aeronautics," Ph.D. dissertation, Columbia University, 1963; Roland, op. cit.

[5] The seven committees were Aerodynamics, Power Plans for Aircraft, Aircraft Construction, Personnel, Buildings and Equipment, Publications and Intelligence, Aeronautical Investions, and Designs, and Government Regulations.

[6] As will be discussed below, Lewis instituted this process in response to major differences between two staff members which came to the attention of a technical subcommittee. Lewis to Langley, November 11, 1926, NASA History Office Archives, Washington, D.C.

[7] It is difficult if not impossible to determine where a specific request came from for this reason. Lewis also funneled the staff's requests through the military when he wanted to assure approval. NACA used the military services in the same manner to obtain its appropriations request from Congress.

[8] The NACA had unofficially adopted a policy from the beginning that there would be no industry representatives on the Full Committee. This policy was not broken until after World War II. The Annual Reports contain a listing of all members.

[9] Roland in a discussion with the author on this subject pointed out that Lewis simply sent the Research Requests back to the Laboratory. The only records which were kept were the Research Authorizations which were approved. If the Laboratory didn't hear from Lewis, approval was assumed.

[10] Memo from Lewis to Staff, February 11, 1922, NASA History Office Archives, Washington, D.C.

[11] Levine, op. cit., discusses this issue.

[12] This was specified in the NACA legislation. Ames apparently was the only member at this time willing to work on the NACA's activities at least once a week. This gave him an enormous advantage over the other members.

[13] Wayne K. Hinklo, "An Administrative Survey of NACA," Rough Draft; Michael David Keller, "From Kitty Hawk to Muroc: A History of the NACA Langley Laboratory, 1917-1947," HHM-15, 1969; and John V. Becker, "Four Case Histories in NACA Flight Research," unpublished manuscript, 1980, provide interesting descriptions of this process. Copies are stored in NASA History Office Files, Washington, D.C.

[14] Roland, op. cit., Appendix H, provides a case study of one research authorization which lasted twenty years and involved numerous individuals. Reid not only felt that some of the projects which were carried out under the research authorization should have required a new research authorization, but also suggested after ten years that the research authorization could be considered finished. Lewis again disagreed, and it continued another ten years. Becker, op. cit., also presents four case studies of this process.

[15] Keller, op. cit., p. 132, footnote 41.

[16] See Roland, op. cit., Appendix H.

[17] Ira H. Abbot, "A Review and Commentary on a Thesis by Arthur L. Levine entitled, 'U.S. Aeronautical Research Policy, 1915-1958.'" Unpublished Manuscript , 1964, p. 178. Copy in NASA History Office Archives.

[18] Work accomplished under job orders did not have to be approved by the Advisory Committee.

[19] This statement is made with some caution. NACA was known for its academic environment, and it used many of the mechanisms, such as publication under one's own name and evaluation by colleagues, used by professional groups. On the other hand, its staff's loyalty was to the organization, not to any profession.

[20] Becker, op. cit., p. 16.

[21] The staff's northern background and level of education created problems with their Hampton neighbors in NACA's early years. It shared the Langley area with the Department of War. All the early staff members were young. Reid was only 30 when he took over the Laboratory, and Lewis was 36 when he became Executive Officer.

[22] The staff's feeling about the organization is best exemplified in Becker, loc. cit., and Abbot, loc. cit. The latter was written in response to Levine's thesis which Abbot felt portrayed the organization and particularly the committee structure inaccurately. Both Becker and Abbot were NACA employees.

[23] Robert L. Rosholt, An Administrative History of NASA, 1958-1963 (Washington, D.C.: NASA, 1966), p. 22.

[24] A complete list of all members of the Advisory Committee and the chairman of its technical committees and subcommittees is given in Roland, op. cit., Appendix D.

[25] Lewis to Reid, February 15, 1926, NASA History Office Archives, Washington, D.C.

26 Roland, op. cit., p. 360. Hinklo, op. cit., also describes this process.

27 The importance of this to NACA's leaders can particularly be seen in their Annual Reports. They are brief, concise and carefully written. The difference between NACA's reports and NASA's current reports which are neither concise nor brief is one of the interesting contrasts between the two organizations.

28 Victory's attitude about these matters is evident in his comments on one of Langley's early directors, DeKlyn. See Victory to Durand, August 31, 1918. National Archives, Record Group 255. Roland, op. cit., and Levine, op. cit., discuss Victory in detail.

29 Even NACA's most severe critics acknowledged that its performance was exceptional for a government agency during most of its existence. This section is not meant to be an evaluation of NACA's technical performance. See General Accounting Office, "Report on Survey of the National Advisory Committee for Aeronautics," forwarded by cover letter from Frank L. Yates, Acting Comptroller General of the U.S. to John Phillips, February 20, 1953, p. 17; Brookings Institution for Government Research, Report 12, published as Senate Select Committee to Investigate the Executive Agencies of Government, Senate Report 1275, 75th Cong., 1st sess., 1937; Roland, op. cit.; and Levine, op. cit.

30 See note 1, this chapter.

31 See NACA's Annual Reports.

32 Seventh Annual Report of the National Advisory Committee for Aeronautics, 1921 (Washington, D.C., 1922), p. 20.

33 Goddard received funding from the Smithsonian Institution and the Daniel and Florence Guggenheim Foundation. The Navy and Army Air Corps provided funds for his work after receiving information on the German aeronautical advancement during World War II. There is still controversy over how much the Germans used his research to develop their V-2s because of the similarity between his liquid-fuel rocket and the Germans' V-2. See Milton Lehman, This High Man: The Life of Robert H. Goddard (New York: Farrar, Straus, 1963).

34 Minutes of NACA meeting, 21 October 1926; Ames to the Committee on Personnel, Buildings, and Equipment, June 28, 1927. George Mead to Vannevar Bush, May 20, 1940, in National Archives Record

Group 255, Entry 1, Box 3, "Executive Committee." There was some concern about this lack of representation, but the fact that Ames and Hunsaker, who was chairman from 1941 to 1956, were both from universities probably meant that universities had a great deal more representation on the Committee than their actual number might indicate.

[35] Barton C. Hacker and James M. Grimwood, On the Shoulders of Titans: A History of Project Gemini (Washington, D.C.: NASA, 1977), p. 7.

[36] NASA was strongly criticized throughout its history because of this. See Minutes of Executive Committee Meeting, March 18, 1927. Part of the problem was that there was no one qualified to systematically analyze the research results of the staff.

[37] See David A. Anderton, Sixty Years of Aeronautical Research, 1917-1977 (Washington, D.C.: NASA, 1980), pp. 12-13, and George G. Gray, Frontiers of Flight: The Story of NACA Research (New York: Alfred A. Knopf, 1948).

[38] When explained in this manner, it sounds as if the type of research which NACA was accomplishing was somehow not as important as scientific research. This implication should not be drawn. NACA's research was recognized as playing a major role in the development of the airplane not through any major breakthroughs, but by refining the design of the existing airplane.

[39] Becker, op. cit., p. 21.

[40] Cited in Roland, op. cit., Chapter 5, footnote 19, from Wilbur Wright Lecture on May 31, 1923, given by Ames.

[41] The scientific community's fear of government control of their research coupled with the military services' procurement regulations which required more government control than the scientist would accept, made a direct link between the two very difficult. The scientists only had to make a final report to the NACA. See Clarence H. Danhof, Government Contracting and Technological Change (Washington, D.C.: The Brookings Institution, 1968) and Daniel S. Greenberg, The Politics of Pure Science (New York: New American Library, 1967).

[42] Anderton, op. cit., p. 13.

43 Edwin P. Hartman, Adventures in Research: A History of Ames Research Center 1940-1965 (Washington, D.C.: NASA, 1970), p. 4.

44 NACA's requests for appropriations were only examined by the Subcommittee on Independent Offices of the Committee on Appropriations. It did not face an authorization committee until after World War II. The Senate Committee on Appropriations generally accepted the House's recommendations.

45 See Richard P. Hallion, "To Study the Problems of Flight: The Creation of the National Advisory Committee for Aeronautics, 1911-1915," unpublished manuscript, NASA History Office, Washington, D.C., 1976; Roland, loc. cit.; Levine, loc. cit.; and Hunsaker, loc. cit.

46 The President was prohibited from appointing any commission which involved government employees without the approval of Congress by Section 9, 35 Stat. 1027, March 4, 1909. See Walter T. Bonny, "So Much, So Quietly. ...," Unpublished draft of the History of the NACA, n.d., NASA History Office Archives, Washington, D.C.

47 Walcott was one of a number of men who were involved in establishing scientific bureas during this period. See Depree, loc. cit.

48 The major documents are contained in the "Documentary History of the National Advisory Committee for Aeronautics," typescript, n.d., NASA History Office Archives, Washington, D.C.

49 This memorandum is in the "Documentary History...", ibid.

50 W. Irving Chambers, "Report on Aviation," Annual Report to the Bureau of Navigation, published as Appendix 1 to the Annual Report of the Secretary of the Navy for 1912, pp. 155-169.

51 Levine, loc. cit., and Roland, loc. cit., both thoroughly review the "bureaucratic squabbling" that surrounded this issue and its impact on the NACA even after it was created.

52 Chambers, loc. cit.

53 Richard Mac Laurin to Senator W. Murray Crane, February 14, 1913. Taylor made a similar argument in a letter to William F. Durand, February 13, 1913. Durand was a member of the Woodward Commission and an engineer at Stanford University.

[54] See Hunsaker, loc. cit., and Roland, loc. cit., for a description of these laboratories.

[55] The United States at the start of World War I had fallen behind the Europeans in this development as indicated by the number of planes which they were producing. France had 1,400; Germany 1,000; Russia 800, Great Britain 400, and the United States had 23. It was dependent on other countries for airplanes during the war. See Hunsaker, loc. cit., and George G. Gray, Frontiers of Flight: The Story of NACA Research (New York: Alfred A. Knopf, 1948).

[56] Cited in Dupree, op. cit., p. 218. Testimony from Joint Commission to Consider the Present Organization of the Signal Service, Geological Survey, Coast and Geodetic Survey and the Hydrographic Office of the Navy Department, with a View to Secure Greater Efficiency and Economy of Administration of the Public Service in said Bureau..., Testimony, March 15, 1886, 49th Cong., 1st sess., Sen. Misc. Doc. 82 (ser. 2345), pp. 23-26. Hereafter cited as Allison Commission.

[57] Ibid., p. 219. Testimony from Allison Commission, pp. 999-1000. The extreme of this view was seen in the philosophy behind some of the industrial research laboratories in which attempts were made to control the engineers completely. See David F. Noble, America by Design: Science, Technology and the Rise of Corporate Capitalism (New York: Alfred A. Knopf, 1977), pp. 71-72.

[58] Aeronautics: Report of the Advisory Committee for Aeronautics for the Year 1909-1910 (London: HMSO, 1910), pp. 4-5, cited by Roland, loc. cit. The concept of an advisory committee as well as the actual language of the legislation which created the British Advisory Committee were taken from the legislation. The difficulty of determining Congress's intent is partially a function of the lack of interest displayed by Congressmen about the NACA. The appropriation was small and what interest was shown was the result of lobbying efforts of the various participants.

[59] See Dupree, op. cit., for a discussion of this problem.

[60] This assumption was used as the justification for providing aid to industry and is revealed in all early Annual Reports. It was more believable in 1915 than it is today since there is so much difference between military and commercial airplanes.

[61] See Note 1, this chapter.

[62] See National Advisory Committee for Aeronautics, Minutes of Meetings of the Full Committee and the Executive Committee, October 14, 1915 and October 15, 1915, Record Group 255, National Archives, Washington, D.C. This is a simplification of the actual process. The Navy did object to NACA's request and was able to influence President Wilson. A visit by Walcott to a number of congressmen apparently took care of the problem. General Schriven, the NACA chairman at the time and active member of the Army, was responsible for the original idea. Thus the Laboratory's creation may have simply occurred because of interservice rivalry.

[63] Appendix A contains a complete personnel and budget breakdown.

[64] Griffith to Executive Committee, September 4, 1918. Ames to Durand, August 19, 1918; Victory to Durand, August 31, 1918. These memos are stored in the National Archives, Record Group 255, and at the NASA History Office Archives, Washington, D.C.

[65] These duties are specified in the Annual Reports.

[66] Leigh M. Griffith, "Final Report of Engineer-in-Charge to the National Advisory Committee for Aeronautics Covering the Period Ending December 31, 1925." National Archives Record Group 255, Washington, D.C.

[67] Ibid.

[68] One of the reasons that Griffith left was that Ames was not satisfied with the quality of the research produced by the Laboratory.

[69] Both Griffith and Warner questioned Victory's authority to direct the Laboratory. Victory apparently was one of the major reasons for the success of the NACA, but the fact that he was so difficult to get along with was one of the reasons for the high turnover at the Langley Laboratory during this period.

[70] For example, Walcott, Stratton and Ames.

[71] Roland, loc. cit., describes these attempts to hire scientists.

72 Roland, ibid., p. 159.

73 NACA Annual Report for 1927.

74 These attempts are discussed below.

75 Hunsaker, op. cit., p. 263. Hunsaker was trying to justify NACA's failure to keep up with aviation advancements in Europe, particularly the Germans' missile advancements. Levine, op. cit., and Abbot, op. cit., provide interesting arguments for and against NACA on this issue.

76 The result of this type of thinking is that such radical advancements as the jet engine and rockets are ignored.

77 Roland, op. cit., Appendix A.

78 These criticisms ranged from minor criticisms of the work of the subcommittees to major critiques of the quality of the work in the Annual Reports. See Robert A. Milliken to George Ellery Hale, July 31, 1918; E. B. Wilson to Hale, April 25, 1917; Ames to Durand, August 10, 1918; John Victory to Durand, August 31, 1918; Griffith to Executive Committee, September 4, 1918.

79 Griffith to Executive Committee, April 8, 1919.

80 Minutes of Executive Committee Meeting, January 1 and January 24, 1918.

81 Minutes of Subcommittee Meeting on Patents, July 10, 1917. This controversy is discussed in Roland, Chapter 2.

82 Air Commerce Act of 1926, Public Law 254, 69th Cong., 1st sess., passed May 20, 1926 (44 Stat 568) gave responsibility for the promotion and regulation of civil aviation to the Department of Commerce. The various versions of the drafts of this legislation are printed in the NACA Annual Report for 1920, pp. 54-56 and Annual Report for 1921, pp. 13-21.

[83] Reorganization of the Executive Departments, H. Rept. 937, 68th Cong., 1st sess., to accompany H.R. 9629, 1924. Congressional Record, 68th Cong., 1st sess., Vol. 65, Part 10, p. 10414.

[84] Since the Act gave this responsibility to the Department of Commerce, it had little choice by 1926.

Chapter 3

NACA IN THE 1950s

INTRODUCTION

NACA in 1927 had a fairly simple formal structure. It was controlled by scientists and engineers who directed and coordinated the work of its researchers through the use of positive incentives. Its committee structure provided a forum for the exchange of aeronautical research information. It accomplished aeronautical research both within its own laboratory and through contracts. NACA's principal product was the NACA Report containing the results of this research. It had two major clientele for its services--the military services and private industry--both of whom were satisfied with its product. Few members of Congress even knew of its existence, but those who did provided strong support for its continued existence. The environment contained few competitors who could offer similar services, and those, such as the Bureau of Standards which did engage in aeronautical research, did not engage in aerodynamical research, which was NACA's primary focus.

In contrast to this, NACA's structure in the late 1950s was more complex and less informal. NACA no longer played a major role in the coordination of aeronautical research nor was it a major conduit between the military services and private industry. It continued to engage in applied aerodynamical research and produce meticulously edited research reports, but it also was engaged in advanced engineering projects which took its researchers out of the laboratory and into daily contact with development work. Perhaps more important for our purposes, its environment was no longer as benign. Small research organizations, which offered the military services similar to NACA's, had developed and ended the military's dependence on NACA. Oversight agencies had grown in power and size and regulated its activities in ways that NACA's early leaders had never imagined. NACA in 1927 had been one of a number of organizations which maintained an in-house research staff. NACA in the 1950s was somewhat of an archaism. It was one of the few government organizations which continued to conduct in-house research, and it was surrounded by large research and development organizations managed by single administrators who let contracts for their work. NACA continued to retain its reputation for excellence, but it was having difficulty attracting and retaining highly qualified scientists and engineers in this new environment.

The purpose of this chapter is to show how and why NACA changed from the young thriving organization of the late 1920s. The first section examines the organization as it existed in the 1950s in more detail. This is followed by a section which examines the various factors which played a role in the changes which occurred.

I

THE ORGANIZATION OF NACA: ANOTHER LOOK

INTRODUCTION

The most visible difference between NACA in 1927 and the organization in the 1950s was the change in size. As Figure 2 shows, the Advisory Committee had expanded to include 17 members.[1] The four standing technical committees--Aerodynamics, Power Plants, Construction, and Operating Problems--received recommendations from 23 technical subcommittees with a total membership of nearly five hundred individuals. The Committee supervised a staff of close to eight thousand technical, scientific, and administrative individuals located at three research laboratories and two research stations.[2]

The change in size had been accompanied by a change in leadership. A new chairman, Jerome Hunsaker, Chairman of the Department of Aeronautical Engineering at the Massachusetts Institute of Technology, had replaced Ames.[3] Dr. Hugh L. Dryden, a physicist and former Associate Director of the National Bureau of Standards, had replaced Lewis as Director of Aeronautical Research. Perhaps more important, Dryden was both legally and in reality the operating head of NACA. The co-equal rule of Lewis and Victory had been changed.[4] One additional layer of authority had also been added. Gus Crowly, a former Langley employee, was the Associate Director for Research and as such responsible for the scientific and technical activities of the agency.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
(17 members)

4 TECHNICAL COMMITTEES
and 23 SUBCOMMITTEES
(448 members includ-
ing 49 from NACA)

HEADQUARTERS OFFICE, WASHINGTON, D.C.
(165 employees)

INDUSTRIAL CONSULTING COMMITTEE
(9 members)

AMES AERONAUTICAL LABORATORY
(1207 employees)

LANGLEY AERONAUTICAL LABORATORY
(3239 employees)

LEWIS FLIGHT PROPULSION
LABORATORY
(2719 employees)

WESTERN COORDINATION OFFICE
(2 employees)

PILOTLESS AIRCRAFT RESEARCH
STATION
(78 employees)

HIGH-SPEED FLIGHT
RESEARCH STATION
(240 employees)

WRIGHT-PATTERSON
COORDINATION
OFFICE
(2 employees)

Figure 2

NACA Organization Chart, 1952

GENERAL MANAGEMENT

NACA's 1950s committee / agency structure remained very similar to that which existed in 1927, with some very important exceptions. The organization was a great deal more integrated. The formal recognition of Dryden's authority had made him an integral part of the leadership of the organization. The technical committee members, as well as the staff, had enhanced their position in the committee hierarchy. These changes in the position of some of the participants were accompanied by a growing formalization of the structure. The relationships between individuals and groups within NACA had been very informal in 1927. By 1950 it had adopted formal rules and regulations which guided its behavior and gave legal validity to at least some of the participants' authority.

The Leadership

In 1927, Lewis, Victory and Ames virtually controlled NACA's activities. The committees, including the Advisory Committee, played a role in the decision-making process, but this process was tightly controlled by the three. This control, at least in the case of Lewis and Victory, was not officially recognized. Lewis had a great deal of power and for all practical purposes was the operating head of the agency, but he remained a subordinate throughout his tenure despite the recognition given to his administrative talent and authority over the agency. By the 1950s this arrangement had changed considerably. Dryden had been a committee member and worked with Hunsaker before his appointment.[5] He had an international reputation in his field and had credentials as a scientist equal to any committee member's. These credentials gave him a stature which Lewis was never able to attain. Dryden was recognized through an amendment to NACA's Rules and Regulations not only as operating head of the agency, but also as an *ex officio* member of all standing committees.[6] Lewis's power stemmed from his control over information about the agency and Ames' willingness to accept his authority over the laboratory. Dryden's authority was formally recognized, and his power came as much from his credentials as his control over information. This is not to say that the Advisory Committee did not retain its control over the organization, but that Dryden's place among the leaders was recognized and accepted. NACA's leaders in the 1950s compared the role of the Advisory Committee to that which the Board of Directors filled in any private corporation.

> The Chairman and members of the Committee meet monthly and constitute in effect a Board of Directors of a typical American business corporation, serving without compensation. They elect annually a Chairman and a Vice Chairman...The position of Chairman corresponds in effect to that of a 'Chairman of the Board' of a business corporation. The Director, the Executive Secretary, and the Associate Director for Research, are the full-time career executives whose relations to the main Committee, to each other, and to the staff of approximately 7,000 employees, are quite similar to those of a President, Executive Vice President, and General Manager of a corporation. They are the executive officers of the organization who actually manage its affairs.[7]

This change was accompanied by a change in the relationship between the staff and the Advisory Committee. The Advisory Committee in 1927 was very dependent on the in-house staff for information about the progress of aeronautical research and the relationship between NACA's research efforts and the efforts of outsiders. NACA's leaders in the 1950s had more sources of information than were available to its leaders in 1927.

An Industry Consulting Committee, composed of the heads of major aviation companies, had been created. Its objective was to keep NACA aware of industry's views on the relationship between NACA and industry and to advise the Executive Committee on general policy issues. This committee had no legal authority, but the fact that it was the one group which had direct contact with the Advisory Committee, rather than contact through Dryden or one of the other committees, made its recommendations difficult to ignore. The ambivalence of NACA's leadership with regard to this change in policy was reflected in their instructions to new committee members.

> Members of technical subcommittees appointed by the NACA from outside the Government are appointed in their professional capacities as individuals and not as representatives of their employers...In order to promote free discussion, the meetings of the subcommittee are closed; accordingly, the minutes are confidential documents and are made available only for the use of a subcommittee member and his immediate staff.[8]

The technical committees, which provided the Advisory Committee with recommendations regarding future programs, had also become more knowledgeable. In 1927 the role of the subcommittees was at best ambiguous. This was probably best evidenced by the control which Lewis and Ames exercised over the formulation of NACA's research programs, but it was also evident in the lack of understanding which their members had about NACA's policies and programs. NACA's staff and some committee members viewed their role as one of simply rubber stamping decisions which had already been approved by the agency's staff. In 1927 NACA's leaders claimed that these subcommittees were a valuable tool for determining aeronautical research needs, but the subcommittee members actually played a small role in the decision-making process within NACA. Dryden was strongly committed to using the subcommittees to keep himself and the Advisory Committee informed about aeronautical research needs. He not only explained their role, how the research authorization process worked, and the agency's technical activities, he also explained what a research program should look like and pointed out

> It is quite obvious that the ramifications of an adequate research program are so great that no single individual can master or guide the details. The technical staff of the Washington Office has been increased, and we have asked for a further increase in the 1949 budget. I believe that it is your function to determine the general policy as to the objectives of research in relation to aeronautical development and air policy. Through the standing technical committees, the technical goals in specific fields are reviewed in light of general objectives, and recommendations made to you...[9]

By the 1950s the subcommittees were recognized as effective bodies even by NACA's critics.

The Advisory Committee and Dryden could obtain additional information from Headquarters research divisions. A Research Administration Division reviewed and edited reports produced by NACA's in-house staff. A Research Coordination Division was responsible for conducting NACA's contract research program; reviewing proposals; preparing recommendations on them; and auditing the progress of these contracts. Perhaps more important were three research divisions (Propulsion, Aerodynamics, and Aircraft Loads and Structures) and the Operating Problems branch under the Research Coordination Division. They were responsible for reviewing the results of all NACA research and determining their implications for future research. Staffed by technical specialists, these groups provided Dryden and the Advisory Committee with technical expertise, which during the 1920s was only available at the laboratory level.

Research Authorizations

The procedures used to develop broad policy guidelines remained similar to the 1927 procedures. The Executive Committee after receiving recommendations from the technical committees, the military services, other government agencies, and the Director of Aeronautical Research, prepared research authorizations. With the exception of requests from government agencies, all requests were submitted to the technical subcommittees for review, but as the Executive Committee pointed out in the description of the functions of the subcommittees, this submission was not mandatory.[10]

Where the procedures differed was at the Executive Committee's level. Its approval of specific research authorizations was based on a review of the relative research needs in the power plant, operating problems, aerodynamics and aircraft construction areas. The stated criteria used to determine the level of expenditure for each area were: (1) the availability of NACA facilities; (2) actual research needs; and (3) the relative state of aeronautics. Procedures implemented by Dryden gave the Advisory Committee more information about the projects being undertaken, the progress on each project, and the relation of each project to particular program areas.[11] Dryden and the Advisory Committee had more information on which to base their decisions about the allocation of funds and the priority of the projects in which the agency would engage, for the simple reason that they were tracking the progress of the research projects more than Lewis and Ames ever had.

The research authorization process at the operating level was similar to that which existed in 1927, but it was more formalized. Headquarters, as it did in 1927, left the control over research activities in the hands of the individual laboratories. The only formal control device was the Management Control Information System, which was an expanded version of the 1927 research authorization request.[12] Each laboratory was required to obtain headquarters approval for research projects (a specific problem) undertaken and submit a semi-annual report on the status of each program (related projects). The project approval contained a general description of the scope of the project and experiments to be undertaken. It did not specify the methods or procedures which would be used in the project. There were no formal specifications or requirements for these reports. Each laboratory was allowed to develop its own methods and procedures for producing the reports required by headquarters. Although all contained some information on costs, how these costs were reported was different at each laboratory. There was no attempt to standardize the requirements on an agency-wide basis. The primary objective was to prevent duplication of research work and to track the relative amount of funds spent in the four major research areas. Headquarters made no attempt to tell the laboratories what they should be spending on each project or to provide criteria for the evaluation of the research activities.

The Management Control Information System was only used to track some research activities. Instrument and computer research were not tracked by headquarters in any manner. Job orders were used at each laboratory to approve the manufacture, installation, and development of instruments and computing devices (e.g., computers) for research projects. The laboratory staff had to obtain approval from the respective laboratory director, but not from headquarters for these items. As in 1927, the laboratories' staff was not adverse to using job orders rather than formal research authorizations when they felt the research wouldn't be approved.

The headquarters' budget division was responsible for preparing the annual budget and allocating agency funds among organizational units. After receiving the Research Authorizations from the Advisory Committee and consulting with laboratory officials, this division prepared recommendations on the number of personnel and funds required for carrying out all the research programs within any one year at the laboratories. These recommendations were then sent to Dryden, who approved monetary and personnel ceilings for each laboratory. The headquarters budget officer had no control over the laboratories' allotments once they had been approved. This was the responsibility of the budget officer located at each research laboratory.

Construction budgets were prepared separately from design outlines and rough cost estimates received from each laboratory. Laboratory officials consulted with headquarters officials informally before preparing these requests, but they were the responsibility of the laboratories. The priority of the requests was assigned by a facilities panel at headquarters. The headquarters budget officer was responsible only for preparing the actual appropriations request for the Bureau of the Budget after the construction requests had been approved by the Advisory Committee.

Tracking Mechanisms

What had changed from 1927 was the level of tracking which was being accomplished. NACA's leaders in 1927 largely relied on the NACA reports to evaluate the staff's performance. By the 1950s, they had adopted other mechanisms. How effective these measures were was not clear.

The Headquarters Fiscal Division was responsible for the accounting and audit activities of NACA. Except for those procedures required by the General Accounting Office, NACA had no written procedures for auditing and controlling its expenditures. Each laboratory had developed its own procedures for collecting costs and financial data, and these data were only used for making cost estimates, not as a management or control device. The difference in the methods used made it impossible for headquarters to control these activities. There were no audit activities performed on an agency-wide basis. What auditing and accounting were done was accomplished by individuals whose primary job was research, technical services, or another administrative activity.

The headquarters procurement and contract division chief was responsible for the procurement activities of NACA to the Executive Officer, but the laboratory contracting officers were responsible to the Executive Officer for the procurement policies at each laboratory. Purchase of goods and services was done by each laboratory under the supervision of the respective laboratory's contract officer.

Headquarters had little, if any, control over these procurement activities and only monitored the procedures and paper flow at each laboratory. The General Accounting Office in 1953 noted that even those procurement activities which required the Executive Officer's approval by law were essentially handled by the laboratories' staff.

> Almost without exception, the entire preliminary proceedings, including negotiation of these contracts, are conducted by laboratory employees. The contracts are then reviewed by the chief of Procurement and Contract Division (headquarters) and are approved or awarded by the Executive Officer. Information submitted with these contracts is generally inadequate to serve as a basis for evaluating the contracts before their approval or award. Reliance is placed to a large extent on recommendations of the contracting officer who directed the contracting processes.[13]

The headquarters divisions already discussed not only provided information to NACA's leaders, but could be used to track the work of the staff. In addition, the Research Information Division was responsible for the direction, control and dissemination of all NACA Reports. It served as a central clearing house for all published aeronautical research. Although the quantity of research being accomplished throughout the United States made it difficult if not impossible to track, this division could supply information which could be used to examine the progress of NACA's researchers in relation to other researchers.[14]

Dryden, while fully committed to continuing NACA's policy of providing its researchers with a great deal of autonomy, also had formalized some of the previously informal procedures of NACA. He had instituted an index system for the processing of all reports; established memorandum reports which made the results available in a

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Dryden, while fully committed to continuing NACA's policy of providing its researchers with a great deal of autonomy, also had formalized some of the previously informal procedures of NACA. He had instituted an index system for the processing of all reports; established memorandum reports which made the results available in a shorter period of time; and required that all laboratories produce a monthly report listing the status of all of their research.[15] Perhaps more important, he instituted procedures which forced the staff and committees to examine NACA's results not as a solution to one problem, but in relation to an appropriate research program. He accomplished this by requiring the division of research authorizations and job orders into appropriate research programs. The result of these efforts was that it was not as easy to end a project informally or allow it to go unfinished for a long period of time as it had been in the 1920s.

The Laboratory Directors had also formalized their methods of accomplishing their research and tracking it. The research laboratories remained decentralized in that each Director was responsible for determining the methods used to accomplish the research and was able to exercise some control over the priority of the project at the laboratory. A project was assigned to a laboratory was turned over to a Division Chief who in turn sent it to the section head, who assigned it to a project engineer (scientist). The project engineer was responsible for the details of the research, making sure it was completed, and writing a report on it. He supervised the design and manufacture of instruments and construction of test models and test facilities by technical employees. Actual tests were conducted by the project engineer once the technical employees had completed their work. Some laboratories assigned an operations project engineer to supervise the technical employees. The data obtained from the tests were used by the project engineer (scientist) to write a report. Research projects which were theoretical in nature were handled completely by the scientist involved.

Once written, the report went to an editorial committee appointed by the Division Chief. It was composed of four members--the author, a senior engineer and two others. If the project was for another government agency, this agency was generally represented on the committee. After approval by this committee, the report was sent to the respective division chief, whose approval resulted in submission to the Laboratory Director. It was only at this point that the report was sent for final typing and approved for submission to headquarters, where it again went through the editing process.[16]

NACA'S PERFORMANCE:
A RE-EVALUATION

NACA's goal was to advance aviation. Their legislative mandate stated that this should be accomplished by determining which problems existed, recommending possible solutions to the problems, and supervising the accomplishment of aeronautical research directed toward advancing aviation. Although NACA's 1927 leaders argued they were achieving their goal, the lack of representation of some groups, as well as their own failure to develop a research program meant that they were not performing their work as adequately as they claimed.[17] They also were not accomplishing the scientific research which the leaders claimed the organization was. Despite this, the evidence suggests that they were advancing aviation.

NACA's performance in the 1950s was also somewhat different than envisioned by its creators. It was also quite a bit different than envisioned by its 1927 leaders.

Determination of Research Needs and Their Solution

NACA continued to have problems carrying out their objective in the 1950s, but for slightly different reasons than the 1927 organization did. The growth in the amount of aeronautical research being conducted and the increase in its complexity made it difficult for anyone to track and coordinate aeronautical research. As the General Accounting Office noted in its 1953 audit of NACA, "Aeronautical research has expanded to such an extent that it is no longer practical for the NACA to supervise and direct all of the Nation's aeronautical research."[18]

This problem was compounded by the fact that the military services had taken over responsibility for so much of the aeronautical research which was being accomplished during this period. Prior to World War II, NACA had been used by the military services and private industry to avoid some of the problems associated with writing specifications and estimating costs for radically different airplanes. The committee structure provided a forum for the discussion of problems and possible solutions between the two groups.[19] The laboratory could be used to write specifications and to estimate costs and help industry once a contract had been written. Since many scientists refused to work under contract for the military services, NACA also provided a mechanism for supporting basic research. It could let contracts without detailed specifications and assure scientists that they were working for their professional colleagues.[20] Procurement regulations in the 1950s provided the military services with the ability to support research and development projects without using NACA's committees for this purpose.[21] The establishment of their own aeronautical research laboratories ended the services' reliance on NACA's technical staff.[22] NACA continued to provide technical advice and assistance, but the military services did have the legal authority necessary to accomplish these tasks without NACA.

On the other hand, the Advisory Committee, as discussed above, had increased the number of sources it was using to track aeronautical research efforts. It had made memberships, particularly in the case of private industry, more accessible to a larger variety of interests than it had in the late 1920s. The fact that the organization's staff were no longer isolated in their laboratory, but involved in projects with the military services and private industry on a daily basis, meant that they were in many ways tracking aeronautical research activities more adequately than they had in 1927.

Dryden's efforts to involve the technical committees in the decision-making process, as well as his demands that the organization attempt to develop a research program rather than simply solve problems as they arose, also meant that the organization was at least attempting to be more systematic in its research activities.

Research Activities

The agency by the 1950s had broadened its research efforts to include a wider range of activities and different types of research. Although the research staff primarily directed its efforts toward solving aerodynamical problems, one of the new research laboratories, Lewis, had been built specifically to engage in engine research (e.g., rocket, nuclear, fuels). Structural research (e.g., loads, vibration and flutter, materials) was conducted both at Langley and Ames. Research on operating problems (e.g., icing, meteorology, fire prevention) was conducted at both Lewis and Langley. Research on aerodynamics (e.g., fluid mechanics, stability and control, internal flow, propellers) was conducted at all three laboratories, but primarily at Ames and Langley.

The agency had also expanded the types of research in which it was engaged. While this expansion for the most part was a movement from applied engineering to advanced engineering, it also included a shift toward more scientific research. NACA in the 1950s could claim that it engaged in projects ranging from the "development of theory progressing through experimental verification and development in specialized wind tunnels to verifications in large-scale wind and pressure tunnels or actual flight tests."[23]

It was the advanced engineering which during the 1940s and 1950s brought it the most publicity. The High Speed Flight Research Station and Wallops Pilotless Station engaged in the testing of turbojet and rocket-propelled model aircraft.[24] One of the airplanes produced by this group working with the military services and private industry was the first to break the speed of sound.[25] The two stations were established specifically to work with the military services and private industry on research and development projects which required them to engage in many different activities, "from engineering planning on the airplanes, through administration, flight planning, flight testing, ground tracking, interpretation of data, and maintenance."[26] The projects were directed toward the production of research aircraft capable of reaching supersonic speeds.

The work of these two groups differed from NACA's earlier research in a number of important ways. Rather than depending on wind tunnel data, these programs used actual aircraft to determine the impact of flying at supersonic speeds. They required closer collaboration with the military services and private industry than the agency staff had previously been accustomed to. This implied the establishment of tighter administrative arrangements. Because the contractors were given almost complete freedom in designing the planes, NACA was actively involved in the entire design and development phase.

The projects thus brought some of NACA's researchers out of their laboratories and into contact with the development process and the excitement generated by these projects. They required the establishment of schedules and specific objectives. They were directed toward goals which were often political (e.g., breaking the speed of sound) rather than scientific.In contrast to the fiscal conservatism practiced by NACA's leaders, the managers of these projects stressed reaching an objective within a specified time frame, whatever the costs. The careful methodical work of NACA was directed toward producing a report which was highly reliable. The work of these new groups was directed toward producing data as fast as possible to solve specific problems which were preventing the completion of the project.

NACA's Accomplishments

Although NACA played a smaller role in the aeronautical research community in the 1950s, its accomplishments were still significant. John Stack, a Langley staff member, received the Collier Trophy twice for his research on high-speed flight.[27] Harry Julian Allen, an Ames staff member, was responsible for the discovery of the blunt nose principle. The blunt nose design for reentry vehicles minimized the aerodynamic heating of reentry and was used on most ballistic missiles after its discovery.[28] Richard T. Whitcomb also received the Collier Trophy for the discovery of the area rule, a design rule which made supersonic flight more of a possibility.[29] The supersonic research programs of which they were a part played a major role in the advances made in supersonic flight in the 1950s.[30]

The committees also continued to have an impact, although perhaps less than in 1927, on the development of aviation. This is best evidenced by NACA's ability to bring together leading scientists and engineers in 1957 when the Soviets launched Sputnik I. NACA's leaders appointed a Special Committee on Space Technology which was composed of almost all the leading scientists and engineers who were interested in the new space program.[31]

DIRECTION AND COORDINATION OF RESEARCH

NACA in the 1950s was a great deal larger and more complex. It also engaged in more diverse activities than it had in 1927. Despite this, its leaders continued to allow its researchers a great deal of discretion. They had adopted more tracking and authorizations mechanisms, but these mechanisms were not terribly effective and were largely used to provide NACA's leaders with more information. They continued to rely on many of the same mechanisms which had been used in 1927 to direct and coordinate the activities of the organization.

Internalization of Values

One of the major methods of ensuring its staff's compliance in 1927 was the gradual internalization of NACA's values which occurred as the result of such factors as the selection process, the early training in NACA's method of operating, and the environment provided by its leaders. NACA's researchers in the 1950s continued to be known for their high *esprit de corps*, but there were some important differences in the methods used to ensure their compliance.

In the first place, while NACA's leaders continued to recruit individuals from top flight schools, they were having difficulty recruiting and retaining highly qualified individuals. The new technologies of the 1950s had increased the need for scientists and engineers throughout the United States. Competition for them was enormous and NACA, as other federal organizations, simply could not compete with the high salaries offered by private industry. The new research organizations, such as the Jet Propulsion Laboratory, could offer an environment similar to NACA and more pay.[32] Some also were performing research activities similar to those which NACA was performing. The result was that NACA had difficulty not only recruiting highly qualified scientists and engineers, but it also had difficulty keeping them once they were hired. Since the older employees were more apt to resist recruitment because of loyalty to NACA, the average age of NACA's staff continued to go up during the 1950s.

Congress passed a number of laws in the late 1940s and 1950s to alleviate some of these problems. Public Law 80-313, passed in 1947, and amended in 1949, 1956, and 1958, allowed NACA to pay a specified number of scientists and technical employees higher salaries, but these positions were used by NACA to reward older employees rather than for the recruitment of newer ones. The Classification Act of 1949 which created three new supergrade positions, also provided NACA with a mechanism for providing higher salaries to its employees. But again, rather than recruiting more scientists and engineers for these positions, it promoted the older employees and in some cases gave the positions to administrative personnel--a practice which resulted in the Civil Service Commission questioning NACA's need for these positions in the first place. The problem was that NACA's leaders were having to balance the needs of their older employees with the need to attract new employees. If they focused on attracting new scientists and engineers, their older employees, who were being recruited by industry, would leave. If they focused on retaining older researchers, as they did, they would not be able to attract new researchers of the quality they wanted. They had neither the funds nor had been allocated the positions by the Bureau of the Budget to meet both needs.[33] As NACA's leaders argued,

> [It was] losing outstanding and irreplaceable leaders in aeronautical science. Simplest and best remedy [was] enactment of legislation authorizing the government to pay the going rate for scientists and engineers.[34]

The problems associated with recruitment and retention of highly qualified individuals was not the only difference in the methods used to internalize NACA's values. The informal transfer of ideas and socialization into the agency's method of operating had become more formal. Graduate Study programs which provided a year's leave of absence with pay for promising scientists and engineers had replaced the informal in-house training offered during the 1920s. The informal exchange of ideas over lunch was not as easily accomplished in the larger organization, but the staff's work brought them into contact with other groups' ideas and methods and thus ended some of the isolation from other ideas which had existed in the 1920s.

NACA was also not the tightly knit group which existed in 1927. This situation was partially a function of the size and geographical distribution of the research laboratories, but it also occurred because different types (e.g., applied and advanced engineering) and categories (e.g., engine, structural, and aerodynamics) of research were performed by different groups and laboratories.

The Ames Laboratory contained the largest complement of "research-minded" individuals.[35] Their work was primarily theoretical and applied research on general aerodynamical problems. The researchers had come to NACA and particularly Ames because of "its quasi-academic focus on research, its receptiveness to new and sometimes radical concepts, its relative obscurity and freedom from politics..."[36] These individuals had little interest in managing large programs, engaging in the politics necessary to obtain a high level of appropriations, or coping with individual contractors.

Research at Langley ranged from theoretical to development, but the development work was performed only by specific units. These included the Flight and Instrument Research Divisions, the Pilotless Aircraft Research Divisions, and the semi-autonomous Pilotless Aircraft Research Station at Wallops Island. This arrangement worked, but it was not always harmonious. As Becker pointed out rather cynically,

> To a large degree, therefore, one finds that the Pilotless Aircraft Research Division (PARD) reports tended to be data reports for specific test objects rather than general or analytical treatments of research problems.[37]

In contrast to this, the Wallops Island staff gave first priority to specific projects and argued,

> ...general research program at Wallops was less exciting than the specific model program because it did not relate directly to airplanes and missiles in being.[38]

Lewis engaged in both applied and development work, but its development work was also located in one division--the Flight Research Division.

NACA's leaders organized and coordinated these different activities through the use of permanent and *ad hoc* committees both within and between laboratories, but this did not solve the problem of competing objectives which existed within the organization. NACA in the 1920s had been a tight-knit highly integrated group whose members had similar objectives. NACA in the 1950s was very distinctly split into two groups. What had ended, though, was the tendency to completely feel that NACA's way of accomplishing its work was the only way. The advanced engineering group had its own method of operating which was heavily influenced by the methods used by private industry and the military services. These methods were not the same as the applied research group's, and both groups tended to disparage the other's methods. Despite this, NACA's researchers continued to be known for their attachment to the organization and the closeness of its researchers.

Research Environment

NACA's leaders also continued to provide their researchers with an environment conducive to research. Its role in the supersonic research aircraft program provided NACA's leaders with an important incentive which could be used to attract advanced engineering researchers. The program gave these individuals the opportunity to work with both the military services and private industry on some of the most exciting aeronautical programs of the 1950s.

Although NACA had always provided its staff with the opportunity to be involved with other groups engaged in aeronautical research, its ability to do so was much greater in the 1950s than it had been in 1927. This situation existed because the staff's position in the committee hierarchy had improved and because they also attended meetings sponsored by the Department of Defense and private industry. The change in their role can best be seen in their enhanced position on the technical committees. The three top officials were members of the Executive Committee and could be appointed chairmen of standing committees.[39] Each subcommittee had at least one staff member from each of the research laboratories and one member from the headquarters staff who served as secretary for the committee. In 1927 agency researchers had attended meetings, but they functioned as committee staff, not as actual members of the committee. By the 1950s they were actual members and served as chairmen of some of the subcommittees. NACA's researchers had earned the right to go to the committee meetings as professionals well respected in their fields. The relationship between the researchers and individuals from outside of NACA who served on the committees was between professional colleagues. They also served on the Department of Defense committees which made decisions about the military services' aeronautical research programs. Their attendance at these meetings, coupled with their memberships on NACA's committees, made them a much more important part of NACA's technical decision making than NACA's researchers had been in 1927 when they only attended the meetings as representatives from the laboratory.

Although the new role of the staff on the committees and as emissaries of NACA to other groups enhanced the use of this incentive for encouraging the staff to work, it also meant that the researchers had to attend meetings more often, which gave them less time for their research. The attitude of some of the researchers was not always positive to this incentive.

> At Langley there were local committees which paralleled the NACA committees; their function was to facilitate the exchange of information at the working level on common problems and to coordinate general research activity. Most new proposals for research were

> referred to such committees for comment. These committees were useful as a means of keeping up with new research findings all over the laboratory but they were rarely a source of new ideas. Ideas came from individual workers. To these idea men, the various committees were a part of the system which they had to tolerate.[40]

Control of Output

Whatever the other incentives, NACA's researchers in 1927 directed their research activities toward the organization's goal because they accepted its goals and the authority of the individuals who made decisions about the projects in which they would engage. NACA's leaders had established an internal structure which ensured that its researchers were evaluated for performance by individuals who were experts in their fields. NACA's leaders in the 1950s continued to provide this structure, and the enhanced role of the staff on the committees undoubtedly increased their acceptance of the decisions of NACA's leaders. Its report system remained the major method of evaluating the researchers' performance, and promotions as in 1927 were based on performance, but NACA's leaders had made some important changes in their method of controlling their subordinates.

Job descriptions had been categorized into standardized Civil Service job descriptions. A general schedule of graded responsibility with a maximum and minimum salary range for each grade had been established. Each laboratory continued to be responsible for promoting individuals into grades below GS-14, allocating jobs within each category, and there was little tracking of personnel statistics. Whatever the autonomy provided to the laboratories, NACA's leaders had accepted a concept which they had previously rejected because classification systems in their minds placed labels on people and restricted the free flow of ideas. Since their researchers were rewarded for performance, not tenure or position, the acceptance of mechanisms more representative of structures based on position and tenure struck at the underlying philosophy of NACA's method of controlling its staff's activities. NACA's leaders avoided the conflict between the two structures by continuing to promote for performance, but their adoption of the new mechanisms was not a good omen for their future capability to maintain their rather unique structure.

NACA AND OTHER ORGANIZATIONS

The rather benign environment in which NACA accomplished its activities in 1927 had changed to one which was both very complex and somewhat threatening. The small aeronautical research organizations within the military services had been replaced by large research and development organizations under the direction of a centralized Department of Defense.[41] These organizations controlled by single administrators who had responsibility for a centralized vertical hierarchical organization let contracts to private industry for the manufacture of specific products. They had established contract relationships with small aeronautical research organizations controlled by Universities, but owned by the government to meet their basic and applied research needs. The military services continued to come to NACA for technical assistance and advice, but they also had their own in-house staff to which they could turn when they needed technical assistance.[42]

The small, financially strapped aviation industry with which NACA worked in 1927 had become by the 1950s a major political and economic power which made its demands known to Congress.[43] Its power is best evidenced by the existence of the Industry Consulting Committee discussed above, but it was also evident in the increase in the number of industry representatives on NACA's committees. NACA's 1927 policy of limiting the role of industry representatives in the committee structure had been abandoned by the 1950s. Three of the non-government positions on the Advisory Committee were filled by representatives from industry. Industry held more than forty percent of the memberships of the technical committees and accounted for the chairmanships of all four of the main technical committees, as well as sixteen of the subcommittees.[44] In 1956 James H. Doolittle, who replaced Hunsaker as chairman of the committee, became the first chairman who was not a practicing academician, engineer or scientist.[45] NACA continued to work closely with industry and the military services and they remained satisfied with its services, but the two groups were not as dependent on NACA as they had been in the 1920s.

Perhaps more important, NACA in the 1950s had lost many of its friends in Congress. Albert Thomas from Texas who had replaced Judge Woodrum from Virginia as Chairman of the Appropriations Subcommittee which reviewed NACA's requests, had neither a laboratory in his state nor a great love of NACA. He disapproved of the committee structure and the fact that NACA did not have to go through the normal authorization process for its construction requests. In 1950 he warned Victory that NACA's "days were numbered" and forced NACA to obtain annual authorization legislation for its construction projects.[46] In 1952, 1953, and 1954 he requested audits of NACA from the General Accounting Office.[47] NACA may have been able to ignore this change in its Congressional relations if Congress hadn't also begun to cut its budget requests. Between 1953 and 1955, the funds it had available dropped steadily.[48] This occurred despite the Korean and Cold War, and at the same time the military services were receiving increases in their research and development funds.[49]

These changes were accompanied by changes in other oversight organizations. Although the Bureau of the Budget, the General Accounting Office, and the Civil Service Commission existed in 1927, their activities had little impact on NACA, whose primary concern was Congressional oversight. By the 1950s NACA faced personnel ceilings set by the Bureau of the Budget, investigations by the General Accounting Office, and personnel regulations issued by the Civil Service Commission. The discretion with which its leaders operated in 1927 had almost disappeared by the 1950s. Any deviation from what the three agencies felt were efficient management practices was being reported to the President and Congress.

II

CHANGES IN NACA

THE YEARS BETWEEN 1927 AND THE 1950s

The change from the 1927 organization to the organization just discussed was not made easily nor willingly in some cases. The years between the two periods were ones in which the organization both made significant contributions to the advancement of aviation and ones in which its failures became evident both to its clients and Congress. They also were years in which its environment changed so dramatically that NACA's place in the aeronautical research community continually became less secure.

NACA's leaders by the 1950s had found methods of coping with the technological changes and the changes in the aeronautical research community. They had not found an answer to the changes in federal management policies which was acceptable both to the organization and to the oversight agencies which demanded they change their methods of operation. NACA's leaders, unless they were willing to give up their method of controlling the organization, had no method of coping with these changes. This section discusses a number of factors which played a role in the development of the 1950s organization and set the stage for NACA's acceptance of its transformation into NASA, but its particular emphasis is on the changes in federal regulations which undermined the entire structure of NACA.

THE PERIOD OF CRISIS

NACA's leaders by the mid-1930s had established some of the best aeronautical research facilities in the world. They had, or at least thought they had, overcome the early lead of the Europeans in aeronautical research. Their relationships with the military services, private industry, and Congress were excellent. NACA's world began to change in the mid-1930s when the military services approached NACA and requested an expansion of its research program to include more research in propulsion and structural areas.[50] This request was followed by reports from both its Office of Aeronautical Research and Charles Lindbergh, an Advisory Committee member, on the advancements being made in Europe. It was these reports, the increase in work load at Langley, and the impending war in Europe which led to the establishment of two new laboratories, Ames and Lewis.[51]

The establishment of two new laboratories and an increase in its appropriations did not solve the need for more research nor did it end the gap between the research being accomplished in Europe and NACA's research. It was not until 1941 that NACA began to realize the full extent of these advancements. Responding to a request from the military services, its leaders created a special committee on Jet Propulsion which recommended letting contracts to industry for the development of jet propulsion, but by that time both the British and Germans had already flown turbo jets. The full impact of the nation's failure to keep abreast of aeronautical advancements was not fully recognized until the discovery of the Germans' V-2 rocket program at Peenemünde and their plans to build a ballistic missile capable of striking the United States.[52] This discovery brought an end to NACA's previously unquestioned reputation for excellence in aeronautical research. The German advancements in jet propulsion and ballistic missiles were unmatched in the United States.[53]

The impact of this development was enormous not only on the relationship it had enjoyed for years with the military services and private industry, but also its own perception of its aeronautical research capabilities.[54] NACA from the time of its creation had argued that it was responsible for the research necessary to ensure the United States' aeronautical superiority. Although Congressional investigations after the war failed to place the blame on NACA, the military services didn't agree. NACA was excluded from their jet engine development program for the remainder of the war. Questions from NACA about the development of the jet engine were met by directives to continue its work on conventional engines for the duration of the war.[55]

The services began to look elsewhere for technical advice on jet engines. In 1940 the Army took over sponsorship of the Jet Propulsion Laboratory and continued to fund it until it was transferred to NASA. After the war, it turned to Wernher von Braun and the other German scientists who had created the German ballistic missiles. The creation of the Research and Development Board in 1947 under the Department of Defense ended the military services' complete dependence on NACA and established the policy of keeping a group within the Department of Defense which could provide adequate technical aid to all research and development programs.[56]

NACA by the 1950s had established a place for itself in the new technologies, but its attempts shortly after the war were not very successful. Hunsaker in 1944 established a Special Committee on Self-Propelled Guided Missiles, but it was disbanded in 1947.[57] The Department of Defense by this time had established its own Guided Missiles Committee under the Research and Development Board.

NACA's leaders' efforts to establish a coordinating role for the organization in nuclear propulsion were met by objections from General Curtis LeMay, Deputy Chief of the Air Staff for Research and Development, who made it quite clear to NACA that only the Army Airforce had approval for a nuclear research program, not NACA.

> The establishment of a new and separate N.A.C.A. committee or group to pursue such work would, in essence, duplicate to a large degree authority and responsibility already vested in the A.A.F. and, insofar as is presently understood, would be contrary to the desire of the Atomic Energy Commission.[58]

In 1949 when it requested funds for a National Supersonic Research Center, Congress provided the new Air Force with funds to build a new aeronautical research center, while at the same time turning down NACA's requests.[59] NACA's leaders' strategy of showing industrial support by obtaining endorsements was met with a note of sarcasm by Senator Hugh Mitchell.

> We would be glad to have those for the information of the committee but I don't think they should go into the printed record of this hearing. Of course, there are any number of people who will praise the work of NACA and certainly we don't want to do anything to lessen that praise of the job you have done. Everybody agrees on that. I think the committee is interested in knowing the reason why a greater job, a better job--well, not a better job but a bigger job--was not done in leading up to the war.[60]

Although the military services were unwilling to allow the Advisory Committee to play a role in some of the new technologies, they did accept the NACA's proposals for joint research programs. In 1941 John Stack, a Langley researcher, proposed a research aircraft program to Lewis. Although he was turned down, other individuals from Bell Aircraft Corporation, the Army Airforce Aeronautical Laboratory at Wright Field, and the Navy Bureau of Aeronautics were also pressing for some type of program. In 1943 Robert A. Wolfe from Bell proposed a joint Army-Navy / Private Industry / NACA research program to produce aeronautical data on the effect of transonic speeds. Both the Army and Navy agreed to these proposals and NACA's inclusion in the projects.[61] In the mid-1940s NACA established a group to work at the Army Airforce Flight Test area in Muroc Dry Lake, California, on the Bell XS-1 research plane. At the same time, it agreed to a joint program with the Navy and Douglas Aircraft Corporation to produce a turbojet propelled aircraft.[62] In 1945 NACA established a testing site for rocket-propelled model aircraft at Wallops Island, Virginia. The Bell aircraft was the first airplane to break the speed of sound and brought a great deal of positive publicity to NACA.

The success of the research aircraft programs ended NACA's exclusion from the new technologies, provided NACA's staff with a major role in their development, and improved the agency's stature in the aeronautical community and with Congress. What the research programs did not do was return NACA to its pre-World War II place in the aeronautical research community. NACA became part of the military / industrial research and development world, but the military services established the objectives of the research and development programs, directed the accomplishment of the research, and evaluated the performance of the various participants. NACA neither directed nor coordinated the aeronautical research which was being accomplished. It provided a research staff and directed this staff to help the military services with their technical problems. This is not to say that NACA played no role in the new fields beyond research. It was just that this role changed from one in which NACA had appointed committees under its auspices to study the various aeronautical research problems, to one in which NACA was invited to join committees established by the Department of Defense and under its authority. The laboratories continued to play a role in the research process, but NACA's role in the formulation of aeronautical research programs had changed. The impact of this change was enormous. NACA's pre-World War II research coordination had occurred not through coercion, but through its control over information. What NACA lost after World War II was its control over information. This control passed to the military services.

NACA's period of crisis played a role in its acceptance of other changes and ended the dependence of the military services on NACA's services. The military services had found and created other organizations on which they could depend for basic and applied research during the period in which they were disillusioned about NACA's performance. These organizations ended the services' dependence on NACA and brought NACA's claim that it was meeting a unique need which no other organization was meeting, into question. In addition, its acceptance of development work as one of its research activities took it one step further away from the scientific research for which it was created.

Finally, it ended NACA tradition of keeping at least some minimum distance between itself and private industry. George J. Mead, a retired aircraft executive with experience in propulsion research, was appointed to the Advisory Committee after NACA began experiencing problems with the Lewis laboratory. Its lack of experience in engine research coupled with the criticism it was receiving regarding this laboratory's performance weakened its ability to withstand the pressures for the inclusion of industry representatives on the Advisory Committee. Once the tradition had been broken, industry's memberships on NACA's committees increased significantly.

APPLIED AND ADVANCED ENGINEERING
CHANGES IN NACA'S STAFF

One of the reasons that NACA's leaders in the 1920s were unable to keep their commitment to engage in scientific research was their inability to attract and retain highly qualified scientists. The 1940s brought a new problem--difficulty in attracting and retaining highly capable individuals who were qualified to engage in applied engineering and were willing to ignore the excitement of the new development projects. This situation was exacerbated by the necessity of hiring poorly trained researchers during World War II.

NACA's work during the War primarily involved making changes to existing airplanes for the military services and responding to any emergency problems which arose. By 1941 it had changed into an organization which admitted it did development work, while at the same time trying to accomplish at least a minimum of applied research.[63] Over seventy percent of its work was devoted to meeting the emergency needs of the military services. The work load was so heavy that NACA even with its commitment to in-house research started letting contracts for its work, as well as recommending approval for all University and industry requests for more facilities.[64] Even its claim that it did development work was somewhat idealistic. To accommodate the needs of the military services and the aircraft industry, it became an organization which primarily engaged in quick fixes to airplanes which had already been built. The military services essentially directed what research NACA's laboratories would accomplish and established the priority of that research.

This change in the type of work in which it was engaged was accompanied by a change in the workforce which existed at all the laboratories. NACA's ability to keep its staff trained or even aware of the major technical advancements which were being made in aeronautics during the war was limited. The necessity of hiring untrained or poorly trained researchers and technicians because of the manpower shortage only exacerbated the situation. As Abbot pointed out,

> [NACA] had to rely chiefly on newly graduated engineers from four-year courses (usually lower part of classes and from less well known universities). These people did include some who became excellent research people, but mostly they were incapable of research and mistook the testing they had been doing at NACA for advanced scientific research.[65]

In 1936 there were only 340 employees at Langley. Approximately 100 of these were actually researchers. From this number NACA had to fill the leadership positions at two new laboratories. Since there was little, if any, hiring of individuals who could fill these top positions during the war, this left very few experienced researchers responsible for over four thousand employees.[66]

Hunsaker, Lewis, and Dryden, after his appointment in 1947, were strongly committed to returning the laboratories back to their pre-World War II applied research work. A major retraining program was implemented and a deliberate attempt was made to get rid of the poorly trained members of NACA's staff. This attempt was not totally successful for reasons similar to those which had made NACA's commitment to basic research so difficult to achieve in the first place. The revolution in aeronautics which occurred during and after the war and the military services' commitment to "catch up" with the new advancements meant that the end of the war did not completely alleviate the need for NACA to be involved in research on specific airplanes. NACA's failure to keep up with the changes in technology prior to the war meant that it could not afford to ignore the needs of the military services. Some of its resources had to be directed toward meeting these needs, whatever its leaders' desire to return to applied research. The demand for highly qualified scientists and engineers after the war remained high, and NACA's tarnished reputation made attracting the individuals who were available ever more difficult. Although many of the individuals who remained with NACA returned to applied research, some groups of even the most highly qualified researchers were more interested in solving the new development problems associated with the new airplanes. They had no interest in returning to NACA's laboratories and engaging in applied research when they could be engaged in the excitement of major research and development programs.

The success of the supersonic research aircraft programs made dropping them almost impossible and only increased the enticement of development work for NACA's researchers. By the end of the 1940s NACA was an organization which accomplished both applied and advanced engineering research, and its ability to change back to an organization whose primary work was applied research was decreasing as it entered the 1950s.

TECHNOLOGICAL CHANGE: ITS IMPACT ON NACA

NACA's leaders may have been able to return the researchers to applied research, if the technological changes of the 1940s had not created such an enormous need for the assistance it gave on the supersonic research aircraft projects. The discovery of the German advances not only brought NACA's reputation into question, it also hurt the military services' credibility. Both the services and Congress were committed to regaining the nation's leadership in aeronautical research. This commitment coupled with the rapid technical change which was occurring in the field meant that costs of any project was not as important as completing the project. The military services needed a major achievement in as short a period of time as possible. Breaking the speed of sound, since it could be understood by all Americans as a major breakthrough, became one of the major objectives of the new programs.

The problem was not as much one of technology, as the lack of knowledge about the impact of high speeds on the airplane's structure and pilot. NACA's usual procedure, when faced with a problem preventing the advancement of aviation, was to use its wind tunnels to test the various designs, but wind tunnel technology had not kept pace with advancements in aeronautics. Reliable measurements could not be obtained between Mach .07 and Mach 1.3, and this was the area of most concern to the researchers.[67] If NACA was to meet the needs of the military services, it had to find another method of gathering aerodynamical data. The research aircraft proposal, while more expensive, had a major advantage. It would provide the data not available through wind tunnel testing.

These events played a role in NACA's adoption of the new advanced engineering task, but the new research's actual impact on the organization came after its adoption. The high level of uncertainty surrounding any research and development project was particularly evident in projects involving the production of the new airplanes. The speed of technological change and the lack of understanding of the new technologies meant that the final airplane could be radically different from the original design. As Price argued,

> Very few complex systems are ultimately developed along the lines laid down at the beginning; for example, more than half the aircraft developed since the second World War were finally built with engines quite different from those originally planned for them.[68]

The consequence of this uncertainty was that the engineer, whether originally engaged in applied research or not, was drawn into the development phase of the project. All the design problems could not be solved prior to the start of the project. While the time-consuming, well edited NACA reports remained useful to NACA's clients, they were not adequate during a period when time was so important to the participants and the actual problems might not be known until the project was already started.

It was the increase in complexity of the new airplanes which changed the approach to aeronautical research and introduced the advanced engineering group and other NACA researchers to new methods of organizing their work. The federal government's commitment to using industry for its work whenever possible coupled with the increase in the number of subsystems (e.g., propulsion, communications, navigation) and their complexity meant that NACA was only one group of many groups from different organizations involved in the production of the new airplane. Producing a new airplane, after the second World War, became as much of a management problem as a technical problem. The military services adopted a number of management tools to solve these management problems, two of which brought NACA even closer to the development phase of the research and development projects. The first, "concurrency," involved the

> Parallel advances in research, design, testing, and manufacture of vehicles and components, design and construction of test facilities, testing of components and systems, expansion and creation of industrial facilities, and the building of launch sites...[69]

The new management technique was adopted to expedite the production of new weapons systems during a period when the step-by-step process resulted in an obsolete airplane before it was even produced. It also meant that individuals, such as NACA's researchers, who were generally only involved in the research process, became actively involved in all aspects of the production of a new airplane or missile system. In the process at least some of NACA's researchers were becoming accustomed to new methods of research and accomplishing their work activities.

The second management tool involved the development of formal and informal administrative arrangements to coordinate the various project subsystems. As Hallion argued,

> One area in which the research-aircraft program contributed to the future was that of research organization...As the research activities of the X-1 and D-558 at Muroc expanded, so did the need for tighter organization, with the activities of the other NACA research centers...[In 1948 this resulted in the] formation of a Research Airplane Projects Panel with representatives from the various NACA laboratories...Later, in 1954 when initiating development of the X-15, NACA, the Air Force and the Navy formed a special three-man X-15 steering committee better to administer the development program on the airplane. Of particular importance, however, was the tight organizational relationship between NACA, the military services, and private industry in the development and testing of the research airplanes.[70]

NACA's advanced engineering group was not only actively involved in projects which were changing the nature of the airplane, they were also being trained in the new management techniques which were adopted to produce the new planes. NACA's leaders made few changes to accommodate the new research activities, but at least part of its staff was becoming accustomed to time schedules, set objectives, priorities established by others, and new management techniques more representative of a development organization than an applied research organization.

NACA'S LEADERS:
THEIR IMPACT ON THE ORGANIZATION

The period of crisis which the organization found itself in during the 1940s, the changes in the composition of the workforce, and the technologies changes which occurred all acted as stimuli to the creation of the 1950s organization, but these factors only partially explain the development of this organization. The specific steps which were taken in response to the above changes were made by NACA's leaders, and these were not the same leaders who brought NACA into this period.

The membership of the Advisory Committee, which had been stable for many years, began to change in 1937, and many of the new members had been former critics of both NACA's research programs and its failure to coordinate adequately the aeronautical research programs of the universities and industry. Ames and Lewis, after the departure of Munk, had done little with regard to developing a research program for NACA. They had not been interested in coordinating the research programs of industry and the universities except informally through the technical committees after 1926. Perhaps more important for the future of NACA, both Ames and Lewis refused to acknowledge that changes were occurring in the airplane. In 1926 they were confident enough to argue that the

> time had arrived when [the] main theoretical foundations have been laid and we may in the future expect to find extensions of and additions to existing theory rather than new fundamental conceptions...[71]

They not only dismissed the work of the Jet Propulsion Laboratory on liquid-propelled rocket engines, but recommended against the Army funding a request for wind tunnels for the laboratory in 1938.[72]

Edward Warner, the former Langley employee, who had been a member since 1929, had been pushing unsuccessfully for changes in NACA's policies toward representation of universities and industry. After 1935 Charles Lindbergh, another Advisory Committee member, joined Warner in criticizing the policies of NACA, but he focused on the lack of engine research at Langley. In 1938 these two individuals were joined by Jerome C. Hunsaker of MIT and Vannevar Bush of Carnegie Institution. Hunsaker, who for many years had been a critic of NACA, felt that its research program should be broadened, the committees should provide more representation to the aviation community, and that more research contracts should be let to universities. In addition, he was critical of the quality of reports produced by Langley.

The new members brought in new ideas with respect to how NACA should be run and were more willing to play an active role on the Advisory Committee than the older members had been. Such changes as the industrial representation on the Advisory Committee, written formal procedures, expansion of NACA's research program, and additional laboratories were made by these leaders. More important to NACA's future, though, was their appointment of Dryden in 1947. Dryden from the beginning found the co-equal rule which had existed between Victory and Lewis unacceptable. He was used to the traditional structure at the National Bureau of Standards and was not willing to share his authority as Director with Victory. His rejection of the informal rule worked out between Lewis, Ames, and Victory ended with his being given legal authority over the entire organization. It was at Dryden's direction that the technical committees become more knowledgeable and effective, that the organization became more systematic about its development of research programs, and the formalization of the procedures discussed above occurred.

FEDERAL MANAGEMENT POLICIES AND NACA

NACA's leaders were able to adjust to the technical changes which had occurred, as well as the changes in the aeronautical research community. By 1956 its appropriations requests were being approved; it had regained the confidence of the military services; and it had found a place in the new aeronautical research community. It was the change in the federal management policies which presented NACA's leaders with an unsolvable problem--that is, unless they had been willing to give up their method of controlling and directing the activities of their researchers.

NACA throughout its history had been subject to criticism because its committee / agency structure did not fit the more accepted conception of an efficient organizational structure. This criticism did not end in 1927. In 1937, a study by Brookings for the Senate Select Committee to Investigate the Executive Agencies of Government concluded that NACA's committee structure was inefficient and did not provide the President with adequate control over government funds.[73] NACA's leaders responded by arguing that the nature of their work required that those individuals responsible for making decisions within the organization be scientists and engineers because individuals without this background were unable to evaluate technical proposals and their relationship to the advancement of aviation. The committee structure provided NACA's leaders with the advice of experts from many different fields without any cost to the government. They also argued that their performance was not in question and this was ample evidence that their structure was efficient. The response of Brookings to this argument provides some indication of the problems facing NACA's leaders when trying to respond to what was essentially an ideology.

> It seemed to the staff of our Government Research Division ...that, whatever might be the efficiency with which the N.A.C.A. has been conducted as an independent agency, its independent status could hardly be justified in terms of effective permanent organization. The problem was studied solely in terms of general principles of organization. The fact that the committee had been of a unique character, and that it has thus far functioned effectively, did not seem a sound reason for recommending that it be maintained indefinitely as an independent establishment.[74]

Before the second World War, NACA's leaders had been able to ignore these criticisms, because NACA had friends in Congress who provided it with adequate support, but the situation changed after the war both because its competence was in question and because Congress began to pass legislation setting personnel ceilings and standardizing the federal government's operating procedures.[75] Congress was aided in these attempts by changes in the Executive Branch and the growth in power of the oversight agencies in NACA's environment.[76]

The rejection of NACA's structure by the Executive Branch was shown by President Truman's veto of the National Science bill in 1947.

> Full Governmental authority and responsibility would be placed in 24 part-time officers whom the President could not effectively hold responsible for proper administration. Neither could the Director be held responsible by the President, for he would be the appointee of the Foundation and would be insulated from the President by two layers of part-time boards.[77]

When the Bureau of the Budget, under Harold D. Smith, began to examine the structure and procedures of federal agencies, organizations such as NACA came under surveillance for the simple reason that they did not have the "proper" structure. The Bureau of the Budget took this one step further by arguing against the scientists' claim that they needed more autonomy than other federal workers and rejected the notion that scientists must head scientific organizations. As Willis Shapley, the Bureau of the Budget analyst who handled NACA's appropriations request, argued,

> A specialized scientific agency like the NACA requires somewhere in the top command someone whose qualifications extend beyond the scientific fields covered by the agency, and while some members of the main committee meet this need in part, I believe that it would be desirable if either the head or the assistant head of the agency be a nontechnical person. The Research and Development Board is learning the hard way that the management of a scientific research and development program does not require scientists, but administrators, and it is well known that it is very rarely that one finds scientists who are also administrators.[78]

NACA's leaders might have been able to ignore the Bureau of the Budget's philosophy of management if it had not been required to obey the Civil Service Commission's personnel regulations. NACA's standardization of job descriptions, acceptance of grades, and salaries based on these grades, which were slowly undermining its structure based on evaluation by colleagues, were all responses to the Civil Service Commission's personnel regulations. The fact that the Bureau of the Budget was given the authority to set personnel ceilings only made their attempts to cope with the new regulations more difficult.

It was the General Accounting Office which increasingly made it more difficult for NACA to avoid these two agencies, and it was known for its ability to do this. The General Accounting Office, at the request of Congress, began to audit NACA's activities. It, as other evaluators, found NACA's performance satisfactory.

> ...NACA activities are generally conducted satisfactorily. This is attributable, we believe, to the high quality of its employees, their high morale, and their sincere interest in the development of aeronautics. Although in isolated instances there is evidence of uneven distribution of workload, general overstaffing is not evident in the agency.[79]

But funds appropriated for salaries and expenses were being spent on construction and equipment; its accounting was "only a historical record of expenditures and internal auditing did not exist"; there was inadequate control of the laboratories' operations; "inadequate direction and control of laboratory contracting activities"; and individuals whose primary task was non-administrative were performing administrative tasks.[80] The problem, in the General Accounting Office's auditor's mind, was that NACA was only performing those administrative functions required by the Bureau of the Budget, the General Accounting Office, and the Civil Service Commission.

> Positive controls through inspection and reporting do not exist to the extent necessary in a decentralized operation of this nature. Management decisions are therefore based to a large extent on telephone calls, correspondence, personal contact, and the general information provided by the budgetary system.[81]

This, they felt, stemmed from the fact that NACA's research philosophy of freedom from direction and control had been extended to the administrative activities of the organization.

NACA had two options when faced with these criticisms. It could either totally reject them or it could establish a program or organization unit which made the organization at least look like it was carrying out the recommendations or directives of these organizations. Two of its responses to the oversight agencies are indicative of its attitude toward recommendations that it tighten up its procedures and control structure. The recommendation of the General Accounting Office that it integrate its accounting and budgeting so that top managers could control its expenditures better "was rejected on the basis that it would cause undesirable rigidity in the conduct of the operations and would also result in additional expense to operate the accounting system."[82] This response was given two years after the General Accounting Office first made the recommendation. During the first year, NACA did implement a new accounting system, but it didn't meet the General Accounting Office's standards.

A request by the Bureau of the Budget that NACA implement a Management Improvement Program with the objective of developing "standard organizational patterns for NACA administrative Offices," resulted in the creation of a Management Improvement Office at headquarters and Lewis. Ames and Langley made little if any response. The comment on the last page of the 1953 report written in response to this request and the Bureau of the Budget's questions about why a federal-wide awards program had not been implemented provides some indication of the staff's attitude toward the whole program. It stated that NACA's staff felt the awards program to be unnecessary at NACA, "because it assumes creative and innovative work from all its employees."[83]

NACA's responses, though, were not solving the problem. They were only diversionary strategies. NACA's leaders by the mid-1950s faced what from their perspective must have been an unsolvable problem. On the one hand, their internal management system was based on a belief that scientists and engineers could only be managed by other scientists and engineers. Their researchers accepted their decisions about the organization's research programs because those individuals making the decisions about their work understood the needs of aeronautical research and the relationship bewteen the researchers' work and the advancement of aviation. On the other hand, they were faced with demands from external actors which made maintaining their method of controlling the activities of the organization very difficult if not impossible. In the 1950s they had found apartial solution by continuing to promote for research achievements and maintaining the committee structure, but this was becoming increasingly more difficult. As Abbot argued,

> ...times have changed. The NACA-type organization was well suited to promote scientific research in an important area at a time when scientific research was still something of a novelty in government, and the expenditures for it were not so large as to be of very much concern to anyone. It is scarcely conceivable that such a situation will ever arise again.[84]

NOTES

[1] These changes were made through amendments to NACA's original legislation. Public Law 908 (70th Cong., 1st sess.) approved March 2, 1929 (45 Stat. 1451) increased the membership to 15. Public Law 706 (75th Cong., 2d sess.) approved June 23, 1938 (52 Stat. 1027), *Civil Aeronautics Act of 1938*, required that two representatives from the Department of Commerce be members. Public Law 549 (80th Cong., 2d sess.) approved May 25, 1948 (61 Stat. 600) increased the membership to 17 and also limited the tenure of non-government members to 5 years. The Air Force representative replaced the Army representatives and a representative from the Department of Defense was added. This left the government positions at 10 and the non-government at 7.

[2] The laboratories were located throughout the United States as follows: Ames, established in 1941 at Moffett Field, California, is currently called Ames Research Center; High Speed Flight Research Station, established in 1946 at Edwards Air Force Base in California, is today the Hugh L. Dryden Flight Research Center. Langley, established in 1917 at Langley Field near Hampton, Virginia, is now the Langley Research Center. Lewis, established in 1942 at Cleveland, Ohio, is Lewis Research Center today. Pilotless, established in 1945 at Wallops Island, Virginia, is currently the Wallops Flight Center.

[3] Vannevar Bush replaced Ames as chairman in 1940, but was only chairman for a year. Hunsaker replaced him in 1941 and remained chairman until 1956. James H. Doolittle, a Ph.D. from MIT, retired Lieutenant General from the Air Force and former Director of Shell Oil Company, was chairman from 1956 until NACA became NASA. As will be discussed below, 11 of the then 15 member Advisory Committee were appointed between 1937 and 1939.

[4] This was accomplished through formal changes in NACA's rules and regulations in 1944 and 1949.

[5] Dryden was chairman of the NACA subcommittee on High Speed Aerodynamics at the time of his appointment. He was also a member of the Air Force's Scientific Advisory Board, the National Academy of Sciences, and former member of the National Defense Committee. He worked under Dr. Ames and had authored numerous NACA technical reports. See Richard K. Smith (ed.), *The Hugh L. Dryden Papers 1898-1965: A Preliminary Catalogue of the Basic Collection* (Baltimore, Md.: The Milton S. Eisenhower Library, The Johns Hopkins Univ., 1974).

[6] Dryden was designated as the head of the agency by a formal change in the rules and regulations in 1949.

[7] Jerome Hunsaker to Harry S. Truman, February 7, 1949. As will be discussed below, NACA's structure was strongly criticized from the 1930s on. Since many politicians believed that private industry could do everything better than the government, the statement was a rather obvious attempt on NACA's part to associate its structure with private industry's method of accomplishing its work.

[8] "Functions and Responsibilities of Standing Committees and Subcommittees of the National Advisory Committee for Aeronautics," prepared by Hugh L. Dryden, January 1, 1950, p. 1. Copy in Alex Roland, "Research by Committee," Comment Edition, April, 1980, Appendix H.

[9] Dryden, op. cit., p. 5.

[10] Ibid.

[11] These procedures are discussed below.

[12] See General Accounting Office, "Report on Survey of the National Advisory Committee for Aeronautics," forwarded by cover letter from Frank L. Yates, Acting Comptroller General of the U.S. to John Phillips, February 20, 1953, for a discussion of the Management Control Information System.

[13] Ibid., p. 50.

[14] See W. R. Sears to Jerome Hunsaker, March 30, 1948; Hugh Dryden to Jerome Hunsaker, April 13, 1948; and Dryden to Sears, April 13, 1948, for a discussion of the problems associated with tracking aeronautical research after World War II. Part of NACA's problem was that it existed during a period in which information problems were increasing. Today this type of tracking is accomplished through data management information systems such as the Defense Technical Information Center, which enable scientists and engineers to identify research in progress through the computer.

15 The semi-annual reports were a required part of the Management Control Information System. The monthly reports simply listed by title all the projects in which the laboratories were engaged. Dryden made the monthly reports a requirement in response to continual demands for more information regarding the laboratories' projects from industry. The laboratories' unwillingness to supply complete information as industry desired resulted in a list of titles with no description.

16 See General Accounting Office, op. cit., for a discussion of this process.

17 As will be discussed below, NACA's failure to keep abreast of all aeronautical research was demonstrated quite clearly to all participants when the German aeronautical advancements became known during World War II.

18 General Accounting Office, op. cit., p. 17.

19 See Clarence H. Danhof, Government Contracting and Technological Change (Washington, D.C.: The Brookings Institution, 1968) and Merton J. Peck and Frederic M. Scherer, The Weapons Acquisition Process: An Economic Analysis (Boston: Harvard University, 1962) for a discussion of the problems surrounding government contracting for research and development work.

20 The military services established contract relationships with scientists during the Second World War which were very productive for both groups. After the war, scientists continued to work for the military services and other federal agencies. The success of these relationships mitigated at least some scientists' fear that working for the federal government would end their research autonomy. Don K. Price, The Scientific Estate (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1965); Daniel S. Greenberg, The Politics of Pure Science (New York: New American Library, 1967); and A. Hunter Dupree, Science in the Federal Government (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1957).

21 The National Defense Expediting Act of July 2, 1940 (P.L. 703, July 2, 1940) and the First War Powers Act of 1941 (Title II, Act of December 18, 1941, 55 Stat. 83, implemented by Executive Order 9001, December 20, 1941) provided the services and any government department designated by the President with the authority to negotiate, amend, or modify contracts if America's war effort would be facilitated. The two acts permitted the government to negotiate contracts when a high level of uncertainty surrounded the development of a final product. Danhof, loc. cit., discusses these acts in more detail.

[22] Unitary Wind Tunnel Act of 1949, Public Law 415, 81st Cong., October 27, 1949. The history of this act began in 1944 with a request by the Army Airforce for funds for a research center. After it became obvious that NACA and the Army were in competition for funds, it proposed a combined plan for research facilities. The original estimated cost was $2,200,000,000. Congress appropriated $253,000,000. NACA's Thirty-Ninth Annual Report, pp. 4-6, contains a short history of this proposal. The Department of Defense also used the California Institute of Technology's Jet Propulsion Laboratory for some of its research needs.

[23] General Accounting Office, op. cit., p. 36. Eighty to eighty-five percent was applied research directed at design problems of specific airplanes. Seventy percent of this applied research was in response to specific military requests.

[24] See Richard P. Hallion, Supersonic Flight: The Story of the Bell X-1 and the Douglas D-558 (New York: The MacMillan Co., 1972); and Joseph A. Shortal, A New Dimension: Wallops Island Flight Test Range: The First Fifteen Years, NASA Reference Publication (Washington, D.C.: National Aeronautics and Space Administration, 1978).

[25] The sound barrier was first broken by Air Force Captain Phillip E. Yaeger in the X-1 research airplane. It was built by Bell Aircraft Corporation and was part of a joint NACA / Airforce project. See Hallion, ibid.; David A. Anderton, Sixty Years of Aeronautical Research 1917-1977 (Washington, D.C.: NASA, 1980); and NACA's Forty-third Annual Report "High-Speed Flight Research," pp. 5-10.

[26] Hallion, op. cit., p. 196.

[27] Hallion, ibid., discusses John Stack and his achievements. Also see John V. Becker, The High-Speed Frontier: Case Histories of Four NACA Programs, 1920-1950 (Washington, D.C.: NASA, 1980) for a more personal discussion. Becker worked for Stack.

[28] The blunt nose design was also used on Mercury and Apollo space vehicles. See Lloyd S. Swenson, Jr., James M. Grimwood, and Charles G. Alexander, This New Ocean: A History of Project Mercury (Washington, D.C.: NASA, 1966) for a discussion of Harry Julian Allen.

[29] Anderton, op. cit., p. 35, describes the discovery of the area rule.

30 See NACA's <u>Thirty-third Annual Report</u>, loc. cit.

31 The Committee's chairman was H. Guyford Stever. James A. Van Allen, Wernher von Braun, Milton O. Clauser, James R. Dempsey, William H. Pickering, Hendrick W. Bode, and William Randolph Lovelace were chairmen of the subcommittees under this committee.

32 During the 1920s NACA had very little competition from other research organizations. During and after World War II, small research laboratories, such as the Jet Propulsion Laboratory and MIT Radiation Laboratory, became a permanent part of the federal government's research and development structure. These laboratories provided an environment similar to NACA's but avoided the personnel regulations and pay limitations which so plagued NACA during this period. Peck, op. cit., and Dupree, op. cit., discuss the changes in the federal establishment for research.

33 See Braithwaite to Shapley, "History of Super-Grade Positions: NACA / NASA," April 23, 1968, NASA History Office Files, for a discussion of NACA's pay problems. Roland, op. cit., Chapter 11, discusses NACA's funding and personnel problems in the 1950s.

34 NACA's <u>Annual Report</u> for 1956.

35 This section relies heavily on Swenson, op. cit., and Edwin P. Hartman, <u>Adventures in Research: A History of Ames Research Center 1940-1965</u> (Washington, D.C.: NASA, 1970).

36 Swenson, op. cit., p. 85.

37 Becker, op. cit., p. 86.

38 Shortal, op. cit., p. 159.

39 Although not specifically stated in NACA's Rules and Regulations, this rule was apparently also extended to the staff, since Reid, the Director of Langley, was also chairman of one of the Aerodynamics subcommittees. A complete listing of all committees and their chairman is given in Roland, op. cit., Appendix B.

40 Shortal, op. cit., p. 161.

41 The Department of Defense was created in 1947 to provide the United States with a unified military establishment. A separate Air Force within DOD was created at that time. The National Security Act of 1947 (Public Law 253, 80th Cong.).

42 Wernher von Braun was the Director of the Army's space program at the Army's Ballistic Missile Center. See note 22.

43 At the beginning of World War II the aircraft industry ranked 44th in dollar output in the United States. At the end it was first. See John B. Rae, Climb To Greatness: The American Aircraft Industry, 1920-1960 (Mass.: The MIT Press, 1968). The political power of the industry during the post-war period is best evidenced in the House Report accompanying the Unitary Wind Tunnel Plan Act of 1949.

> Inasmuch as the primary purpose of the facilities to be allocated to the NACA is to provide wind tunnels necessary for testing aircraft and guided missiles under development by industry, it is the sense of the committee that strong language should be incorporated in the bill which will insure that these facilities, although allocated to the NACA on a so-called housekeeping basis and staffed by its personnel, shall be available to satisfy industry's requirements for the testing of experimental models in the course of development of new aircraft and missiles. It is absolutely essential that tests be scheduled and conducted in accordance with industry's requirements and that laboratory time be allocated with proper emphasis upon the requirements of the various contractors engaged in the development of new types of military aircraft for the services.

U.S. Congress, House, Committee on Armed Services, H.R. 1376, 81st Cong., 1st sess., October 4, 1949, p. 4.

44 Roland, loc. cit.

45 As a retired Lieutenant General from the Air Force and Director of the Shell Oil Company, he had stronger military and industrial ties than had previously been acceptable for the chairman of NACA. His appointment was the final blow in a long string of events from the early 1940s which began NACA's tradition of not appointing industry members to the Advisory Committee.

46 Roland, op. cit., p. 332, describes what turned into a personal feud between Thomas and Hunsaker and at times other NACA leaders. Arthur L. Levine, "United States Aeronautical Policy, 1915-1958: A Study of the Major Policy Decisions of the National Advisory Committee for Aeronautics," Ph.D. Dissertation, Columbia University, 1963, argued that whatever NACA's disagreements with Congress prior to this time, it had enjoyed a very friendly relationship with Congress and had escaped much of the Congressional oversight inflicted on other government organizations for this reason.

47 The General Accounting Office Reports for 1953 and 1955 can be reviewed at the Headquarters History Office, Washington, D.C.

48 See Appendix A for appropriations.

49 The reasons for this are difficult to determine. Thomas's lack of support as well as NACA's inability to justify its continued existence in light of the small private research organizations performing similar work and the success of the large research and development organization which accomplished their work by letting contracts, all probably played a role. NACA's appropriations requests began to be improved without any trouble again in 1956.

50 NACA's Annual Reports for 1935 through 1936 describe the various steps in this process.

51 Ames was approved in 1939 and staffed by Langley employees. Lewis was approved in 1940 and was supposed to be NACA's response to the need for propulsion research. It created problems for NACA in its early years, because of NACA's lack of experience in this type of research. George J. Mead, a retired aircraft executive and the first industry representative to be appointed to the Advisory Committee, was appointed because of these problems.

52 The impact of this discovery was psychological as much as anything else. Part of the reason for the U.S.'s neutrality prior to entering the war was based on the feeling of invincibility generated by its distance from Europe. Neither the German rocket or jet program had an impact on the outcome of the war, but they did result in deep criticism of the military services after the war.

[53] Theodore von Karman at the Jet Propulsion Laboratory began to work on liquid-propelled rocket engines in the belief that the piston engine propeller-driven airplane had reached the peak of its technological development and that further advancements in aeronautics would require a different type of engine. NACA's leaders dismissed what they were doing and recommended against the Army's funding a request for wind tunnels for the laboratory in 1938. The request was made at the same time NACA was trying to obtain approval for two new laboratories.

[54] Ira H. Abbot, "A Review and Commentary of a Thesis by Arthur H. Levine entitled 'U.S. Aeronautical Research Policy, 1915-1958,' " Unpublished Manuscript, 1964, attempted to provide an explanation for NACA failure, but admits there was really no justification for the failure. Levine, op. cit., argued that part of the problem was NACA's feeling that its methods were the best and a total unwillingness to listen to outsiders. Roland, op. cit., also discusses the failure and notes that NACA, the military services, and engine manufacturers had agreed shortly after NACA was created to give private industry responsibility for engine development and that it would have been difficult for NACA to engage in propulsion research, given this agreement. The problem, as Hunsaker noted in 1956, was that industry was interested in standardizing the airplane, not in radical departures from the existing engine. Jerome C. Hunsaker, "Forty Years of Aeronautical Research," in Annual Report of the Board of Regents of the Smithsonian Institution, 1955 (Washington, D.C.: GPO, 1956).

[55] Rae, op. cit., argued that some of the former engine manufacturers were met with the same directives.

[56] See note 21.

[57] NACA, "Guided Missiles, NACA Program and Facilities," December 15, 1944. National Archives, Record Group 255, Washington, D.C.

[58] LeMay to Condon, March 4, 1947, cited in Roland, op. cit., p. 373.

[59] This occurred during the Unitary Wind Tunnel Act controversy.

[60] U.S. Congress, Senate, Special Committee Investigating the National Defense Program, Investigation of the National Defense Program, Senate Report 110, Part 7, 79th Cong., 2d sess., September 3, 1946, p. 147148.

[61] These proposals resulted in the Bell X-1 and Douglas D-558 programs discussed above.

[62] See Hallion, op. cit.

[63] NACA in its *1941 Annual Report* claimed that its task was to: (1) furnish new ideas and (2) develop and apply new ideas. This was a change from its earlier reports which denied that it was doing any development work.

[64] Lewis was given contract approval authority in 1943. Minutes of the Executive Committee Meeting, May 20, 1943 and June 16, 1942.

[65] Abbot, op. cit., p. 172. Industry also had difficulty during this period obtaining qualified personnel. See Rae, op. cit., pp. 149-157.

[66] See Abbot, op. cit., p. 171, for a discussion of this problem.

[67] See Hallion, op. cit.

[68] Price, op. cit., p. 36.

[69] Swenson, op. cit., p. 25.

[70] Hallion, op. cit., p. 196.

[71] NACA, *Twelfth Annual Report*, p. 57.

[72] See note 53.

[73] Harold G. Moulton to Vannevar Bush, June 3, 1940. Brookings Institution for Government Research, Report 12, published as Senate Select Committee to Investigate the Executive Agencies of Government, Senate Report 1275, 75th Cong., 1st sess., 1937.

74 Moulton, ibid.

75 Joseph P. Harris, Congressional Control of Administration (Washington, D.C.: The Brookings Institution, 1964), chapter 7, discusses Congress's attempts to control federal personnel practices. It is easy to blame the agencies doing the enforcement, but many are only carrying out their mandates. Apparently, the Civil Service Commission of the 1950s was not the same organization it is today. In 1952 its Annual Report stated:

> The last few years have seen a growing tendency on the part of Congress to legislate on the details of personnel administration. The Commission believes that by going beyond statements of policy and legislative intent to spell out procedures of carrying them out, Congress often creates a rigidity of operation and administration that interferes with efficient personnel management in the executive branch. Administrative rules and regulations are flexible and easily altered to suit changing conditions. Personnel procedures set by law can be changed only by new legislation after a necessarily lengthy process.

U.S. Civil Service Commission, 69th Annual Report (1952), p. 20. Cited in Harris, p. 167.

76 The Bureau of the Budget and General Accounting Office were established through the General Accounting Act of 1921 (42 Stat. 20). BOB was relatively ineffective until 1939 when it was transferred to the Executive Office of the President by Executive Order 8248 signed September 8, 1939, and placed under the direction of Harold D. Smith. The General Accounting Office remained rather ineffectual until the passage of the Legislative Reorganization Act of 1946, and the Budget Accounting Procedures Act of 1950 made it responsible for providing Congress with expenditure analysis of all federal agencies. After 1946 Congress began to use these reports. The Civil Service Commission was established by the Pendleton Civil Service Act of 1883 (16 Stat. 514). Until the 1940s it largely delegated its personnel responsibilities to the agencies. The Civil Service Classification Act of 1949 extended its authority.

77 "Memorandum of Disapproval" accompanying pocket veto of the first bill to create a NACA-type structure (H.R. 5448, 79th Cong., 2nd sess.). This plan was drafted by Bush and Victory. The final NSF bill mandated a director with a consulting board. It was passed in 1950 (PL 81-507). See Congress and the Nation, Vol. 1, Congressional Quarterly Service (1965), pp. 1203-1204; pp. 1199-1200. The Atomic Energy Commission established in 1946 was directed by a civilian commission, but these

members were full-time paid employees. Its passage, though, was preceded by an argument over whether there should be civilian or military control of the agency, not over the particular structure of the organization. See Congress and the Nation, ibid., p. 246.

78 National Security Branch (W. H. Shapley) to Staats, "Proposed Amendments to NACA Regulations Submitted February 7, 1949," May 11, 1949. Cited in Roland, op. cit., p. 340.

NDRC was created in 1940 to bring together the various skills and facilities necessary to apply scientific advancements to the war effort. NACA was the model for its creation, and Victory wrote the draft for the Executive Order which established it. OSRC was created because of deficiencies in NDRC. NDRC had a bureaucratic structure with a single director. It was successful.

79 GAO Report, 1953, op. cit., p. 4.

80 Ibid., pp. 9 and 11.

81 Ibid., p. 42.

82 GAO Report, 1955, op. cit., pp. 11-12.

83 NACA, Report on the NACA Management Improvement Program, Fiscal Year 1953, Washington, D.C., copy in NASA History Files, p. 2.

84 Abbot, op. cit., p. 208.

Chapter 4

NASA IN THE LATE 1960s

INTRODUCTION

The launch of Sputnik I on October 4, 1957 sent shock waves through the nation and brought demands from both Congress and the American public for a similar feat by the United States. It also provided NACA's leaders with an answer to their budget and internal management problems. Responsibility for the new space program would provide more than ample justification for its continued existence and increases in its appropriations. It would lessen at least some of the demands for personnel and administrative changes.

In January of 1958, NACA's leaders proposed that it be given responsibility for the research necessary to provide the nation with a space program equal to that of the Russians. NACA's role, according to the proposal, would be similar to that which it filled in the research aircraft program. The military services would manage the program.[1] Whatever NACA's leaders' feeling about their role, the results were quite different than they had envisioned. NACA was transformed into the National Aeronautics and Space Administration in July of 1958.[2] The new organization was to be managed by a single administrator responsible to the President with complete responsibility for the new space program.

NASA's first ten years were years of enormous achievements. They also were years in which the worst fears of NACA's leaders came true. In 1961 James Webb, a non-technical administrator, was appointed. By 1965 NASA had lost the support of not only many of its in-house scientists and engineers, but also many scientific groups outside of the organization.

In 1965 Congress began cutting its appropriations and personnel levels, and by the end of the 1960s it had entered a decline which continues to the present time.

This chapter examines NASA in the late 1960s in an attempt to show how its leaders' failure to understand the importance of scientists and engineers to the research and development process, as well as the importance of an internal management structure which would meet the needs of these individuals, ended with its decline by 1955. The first section presents an examination of NASA as it existed in the late 1960s. It is primarily descriptive and there is no attempt to explain why it had developed as it did. The second section examines the factors which played a role in the development of this organization.

I

THE ORGANIZATION OF NASA IN THE LATE 1960s

As with our two previous periods, the most visible change between the 1950s and the 1960s was the change in size and complexity of the organization. NASA in 1968 employed over 32 thousand full-time employees and over 200 thousand contract employees. NACA, shortly before it was transferred to NASA, employed only eight thousand full-time employees.[3] This growth in size was accompanied by a change in the level of appropriations available. NASA had more than 4.5 billion dollars available for its operations in 1968. NACA's highest appropriation was slightly over 100 million dollars. The number of Research Centers had increased to nine, with one Research Station and one government-owned facility under contract.[4]

NASA's structure in 1968 was significantly different than NACA's. As Figure 3 shows, the headquarters unit had grown more complex and the distinction between support and research activities was not as clearly defined. James Webb, a lawyer and former Director of the Bureau of the Budget with experience in the aircraft industry, had been appointed Administrator of NASA in 1961 with full responsibility for its operations.[5] The Advisory Committee was gone and there were more layers of authority.

The chart, though, does not show the actual division of responsibilities within NASA. At its simplest the organization could be described as having a two-tier structure with a division of responsibility similar to that between the Advisory Committee / Headquarters tier and the Laboratories tier when NACA existed.

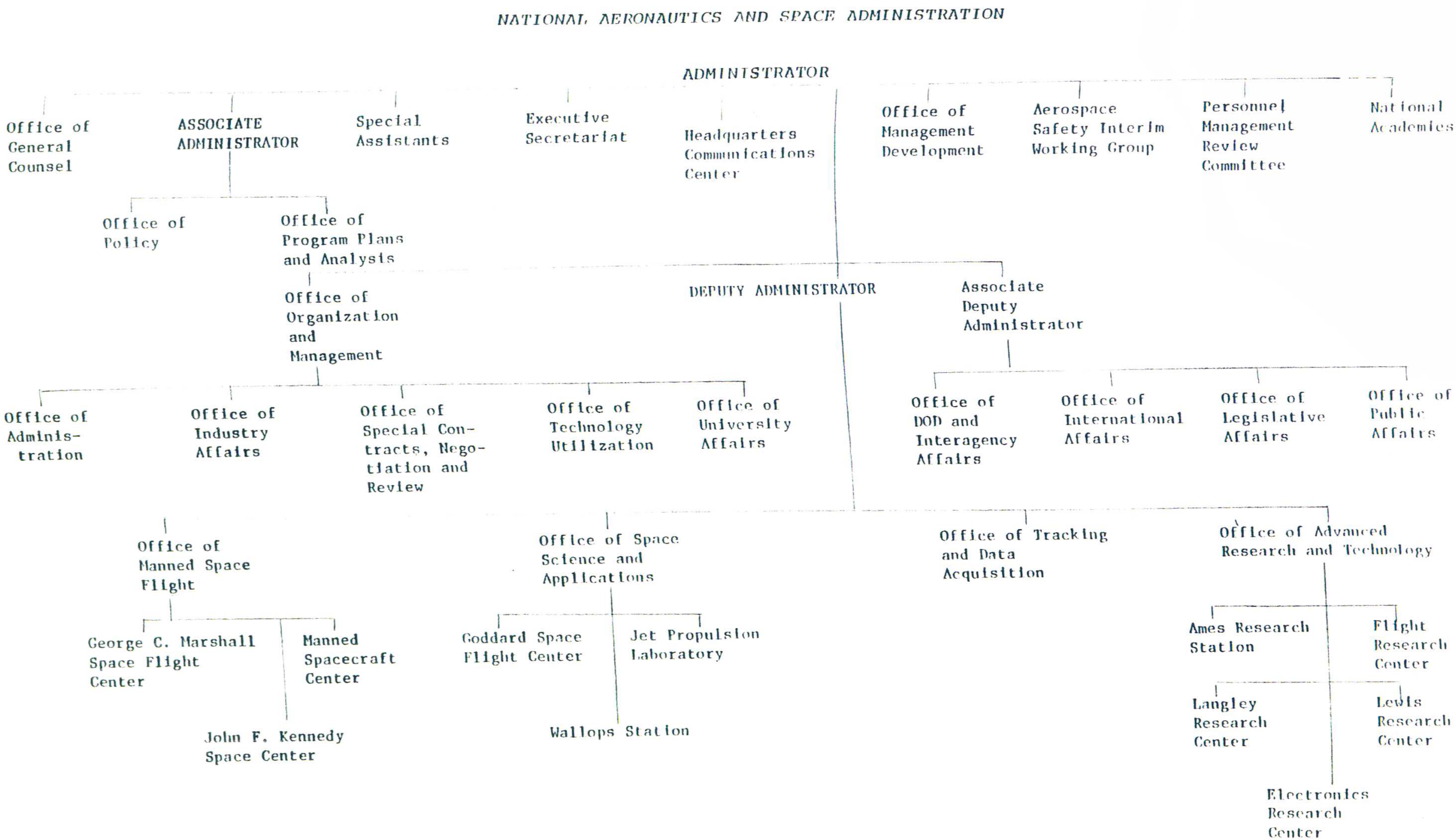

Figure 3

NASA Organization Chart, 1967

The headquarters unit was responsible for general policy decisions; determination of program objectives; integration and review of agency programs; relationships with other organizations; and management functions such as planning, contracting agency-wide, and budgeting. The NASA Centers, as the NACA laboratories in the 1950s, were semi-autonomous with responsibility for the day-to-day operations of the organization. The Center staff supervised and directed the implementation of contracts, generated the ideas for future programs, and managed and recruited their own personnel. Center Directors could reprogram funds within one program area. They were responsible for assigning employees to specific projects and could reassign them when desired. The division of responsibilities was somewhat mitigated by headquarter's responsibility for reviewing the Centers' implementation of those programs which were covered by federal regulations, but even these headquarter's functions were accomplished only through periodic reviews rather than specification of what the Centers should do.

The description of a two-tier structure still remains a simplification because it ignores the project management structure which overlay the two-tier headquarters / center relationship and cut across all traditional authority and communications structures.[6] Project management was the mechanism through which NASA accomplished its research and development activities. The Headquarters Program Offices had responsibility for specific program areas (e.g., Manned Space Flight Program) and the projects (e.g., Apollo) necessary to meet program objectives. The implementation of project management varied among the program offices, but all offices were responsible for resource allocation for the various projects under their jurisdiction, review of project implementation, contact with applicable Congressional committees, and integration of the various projects within their jurisdiction into meaningful programs. Although each program office had specific centers under its jurisdiction, all centers also performed work for program offices other than the one to which they were assigned.

The link between the Program Offices and the various centers occurred through the Program Manager located within the Program Office and the Project Manager located at one of the centers. The relationship between these two individuals was a mirror image of the relationship between the centers and headquarters. The Project Manager was responsible for the execution of the project and supervision of the contractors. Since projects crossed organizational boundaries, the Project Manager could be responsible for supervising individuals who remained under the direct control of another field installation or organizations outside of NASA. If the project crossed organizational boundaries, one center was appointed lead center with final responsibility for the total project. The Program Offices in 1968 were autonomous units within headquarters and had their own contacts with Congressmen and contractors.

Compounding the problem of understanding how NASA was organized was the fact that the connection between the Administrator and the Program Offices was not direct. As with NACA, responsibility for the administrative and technical aspects of the organization was parceled out between the Office of Organization and Management, the Deputy Administrator, and the Associate Deputy Administrator.

The various groups were integrated somewhat through the use of permanent and *ad hoc* committees and panels which also crossed traditional authority and communications lines. These committees existed both at the headquarters level and the center level, and depending on their purpose were composed of individuals from only one level or all three levels, as well as members from the scientific community, private industry, and other government organizations.

This discussion has largely focused on the relationships between full-time employees of NASA, but NASA had also established relationships with the Department of Defense and private industrial firms which tended to obscure any organizational boundaries. NACA had been involved in a minimal amount of contract administration and thus had little experience with the management of large-scale research and development projects beyond what it had learned through its involvement with the military services on the research aircraft program. Using its authority to request the use of military personnel, NASA was able to obtain the expertise in program management which it lacked. Some of its managers, including the program manager for Apollo, were military men stationed temporarily with NASA.[7] NASA also delegated many of its contract functions to the Department of Defense. The Army Corps of Engineers let contracts for the construction of facilities at Marshall and Kennedy. Although NASA provided the specifications, the Corps supervised and inspected the construction. NASA retained responsibility for the terms of the contracts, technical specifications, and approval of any changes in the contract.[8]

Similar relationships were established with private firms. System engineering work, such as the integration of subsystems, assuring reliability of all components, checking out hardware, preparing specifications and evaluating the Apollo program, were performed by contractors. They were hired to define scientific objectives, establish future objectives, and operate test facilities. Until 1967, they were also used extensively to perform such support work as data processing and maintenance.[9]

GENERAL MANAGEMENT

NACA's Advisory Committee with the assistance of the headquarters unit formulated policies and made general management decisions for NACA. By 1968 these functions were primarily accomplished by three individuals. James Webb was responsible for the administration of all of NASA's activities and final research and policy decisions. He had delegated many of his responsibilities to two individuals, Dr. Homer E. Newell and Harold Finger.[10] Although other individuals had a great deal of power in the organization, it was Finger and Newell who were effectively managing NASA in 1967 and 1968.

Leadership

In contrast to NACA, which essentially used its research authorization process both for approving research and any type of long-range planning, NASA had two separate systems for authorization and planning. Harold Finger, the Associate Administrator of the Office of Organization and Management, reported directly to Webb and was the operating head of NASA. He had been appointed to this position by Webb from the Office of Advanced Research and Technology because of his success at managing various NASA programs and working with other organizations. He was responsible for approving all programs, allocating resources, major contracts, and other support activities. Willis Shapley, Associate Deputy Administrator, who handled NASA's relationships with other organizations, was responsible for assuring that his activities fit Finger's general plan for the organization.[11]

In a discussion of organization changes from 1958 through 1968, Webb adverts to the power of the Office of Organization and Management:

> And we gave this Office of Organization and Management police authorities over the system. We say, 'You've got to prescribe the system, you've got to monitor the system, you've got to audit performance under it, and these fellows can't get the money to go forward without you.'[12]

Finger, according to Webb, was supposed to have the same relationship with other units within NASA as the Bureau of the Budget had with other federal agencies. All Program Offices reported to him rather than to Webb and support offices were directly under his control. He was also a member of the Management Council, which was composed of representatives from all the program and functional offices at headquarters. This Council, along with monthly status meetings, was used to establish agency policy and to review any problem areas within the organization. All programs which involved more than one organizational unit were reviewed by the Council, so that its members knew their status before problems brought the programs to the attention of top management.

Newell was responsible for long-range planning and the integration of numerous proposals for future programs from the centers and Program Offices into an agency-wide long-range plan.[13] Newell had established a planning committee structure similar to NACA's committee structure.[14] Program memoranda were drafted by working panels composed of individuals from headquarters, centers, and major program offices. These working panels were supervised by a Planning Steering Group, composed of headquarters-level planners whose responsibility was to synthesize the various program memoranda into an agency-wide plan. A

Planning Review Committee, composed of Newell, the center Directors, the Deputy Directors of the Program Offices and various Associate Administrators, reviewed all plans and provided guidance and recommendations to the Administrator.[15]

The planning committee structure worked in a manner similar to NACA's subcommittee mechanism, but it was never effective enough to produce an agency-wide long-range plan acceptable to all the participants or to the Executive Branch and Congress, both of whom continued to ask for new ideas which they could support with additional funds.[16]

NASA also had one other source of ideas for new programs. Members of the National Academy of Sciences and the National Academy of Engineers acted as advisors with regard to future NASA programs. In 1968 the only officially recognized group was the Lunar and Planetary Mission Board. This Board, composed of members of the two Academies, as well as representatives from the University community, was supposed to advise NASA on post-Apollo planning, but conflict between its members and NASA's leaders over the content of NASA programs prevented it from fulfilling this objective. By 1969 it had essentially stopped working and was formally disbanded in 1970.[17]

NASA'S RESEARCH AND DEVELOPMENT ACTIVITIES

In contrast to NACA, NASA was responsible not only for aeronautical research, but also "the development, construction, testing and operation for research purpose of aeronautical and space vehicles."[18] Although NACA let some contracts, its work was primarily accomplished by its own researchers in NACA's laboratories. More than 90 percent of NASA's budget was devoted to contracts by the 1960s.[19] Perhaps more important was the difference in their objectives. NACA's work was directed toward improving the quality, speed, and reliability of airplanes. NASA's objective was as much political as scientific. It was established to regain the nation's leadership in space. The mechanism to accomplish this objective was the Apollo program.[20]

By 1968 NASA was engaged in three types of research to meet its objectives. The research previously performed by NACA was continued and generally involved numerous, continuing low-cost projects with no schedules. The projects related to this type of research were performed primarily in NASA's own laboratories, although NASA was letting contracts for a great deal of applied research by the mid-1960s. This was particularly the case for applied research required by the manned space flight program and other reseearch and development groups. In most cases, the applied and advanced engineering projects involved only one center.

The large research and development projects were divided into two types, the manned and unmanned space flight programs. The manned space flight program by 1968 consisted of the Apollo program. The unmanned space program projects were supposed to be directed toward the advancement of science, not toward increasing the nation's technological capability or catching up with the Russians as was the manned space flight program.

NASA's three types of research had some important differences which played a role in the development of the organization. Small applied research projects generally involved only one group of researchers within one center. The space flight programs required the production of a product and the collaboration of numerous organizations in many disciplines, both in the public and private sectors. The large number of organizations required, the interdependence of the various components, as well as the high levels of quality and performance required meant that "precise integration and coordination" of these organizations was required.[21] Control had to be exercised not only over individuals within NASA, but also over the numerous satellite organizations with which NASA had contracts. The uncertainty involved in the performance of their research and development work meant that individual performers had to be allowed some discretion, but the complexity and need to integrate the numerous components required a high level of centralization.

These characteristics exist in all large-scale development projects, but NASA's development projects varied greatly. The Apollo project had a very distinct political purpose. It was attacked by scientists who felt that the nation's resources were being wasted on what they considered a purely political stunt.[22] The unmanned space flight program was more oriented toward scientific and engineering objectives. Although some of the projects had only engineering objectives, such projects as the Voyager space project were attempts to learn more about the universe and were strongly supported by the scientific community.

The manned space flight program was under constant scrutiny by Congress and the Executive Branch. Delays in scheduled milestones and cost overruns were questioned in detail. Some early programs of the Office of Space Science and Applications (OSSA) suffered from the same visibility, but neither Congress nor the American public were as interested in the scientific unmanned space programs as they were in the manned space flight program.

The astronauts, while generating a great deal of interest in NASA, also made the projects more complex and more vulnerable to failure. Assuring the safety of astronauts was given the highest priority of any aspect of the space program. The unmanned space project did not have to have the same level of reliability.

Both programs involved the production of a final product, but not all of the unmanned projects involved more than one center or the collaboration of many disciplines. Some were accomplished within one center and could be completed with a relatively small amount of expenditures compared to the larger space programs. They were less complex, required less integration of components, and could be accomplished in a relatively short time frame compared to the Apollo project. The result of these differences in the unmanned space flight projects meant that some had little resemblance to the manned space flight project, while others were very similar. The Apollo project by 1968 had such a high priority and was so visible and costly that it was in a class by itself.[23] Delays, cost overruns, or system failures brought investigations for both the unmanned and manned programs, and changes in standard operating procedures and contracts, but when failures occurred in the Apollo program, they brought agency-wide organization changes.

THE MANAGEMENT OF RESEARCH AND DEVELOPMENT

NACA's leaders had allowed their researchers a great deal of discretion. The research division at headquarters in the 1950s had no authority over the laboratories' research. What they did provide was a mechanism for informing the Director and the Advisory Committee of the agency's progress with regard to aeronautical research and some idea of how the various NACA projects related to the agency's programs. The tracking mechanisms which were adopted were simple reporting devices which just listed the research underway. NACA's research authorization process in the 1950s was a great deal more formal than in the 1920s, but its general nature and lack of standardized information with regard to costs, administrative information, and manpower requirements made it almost useless as a tracking device. Since the authorization process was only accomplished annually and authorization was given for general categories (e.g., propulsion) and programs, not for specific projects, the centers had a great deal of discretion with regard to how they allocated their funds among projects.

NASA, in contrast to this, had developed an extensive tracking and authorization system. Its program offices, while varied in the amount of control they exercised, played a major role in NASA's research and development program.

Program Offices

NASA, following the military services, used a project management system to accomplish its research activities. Each program office was given responsibility for one of four NASA program areas. The program offices provided the link between the centers and the general management discussed above. They reported directly to Finger. The philosophy behind project management was that it allowed the integration of the many different skills required for NASA's tasks without disturbing the traditional public / private relationship which existed in the United States. NASA was able to use individuals from many different organizations without making them permanent members of the organization. Within NASA it also allowed project managers to call on individuals throughout the organization without bringing them into the project organization permanently.

The effectiveness of the entire system rested on informal relationships between the various participants which crossed the formal authority and communication boundaries of the organizations involved in a project. The programs' managers had no formal authority over the project managers at the centers, nor did the project managers have any formal authority over the project staff. The formal authority link existed between the Associate Administrator responsible for the program office and the center Director. The legal relationship with contractors existed between the center Directors and private firms. Both the project manager and the program manager based their authority on their own expertise, knowledge of the project, personal skills, and their ability to persuade others to do what they wanted done.[24] At least this was how the system was supposed to work, but each program office had developed its own approach to project management.

The Office of Manned Space Flight (OMSF) was directed by George E. Mueller, a physicist and former systems engineering contractor. It was responsible for the development and operations efforts of the manned space flight program and was organized around a few large projects (e.g., Apollo, Mercury, and Gemini), but by the late 1960s its major emphasis was on the Apollo program. OMSF was the most centralized of the program offices, and its Director specified the formal structures of the centers (Marshall, Manned Spacecraft Center, and Kennedy) under its jurisdiction. The office was divided into program areas and then subdivided into program subsystems. Each center was responsible for one major system of the project (e.g., spacecraft or launch vehicle). The centers' project offices had to correspond to the appropriate headquarters structure. Each center had one individual responsible for the scheduling, costs, and performance of each major system, but the project manager for the Apollo spacecraft came from headquarters.

Mueller had his own functional (e.g., budgeting, procurement, personnel) staff who were separate from the headquarters functional staff. This staff worked directly with the centers' functional staff and virtually ignored the regular headquarters staff. OMSF received over 67 percent of NASA's research and development budget within its first ten years.[25] Although the other program offices "had to ask for many clearances for various projects...OMSF had standing clearance for Apollo."[26]

It also had a number of characteristics which made it very different from the other program offices. Contract employees were an integral part of the OMSF organization. They were actively involved in its decision-making apparatus and made not only technical decisions but also administrative ones. They were used by Mueller to evaluate the technical performance of the research staff and to produce proposals for long-term objectives. OMSF researchers were engineers, not scientists. Engineering considerations were placed first and scientific objectives were only given token support. Its objective was to develop a technical capability. Determining how that capability was to be used was simply not its job, but a decision which was supposed to be made by others. As von Braun, the Marshall Center Director, argued when asked to justify a space station,

> Speaking of the space station, to justify a space station with what we will discover there, is a little bit like asking that question before you make a decision that you want to build a new research institute or a new university. If people have to spell out in advance what they are going to discover in a research institute, I don't think any research institute would ever have been built.[27]

More important, its major program, Apollo, had the top priority within NASA and its success was linked to the organization's survival.

> In negotiations with BOB, NASA showed itself committed to manned space flight...gave up all Surveyor and Orbiter [all unmanned lunar explorations]...one-half of its sustaining university program, the request for 100 million for space station development...the NEWVAII.[28]

The Office of Space Science and Applications was responsible for the scientific program of NASA. Although most of its research and development programs (e.g., Voyager, Ranger) were unmanned, it was responsible for the scientific experiments on all space flights and had strong ties to the scientific community. Newell was the Associate Administrator of this office until 1967 when he was replaced by John Naugle. Newell's belief in the unmanned space program brought this office into continual conflict with OMSF. OSSA was responsive to ideas from the centers and the scientific community. Its staff, particularly under Newell, believed that planning for new projects should come from the centers' research staffs, not headquarters.

> We should promote letting ideas flush-up from the grass roots within NASA and stop going outside for help when a problem comes up.[29]

Newell and Naugle also placed engineering considerations above scientific experiments when NASA's appropriations were reduced. By the end of the 1960s, OSSA had also lost the support of the scientific community.[30]

OSSA was responsible for both large and small space flight programs. Two of the centers, the Jet Propulsion Laboratory and Goddard, had a strong in-house research capability. Its projects were assigned to both the centers under its jurisdiction and the old NACA centers.

NASA was known for its program management, but it was within the OSSA that this form of management was most evident. The Director of the center to which the project was assigned was responsible to OSSA's Associate Administrator for the project. The project manager worked informally with the program manager on an almost daily basis for most projects and worked directly with the contractors responsible for the project. It was the second most powerful program office within NASA headquarters and received 18.8 percent of NASA's funds for research and development in its first ten years.[31]

The Office of Advanced Research and Technology (OART) was responsible for the old NACA programs, as well as any NASA research from basic to engineering applications. Its activities differed from OSSA's and OMSF's in that it was responsible for numerous small applied research projects. In theory, OART was supposed to do the applied and advanced engineering research for the entire organization, but OMSF and OSSA generally relied on contractors for their advanced engineering studies rather than OART. Since NASA's leaders including the center Directors kept their research, development, and operations activities separate, the advanced research groups had little contact with the individuals involved in the large research and development projects.

The OART centers (Ames, Langley, Lewis, Flight Research Center) were known for their unwillingness to engage in too many large-scale contractor projects. The relationships between the program office and the centers was in most cases informal and personal. Generally the program office established a relationship with the center Director, and unless the project was large, there was little, if any, contact between the program manager and the project manager. The OART centers' relationship with the OART program office was similar in many ways to that which existed between headquarters and the centers in the 1950s. Its projects were not given the priority which was given to the OSSA and OMSF projects. The impact of this is probably best evidenced by the fact that OART had five directors between 1962 and 1968.

The fourth program office, Office of Tracking and Data Acquisition (OTDA) differed from the other program offices in that it used support contractors for all of its work and existed to provide support to the other program offices. It was responsible for NASA's worldwide network of tracking stations and receiving and processing data for all of NASA's and some of the Department of Defense's programs.

Research Authorization

NACA's research authorization process in the 1950s was a great deal more formal than in the 1920s, but its general nature and lack of standardized information with regard to costs, administrative information, and manpower requirements made it almost useless as a tracking device. NASA's project approval process had been standardized, required a great deal more information, and involved a number of approval stages. It also reflected the differences between the activities of the program offices. While OMSF and OSSA used similar procedures, OART's procedures were quite a bit different.

Project approval for OSSA and OMSF was accomplished through the use of a Project Approval Document (PAD) which contained a broad description of the project; technical objectives; its place in the agency-wide program; its administrative arrangements; schedule of major task completion which could be used to measure progress; estimates of costs; a description of required facilities; and the number of personnel required to complete the project. The document was prepared by the appropriate program office which worked with the center that proposed the project. After a review by the program office and the functional offices, the PAD was submitted to Finger, whose approval was required before it was submitted to Webb for approval. The PAD was similar to a contract between a government office and a private firm and was considered as such by NASA officials. The program offices were responsible for allocating funds and personnel to the project once it was approved.

The PAD was the final document in the approval process, but the centers were required to submit a project plan before starting on the PAD. The project plan was a detailed version of the PAD which was prepared prior to the preparation of the PAD. Only the program offices had to approve the project plan. Any change in either of these documents after they were approved required approval from the same level of authority which had originally approved it.

In contrast to NACA's one-step process, project approval by NASA was required at four phases. In phase A, the preliminary analysis, the center examined various alternatives for meeting a technical objective and the resources required. This step was generally started at the appropriate center, but the program office was also involved. In phase B the project was formally established through the PAD approval process. It involved "detailed study, comparative analysis, and preliminary systems design."[32] Project and program managers were selected and personnel were assigned to the project team. All centers which were involved in the project were selected and assigned their responsibilities with regard to the project. If the project involved space flights, the specific launch vehicle and spacecraft were selected. Technical specifications were written; personnel and funds were allocated; the management plan was developed; and facility and tracking requirements were determined. It was during this phase that Finger and Webb gave their approval and funds were allocated to the appropriate program office and then to the centers. The center Directors were responsible for allocating the funds to the various project managers. In phase C, the detailed design and integration studies were made. All centers involved in the project took part in this phase. Requests for proposals were sent out for any work required by contractors. In phase D, design and development, the project was completed.[33] The purpose of this four-step process was to allow any of the levels to terminate the project before the fund commitment was too high.

The OART project approval process was a great deal more simple. The project approval document was used as an annual authorizing document and did not contain the detail given for the larger projects. Formal reporting was accomplished through a Research and Technology Objective and Plan document (RTOP). It included the technical approach, contracting plan and resource requirements. RTOPs were not prepared for specific projects, but for broader technical areas (e.g., subsonic aircraft). They did not include information below the project level and were thus not very useful for monitoring costs or technical progress. Center directors could reprogram funds between separate RTOP projects.

Tracking Devices

In contrast to NACA's minimal tracking mechanisms, NASA was known for its heavy documentation requirements, but the reporting requirements varied among the program offices, with OMSF's requirements the heaviest. OSSA and OMSF had a number of reporting requirements in common. They included:[34]

1. The Project Operating Plan on which all financial data on projects or items above five thousand dollars were reported down the working level. The plan was submitted monthly to the program office which transferred it to the Office of Administration under Finger where the budget was prepared.

2. The Project Management Report which was prepared by the project manager for the center Director at least monthly, but weekly as the project progressed. It was used to prepare the Management Information and Control System data for the program offices, but was given to the program manager directly if the relationship between the project and program managers was successful.

3. The Management Information and Control System which provided top management with data on the financial details, technical progress, and schedule of the project. This document provided the program manager with a listing of any problems and recommendations for changes. It was submitted monthly.

Additional control was exercised through the use of formal meetings on the status, design, and progress of the projects. These formal meetings were held at the systems, project manager / center Director, program office and top management levels. Informal meetings were also held at all levels when problems arose. Mueller, the OMSF Director, met with the directors of the major contractors at frequent intervals. In addition Mueller, Finger, and Webb used private contracting organizations (e.g., Belcomm, Boeing, and G.E.) to help them track manned space flight activities. The contract organizations provided top management with the technical expertise necessary to evaluate the work of the centers and make decisions about technical matters.[35]

Although the OART centers were originally required to submit similar documents, the sheer volume of their projects (4,000 in 1969) meant they were generating more data than anyone was willing to review. Centers involved in OART projects submitted monthly reports on costs and expenditures for major research items. The reports were recognized as useless for tracking and control purposes. The OART centers, except when involved in an OSSA project, primarily relied on the telephone to communicate their technical progress or any problems which they might encounter when accomplishing a project.

Procurement

The procurement division, located in the Office of Industry Affairs under Finger, established general rules, coordinated NASA's procurement matters, and made recommendations to the Office of Industry Affairs. The centers made such decisions as whether the contract would be sole-source or competitive; drew up the procurement plans including the technical specifications used for preparing the Requests for Proposals sent to contractors; and provided headquarters with estimates of costs.

The centers were authorized to negotiate sole-source contracts up to $2.5 million and competitive contracts up to $5 million.[36] A headquarters Source Evaluation Board was used to evaluate and rank contract sources above a certain amount. Webb and Finger made the final decisions on large contracts. Since center Directors were members of the Source Evaluation Board, they did have some influence in the decision making. The only exception to this method was when the contract involved support contractors. All support contracts over one hundred thousand dollars had to be approved by Finger.[37]

Program Management--An Assessment

Although Webb in the late 1960s claimed to be exercising an enormous amount of control over the organization, this claim is difficult to substantiate when some of his major authorizing and tracking devices are examined closely.[38]

The power of OMSF and the high priority given the Apollo program meant that approval of most of its projects was given almost automatically. The fact that OART's PADs were only used as an annual authorizing device and provided little information about specific projects made them useless for tracking on a regular basis. The project approval process undoubtedly worked best with OSSA's projects where they were most extensively used. The Phase Project Planning process offered a mechanism through which headquarters could intervene and stop a project, but even this authority was limited by the imbalance of power of the various participants. When NASA was told by the Executive Branch to cut their expenditures, cuts were more likely to be made to OSSA and OART projects than to OMSF projects to which the major portion of NASA's funds was allocated.

It was the tracking mechanisms which were the least effective. Since OART projects only required monthly lists of costs and expenditures, the reports were generally out-of-date before they were submitted to headquarters. OSSA's reporting, although meeting most of the requirements, suffered from some difficulties. The reports were not used by the project managers for management of the projects, since both the project and program managers relied on informal interpersonal contacts either by telephone or through informal visits. For this reason, they were not always up-to-date. There was little incentive to report problems until absolutely necessary so that the reports provided little indication of actual problems with the project. Perhaps more important, they were used by some managers to inundate management with data. Since this was one of the reasons that OART had been allowed to drop out of the reporting system, the centers had some incentive to do the same.

The reporting systems were primarily used to provide top management with data when problems occurred with the large research and development projects, not as a tool for daily oversight. OMSF was perhaps the most effectively controlled through the documentation process, but the enormous amount of data generated by the Apollo project made it difficult for anyone to track what was actually going on. As Webb noted,

> At one of our development Centers in NASA... twenty-two railroad boxcars of data are generated in one year, and for the whole of our Apollo program something on the order of 300,000 tons of data will have been required by the time of its completion.[39]

The reports also had their dysfunctional aspects. They interfered with the informal project and program management relationships so crucial to the success of the project management system. If this relationship was good, the various levels kept each other informed as a matter of course. If there were no informal ties between the participants, there was no way except through the formal reporting system for the various levels to even know what was going on or to establish any control over the project. NASA's increased reporting requirements by the end of the 1960s were causing distrust at all levels and made the informal ties necessary to the project management system very difficult to establish.[40]

The reporting requirements lengthened the decision-making process and made the various parties very risk-averse. Innovation and creativity were increasingly becoming difficult. This problem was particularly acute where small projects were involved.

> The managers of small in-house projects are especially sensitive to the longer decision process. Many of these projects are completed in less than two years. These managers observe that the project approval process frequently takes longer than the execution of the project. This, they believe, tends to inhibit innovative research ideas being developed in the field installations, because researchers become less inclined to fight an extended battle with the bureaucracy when the chances for success seem slim.[41]

The gradual centralization of the decision-making process may have given headquarter's leaders a feeling they were controlling the decision making, but it also meant that they were making decisions on individual projects and not on agency-wide objectives or policies. Webb recognized the problem and tried to turn the upper-level committees into policy-making, not project decision-making, groups, but he was not successful in this effort.[42]

The centers particularly objected to the contractor oversight. Even the contractors complained of the centers' lack of appreciation for the assistance they were offering.

> Edward S. Miller of General Electric said: 'The contractor role in Houston was not very firm. Frankly, they didn't want us. There were two things against us down there. No. 1, it was a Headquarters contract, and it was decreed that the centers use GE for certain things; and [No. 2] they considered us Headquarters spies.' For some time after the contract award, just exactly what General Electric would do was not exactly clear.[43]

COORDINATION AND DIRECTION OF RESEARCH

NACA's leaders had controlled the activities of the organization by providing the researchers with a great deal of discretion, while at the same time providing them with an environment in which there was a great deal of incentive to produce as they desired. The researchers had internalized NACA's values and accepted the authority of their superiors to make decisions about their research projects. NASA's leaders, as discussed above, had not only adopted many more tracking devices, they had also made important changes in the incentives which were used to ensure their subordinates' compliance. NACA's incentives and NASA's use of them are discussed in this section.

Internalization of Values

NACA had established a highly qualified work force by recruiting from top colleges; ignoring many civil service regulations; and providing both in-house and formal training for its research staff. NASA in the late 1960s was having trouble both retaining and recruiting highly qualified individuals. The Bureau of the Budget required a reduction in its personnel after 1965 and between July of 1967 and the end of the fiscal year of 1969, NASA abolished 2850 permanent positions. To accomplish this it was required by the Bureau of the Budget to undergo a number of reductions-in-force. These reductions had an enormous impact on the organization's ability to provide any of the incentives used by NACA.

It had established mechanisms for recruiting college graduates, but did not have the positions to hire new personnel. As one staff member pointed out in a budget review with Webb:

> ...One point about cuts...you get into the position of being unable to recruit. One of the most serious things that we have to deal with is the ability to recruit college graduates. You see, that is the secret of eternal youth,...to be bringing in college graduates some way or another and we, at one time, before the space expansion, we even invented a plan that was never executed where we could bring boys in and train them for a period without keeping them, that sort of thing.
>
> But this..., the ability to bring in college graduates and continuing our relationships with colleges, is a very serious matter and once you break the chain, it is very hard to establish it again...[44]

The informal in-house training used by NACA to socialize its recruits into NACA's way of accomplishing its research, as well as attracting new recruits, was also difficult to provide within NASA. The average age of NASA's scientific and engineering workforce was 37.5 in 1968.[45] The individuals in the mid-level grades who would normally provide this training were also the ones who could find employment elsewhere when NASA began to have budgetary difficulties. As the Personnel Management Review Committee pointed out, the reductions-in-force often caused the most highly qualified researchers to leave despite the fact that they were under no danger of being deprived of their positions.

> The experience at Marshall, where the RIF procedures were religiously applied, was that the RIF not only paralyzed the on-going projects but inflicted irreparable damage on the engineering, scientific, and management talent upon which Marshall depends for its success and its future. The most promising and recently acquired young engineers and scientists were the first to leave the organization...even though the scientists and engineers were not included in the planned reduction; and it is believed that Marshall will similarly continue to lose its most promising and productive personnel long after the formal reduction-in-force has been concluded. Furthermore, the immediate task of recruiting replacement personnel of

> equal stature may now prove to be virtually impossible of accomplishment. The long-term effects of the Marshall reduction-in-force are, at the present time, incalculable.[46]

The sense of community and commitment to the organization which existed within NACA throughout its history also did not exist within NASA. NASA's staff was not known for either its high morale or its commitment to agency-wide objectives in the late 1960s. The staff's identification was first with the center to which they were attached, then with the program office, and last of all with the agency. Scientists and engineers were unwilling to move to another center and, since the headquarters staff were considered "paper pushers," they were particularly unwilling to move to headquarters. When the Personnel Review Committee reviewed Lewis's attitude with regard to mobility, it found

> ...no real incentive for mobility...NASA must realize that at the present time, people hired in the field identify and relate primarily with the field center and not with NASA generally.[47]

The personnel of the research centers, such as Lewis and Ames, considered the OMSF development centers' work to be primarily administrative in nature. As one Lewis staff member pointed out,

> ...our only contractors are the janitors. I believe in growing people, I want an academic environment, a working environment, not a transient environment.[48]

Although NACA's two groups had similar attitudes toward each other, they continued to communicate. The gap between the advanced engineering groups and the development groups during the late 1960s had grown to the point where there was little communication. The development centers let contracts for their applied research needs and at times simply ignored the fact that an in-house group existed which not only might have been able to accomplish the research, but in some cases was already accomplishing it.[49] This situation occurred between centers, but also within centers where development groups were kept physically separate from the advanced research groups.

The project management system also hindered the development of cohesion. The project groups' work was directed toward the objectives of projects, not toward the centers' objectives or agency-wide objectives. When the project was completed, the team was disassembled, and its members were sent back to their parent organizations. This worked when the project was of short duration, but when it had lasted more than a few years, the project members no longer had an attachment to the parent organization and many simply took advantage of their contacts with the military services and private industry and left NASA.[50] Those centers with a number of large projects simply had no mechanism for sustaining group cohesion beyond the completion of specific projects.

Webb was aware of the lack of consensus about objectives and recognized its impact not only on NASA's ability to plan, but also on his own ability to control the organization.

> So we just didn't really supervise them enough to get the broad concept across to them, and each one began to have around him his own people, you know, who tended to be autonomous, run things his own way, and [not]...reticent to come up when he had a problem with a Senator or Congressman to get help at the top.
>
> But you found them very ready to make decisions that did affect the top without bearing in mind that they should come up and talk about that, too.[51]

Although the OART centers were recognized as having tighter organizational cohesion than the rest of NASA, they also had changed a great deal from what they were in the 1950s. The OART program office, as suggested above, was not able to retain a director for any length of time and many researchers had left the organization. Personnel ceilings had forced them to let contracts for a great deal of their work. The separation of development work from the research activities of the centers made cohesion difficult to achieve and left the centers as a whole reporting to OART, and some groups within the centers reporting to OSSA.[52]

Research Environment

NACA's researchers were very proud of their creativity and innovation and their ability to engage in new and sometimes radical projects. Although some of this research had to be accomplished with the approval of top management, the leaders of NACA were recognized for their willingness to try most of their staff's proposals for research. This support of new research ideas was not as evident among NASA's leaders. Advanced studies which looked like they were the first steps to a large-scale development project were not approved because of Congress's objections to new programs. Demands from headquarters and the OMSF centers that OART relate its research to NASA's missions meant that it was difficult to obtain funding for non-mission related research. As Finger, one of those who didn't agree with this policy, argued,

> Any effort to define the experimental engineering as mission research and technology...weakens the entire basis for OART and for the OART program. It makes that program susceptible to assessment of the missions and dates defined rather than to the basic advances in capability to be generated by that work.[53]

It was also difficult for NASA's leaders to accept proposals for any new projects when they were cancelling existing programs which had been supported for many years. As one staff member pointed out in a budget discussion with Webb when he proposed cutting the Voyager program:

> ...I think the cumulative effect would be very serious...There has been so much talk and so much anticipation for the past 2 to 3 years and so much disappointment, that if we swallowed it at this point in time and said, well, we are going to defer it again for an indefinite number of years, this would be tantamount to telling people who really believe in it that we don't really have the courage of our convictions, and that this thing may slip indefinitely. So we will lose an important, fairly large chunk of the community in a way that we could not easily get them back any more than we could easily resurrect Voyager.[54]

NASA's researchers had few incentives for proposing new research ideas. As discussed above, the time-consuming approval process stopped some people from proposing new ideas. Researchers working for OMSF, which did have more slack funds, were busy with Apollo and thus had little time to generate new ideas for new programs. They were also engineers whose work involved solving problems, not generating ideas for new projects. OART researchers, who were supposed to produce the new ideas for OMSF, had little contact with it and thus were unaware of what research was required. Even if they were willing, NASA's management tended to accept contractors' ideas before the staff's. The acceptance of Belcomm's, a NASA contractor, long-range plan in 1969 coupled with the rejection of a plan produced by Newell's planning group only confirmed the rejection by NASA's leaders of its staff's ideas.[55]

NACA's leaders in the 1950s had provided their researchers with the opportunity to publish their research results as NACA reports under their own name, contacts with other experts in their fields, and the excitement of being involved with projects which were making radical changes in the nature of the airplane.

NASA continued to offer the latter incentive to some of its staff. Its research and development groups had the opportunity to work on some of the most exciting projects in existence at that time. The individuals working on some of the major projects, particularly Apollo, were known for their commitment and dedication to the project. They had the opportunity to learn management skills which were in high demand during this period, and their contacts with numerous other groups provided them with career opportunities unavailable to most government employees, but there were costs involved. Their attachment to a project team meant they often lost contact with their professional colleagues and research advances in their fields. These researchers involved in long-term projects had trouble returning to any position involving actual research.

Even those individuals who remained active researchers were not provided with similar incentives. They could keep up their contacts with professional colleagues by going to conferences in their respective fields, but there was no permanent group established within NASA which brought outside researchers into contact with NASA researchers. Attempts to establish permanent scientific and engineering groups ended in frustration for both parties. NASA's commitment to the manned space flight program and the development of a technical capability in space was not accepted by many outside scientists and engineers. Many felt that the entire manned space flight program was a waste of resources which would have been more efficiently spent on scientific advancements. By the late 1960s, most scientific advisory groups refused to have anything to do with NASA.

The incentive for publishing also no longer existed. NACA's leaders had required their researchers to publish their results first as a NACA report. Individuals outside of the organization evaluated NACA's performance by reading these reports. NASA was evaluated on the success of its space missions. Failure of a major space launch resulted in a Congressional investigation or a cut in its appropriations, whatever the quality of its research efforts. Advancement in the organization did not depend therefore on the researchers' publishing record. Since publishing remained a method of advancing professionally in their fields, the researchers continued to publish, but professional journals were preferred over NASA's report system. It was obvious by the end of the 1960s that even the OART center managers had changed. As one Lewis manager so succinctly pointed out,

> ...he runs into some staff problems because after the researchers have done the 'hard' creative part they want to sit back and enjoy the 'easy' part--writing journal articles, giving lectures, etc.--but Abe [Silverstein, Lewis Center Director] does not let them.[56]

Control of Output

NASA differed significantly from NACA in one important aspect. It was not controlled by scientists or engineers, nor were promotions based on technical expertise. NACA's leadership positions were held by individuals who had established a reputation in their fields and had been with the organization for many years. Even Dryden, who was selected from outside of the organization, had been a NACA committee member before his appointment. Its researchers were promoted for their technical performance. NASA's promotion policies were quite a bit different.

Webb was an administrator with a law degree, not a scientist or engineer. He brought in his own people from other organizations and these individuals also were not scientists and engineers. Promotion to the top grades was based on an individual's management capabilities. Technical competence did not go unrecognized, but if the individual was not a good manager, he could not be promoted to the top grades.

Individual researchers, particularly those involved in the research and development projects, were evaluated with regard to three criteria: (1) producing a product within a specified time frame; (2) producing the product within the original cost estimates; and (3) the quality of the product. While producing a bad product and meeting the first two criteria was not acceptable, the first two criteria were evaluated above the last.[57]

NASA, as NACA in the 1950s, was having trouble promoting anyone by the end of the 1960s. Individuals in the top grades were simply not leaving the organization in the numbers which occurred in the mid-level grades. All of the centers were having trouble promoting individuals above GS-15.

The personnel ceilings and cuts in NASA's appropriations, which occurred after 1965, did have a positive side to them. Webb was forced to begin promoting his in-house staff to the top positions. Both Finger and Newell were promoted into headquarters positions from the centers, not from outside, but their promotions were based on their administrative capabilities, not their technical competence.

Vestiges of the old NACA system of control were still evident in the relationships between project and program managers and the relationships which these individuals established with their project teams and the contractors who worked on their projects. Since the project manager had no legal authority over most of the individuals involved in projects, he had to rely on his personal expertise to ensure compliance with his directives. The acceptance of the project director's authority because of his expertise (both technical and administrative) was similar to the acceptance of the authority of NACA's leaders in the 1950s because of their personal expertise. It was also a relationship which ignored the formal lines of authority which are based on position more than technical expertise.

Establishing and maintaining these relationships was becoming increasingly more difficult in the late 1960s. As discussed above, the formal reporting requirements, which did follow the formal lines of authority, were beginning to have an impact on the informal relationships established by the project management team. This situation was exacerbated by the fact that NASA's leaders, in contrast to NACA's, had accepted the personnel requirements of the Civil Service Commission. They had adopted a Personnel Management Information System, which supplied computerized data on grades, occupations, and kinds of appointment. Although this system was rudimentary and did not supply all the information desired by the Civil Service Commission, its implementation was supported by NASA's leaders who made a concerted effort to standardize their personnel procedures and relate personnel to the work load.[58] Webb had established a Personnel Management Review Committee to evaluate agency-wide personnel management practices and make recommendations with regard to personnel policies.[59]

Even if NASA's leaders had wanted to maintain a formal structure based on expertise, the personnel and grade ceilings established by the Bureau of the Budget after 1965 made this very difficult. The fact that these ceilings had to be met within Civil Service Regulations left NASA's leaders with little discretion with regard to the management of their personnel.[60] Veterans had to be given preference over non-veterans, whatever the competence of the veteran. Individuals whose position had been abolished could take a lower position from more highly qualified personnel. Retirement of individuals not performing adequately could only be accomplished with the individual's consent.

By the end of the 1960s NASA, both because of the reporting requirements of its leaders and the requirements imposed on it by external actors, was becoming an organization in which the relationships between program and project managers and the project teams, which had proven so successful for managing its aeronautics and space program, were becoming increasingly more difficult to maintain.

NASA AND OTHER ORGANIZATIONS

NACA's transformation into NASA brought a change in the organization's relationships with all the groups in its environment. NACA provided technical assistance to the Department of Defense. NASA continued to provide this assistance, but the military services also provided manpower, technical assistance, and facilities for NASA's use. The relationship between the two was not as simple. A formal committee, the Aeronautics and Astronautics Coordinating Board with representatives from the two groups, had the authority to negotiate any conflicts between the two organizations and to establish the regulations necessary to coordinate their programs.[61] Facilities or services were exchanged through formal, not verbal agreements. NASA was no longer in a subordinate position. Many of the research organizations (e.g., Jet Propulsion Laboratory, Navy Research Laboratory) which the military services had established after World War II to meet their research needs had been transferred to NASA, and the military services were again dependent on NASA for development in space technology.

The change in this relationship was accompanied by a change in the relationship between private firms and the organization. NACA's relationship with private industry was one of two research groups working together to provide technical support for the Department of Defense. NACA assisted industry and provided them with research assistance when necessary. NASA's policy of using contractors for all its products and services changed that relationship to a contractual one. Although NASA's researchers continued to work closely with industry's researchers, the nature of this relationship had changed. The contacts between the two were defined by government regulations. The high visibility of the space program meant that technical failures could result in Congressional investigations and demands from NASA that the contractor change its entire management structure. The large amounts of money involved meant that the relationship was not as straightforward as it had been in the 1950s. It also left some companies highly dependent on NASA for their continued existence.[62]

NACA in the 1950s had to meet demands for the standardization of its methods of operation from oversight agencies, as well as from Congress. The list of agencies whose regulations affected NASA was impressive. The Bureau of the Budget had three analysts assigned full time to review its budgetary activities. NASA was required not only to submit budgetary information, but also program memoranda and special studies for the Planning-Programming-Budgeting System required by President Johnson. NASA's heavy reliance on contracting also increased the number of General Accounting Office investigations into its activities. Its procurement activities had to comply with Equal Employment Opportunity and Small Business Administration regulations, the Buy American Act, the Fair Labor Standards Act, the Work Hours Standards Act of 1962, and the Copeland Anti-Kickback Act.[63] In addition, the Civil Service Commission continued its investigations into NASA personnel management activities.

The President had also established his own staff to help him make decisions on space policy and programs. A Science Advisor had been appointed and was responsible for the President's Science Advisory Committee, the Federal Council for Science and Technology, and the Office of Science and Technology, all of which provided the President with information on NASA's space activities.

In contrast to NACA, which only faced an annual appropriations committee, NASA faced both appropriations and authorizations committees.[64] These committees were familiar with every aspect of their technical program and budget. The committees visited contractors, talked to astronauts and NASA scientists and engineers, and held their own investigations into technical problems, cost overruns, and delays in schedules. Congress questioned NACA's expenditures. It asked questions about NASA's program decisions and made its own choices about which programs it would fund. It also had a Science Policy Research Division in the Library of Congress which could be used to provide it with any additional assistance it might require to evaluate NASA's activities.[65] NACA's Annual Report was simple, straightforward, and except for the researchers' reports which were included, could be understood by any layman. Its focus was on what the agency had accomplished. NASA's reports to Congress provided detailed explanations of the programs in progress and those which were being proposed. Justification for each expenditure was required. Estimates of costs and the details of proposed programs had to be provided.

NASA's environment in the late 1960s was neither a simple one nor a very friendly one. It had to compete with the Department of Defense and the Great Society Programs for funds during a period in which there were "balance-of-payments deficits, [and] an overheated economy..."[66] The drop in its appropriations and personnel levels from 1965 on showed that it was slowly losing ground in the competition.

II

THE DEVELOPMENT OF NASA

NACA had retained its unique structure despite pressures from oversight agencies that it comply with federal regulations and standardize its operations. NASA by the end of the 1960s displayed many signs of an aging bureaucracy. Research activities were heavily monitored and a time-consuming approval process was stifling innovation. NACA's leaders' support of in-house applied and advanced engineering research activities was not duplicated within NASA. Its leaders gave their highest priority to development programs and placed pressures on the centers to let contracts for their research activities. Its leaders' promotion policies and their allocation of resources all provided evidence that the management of research and development projects, not in-house research, was the primary objective of the organization.

Despite these changes, NASA's accomplishments continued to be impressive. Its lunar landing in 1969 was one of a long list of accomplishments in the 1960s which showed the world that the nation had surpassed the Soviets in space. These accomplishments, though, did not stop the cuts in its appropriations or personnel levels which started in 1965 and continue till the present time. What the above does not show is how the organization changed during its first ten years or why it took the path that it did. The latter question is perhaps most important because it was obvious that NASA by the end of the 1960s had somehow chosen the wrong path. There are obviously no absolute answers to these questions, but a review of the years between our last examination of 1968 and the end of the 1960s and some of the factors which played a role in the development of NASA provides some insight into its development.

THE CREATION OF NASA

The legislative history of NASA provided NASA's leaders with some very definitive ideas of what Congress and the Executive Branch did not want and a great deal of ambiguity about what they did want.[67] While NACA was the one organization acceptable to both Congress and the Executive Branch, there were features of its method of operating and the nature of its research activities which were unacceptable to both.

Both rejected NACA's committee structure from the beginning. It did not provide the executive power necessary to manage a large research and development organization or "to deal effectively with the powerful military and industrial groups, each with its special interests."[68] It may have been adequate for a research organization, but not for a large operating organization. NACA's argument that its structure was one of the reasons for the high quality of its performance was simply not an adequate justification for keeping the structure, according to some Congressmen.

Congress and the Administration were also quite certain that the agency should be civilian. Although military-related space activities would remain in the Department of Defense's domain, it was not to manage the civilian space program. Any space projects for which the military services had responsibility had to be transferred to NASA. NASA could use the Department of Defense's facilities and manpower, but it had to manage its own projects.

Neither Congress nor the Executive Branch was willing to maintain NACA's research tradition. NASA was given responsibility for NACA's aeronautical research program, but research was not supposed to be its major activity. NACA's claim that it was an operating agency, not only a research organization, was not believed by Congress:

> NACA, as now constituted, is a research agency, with the traditions of a research agency. It has acted through the years as a sort of extraordinarily valuable problem solver for the services and for civil aviation. But all the problems it has solved have been technical. Although NACA is very definitely, as Dr. Dryden put it, an operating organization, its operating traditions have all been consultive, advisory, mediatory.
>
> ...But the lack of any tradition of direction and coordination could be very serious. This is a problem by itself. Without drastic sweeping changes, it is no mean feat to inculcate a spirit of decision-making in an organization that has lived and thrived on a tradition of peaceful advice-giving. And any space agency, by the urgent nature of its mission, by the inevitable commingling of civilian and military in many fields, will have to know how to rap knuckles.[69]

What the new organization was supposed to do was not quite as clear. It was obviously supposed to demonstrate the nation's technical capabilities in space in a manner which would show the world that America was technically superior to the Russians. It was also obvious that having the technical capability was not enough. When Dryden rejected von Braun's suggestion for a manned space flight by pointing out that "such a flight has about the same technical value as the circus stunt of shooting a young lady from a cannon," Congress refused to consider him for an appointment as the new NASA Administrator.[70] How exactly NASA was supposed to regain the nation's prestige beyond producing and launching spacecraft was left to the new agency to decide.

Before leaving this discussion of NASA's creation, some note should be made of the role of Congress in the establishment of NASA. Congress, from the time Sputnik I was launched, was the leading advocate for a new space agency. President Eisenhower submitted the first draft, but this was only under Congressional pressure and after attempts to launch a test satellite by the Navy in December of 1957 ended in what Senator Lyndon B. Johnson called a "humiliating" failure.[71] Johnson began an inquiry into the nation's technical capability shortly after news of Sputnik I reached the United States and continued to play a major role in its establishment and early development.

NASA thus came into existence with a new mandated structure which was opposed by the organization which was supposed to be the nucleus of the new agency; a research and development management responsibility which many individuals on NACA's staff including Dryden didn't want; responsibility for a program directed toward political objectives which NACA's applied research group felt would destroy their applied research activities; and a Congress which was fascinated with its new creation and prepared to become intensely involved in its activities.

NASA'S EARLY YEARS

1958-1961

On October 1, 1958, the National Advisory Committee for Aeronautics officially became the National Aeronautics and Space Administration. Thomas Keith Glennan was appointed the first Administrator of NASA on August 19, and Dr. Dryden became the Deputy Administrator. Glennan's tenure lasted until January of 1961, when he was replaced by Webb. Although he failed to satisfy Congress's desire for a major space achievement, he did turn NASA into a functioning organization. Various organizations were transferred to NASA and organized into distinct program groups. New facilities were added and three new centers were created. Glennan established new management devices and documented what all the new units were doing and the contracts which had been let. He started NASA's policy of separating its research and development groups and established what became its policy of letting contracts for most of its work. He also established two new standard operating practices by hiring management consultants to evaluate NASA's organization and procedures and bringing in individuals whose sole job was to improve NASA's management. What he did not change was the methods by which NACA or the other new components were controlled, nor did he accomplish the objective assigned to him by Congress.

The Growth of NASA

NASA's growth in its first few years largely occurred through the transfer of a number of existing organizations to its jurisdiction.[72] The Project Vanguard team from the Navy Research Laboratory was transferred intact and became the core group of the new Robert H. Goddard Space Flight Center established in March of 1961. Jurisdiction over the Air Force's and Army's lunar probes, as well as some engine development projects, was given to the new organization. But the major organizational components added to NASA were the Jet Propulsion Laboratory and the Development Operations Division of the Army Ballistic Missile Agency near Huntsville, Alabama.

The Jet Propulsion Laboratory of the California Institute of Technology in Pasadena, which had been working under contract for the Army, was transferred to NASA in December of 1958 as a government-owned facility directed by the California Institute of Technology. It had been involved in the Explorer I project, which produced the first successful American satellite, and the Vanguard Project, which produced the second. As NACA had earned a solid reputation for its aeronautical research, JPL enjoyed an equally strong reputation for its intellectual and professional competence in rocketry, earth satellites, and advanced research in these fields. Its staff were researchers and academicians, not contract administrators. Its work was conducted in-house with only minor participation of industry in the construction of facilities. Promotion was based on advancements made in the individual's field and, as NACA's applied research group, there was little interest among its staff in becoming contract managers. Since the Army administered all of its contracts, including the construction and design of its facilities, JPL had even less experience than NACA in contract administration.[73] Although all the former NACA centers had a great deal of operating freedom, JPL established, through its contract with NASA, legal operating freedom. Any work undertaken by JPL required the mutual agreement of both parties before it was assigned. The technical reputation of JPL, the fight which occurred between the Army and NASA over its transfer to NASA, and the success of two of its major projects contributed to a feeling of elitism within the organization probably unmatched by the other organizational components.

The other major group, the Army Ballistic Missile division headed by Wernher von Braun, had also participated in the successful Explorer project. Its 4000 member staff became the Marshall Space Flight Center in 1961 after two years of sometimes bitter arguments between the Army and NASA over the transfer. In 1962 part of this group, under Dr. Kurt Debus, was transferred to the newly created Kennedy Space Center in Florida. The von Braun group, although technically remaining under the control of the Army until 1961, had worked with NASA from its creation and supplied many of the launch vehicles used by NASA in its first years. Its staff was composed of civil service personnel and, as such, was used to the procedures and operations of federal organizations. It differed from NACA in that it engaged in both research and development, but this work including some fabrication was largely accomplished in-house.

Marshall, which was responsible for the development of launch vehicles, and Kennedy, which was responsible for the launch management of satellites, were joined by the Manned Spacecraft Center in Houston in 1961. The three groups formed the nucleus of the NASA manned space program. The latter center differed from the other two in that its staff and management was drawn largely from a Langley-Lewis Space Task group which had been responsible for NACA's supersonic research and development activities with the military services. This group originally had been scheduled for the Goddard Space Flight Center, but it was placed in Houston in 1961.[74]

Whatever the difference in origin of the new Centers, they did have a number of characteristics in common. All had achieved excellent reputations in their area of expertise, had primarily engaged in in-house research and believed in its importance, and were managed by leaders who had achieved worldwide recognition in their fields. The NACA laboratories and JPL were known for their academic research environment. This was less so in the case of Marshall, but this group prized its autonomy and its right to accomplish its research in-house. The only group with extensive experience in operations was the Goddard group. All of the centers' activities had involved working in some type of close relationship with the military services and private industry. None had extensive experience with contract administration, nor the management of large-scale research and development projects.

The Development of Program Areas

By the end of Glennan's tenure, the various groups had been organized into specific research areas. Marshall and Kennedy had become responsible for launch vehicles. The Manned Spacecraft Center, JPL, Goddard, and Wallops were made responsible for the spaceflight activities of NASA. The former NACA centers, as well as the Flight Research Center, became responsible for the aeronautical research and development programs and the in-house research required to support the other two groups.

This division, while it reflected the different types of research and development activities, also provided a solution to an entire group of problems which faced Glennan when he attempted to assimilate the various groups into a single organization. NACA's applied research groups remained strongly opposed to NASA's new development responsibility. They believed that exposure to this type of research would only result in the group's being coopted by the development group. Dryden and Glennan concurred with this assessment, but they also believed that the NACA centers would not accept the controls necessary to manage the new research and development activities. Perhaps more important was the reality of the separation of these individuals from the organization. From 1955 to 1960, the organization had lost 250 of NACA's GS-11 through GS-16 researchers to private industry. Their median tenure was 11 years.[75] NASA's leaders during this period felt they needed an in-house research capability to provide ideas for new research projects and to handle development problems on their major projects. They also recognized that they would have to have some mechanism for keeping their staff trained, and placing the development group back into a research environment for retraining after the completion of a project was one method of ensuring that the organization could provide technical direction to its contractors.

The NACA centers were theoretically supposed to continue performing the same type of work as they always had except that they would provide a service to other NASA centers rather than to the Department of Defense. Since NASA had more than adequate funds, it was possible to simply create new centers which were development centers from the beginning and thus could accept the controls which most observers felt would be necessary to manage the new space program. The NACA centers would remain research organizations and be allowed to retain their research autonomy.

NASA's Contracting Philosophy

NASA's change to a contracting organization happened in a similar fashion except that there was no grand design with regard to contracting. As with the division into research groups, the decision to let contracts for most of its work was made in an environment which contained few alternatives.

Congress and the Executive Branch, as they had for years, assumed that industry would do as much of the development and production of hardware as possible. This alone meant that the organization would have to let some contracts, but additional complications existed. Some of the projects which were transferred to NASA from the Department of Defense were already underway and contracts had already been processed for their performance. For these projects, unless NASA's leaders wished to break the contracts, the decision with regard to contracting had already been made. But NASA's leaders also had few alternatives on projects initiated by their own staff. NASA was expected to develop a technical capability and build the hardware as fast as possible to regain the nation's prestige. Its civil service complement was technically very capable, but its researchers had little experience in managing large research and development projects or developing and building hardware. Unless its leaders were willing to increase the size of NASA's in-house staff tremendously, and the Bureau of the Budget's personnel ceilings precluded this, contracts had to be let for the development and production part of these projects.

Perhaps more important to the final division of labor on NASA's contracts was the previous experience of NASA's development groups. All had worked on projects with the military services and industry. Each of the groups had specific roles in this relationship and, while the exact working relationships varied on the project, in that the Air Force allowed contractors to handle all the activities and the Army did a good portion of the development work in-house, they all involved a division of labor among the three. This was standard operating practice for the military services' projects, and any change would have meant a major change in the new organizations' operating procedures.

The result of the above factors was the development of a relationship which lasted until the end of the 1960s. NASA's project management was a combination of the Army's and Air Force's management, but because of its strong in-house research capability it provided more technical direction than the Air Force group. The relationships which developed were also very similar to that which NACA had proposed for itself in 1958. Industry was responsible for development, fabrication, and systems engineering. The Department of Defense was responsible for providing personnel for systems management, but NASA had total responsibility for the final product.

Glennan's Management

Glennan as NASA's first Administrator had two major impacts on its future development beyond those discussed above. He formalized many of the financial and program management procedures, and he took the first steps in the adoption of what was a new philosophy of management for all the components which came together to form NASA.

Although Glennan had a technical background, it was obvious from the beginning that his management philosophy was different from that of NACA's leaders. Shortly after being confirmed, he contacted a management consulting firm, McKinsey & Company, for recommendations on organizing NASA. On October 10, 1958, this company was awarded NASA's first contract.[76] Glennan accepted the recommendations made by McKinsey & Company despite the fact that NACA's leaders had also prepared a report describing changes which they felt should be made in NASA's management structure.[77]

Following the submission of the McKinsey report in December, Glennan made some significant changes in the structures of the headquarters unit. He created a new Associate Administrator position in order to appoint a General Manager for NASA and added an Office of Business Administration to handle the increase in NASA's financial management activities.[78] The changes were accompanied by changes in personnel at the top levels of NASA's management. The new managers were drawn from the military services and other large government agencies.

Many of the appointments were based on recommendations submitted by McKinsey & Company.[79]

Glennan continued to use NACA's financial and program management mechanisms until 1960 when he made significant changes in both. In May of that year, a new program management system was established with the objective of tracking exactly what projects were being accomplished, as well as the status of each. As part of this system, a new project approval plan was established. To obtain approval for a project, the centers had to submit a Project Development Plan which described the project and its history; the technical and management plan; resources required; and some justification for the project. These plans had to be submitted to the appropriate program office which in turn sent them to the Associate Administrator for approval. They had to be reviewed and approved annually or whenever significant changes were made. The Project Approval Plans were used to prepare a Master Program Management Plan which contained a list of all NASA projects and expected milestones. This document was issued monthly and was NASA's first effort to establish schedules for its projects. Project status reports, which listed the status of each project, were issued bi-weekly. Glennan also held bi-weekly status meetings in which any problems with projects were discussed.

In August of 1960 he implemented a Financial Operating Plan system which required the centers to submit a plan for all resources allocated to them. This plan became the basis for all future allocations. Although Glennan asked McKinsey & Company to prepare a report on NASA's contracting procedures, he took no steps prior to his departure to standardize its procurement practices, beyond preparing a list of all existing contracts.[80] Contracts continued to be let in any manner desired by the centers, including verbal agreements.

As one of his final actions, Glennan issued a Project Management Manual which explained project approval and planning and provided NASA with its first formal project approval process.[81]

What Glennan did not do was provide a strong central headquarters unit for managing projects or the administrative facets of the centers. With one exception the early technical developments in the space programs were accomplished within the centers with little interference from headquarters. It was two years before such projects as the Surveyor program were even assigned a headquarters program officer, and it was only because of complaints from the centers that headquarters finally established a project approval form.[82] The only exception to this situation was the manned space flight program. Since these centers were all created after 1958, headquarters played an active role in the technical decision making and coordination of this program from the beginning.

THE NEW NASA

By 1961 NASA's project managers, with the exception of the manned space flight program, had established their own methods of operating, and were used to having total control over their own projects. The centers were responsible for the projects assigned to them, personnel management, procurement, and other administrative functions. The problem was that NASA was being heavily criticized for its management of the space program and its failure to produce even a plan for that major achievement which would re-establish the nation's prestige. Its critics had ample evidence to substantiate their criticisms. From 1958 to 1960, NASA had launched 25 spacecraft. Only eight were successful.[83] The Soviets continued to increase their lead, and by January of 1961 they had photographed the moon and launched two dogs into space.[84]

Its critics and friends agreed on one thing. NASA had a major management problem. Internal evaluators, NASA-sponsored groups, and the Bureau of the Budget all agreed that NASA needed to make significant changes in its structure.[85] It was the Wiesner Report prepared by Jerome Wiesner of MIT for the newly elected President Kennedy which was the most critical.[86] The report not only criticized NASA's lack of technical progress, it also criticized NASA's entire management structure. NASA's problem was not technical capability, but "lack of 'efficient and effective leadership' together with 'organizational and management deficiencies' and problems of staffing and direction.'"[87] It had over-emphasized in-house research capability and facilities; given too high a priority to the manned space flight program; and not enough priority to space applications. NASA was also being criticized by many of the nation's top scientists for its failure to establish an adequate scientific program.

It was in this environment that President Kennedy appointed James E. Webb as NASA's second Administrator. Shortly after his appointment Yuri Gagarin became the first man to orbit the earth, and NASA was given what became its primary objective--landing a man on the moon within ten years.[88] To accomplish this objective, its personnel complement and appropriations were to be increased as necessary. Congress strongly supported both Webb's appointment and the new objective.

Webb's appointment represented a major change in NASA's management philosophy and the priority given to its different research activities. Glennan had hired outside consultants and appointed individuals whose specialty was management, but he continued to work with NACA's former leaders and made no attempt to interfere with research activities. From the beginning Webb emphasized the need for greater headquarters control and direction over both the administrative and technical facets of the organization. His tenure was characterized by a slow, but steady, centralization of the organization and increases in the amount of controls exercised over the activities of the organization. If NASA failed to produce at some acceptable level, it was because management had failed to somehow implement adequate controls. The response to each problem was a shifting of divisions of work, adoption of new control mechanisms, or removal of the individuals responsible for the particular problem area. It also was the period in which NASA's change to an organization whose primary objective was the manned space flight was made.

Formal Organization

Webb's tenure was marked by frequent reorganizations which were made both in response to some technical failure and studies which recommended changes in the management of the organization. He announced his first reorganization in November of 1961. Its objective was to improve NASA's leaders' control of the organization and to stop the drift toward semi-autonomous program offices. In contrast to Glennan, Webb argued that his first reorganization was produced by in-house efforts.

> This is largely an internal effort based on staff papers prepared by Al Siepert and Young and their associates, examined by others in the organization, discussed with Dryden and with me, but basically it was my application of what I learned in the Bureau of the Budget, and with the experience in industry, beginning with the Sperry Gyroscope problem of large organized effort.[89]

This in-house effort, though, did not include NACA's former leaders. It was based on a study by Jack Young, Deputy Director of Administration, who had been recruited from McKinsey & Company, and Alfred Siepert, who had been recruited from the National Institutes of Health at the recommendation of McKinsey & Company.[90]

Dr. Robert C. Seamans, Jr. was retained as the Associate Administrator and general manager, but he was given direct authority over the centers.[91] The four program offices to which the centers had

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

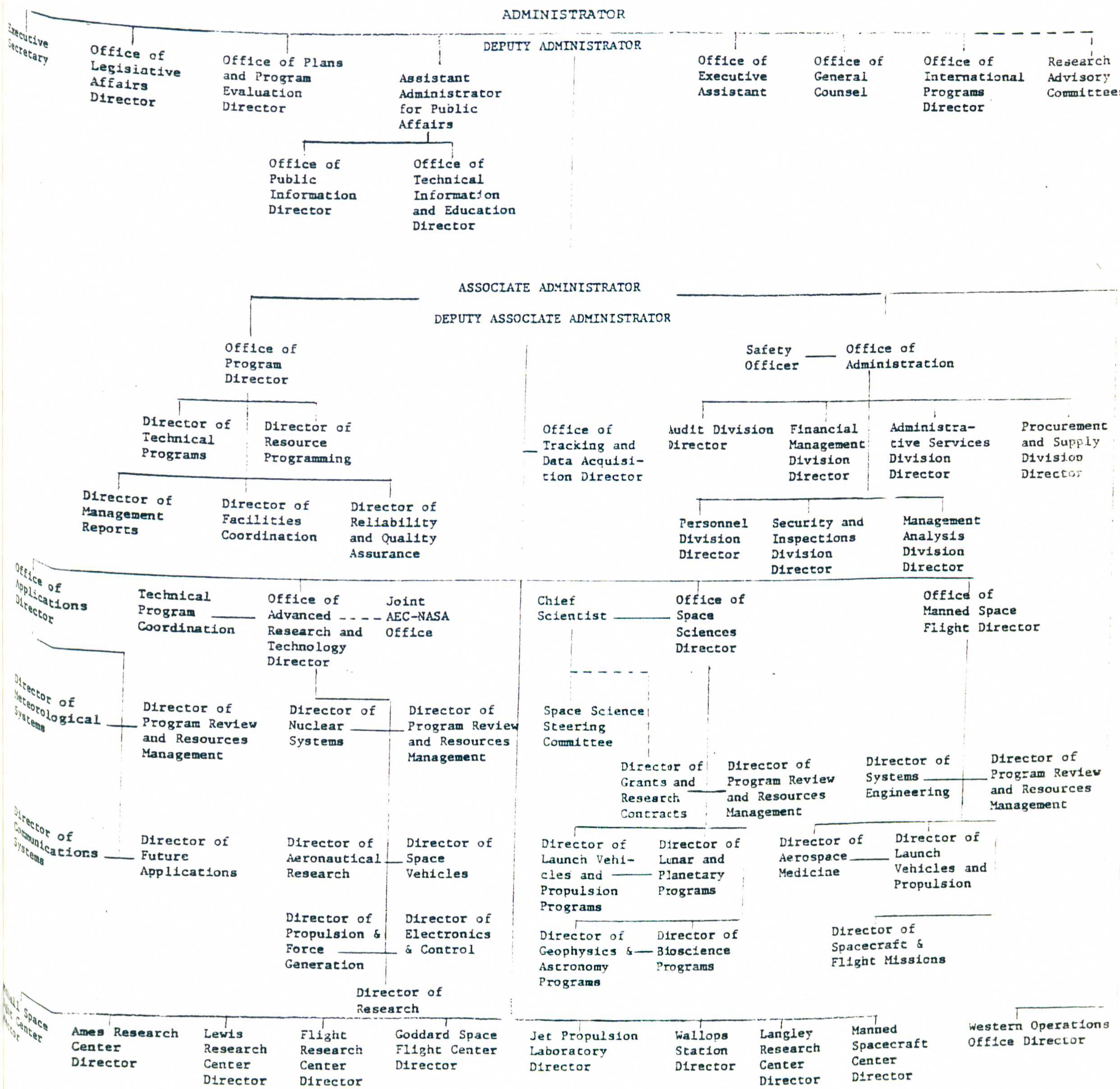

Figure 4

NASA Organization Chart, 1961

reported prior to the reorganization were replaced with six new program offices. The program offices were responsible for working with the center Directors to execute their programs, but the center Directors reported to the Associate Administrator for all other matters. The second major change was the addition of an Office of Plans and Program Evaluation which was "intended to be a self-policing, examining activity, as well as a forward-looking activity."[92]

The 1961 reorganization effort failed, and in 1963 the organization reverted back to the centers reporting directly to the program offices. The major reason for this change was that the OMSF Director had complained that he could not be responsible for Apollo without adequate control of resources. The other centers had also complained that they did not know who was responsible for their programs, the Associate Administrator or the heads of the program offices. The 1963 reorganization was an attempt to provide the centers with more responsibility for their programs. A lead center for each project was appointed and given responsibility for the management of an entire project. The program offices were supposed to work directly with Webb and Seamans to ensure the control of the organization. The practice of holding Management Committee meetings was established. Monthly status reviews in which the program offices presented their programs, planned and actual manpower, schedules, and expenditures were implemented. Each program was to be given an extensive review each year. Although the centers reverted back to reporting to the program offices, they never regained the control of their activities which existed prior to the 1961 reorganization. As Webb noted,

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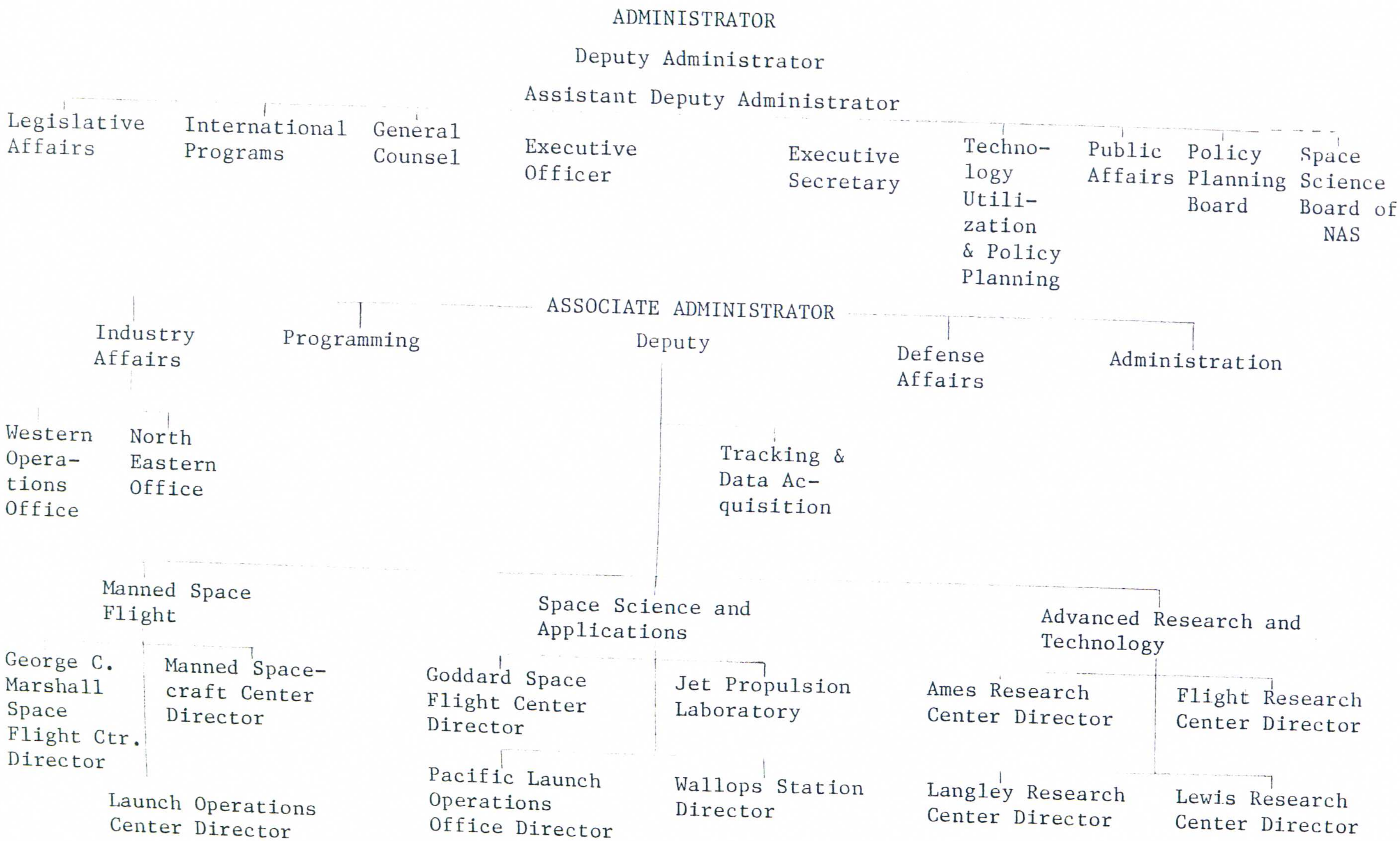

Figure 5

NASA Organization Chart, 1963

> And so it was in a sense of yielding on the part of senior offices to pressures generating in the organization, but yielding in the direction of certain things that we thought were important, and some of those were continuing from the past and some of those were introduced as a result of experience.[93]

It was not until 1967 that Webb again made major changes in the organization in an attempt to gain more control over its activities. The Apollo fire and the investigations by Congress which followed the fire were the catalyst for these changes. Seamans was replaced with Finger and Newell was moved into the position he held in 1968. Finger was given the necessary authority to manage the organization.

Other Administrative Changes

In contrast to the reorganizations, the changes in program and financial management mechanisms were accomplished incrementally. The stimulus for the changes appeared to be management studies by headquarters staff members.

The project approval system implemented by Glennan was changed in 1962 to provide Seamans with a less detailed and more comprehensive summary of all proposed projects. The programs offices after receiving project proposals from the centers submitted a two-page summary to the Associate Administrator. This summary was used to prepare the authorizing document (PAD) for all projects. The Financial Operating Plan submitted by the centers had to concur with the PAD.[94]

In 1961 NASA also adopted a new management tool called Program Evaluation and Review Technique (PERT) which allowed project managers to track the progress of all subsystems of a project and the impact of any delay on the entire project.[95] The integration of PERT with the

Financial Management Reporting System was supposed to provide NASA's managers with a mechanism for tracking planned and actual costs and schedules.

In 1964 Webb implemented a recommendation of a staff report by Jack Young and his staff by creating an Executive Secretariat position to provide him with additional information on the activities of NASA.[96] This office implemented a Critical Reports and Correspondence Review System which summarized all the significant matters covered in any reports produced by NASA and codified all of NASA's directives. In 1965 Webb created the Office of Administrator and appointed Willis Shapley, the Bureau of the Budget analyst who had monitored NACA's budget, been so critical of NACA's structure, and helped draft the Act which created NASA's structure, as his Chief of Staff.[97] This office was also created at the recommendation of another staff paper by Jack Young.[98] The Office of Organization and Management was created in 1967 shortly before the Apollo fire. Finger, who had written the report recommending its establishment, was appointed the new Associate Administrator of this Office.[99]

Phased Project Planning, NASA's four-step approval process, was initiated in 1965 after a schedule and cost study by headquarters found slippages in all of NASA's programs and increases in costs because of these slippages.[100] Since Apollo was one of the programs falling behind, Webb felt that more control should be exercised over program planning. It was not fully implemented until after the Apollo fire in 1967.

Webb and In-House Research

Webb's changes in the formal structure and reporting mechanisms were accompanied by an increase in the pressures to let contracts for research activities whenever possible. The assignment of two major research and development space projects to the Jet Propulsion Laboratory, while at the same time placing manpower ceilings, forced this organization into more contracting.[101] By 1965 even Ames had been forced to resort to letting contracts for maintenance, computing services, and operation of one of its wind tunnels. Private firms became responsible for the

> design and construction of research instruments...the planning and execution of research projects; [and] the analysis of the resulting data and the writing of research reports.[102]

Ames, along with the other NACA centers, simply could not handle the volume of work assigned to it by headquarters within the manpower restrictions imposed by headquarters. The OART programs had been given the lowest priority in terms of resources and manpower from the beginning, and the centers under its jurisdiction moved into project management partially to increase their share of the organization's total resources and to provide their staffs with new ideas for research. The reaction at Ames and the other centers which had previously engaged only in in-house research was not positive.

> From the standpoint of the Center [Ames], whose interest lay mainly in basic research, such contracting was in many respects debilitating. It would, of course, inhibit the full development of the Center and would dilute the quality and reduce the morale of the staff. It would render more difficult the problem of acquiring and retaining

> research men of the highest quality and would be particularly harmful if it reduced the Center's best research men to mere contract monitors--assuming they would accept such a role.[103]

Perhaps more important, the cost of letting contracts for more and more of its work was costly in terms of in-house morale and technical capabilities. These problems, while affecting the various groups differently, hurt all of them. As Gilruth, the Director of the Manned Space Flight Center, argued in 1969,

> We have agreed with the 'surge tank' philosophy and have recognized that an adequate in-house manning of Civil Service Personnel was out of the question. However, we think that this in-house capability should have been greater and have, from time to time, requested a larger in-house manning...We have been very weak in systems engineering, analysis, and trajectory work. We have developed practically no engineering competence in the field of Reliability and Quality Assurance. We have probably been too dependent on Philco, IBM, and TRW in the operation of the Mission Control Center and in operations generally... We are studying intensely what we can do to reduce our dependence on engineering support contractors... We are sure that it will not be practical to eliminate outside engineering support for several years. However, we do plan stronger program level systems groups and well defined tasks for the outside engineering support.[104]

Webb was not the only decision maker with regard to NASA's affairs. Both its structure and research activities were heavily influenced by oversight organizations. NASA's relationships with these organizations were quite different than those which existed during NACA's existence. This occurred partially because of the difference in the level of appropriations between the two organizations and the fact that oversight agencies continued to expand their authority over government agencies, but it also occurred because Webb's reaction to the demands of oversight organizations differed quite a bit from NACA's leaders' responses. NACA's leaders fought for their unique structure and the right to engage in the type of research they felt was necessary to advance aviation. Webb accepted the authority of outsiders to make decisions about NASA's internal management and the specific technical projects which were necessary to advance aeronautical and space research.

Oversight Agencies

Three organizations played a role in NACA's activities during its history, but the changes which they effected were largely of an administrative nature. The oversight of NASA's activities was more invasive and involved the performance of NASA's technical work.

The Civil Service Commission investigated NASA's personnel management activities in 1962 and 1967.[105] In the 1962 investigation the Civil Service Commission found some irregularities, but it did not carry its investigations any further or report them to Congress. Webb responded by directing the headquarters Personnel Office to inspect and evaluate the centers' personnel management activities on a regular basis. The 1967 investigation found a number of discrepancies including a lack of uniformity in personnel management practices. Webb's response to this investigation was to establish the Personnel Review Committee to evaluate all centers' personnel practices.[106] In contrast to the Personnel Office which reported to Finger, the new committee reported directly to Webb.

The General Accounting Office also investigated NASA's activities throughout its first ten years, but it was not until 1965 that these investigations began in earnest. The increase was partially a function of the increase in NASA's procurement activities. The General Accounting Office not only had responsibility for its own investigation of procurement, it also had to respond to complaints from contractors about NASA's contract awards. It reviewed NASA's implementation of Planning, Programming and Budgeting and the equal opportunity program. Cost overruns and slippages in schedules were investigated. Not only did it report to Congress on these investigations, it also sent the Civil Service Commission and other organizations reports on practices it considered questionable. In 1967 the Civil Service Commission ruled that NASA's use of support contracts was illegal after the General Accounting Office sent it a report on its investigations.[107] Webb responded by directing the centers and program offices to submit all support contracts over one hundred thousand dollars to Finger for approval. In 1964 after it reviewed Goddard's contracting activities and sent its report to the Civil Service Commission, the Commission declared that Goddard's activities violated federal law. Webb responded by establishing specific criteria for letting contracts.[108] After 1967 and following a steady increase in the General Accounting Office investigations, Webb issued a directive ordering the submission of all responses to the Office's investigations to Finger for approval.

The activities of these two organizations had an enormous impact on NASA, but the Bureau of the Budget played a larger role. Webb, as early as 1961, went to President Kennedy because of cuts in NASA's requests. The establishment of NASA's lunar landing objective only eliminated the problem for a short period of time. By 1963 its requests were again being challenged by the Bureau of the Budget. Not only were some of its appropriations requests being cut, but also entire programs were eliminated. As Levine noted,

> It was the action of the Bureau, not Congress, that led to the cancellation of (or caused NASA to cancel) the last two Apollo flights; to the reduction of Surveyor flights from 17 to 10; to the freezing of NASA-excepted positions at 425; and to the elimination of certain programs before reaching the development stage, such as the Advanced Orbiting Solar Observatory cancelled by NASA in December 1965.[109]

The adoption of the Planning, Programming and Budgeting System only added to NASA's problems. NASA's programs were not amenable to cost-benefit analysis, and it had difficulty showing that its programs were contributing to the Great Society objective of President Johnson. Perhaps more important, it was hard to justify some of the large research and development programs which essentially had political objectives that were no longer in vogue. Using the gap between the Russians and the United States as their justification worked well until

1965 when "the United States caught up with and surpassed the Russian manned space accomplishments."[110]

The three organizations not only played a role in standardizing NASA's activities to fit federal guidelines and reducing their appropriations, they also limited NASA's discretion with regard to handling the cuts in appropriations and personnel. Lower appropriations could be dealt with by performing more work in-house, but this alternative was of little value after personnel ceilings were lowered. Personnel ceilings could be handled by cuts in programs and / or letting contracts, but the Civil Service Commission's decision to disallow NASA's support contract practices made this alternative less desirable. The Bureau of the Budget's increasingly restrictive personnel ceilings finally forced NASA into reductions-in-force. This NASA could accomplish, but reductions-in-force had their drawbacks. As Julius Allen, the Director of Ames, argued,

> I would like to say again what I said before, that when it comes to reduction in personnel and that may be required, to please give advance notice so that we can back down gracefully on this thing because the civil service methods of backing down are not acceptable. They just leave you a torn, messy, shred of a place when you get through.[111]

Even ignoring the impact on morale of reductions-in-force, they did not always produce the desired results. As suggested above, Civil Service regulations gave employees rights which prevented NASA's leaders from simply dismissing employees as they desired. At Marshall "from 1 to 10 personnel actions were required per release of an employee during reductions-in-force."[112]

Congress

That NASA's relationship with Congress was going to be different than the one which had evolved between Congress and NACA was evident in its first few years. Congress was fascinated with NASA and showed its fascination by bringing in experts to testify on even the most technical aspects of the space program. The Johnson Rider to NASA's first Appropriations Bill in 1959 made Congress's role formal.[113] NASA not only had to obtain Congressional approval for its appropriations, but also annual authorization of each program. In contrast to Congress's oversight of NACA's activities, its oversight of NASA's activities was such that some of its members became experts on even the technical aspects of each program. The various committees placed limitations on how NASA spent its appropriations; determined the conditions under which it could reprogram its funds and specified the percent of funds which could be reprogrammed; held detailed hearings on NASA's administration of its programs, any cost overruns or slips in schedules, and technical failures; and made decisions about which programs NASA would accomplish and the actual execution of those programs.

> The average Congressional committee would have received testimony from the responsible top officials, and tried to resolve any disputes at the very top. The Science and Astronautics Committee and its subcommittees, given free rein by Chairman Miller, went out to the contractors, the NASA centers throughout the country, sought the advice of independent experts, talked to the workers in the plants and their foremen, and had a real understanding of what was going on in every program.[114]

The actual impact of Congress on NASA, though, occurred not through directives from Congress, but Webb's actions following investigations or hearings on NASA's programs. For example, the Surveyor lunar roving vehicle experiment proposed by NASA was dropped after Congress objected. The last six scheduled missions for the Ranger program designed to examine the surface of the moon were dropped because of pressures from Congress. One of the Mariner space probe missions was cancelled after Congress recommended a fifteen million dollar reduction in its funding.[115]

Webb responded to investigations of NASA's technical failures, cost overruns and delays in schedules by increasing the documentation requirements for all NASA programs. In 1962 the Subcommittee on Space Science and Astronautics made the first serious evaluation of NASA's programs when it investigated the Centaur program which was supposed to provide the launch vehicle for the Ranger and Surveyor spacecraft. The Committee concluded that:

> Putting out fires is no substitute for effective program management. The subcommittee is forced to conclude that management of the Centaur development program has been weak and ineffective both at NASA headquarters and in the field, and that the program has suffered from a diffusion of authority and responsibility.[116]

NASA's leaders transferred the Centaur program from Marshall to Lewis shortly after the investigation. In 1964 its investigation of the Ranger Project found that the Jet Propulsion Laboratory had not provided adequate management nor technical supervision of the program and recommended that NASA "oversee or supervise, not just management practices at JPL, but technical approaches as well."[117] Webb responded by forcing JPL to accept a general manager, Air Force Major General Alvin R. Luedecke; increased the number of staff supervising the contractor; and changed the contract with the Jet Propulsion Laboratory to provide NASA with more say in the selection and execution of its programs. After these hearings NASA adopted an unwritten rule of "no failures."

In 1965 the same subcommittee investigated NASA's Surveyor program because its first launch was two and a half years late. The committee again faulted NASA for lack of adequate management control of JPL and JPL of inadequate supervision of its contractors. JPL was again required to increase the number of individuals supervising the prime contractors.

Despite these investigations, Congress supported NASA for most of the period preceding 1965. From 1965 on, it began to cut NASA's appropriations requests. After 1967 Congressional support of NASA steadily declined. The decline in the agency's appropriations began shortly after the successful Mercury flights which showed NASA's ability to launch a man into space. Attempts by Webb to stop the cuts were not as successful as they had been in earlier years. As he argued,

> Now, we are dealing with the institution of the Presidency and a lot of problems and we are not dealing with the guy [Johnson] who said, I am your champion, I will go out there and fight your battles, I will get Kennedy and this Congress to give you the money. He is saying, by God, I have got problems and you fellows are not cooperating with me. You could have reduced your expenditures last year and helped us out, you didn't do it. So, you are absolutely right when you say that there has been a radical change of the environment within which we have got to work.[118]

Two events, though, changed NASA's relationship with Congress. The first was Webb's failure in 1966 to present the Committee with his recommendations for future space objectives after repeated requests from the committee for these objectives. Webb responded to the request by arguing,

> Because of the difficult budgetary situation resulting from the war in Vietnam and other factors, we are uncertain at this time as to what the President will approve for our fiscal year 1968 budget. Even in the absence of these uncertainties, of course, we would be precluded by the regular budgetary procedures from presenting specific statements on our future plans at this time.[119]

The House Committee refused to accept this explanation, but despite additional pressures Webb would not propose a program without the consent of the Executive Branch.[120]

The Apollo fire on January 27, 1967 was qually disruptive to NASA's relationship with Congress. Webb refused to turn over to either the House or Senate Committees a memo sent by General Phillips, the Apollo project manager, to Nor-h American Aviation, on the management deficiencies which he had uncovered in a 1965 investigation. Congressman Fuqua noted that:

> I think the committee has gone out of its way to cooperate with NASA in every way. I am getting the feeling that maybe you haven't really cooperated with us in not providing us with the information about some of these management problems that you have with the various contractors.[121]

Although Webb responded to Congress's questions about the fire by letting a contract to Boeing for an evaluation of the Apollo project and implementing the management changes discussed above, Congress's support of NASA was never as strong as it had been prior to the fire.

Congress's actual impact on NASA is difficult to assess. Many of the changes made were changes which were made voluntarily by NASA's leaders. On the other hand, it also seems fairly evident that Congress's "actions in the oversight area helped to shape NASA's management."[122] The problem, from NASA's perspective, was that this oversight left no margin for error on its part. As Webb pointed out,

> I am not sure that they [center Directors] fully realize that whereas weapon systems and atomic developments of comparable or lesser difficulty can be and are carried out under rigid security restrictions which effectively limit public understanding and discussion of program development details, including failures to meet milestones and costs, our whole program is being conducted under the fullest public scrutiny and we must defend every step that we take without the advantage of letting the final result be our record of performance. I still feel absolutely convinced that our final results will be good, but the image is now most vulnerable to distortion and misrepresentation by everyone who wants to jump on us or just wants a headline.[123]

THE NEW PHILOSOPHY

It is tempting to explain the changes in NASA by arguing that they were simply the result of a political decision to stop supporting the exploration of space and pressures from Congress and other oversight agencies to conform to federal standards and implement better control mechanisms, but this ignores NASA's role in its own decline, as well as the fact that NACA was able to withstand the pressures placed on it by external organizations at least until 1958. Granted it had less pressures, but it was also a great deal less powerful than NASA and thus theoretically less able to resist the pressures from external organizations. The changes NACA did make in response to these organizations were in most cases surface changes with little impact on the actual functioning of the organization. It was only those demands, such as pay scales, which they could not ignore that had a real impact on the organization. It was evident by the mid-1950s that NACA was losing its battle to retain its unique structure, and the decision to ask for a role in the new space program was in hindsight fatal, but until this time it was able to give its researchers an environment which was conducive to their research efforts.

NASA, in contrast to this, appeared to react to every demand made upon it. The ten years which we examined above contained four major reorganizations and continual changes in the organization's financial and administrative management mechanisms. The organization reacted to every pressure from outside with little indication that there was any control being exercised over the responses made to these demands. The reactions were generally in one direction--the adoption of more control mechanisms. Failures occurred and additional controls were added with little concern about the impact of the controls on the work of the organization. Pressures to let contracts resulted in an almost total reliance on contracting for its work, despite complaints from its staff that some mechanism had to be developed for providing the researchers enough training to supervise the work of contractors. Congress's commitment to the manned space program was translated into total commitment to this program. The BOB's reductions in its budget and refusal to allow it to present new programs to Congress were simply accepted. The adoption of new control mechanisms continued relentlessly despite growing evidence that they were pushing highly qualified scientists and engineers out of the organization and creating morale problems.

What then made NASA so vulnerable to pressures from external organizations? To answer this, it is necessary to look closer at one major difference between NACA and NASA. NACA's history was in some ways the story of the working out of a conflict between two philosophies of how organizations should be managed and what types of research they should accomplish. NACA's creators believed that if the nation was to make advances in aeronautics, it would have to establish a laboratory in which scientific research was performed. They also believed that research had to be accomplished in an environment in which controls were minimal and evaluation of the work of the staff was accomplished by other scientists and engineers. Scientists had to have adequate freedom to change direction when necessary.

This philosophy of management was attacked by various groups who believed that government agencies should be directed and controlled by a single administrator appointed by the President. They used terms such as control, efficiency, and sound management practices. In contrast to NACA's leaders, they believed that NACA's task should be applied research or engineering and that the staff's work could be directed toward a specified objective.

Although NACA's leaders never achieved its creators' ideal structure or engaged in the scientific research they felt was necessary, their ideas about what the organization should do and look like served as a standard from which to judge all suggested changes. It was these ideas which guided NACA's leaders when they were faced with pressures from outside organizations to bring their structure into conformance with other government agencies. In practice, they were far from achieving their ideal organization, but they were also far from the organization envisioned by many of the groups which controlled their destiny.

By the 1950s NACA was rapidly losing ground in the fight. Federal regulations and investigations by oversight agencies, coupled with declining resources, made it more and more difficult to continue offering the incentives necessary to maintain its leaders' ideal organization in the manner necessary to recruit and retain highly qualified scientists and engineers.

NACA's transformation to NASA was more than an enlargement of NACA's research activities or the size of the organization; it represented a change to a new philosophy of management. NASA's creators believed in the ideology of those individuals who had opposed NACA's structure for so long. They justified the change to more controls by arguing that the new research and development task required an Administrator with adequate authority to control and coordinate the large research and development projects. They, whether intentionally or not, appointed individuals to manage the organization who also believed this management philosophy, and these individuals in turn produced reports recommending the implementation of more controls. Webb believed that NASA should look at its budget requests "under the same criteria that they [BOB analysts] and the President have to look at."[124] NASA could present alternatives to the Executive Branch and Congress, but the final decision was made by them, whatever the long-term impact on the organization. He also believed, as they did, that if NASA was somehow failing to perform at a level that was judged adequate by their standards, it was because of poor management and that was defined as not enough control by top management over the organization. Webb's response to the Apollo fire was to implement additional controls throughout the organization, despite the fact that there was little evidence that the rest of the organization was performing inadequately.[125]

> And here is where it became clear after the Apollo fire in January and the traumatic experiences that we went through there that our organizational system had lost its self-policing features that we thought were built into it.
>
> It's clear that the alternatives being brought up to top management had been screened too much, that you were in effect getting one recommendation or you were getting two recommendations, one of which was clearly good and one which wasn't worth a damn, so

> you in effect were chained to either agree or disagree with one recommendation, and the emphasis on administration as well as program was declining, and that we ought to begin to build a real capability and train someone who would take on the real responsibility as the man who would institute a permanent office as strong as the Director of the Budget is in the United States Government.[126]

Webb's unwillingness to accept NACA's view of the world and its leaders' belief that research required an environment different than that of other government agencies is perhaps best represented in his response to questions about why individual names were taken off NASA's organization charts after 1961.

> Well, we left them out only because we wanted to emphasize the function and not the individual. Then NACA had been an organization that operated by individuals,...They have working habits among individuals, and we wanted to begin to emphasize that that wasn't the way you could organize something as big as NASA had to be.[127]

NACA's leaders did not want to classify their employees because they felt this would inhibit their creativity. NASA's management dealt in classifications.

NOTES

[1] Minutes of Executive Committee Meeting, January 16, 1958. The proposal was written by the staff and titled, "A National Research Program for Space Technology." NACA's decision to propose its inclusion in the new space organization is discussed in detail in Alex Roland, Research by Committee: A History of the National Advisory Committee for Aeronautics: 1915-1958, Comment Edition, April, 1980.

[2] Public Law 85-568, 85th Cong., H.R. 12575. July 29, 1958. 72 Stat. 426.

[3] Appendix A contains a description of NACA's and NASA's employment and appropriations history.

[4] The NACA laboratories were renamed centers when transferred to NASA. Appendix B provides a map with the location of all NASA centers.

[5] NASA's first Administrator was T. Keith Glennan, former President of Cleveland's Case Institute of Technology and sound systems engineer for the motion picture industry. Webb at the time of his nomination was Director of Kerr-McGee Oil Industries and McDonnell Aircraft & Chairman of Municipal Manpower Commission. Prior to this, he had been Under Secretary of State. He was the Director of the Bureau of the Budget from 1946 to 1949. He was appointed by President Kennedy on February 14, 1961.

[6] See Richard L. Chapman, Project Management in NASA: The System and the Men (Washington, D.C.: NASA, 1973) for a description of NASA's project management system. A program is a "related series of undertakings which continue over a period of time (normally years), and which are designated to accomplish a broad scientific or technical goal in the NASA Long-Range Plan..." A project is one of the undertakings of a program "with a scheduled beginning and ending,..." General Management Instruction 4-1-1, March 8, 1963.

[7] See Adm. W. Fred Boone, NASA Office of Defense Affairs (Washington, D.C.: NASA, 1970) for a discussion of the relationships which developed between the Department of Defense and NASA. General Phillips was the Program Manager for the Apollo program. After reviewing the situation at NASA, he requested additional detailees to fill top and mid-level management positions on the Apollo project.

[8] Arnold E. Levine, An Administrative History of NASA, 1963-1969, Comment Edition, August 23, 1977, NASA History Office, pp. 172-173. DOD in 1967 had responsibility for 11.7 billion dollars' worth of NASA contracts (1700 individual contracts). NASA's total budget for this period (1958-1968) was $32 billion.

[9] The Civil Service Commission ruled that NASA's support contracts were illegal after the General Accounting Office reported its findings to the Commission. U.S. Comptroller General, "Report on Potential Savings Available through Use of Civil Service Rather than Contractor-Furnished Employees for Certain Support Services, National Aeronautics and Space Administration," June 1967. The systems engineering tasks were performed primarily by three companies: Belcomm (NASw-147), a subsidiary of American Telephone and Telegraph Co.; General Electric (NASw-410); and a Boeing subsidiary (NASw-1650).

[10] Webb discussed the various organizational changes which he had made in "Transcript of Proceedings, National Aeronautics and Space Administration," Management Advisory Panel Meeting, Washington, D.C., April 19, 1968. Copy in NASA Headquarters History Office Files.

[11] Willis Shapley was the Bureau of the Budget analyst responsible for NACA's budget during the 1950s. He had also been one of the individuals responsible for the draft of President Eisenhower's bill to establish NASA.

[12] Management Advisory Panel Meeting, op. cit., p. 41.

[13] Newell had been transferred to NASA with the Naval Research Laboratory group in 1958. He had been employed by NRL from 1944 to 1958.

[14] Newell's Office was originally established in response to the Bureau of the Budget's Planning, Programming and Budgeting program memorandum and special studies requirements.

[15] See Raymond A. Bauer, et al., NASA Planning and Decision Making, 2 vols., Contract NGR 22-0007-163 and NGL 22-007-124, 1970, for an evaluation of NASA's long-range planning.

[16] The planning process, which had been established to obtain more consensus on agency-wide objectives, ended with the acceptance of a plan in 1969 written by Belcomm under an Office of Manned Space Flight contract. Bauer, ibid., discusses the other program offices and centers' reaction to the rejection of their plan and acceptance of Belcomm's.

[17] Barry Rutzer, "The Lunar and Planetary Missions Board," HHN-138, August 30, 1976. The scientific community disagreed with NASA's emphasis on improving the nation's technical capability and the political nature of the lunar landing mission. They wanted more emphasis on scientific research. NASA's cancellation of what were considered scientific missions to save the Apollo program essentially cost them the support of much of the scientific community.

[18] 42 U.S.C. 2452.

[19] The percentage of contractors to total employees ranged from a low of 77 percent in 1961 to a high of 92 percent in 1964 and 1965. By 1979 it had dropped to 82 percent. NASA, <u>This Is NASA</u> (Washington, D.C., U.S. Government Printing Office, 1979), p. 13.

[20] President Kennedy announced the lunar landing on Mary 25, 1961. The Goett Committee appointed on April 1, 1959 and composed of representatives from NASA's centers, recommended the lunar landing as a logical next step after Mercury. 1970 was set as the target date. On July 9, 1960, headquarters gave approval for the contracts for feasibility studies. On July 28, 1960, the project was officially named Apollo. See Courtney G. Brooks, et al., <u>Chariots for Apollo: A History of Manned Lunar Spacecraft</u> (Washington, D.C.: NASA, 1979).

[21] Leonard R. Sayles and Margaret K. Chandler, <u>Managing Large Ssystems Organizations for the Future</u> (New York: Harper & Row, Publishers, 1971), p. 19. This description of research and development organizations relies heavily on this study.

[22] See Amitai Etzioni, <u>The Moon-Doggle: Domestic and International Implications of the Space Race</u> (New York: Doubleday & Co., Inc., 1964) and Rutzer, loc. cit., for a discussion of this belief.

[23] Apollo was taking three-fourths of NASA's research and development budget in 1967 and one-third of its personnel. See Brooks, loc. cit., and Jane Van Nimmen and Leonard C. Bruno with Robert L. Rosholt, <u>NASA Historical Data Book, 1958-1968</u>, Vol. 1: <u>NASA Resources</u> (Washington, D.C.: NASA, 1976).

[24] See Chapman, loc. cit.

[25] Brooks, loc. cit., and Nimmen, loc. cit.

[26] Emmette S. Redford and Orion F. White, "What Manned Space Program After Reaching the Moon: Government Attempts to Decide: 1962-1968." NASA Research Grant NGL 33-022-099. Syracuse / NASA Program, December, 1971, p. 53.

[27] NASA, Transcript of Proceedings, "Budget Change-Over: Webb, Seamans and all Center Directors, 9/28/66," NASA Headquarters History Office files, pp. 25-26. Wernher von Braun was trying to explain why it was so difficult to justify this program to Congress and the Bureau of the Budget.

[28] Redford, op. cit., p. 193.

[29] Memorandum for the Record, February 14, 1968, Subject: Interview with Dr. Homer E. Newell on February 13, 1968. NASA Headquarters History Office files.

[30] Newell's explanation was that the scientific community just did not understand that Congress would not support a scientific program. See Rutzer, loc. cit.

[31] Nimmen, loc. cit.

[32] Chapman, op. cit., p. 14.

[33] The four-phase approval process was formerly known as Phased Project Planning.

[34] This section includes a description of only some of the agency-wide tracking mechanisms. The specific reporting requirements varied among the projects particularly in NASA's early years. For examples of the forms required for one project see Erasmus H. Kloman, "Surveyor and Lunar Orbiter: Case Studies of Project Management," June 30, 1970. NASA Headquarters History Office files, Washington, D.C.

35 Belcomm was set up in 1962 at the request of Webb to help the Manned Space Flight Program Office make technical decisions.

36 Kennedy, Flight Research Center, and Wallops Station were not included in this authorization. The headquarters Contract Division could only negotiate contracts up to $1 million.

37 This step was taken after a Congressional investigation of NASA's support contracts. House Committee on Science and Aeronautics, Subcommittee on NASA Oversight, Support Services Contracting by the NASA, 90th Cong., 2d sess. (April 1968), pp. 5, 7-8, 19, 23-25.

38 See Management Advisory Panel Meeting, op. cit.

39 James E. Webb, Space Age Management: The Large Scale Approach (New York: McGraw-Hill Book Co., 1969), p. 145.

40 Chapman, op. cit., discusses this problem in detail.

41 Ibid., p. 102.

42 Levine, op. cit., Chapter 3.

43 Brooks, op. cit., p. 119. Both the centers and other contractors resisted these headquarter's contractors. G.E. was under orders from Houston's Apollo project manager not to do anything unless he had a work order directly from him.

44 "Budget Change-Over...," op. cit., pp. 51-52. NASA in 1966 hired 925 scientists and engineers. In 1970 it hired 200.

45 NASA, "The In-House Workforce: A Report to Management," NASA Office of Personnel, 1975. Copy in NASA Headquarters History Office files. The average age had increased to 42.1 by 1975. For non-scientists and engineers it was 43.

46 Oran W. Nicks, "Current Problems in Reducing NASA's Staff," May 26, 1969. Copy in NASA Headquarters History Office files. Nicks was the Deputy Associate Administrator for Space Science Applications.

[47] Memorandum for the Record, February 5, 1968, Subject: Trip to Lewis Research Center on January 26, 1968. Copy in NASA Headquarters History Office files. The interview was part of a Personnel Management Review Committee evaluation of NASA's personnel problems.

[48] Bauer, op. cit., Vol. 2, p. B-84. Interview with Lewis staff member.

[49] This problem was discussed in Edwin P. Hartman, Adventures in Research, A History of Ames Research Center: 1940-1965 (Washington, D.C.: NASA, 1970). There was a great deal of animosity between the various groups because of the fact that the applied research group felt that any time they came into competition with OMSF or OSSA development projects for funds, they would not receive funding.

[50] Chapman, loc. cit.

[51] Management Advisory Panel Meeting, op. cit., p. 29.

[52] Hartman, op. cit., p. 491.

[53] Finger to Ray Romatowski, Director Organization and Management Planning Division, Subject: OART Management and Control System. May 22, 1967. Cited in Levine, op. cit., p. 325.

[54] "Budget Change-Over...," op. cit., pp. 7-8.

[55] See note 16.

[56] Bauer, op. cit., Vol. 2, p. B-83. Interview with Lewis staff member.

[57] See Chapman, loc. cit.

[58] See U.S. Civil Service Commission, "Evaluation of Personnel Management NASA Nationwide, August, 1967," NASA Headquarters History Office files; NASA, Personnel Management Review Committee, "First Report," March, 1968, NASA Headquarters History Office files; and "Considerations in the Management of Manpower in NASA," September 8, 1966, NASA Headquarters History Office files. The latter report was known as the Hjornevik Report.

59 NMI 1152.26, January 3, 1968. The committee was first established as an *ad hoc* committee and then made a permanent part of NASA's personnel organization.

60 See National Academy of Public Administration Foundation, "Report of the *Ad Hoc* Panel on Attracting New Staff and Retaining Capability during a Period of Declining Manpower Ceilings," June, 1973. NASA Headquarters History Office files. The report discusses the impact of Civil Service regulations on NASA's ability to recruit and retain highly qualified scientists and engineers.

61 For a detailed description of NASA's relationship with the Department of Defense, see Boone, loc. cit., and Levine, op. cit.

62 For a discussion of NASA's relationship with industry, see U.S. Congress, House, Subcommittee on Space Science and Applications of the Committee on Science and Technology, *United States Civilian Space Programs: 1958-1978*, Report prepared by Wendy H. Schact, Science Policy Research Division, Congressional Research Service, Library of Congress, Vol. 1 (Washington: Government Printing Office, 1981), pp. 923-973.

63 Levine, op. cit., p. 208. Levine noted that it took 420 days to process a procurement plan contract and 3 months for a headquarters review of a negotiated contract.

64 For a discussion of this amendment, see Redford, op. cit., and U.S. House, *Toward the Endless Frontier, History of the Committee on Science and Technology, 1959-1979*, Committee Print (Washington, D.C.: U.S. Government Printing Office, 1980), pp. 49-50.

65 See U.S. Congress, Senate, Committee on Aeronautical and Space Sciences, *Tenth Anniversary: 1958-1968*, 90th Cong., 2d sess., Document No. 116, July 19, 1968 (Washington, D.C.: Government Printing Office, 1968). The Science Policy Research Division was established in 1963.

66 Levine, op. cit., p. 383.

67 For a discussion of the creation of NASA, see *Toward the Endless Frontier...*, op. cit.; Alison Griffith, *The National Aeronautics and Space Act, A Study of the Development of Public Policy* (Washington, D.C.: Public Affairs Press, 1962); James R. Killian, Jr., *Sputnik, Scientists, and Eisenhower* (Cambridge, Mass.: The MIT Press, 1977); Richard Hirsch and Joseph John Trento, *The National Aeronautics and Space Administration* (New York: Praeger Publishers, 1973).

68 U.S. Civilian Space Programs..., op. cit., p. 52.

69 U.S. Congress, House, Select Committee on Astronautics and Space Exploration, The National Space Program, House Report 1758, 85th Cong., 2d sess., May 12, 1958, pp. 12-14.

70 U.S. Civilian Space Program..., op. cit., p. 53.

71 The test of the Viking Test Vehicle 3 exploded on December 5, 1957, in front of an international group of news reporters. The Russians' offer to provide technical assistance after the explosion did not help the situation. See George N. Chatham, "History of NASA and Its Relationship to United States Space Policy," in U.S. Civilian Space Program..., op. cit., pp. 29-68.

72 NASA was given authority to transfer any "records, property, civilian personnel, and funds to the NASA as required to carry out its responsibilities under the Act. Sec. 302 (a) and 203, 42 U.S.C. 247. The Vanguard project was the first satellite project undertaken by the United States. See Helen T. Wells, Susan H. Whiteley, and Carrie E. Karegeannes, Origins of NASA Names (Washington, D.C.: NASA, 1976) for a description of all NASA programs and centers.

73 NACA designed its own facilities and administered the contracts required to build them. For a discussion of the Jet Propulsion Laboratory, see McKinsey & Company, Inc., "NASA-JPL Relationships and Role of the Western Coordination Office, National Aeronautics and Space Administration," March, 1959. Copy in NASA Headquarters History Office files. Kloman, loc. cit. NASA's History Office files contain numerous memos on the relationship which was less than ideal in NASA's first ten years.

74 For a discussion of the establishment of the Manned Spacecraft Center, see Thomas P. Murphy, Science, Geopolitics, and Federal Spending (Mass.: D. C. Heath and Co., 1971) and Lloyd S. Swenson, Jr., James M. Grimwood, and Charles C. Alexander, This New Ocean: A History of Project Mercury (Washington, D.C.: U.S. Government Printing Office, 1966).

75 Levine, op. cit.

76 NASw-1. The report produced from this contract was "Organizing Headquarters Functions, NASA," December, 1958.

[77] The NACA report was known as the Abbot Report. See Robert L. Rosholt, An Administrative History of NASA, 1958-1963 (Washington, D.C.: NASA, 1966), Chapter 3.

[78] Both of these changes were contrary to the Abbot Report recommendations. It recommended the placement of an Office of Financial Management at a higher level in the organization. Many of NACA's leaders felt that a general manager would interfere with the centers' contact with top management.

[79] The Director of the Office of Business Administration, the Comptroller, and Assistant to the Administrator were appointments made at the recommendation of McKinsey. Many of the military detailees were assigned to the Procurement Office because of their experience with research and development contracting.

[80] McKinsey & Co. was hired to produce a "Management Study Covering the Appraisal of NASA's Contracting Policies and Industrial Relationships." NASA contract NASw-144.

[81] General Management Instruction, No. 4-1-1, January 18, 1961.

[82] See Kloman, loc. cit.

[83] Rosholt, op. cit., p. 175.

[84] NASA's Annual Reports to the President give a description of all space flights.

[85] "An Evaluation of NASA's Contracting Policies, Organization and Performance," submitted by McKinsey and Co., October 28, 1960, under NASA contract NASw-144; The Kimpton Report prepared by a seven-member Committee chaired by Lawrence Kimpton, Chancellor of the University of Chicago with staff assistance by McKinsey & Co., "Report of the Advisory Committee on Organization," October, 1960. Attachment B, "Suggested Organizational and Operating Patterns for NASA," July 15, 1960, contains the Bureau of the Budget recommendations.

[86] "Report to President Elect of the *Ad Hoc* Committee on Space," January 12, 1961. Cited in Rosholt, op. cit., p. 186.

[87] Ibid.

[88] Webb was appointed on February 14, 1961. The Gagarin flight occurred on April 14, 1961. For a discussion of the events surrounding Kennedy's decision, see John Logsdon, The Decision To Go To the Moon: Project Apollo and the National Interest (Cambridge, Mass.: MIT Press, 1970).

[89] Management Advisory Panel Meeting, op. cit., p. 22.

[90] Young was one of the authors of the McKinsey reports discussed above.

[91] Seamans came from RCA and had been a project manager at MIT. He was appointed General Manager by Glennan in 1960.

[92] Management Advisory Panel Meeting, op. cit., p. 19.

[93] Ibid., p. 26.

[94] NASA Circular No. 219, Subject: Planning and Implementation of NASA Projects--Interim Changes To, May 7, 1962. Copy in NASA Headquarters History Office files.

[95] General Management Instruction 4-1-5, Subject: NASA Program Evaluation and Review Technique--PERT System, September 1, 1961. PERT in its simplest form is a project management tool which allows the establishment of major milestones for each subsystem and the critical points when the subsystems must be completed to finish the project. Generally computerized, it allows managers to track all subsystems and the points where their completion dates must coincide.

[96] "Plan for Keeping the Members of General Management More Fully Informed," October 2, 1963. Copy in NASA Headquarters History Office files.

[97] Memo from Webb, "Office of the Administrator," December 29, 1965. Copy in NASA Headquarters History Office files. Shapley was also one of the authors of a draft bill presented by President Eisenhower on April 4, 1958 to Congress to create NASA.

[98] "The Office of the Administrator: Evolving Concepts and Practices," prepared by Jack Young and staff, December, 1965.

99 NMI 1130.1, "Roles and Responsibilities--The Associate Administrator for Organization and Management," March 14, 1968. Finger was appointed in 1967. The Office was not officially created until 1968.

100 Phased Project Planning was initially proposed in 1965, but formal guidelines were not issued until 1968. Levine, loc. cit., discussed the problems surrounding the implementation of this system. NMI 7100.4, "Authorization and Control of Research and Development Programs, Projects, Other Activities, and Resources Related Thereto," August 15, 1968.

101 See Kloman, loc. cit. JPL was given responsibility for the Surveyor and Ranger unmanned space flight programs.

102 Hartman, op. cit., p. 411.

103 Ibid., pp. 411-412. Ames was the most conservative and academic of the OART Centers. Lewis, although recognized as just as independent, was more willing to change its research direction when its leaders felt it was necessary.

104 Gilruth to Mueller, January 9, 1969. Copy in NASA Headquarters History Office files. Gilruth was Director of the Manned Space Flight Center.

105 See Rosholt, op. cit., pp. 268-269, for a discussion of the 1962 Evaluation. The results were never made public. "Evaluation of Personnel Management...," loc. cit.

106 See note 59.

107 Pellerzi Decision, October, 1967. See House, Support Services Contracting..., loc. cit.

108 NPC 401, "Criteria for Contracting Out," in NASA Policy and Procedures for Use of Contracts for Non-Personal Services, April, 1964. Copy in NASA Headquarters History Office files.

109 Levine, op. cit., p. 368.

[110] Marcia S. Smith, "Manned Spaceflight Through 1975," in U.S. Civilian Space Programs, op. cit., p. 366.

[111] "Budget Change-Over...," op. cit., p. 49.

[112] Nicks, loc. cit.

[113] See note 64.

[114] NASA's budget and programs were reviewed by the Senate and House Authorization Committees (The House Committee on Science and Technology, formerly House Committee on Science and Astronautics, and the Senate Committee on Commerce, Science, and Transportation's Subcommittee on Science, Technology, and Space, formerly the Senate Aeronautical and Space Sciences Committee, abolished 1976). Its appropriations requests were reviewed by the appropriate House and Senate Appropriations subcommittees. Ibid., p. 113.

[115] Levine, op. cit., p. 389.

[116] Toward the Endless Frontier..., op. cit., p. 115.

[117] Ibid., p. 120. See also U.S. Congress, House, Science and Astronautics Committee, Subcommittee on NASA Oversight, Investigation of Project Ranger, 88th Cong., 2d sess., 1964, pp. 215-226. Cited in R. Cargill Hall, Lunar Impact: A History of Project Ranger (Washington, D.C.: NASA, 1977), p. 253.

[118] "Budget Change-Over...," op. cit., p. 35. Webb was meeting with the center Directors. NASA's strongest supporter for many years was President Johnson.

[119] Toward the Endless Frontier..., op. cit., p. 191.

[120] This will be discussed further below, but apparently Webb's Bureau of the Budget experiences both made him aware of the difficulties facing Johnson during this period and prevented him from challenging directives from BOB or the President.

[121] Toward the Endless Frontier..., p. 199.

[122] Ibid., p. 121.

[123] Memorandum from James Webb to Dr. Seamans. Not dated, but prior to budget fiscal year 1966. Copy in NASA Headquarters History Office files.

[124] "Budget Change-Over...," p. 40.

[125] In 1966 NASA launched 100 space craft. Of these, only 13 were failures. Its Gemini program was enormously successful and NASA was outperforming the Russians for the first time. The Surveyor space craft had landed on the moon. The two lunar Orbiter missions had sent back pictures which enabled the selection of sites for the Apollo landing. 1965 and 1966 were two of NASA's most successful years with respect to its space programs, and are recognized as the years when NASA achieved its objective of beating the Russians.

[126] Management Advisory Panel Meeting, op. cit., pp. 39-40.

[127] Ibid., p. 24.

Section II

NASA'S DECLINE

The preceding chapters have largely been devoted to a descriptive examination of NACA and NASA. This section discusses the findings from the case study, my interpretation of NASA's decline, and the relationship between my argument and existing theories of organizations.

Chapter 5 will attempt to provide an alternative explanation of NASA's decline to those discussed in Chapter 1. The focus is on the executive function and NASA's leaders' failure with regard to this function. Chapter 6 discusses other explanations of NASA's decline. Chapter 7 examines the relationship between my argument and existing theories of organizations. Chapter 8 concludes the study with an examination of the policy implications of the study.

Chapter 5

NASA AND THE EXECUTIVE FUNCTION

I suggested in Chapter 1 that an adequate explanation of NASA's failure would require not only an examination of its internal management, but also those relationships which the organization established with external actors. The case study thus included a discussion of NASA's internal management and its external management. This, as I shall try to show in this chapter, has proven to be very fruitful in that even a cursory review of the case study shows that NASA's situation in the late 1960s was not totally a function of its leaders' failure to manage the organization properly. Before trying to justify this assertion with concrete examples, it might be worthwhile to briefly describe the general feaures of the argument which guides the analysis presented in this chapter.

First, I might note that such difficulties as NASA's low morale, difficulties with retaining and attracting highly qualified scientists and engineers, and the aging of its staff, are by the late 1960s probably best attributed to the personnel ceiling, appropriations cuts, and the restrictions placed on its discretion to handle these problems by oversight agencies. They are, in short, only symptoms exhibited by an organization in decline, not the cause of the decline.

Second, the decline itself is probably best explained in terms of NASA's failure to generate those ideas for new technical projects which would provide Congress with some incentive to at least maintain its 1965 appropriations in the following years. Without these new research ideas, NASA's continued high level of funding could not be justified when competition for funds became high in the mid-1960s. It is this failure which has to be explained, not the impact of the cuts in resources which occurred as a result of this failure.

Third, and central to the argument, is the assertion that it was the lack of acceptable authority structure and organizational goal beyond the manned space flight program which was crucial in NASA's decline. Those individuals who in most research organizations were responsible for producing ideas for new research directions were never willing to accept NASA's leaders' authority to make decisions about their technical projects. NASA's leaders after they lost the support of its scientists and engineers were left without a mechanism for providing the organization with ideas about new technologies. They had, either because of their own unwillingness to accept the ideas of scientists and engineers or because the researchers themselves had given up trying to convince them, no group which could provide the stimulus for a change in research and development activities.

Fourth, this failure is in turn explained by NASA's leaders' failure to properly perform their executive function of establishing some equilibrium between the demands being made by the scientists and engineers within the organization and demands being made by external actors for accountability for public funds and the establishment of authrity structures based upon position. It was this failure which started the chain of events leading to NASA's situation in the late 1960s and which requires further explanation.

It will suffice at this point to outline the general form of the argument. Congress and the Executive Branch following World War II began to make increasingly heavy demands on federal organizations for accountability of public funds and the establishment of bureaucratic structures, which they felt was the most efficient method of ensuring this accountability. The change in the management of all federal organizations which followed these demands made establishing or maintaining any type of structure based on expertise very difficult, if not impossible. Organizations within the federal government simply became more and more bureaucratic after World War II. Most federal organizations were able to cope with these demands, but NASA for reasons which will be discussed below was not successful in the transition from an authority structure based on expertise to one based on position, and it was this failure which started the vicious circle which led to its decline.

The chapter discusses each of these claims. When appropriate, NACA's experiences are used to show how another organization coped with similar problems. It starts with an examination of the federal management policy changes which radically changed the environment in which NACA and NASA existed.

THE EXECUTIVE FUNCTION

Before beginning the explanation of NASA's decline some note should be made of the term 'executive function.' It will be used in this study to refer to the responsibility of executives to maintain an equilibrium between demands being made upon them by external actors and those being made by their subordinates in a manner which will ensure the organization's survival. In general this involves providing their clientele with some type of product which will satisfy the clients and ensure that its suppliers, whether they be a political body such as Congress or the clients themselves, as in the case of most private organizations, will provide adequate funds to meet the needs of the organization. To accomplish this, executives must either through negative or positive inducements convince their employees to produce at the level necessary to ensure that they receive adequate funds. Consequently, there is a very direct link between an organization's external environment and its internal management which cannot be ignored. Public organizations present a special case because the link is more formal in that other organizations can require it to meet certain demands which have little to do with the actual objective of the organization. Personnel regulations are only one of the many examples of these types of demands. An executive in a public organization is not only faced with finding some equilibrium between the demands from external and internal actors, but also establishing this equilibrium with a set of rules and regulations which might make doing so even more difficult.

As I suggested above, this is the function NASA's leaders failed to fulfill, and it is this failure which led to NASA's decline. To understand this, it is first necessary to review the changes in the management of federal organizations which occurred after World War II and what they meant to organizations such as NASA.

THE MANAGEMENT OF FEDERAL ORGANIZATIONS

The management of all federal organizations changed dramatically between the creation of NACA and the late 1960s.[1] Prior to World War II, federal organizations were managed primarily through the appropriations process in Congress. The various agencies had to submit budget requests and expenditure information to Congress, as well as some evidence they were performing as Congress desired, but they had a great deal of discretion regarding the internal allocation of funds once appropriated, the specific projects which were accomplished, and the organization's internal management.[2]

After World War II increasingly heavy demands from Congress and the Executive Branch for accountability led to a number of changes in this situation. The President, by requiring that all federal agencies submit expenditure plans to the Bureau of the Budget, began centralizing his control over the federal bureaucracy in 1939. By the 1950s the Bureau of the Budget was evaluating many of the internal activities of federal agencies and reporting these evaluations to the President and Congress. Perhaps more important, it was given the authority to set ceilings. Its use of this authority as a budgeting mechanism played an important role in its control over the federal establishment.

This change was accompanied by an increase in the power of the General Accounting Office, which was responsible for auditing all financial transactions and administrative practices of federal agencies. It reported to Congress on the legality, efficiency, and economy of each agency's financial administrative practices.

The Civil Service Commission was responsible for the selection, classification, promotion, and dismissal of federal employees, but until the 1940s had largely delegated this responsibility to the agencies.

The Civil Service Classification Act of 1949 coupled with the Bureau of the Budget personnel ceilings had an enormous impact on all government agencies. Their discretion and flexibility with respect to personnel management was severely limited, and the salary and position limitations made it difficult for the federal government to attract and retain highly skillled individuals.

Until the 1950s these oversight activities were largely related to the agencies' administrative activities, but in the late 1950s Congress began to require federal agencies not only to obtain annual approval of their budget requests, but also annual authorizations for all of their activities.[3] Congress and the Executive Branch began playing an active role in all federal agencies' administrative and technical management. This role extended to decisions about such details as which launch vehicle would be selected for a specific space shot. By the 1960s the relationship had changed from one in which outsiders evaluated only the output to one in which they selected the methods of obtaining that output and the internal management structures which would be used to accomplish the organization's work activities.

These changes might not have had the impact they did if they had not been guided by a belief that a single administrator appointed by the President and responsible for a centralized hierarchical bureaucracy was the best method of ensuring accountability for public funds. All federal agencies were thus required to adopt structures resembling a centralized hierarchical bureaucracy with a single administrator, with standardized personnel, administrative, and financial procedures and numerous impersonal rules and regulations. It was these requirements which changed the underlying character of the federal bureaucracy.

R&D Organizations--A Special Case

The changes in the management of federal organizations obviously had an impact on the operations of all federal agencies, but the impact was quite noticeable with respect to federal research organizations. Private industry could provide higher salaries, and the small research organizations which developed after and during World War II could provide an environment which was more acceptable to scientists and engineers. By the 1950s the federal government was having trouble attracting and retaining highly qualified scientists and engineers for its government operated laboratories.[4] The organizations responsible for research responded to this problem by letting contracts for many of the activities previously performed in-house. After World War II the small in-house government research organizations whose specific output had primarily been determined by scientists and engineers were slowly replaced by large organizations whose primary job was to set technical objectives and manage the research and development projects which were desired to meet these objectives.

The in-house government research activities were taken over by small research organizations administered and operated by universities, but owned by the government who was in most cases their entire source of support. This arrangement allowed the government organizations to obtain the ideas of scientists and engineers without subjecting them to either the salary limitations of government agencies or the government's increasingly bureaucratic environment which so many of these individuals found unacceptable.

Private industry remained responsible for producing the product desired by government, but the relationship changed from one in which it sold finished commercial products to the government to one in which the government initiated a request for a particular product, paid the development costs, and provided the facilities and equipment to manufacture the product.

The changes in the relationships among the various participants in the federal research and development process not only solved many of the problems presented by the changes in the management of the federal bureaucracy, they also were supported by Congress and the Executive Branch, who even prior to World War II had not been particularly supportive of in-house research of any kind and particularly the basic research required to produce ideas for research and development advances.

NASA's Development

NASA, when it was created in 1958, was also required to accomplish its R&D activities within the constraints of the federal management requirements, but its leaders, in contrast to other research and development organizations, did not establish permanent ties with small research organizations nor did they establish relationships with external scientific or engineering groups which allowed them to use these groups as a source of ideas for future projects.[5] NASA's leaders were left with only two sources for ideas for new research directions--their own staff and private industry.

NASA's leaders argued that the organization was set up in a manner which allowed them to use their own staff to produce new ideas. NASA was divided into three major groups--an advanced research group (OART), an unmanned space science and applications group (OSSA), and the manned space flight group (OMSF). In theory, OART was the group which would engage in the basic and advanced engineering research which would provide the basis for future research directions. The Centers under the direction of this office would be kept separate from those Centers engaged in development work. The rationale underlying this separation was the belief on the part of individuals engaged in basic and applied research that exposure to development work would inhibit the performance of basic or applied research.

OSSA, in contrast to this, was supposed to be responsible for the unmanned space flight program. It was supposed to establish contractual relationships with scientific groups to produce those scientific experiments which were the major objective of the unmanned space flight program.

OMSF's objective was quite simply to produce and launch the manned space flight projects. It had no underlying scientific objective beyond the production of these projects and was supposed to rely on OART for any applied or basic research which its staff required. The OMSF staff according to this plan would have the advantage of having an in-house research group, and an organization which they could return to for retraining when they had completed a major R&D project.

This division of responsibilities within the organization was supposed to provide all the ingredients necessary for producing (OART) and testing (OSSA) new ideas and using (OMSF and OSSA) the technologies developed by NASA's own staff. The only outside groups which were needed were private contractors to manufacture the various products required for the launches and the scientific groups to produce the experiments.

The problem, as was shown in the case study, was that it didn't work quite as NASA's leaders argued it did. OMSF did not use the OART centers for pure and applied research, but instead let contracts for any research they needed. OSSA lost the support of scientific groups when the scientists discovered that their experiments were placed second to the completion of a major space launch and thus could be cancelled at any time. But more important for our purposes was the fact that NASA's leaders, when justifying the division of labor within the organization, ignored the reason behind the shift from reliance on in-house research groups to reliance on external groups for research in the first place. They assumed that their scientists and engineers would continue working and producing within the new bureaucratic structure imposed by external actors and ignored the fact that these changes had an enormous impact on NASA's ability to produce new research ideas. To understand what happened to NASA it is thus necessary to return to its early years and review the impact of the changes on the organization.

NASA AND IN-HOUSE RESEARCH GROUPS

NASA was not a new organization, but a conglomerate of organizations similar to NACA which had been in existence since World War II. Most of these organizations had a number of similarities which set them apart from other research and development organizations; they were primarily small in-house research organizations which were very independent, well respected and administered by individuals who had a great deal of expertise in their respective fields. Technical competence was the basis for promotion, and those individuals responsible for making decisions about technical proposals and performance were individuals who had previously attained some measure of success in their technical fields. The researchers were given a great deal of discretion and were evaluated by their own colleagues after the completion of a project. Although there was a defined superior / subordinate relationship within the organizations, this relationship was based on expertise rather than position. The leadership of the different organizations could therefore use their own expertise to legitimize their authority and obtain acceptance for their decisions about the allocation of resources for proposed projects.

NACA's committee structure was a perfect example of the type of authority which was being exercised over the scientists and engineers within these organizations. The committees of experts were important not because they provided the agency with a shield from external interference--a function they did fill--but because they provided Lewis and later Dryden with a group of individuals whose reputations in their different fields made decisions by NACA's leaders more acceptable to both NACA's staff and Congress. The committees, composed as they were of experts in numerous fields, legitimized any decision by their very existence.

The authority relationship between the Committees and the agency was duplicated within the agency. Research achievement was the basis for advancement in the organization and the reason that subordinates accepted the authority of individuals in higher positions.

This type of authority relationship (i.e., one based on expertise not position) existed within all the major groups which were brought together to form NASA, and it was the change in this relationship which created such enormous problems for NASA's leaders. NASA did not have a committee to mediate between external actors and its researchers and it, as other federal organizations, had to accept the civil service regulations which made establishing any type of authority structure based on expertise difficult. To base promotions on tenure without allowing some mechanism for the advancement of individuals whose research accomplishments merited promotion to a leadership position, made maintaining any type of authority structure except one based on position difficult.

The impact of this change was not observable in the first few years for the simple reason that NASA's leaders had a reservoir of ideas from which they could propose projects. Their resources were more than adequate to meet the needs of the various coalitions within the organization, and choices about which projects should be funded did not have to be made. The leaders of the various Centers held their positions because of their expertise, and these individuals' authority was accepted as legitimate by the researchers.

It was the appointment of Webb--an administrator, not a scientist or engineer--which had the greatest impact on the organization. Socialized into accepting authority over their technical research only from individuals with scientific and engineering backgrounds, the researchers were forced to accept an individual with no technical background. His appointment might not have affected the organization in the manner it did, if he had not believed in the management ideology which had been the basis for the changes in federal management in the first place. Webb's appointment of many other individuals without technical backgrounds to leadership positions and his placement of management skills over technical expertise for promotion purposes only confirmed the suspicions of NASA's researchers about the ability of a non-technical administrator to manage a technical organization. Success at NASA was based not on personal achievements in research, but on the ability to manage a major research and development project. Without the latter, major research achievements did not guarantee promotions past a certain level. Webb's support of contracting, the allocation of so much of the organization's resources to the manned space flight program which so many of the scientists and engineers rejected, his demands for additional controls when research failures occurred, and his use of outside consultants only served as further evidence of a non-scientist's inability to understand the importance of basic or applied research and to make decisions about their research proposals.

NASA's researchers had few choices when faced with the new authority structure. They could either leave; avoid the problems created by the authority structure by remaining within the confines of their own Centers, many of which retained authority structures based on expertise; give up trying to convince NASA's leadership of new ideas; or simply join other groups and become involved in development work. The departure of many highly qualified scientists and engineers; the unwillingness of many of the researchers to transfer among the Centers; the growing involvement of the OART research Centers in R&D projects; the acceptance of contracting; and the acceptance of OMSF's control over decisions about future projects all provide evidence that NASA was losing the support of individuals who in most research organizations provide the stimulus for new research direction.

The Role of New Ideas in NASA's Decline

The unwillingness of scientists and engineers within NASA to accept the new authority coupled with its failure to establish any type of satisfactory relationship with external groups which could replace these individuals as a source of ideas played a very important role in NASA's decline. This is best understood by comparing NACA's reaction to a threatening environment in the 1940s and 1950s and NASA's in the mid-1960s when faced with a similar situation.

During the period following World War II, NACA was faced with demands from external actors for some justification of its continued existence in light of its failure to keep abreast of the German advancements in jet and rocket propulsion and the success of the large research and development organizations during the war. It responded to this threatening environment by establishing numerous committees in an attempt to gain a place for itself in the post-World War II aeronautical research environment. Its efforts were not successful until it proposed the research aircraft program. The success of this program allowed NACA to regain the support of Congress and the military services and to establish a role for itself in the supersonic research and development activities.

The history of this program provides us with some evidence of the importance of new ideas in the development of a research organization. John Stack, a Langley employee, initially proposed the research aircraft program in 1941, but was turned down by Lewis, the Director of NACA at that time. NACA's leaders did not accept the proposal until demands for some type of supersonic program from external actors (Congress and the military services) coincided with continued demands from John Stack's group. The actual inclusion of NACA in the research aircraft program only occurred after NACA's leadership had changed and the organization was being threatened by its environment.

What is important for our purposes is that it was the research aircraft group headed by John Stack whose ideas provided the stimulus for the changes necessary to satisfy the demands from external actors. In the process a whole new group of leaders took over NACA and maintained it until Sputnik again changed the direction of aeronautical research.

The same type of process occurred after Sputnik. Those individuals within NACA who had worked with the military services and industry on the large research and development projects fought for NACA's inclusion in the new space program despite Dryden's initial rejection of the change to more development work. It was also these individuals whose research and planning provided some justification for NACA's inclusion and led to the launching of Mercury, the nation's first manned space flight. In both cases NACA's leaders were able to respond with the ideas underlying the research aircraft program and the manned space flight program, because of the work of their researchers and the researchers' unwillingness to accept the leaders' initial rejection of their ideas. It was the researchers whose ideas laid the groundwork necessary for the organization to make the changes required by events in its environment.

NASA in the mid-1960s faced demands from Congress for new research ideas and threats from both Congress and the Executive Branch to cut its appropriations and personnel levels. Its leaders' resolution of these problems did not follow the same process which NACA's followed. They were unable to come up with the research proposals necessary to maintain or increase NASA's appropriations level. At a crucial period in its development NASA was unable to generate those ideas necessary to regain the support of external actors. What it did not have was an in-house group which was lobbying for a radical change in the research direction of the organization. The formal planning mechanism set up by Webb was indicative of the problems facing the organization. In contrast to NACA's leaders, who could respond to the demands from outsiders with concrete proposals, NASA's leaders had to establish committees to search for these ideas, and these committees suffered from the same problems which had led to their establishment in the first place. They were unable to generate proposals for new research directions either because the scientists and engineers were unwilling to offer them or because NASA's leaders were unwilling to listen to the ideas of its researchers. NASA's leaders were, in short, left without an in-house mechanism for generating new ideas.

Webb's Role in NASA's Decline

It is difficult not to conclude when reviewing NASA's historical development that the groups responsible for NASA's decline were Congress and other oversight agencies. It was Congress which was responsible for NASA's continual focus on the manned space flight program and its failure to maintain an adequate basic and applied research program. It was also Congress which cancelled so many of the scientific applications programs, the loss of which caused NASA to lose so many of its supporters in the scientific community. It was oversight agencies which directed NASA to accept those regulations which led to the adoption of an authority structure based on position. It was also Congress and the Executive Branch which failed to understand the importance of basic research in the accomplishment of research and development projects.

This conclusion though ignores Webb's role in the decline and the adoption of an authority structure based on position. Webb could have followed the example set by other research and development organizations and established private research organizations to supply him with ideas for new research projects. He could have been more supportive of in-house basic and applied research or even given technical competence more importance when evaluating his technical staff and making selections for leadership positions.

NACA's responses to similar requirements in the 1950s demonstrate that an organization's leadership can avoid some of the impact of federal management requirements. Faced with the new personnel regulations, NACA's leaders made cosmetic changes, such as the creation of personnel offices with little actual power, which had no effect on the actual management of the organization. Perhaps more important, they diluted the impact of the regulations which would have destroyed their authority structure by continuing to base promotions on technical competence. This policy, while not preventing the establishment of an authority structure based on promotion, at least mitigated the impact on the relationships within the organization by underlying the required position structure with one based on expertise. NACA's leaders also continued to support basic and applied research in the face of Congressional unwillingness to support this type of research. Their support provided NACA's researchers with solid evidence that whatever the change in federal management policies and Congressional research policies, their research proposals were still being seriously considered. NACA's leaders were thus able to maintain a research environment which met most of the minimum requirements of its research staff. Although it was obvious during the 1950s that their inability to compete with the salaries offered by private industry was making it increasingly difficult for them to retain highly qualified scientists and engineers and undoubtedly forced them to propose NACA's inclusion in the new space organization, it is not clear that their inclusion required the massive changes which followed in the ten years after NASA's creation.

NASA's leaders, in contrast to this, did not appear to have a commitment to providing either an environment which would meet the demands of their scientists or engineers, or a commitment to the accomplishment of basic or applied research. The latter is best evidenced by the pressures they applied on Centers which continued to engage in basic or applied research, to let contracts for this work, by refusing to provide funds and setting personnel ceilings for the Centers. It was also evident in the continual acceptance of BOB and Congress's cancellation of the scientific research program and the rejection by NASA's leadership of many proposals for in-house research activities. The result was that most OART Centers had shifted to almost complete contracting for their research efforts by 1965.

The lack of commitment to providing a satisfactory research environment was evident in the appointment of individuals without technical competence to positions over individuals with technical expertise. It was also evident in Webb's interpretation of normal research failures as performance failures and his continual demands for the implementation of control devices which went beyond what was acceptable to the performers of NASA's research tasks. The unwillingness on his part to recognize the importance of individual technical competence and evaluation by peers to those individuals involved in research also indicated that Webb strongly supported an authority structure based on position. Webb accepted the Civil Service Commission's regulations, and created his own personnel management committee for reviewing Center-wide personnel management policies, which reported directly to him. Webb not only accepted the management philosophy behind many of the oversight agencies' requirements, he apparently agreed with it.

THE EXECUTIVE FUNCTION FAILURE

I suggested in the opening chapter that if any organization was to survive, its leaders had to fulfill their executive function of establishing some equilibrium between external and internal demands in a manner which allowed it to obtain those contributions necessary to meet the demands of its clientele and obtain the necessary resources to in turn ensure that the members of the organization produced adequate contributions. I also said that NASA's leaders failed in their executive function because they were not able to meet the demands of one of the more important groups in the organization. They failed to do this in two ways. First, the bureaucratic rules and regulations imposed by NASA's leaders were not acceptable to those engaged in research. Second, the scientists and engineers never accepted the authority of non-technical superiors to make decisions about their technical proposals. They either left the organization or simply stopped contributing their ideas because they felt they would not be seriously considered.

The real issue then becomes why NASA's leaders did not make those changes necessary to obtain the new ideas. This failure appeared to stem from their acceptance of the management philosophy underlying the changes in federal management policies. They not only believed in the bureaucratic control mechanisms which external actors demanded they accept; they also adopted their own mechanisms. But it also followed from NASA's leaders' failure to understand the nature of research and development activities and the importance of basic and applied research in the process. Although it is almost impossible to separate the two failures, since the failure to establish the necessary research environment occured because of the lack of understanding of the nature of research as much as it did the belief in the management philosophy, it is also not entirely clear that Webb or any of the external actors who were demanding the adoption of a bureaucratic structure ever realized that there was a relationship between an organization's internal management and the type of work it performed. This lack of an understanding is best illustrated in a statement of the President of Brookings in 1937.

> ...whatever might be the efficiency with which N.A.C.A. has been conducted as an independent agency, its independent status could hardly be justified in terms of effective permanent organization. The problem was studied solely in terms of general principles of organization.[6]

It appears that most of those individuals advocating the changes in federal management procedures believed that there was one ideal management structure whatever the nature of the task, and it was this belief that made it possible for them to demand that all federal agencies accept the new federal regulations despite the impact of the regulations on the performance of the organizations.

Consequently, while I am willing to argue that NASA's leaders' failure to establish a satisfactory research environment ocurred because they did not fully understand the nature of the research and development, it does not follow that understanding the nature of the research and development process would have avoided the establishment of a bureaucratic structure. The best approach to this problem might be to simply say that it was the combination of the two which led to NASA's decline, but before showing how this occurred, NASA's leaders' failure to understand fully the research and development process needs to be discussed and this requires an examination of what is involved in the research and development process.

Research and Development

Producing a product such as NASA was expected to produce involves four steps:

1. Scientific (basic research) research directed toward the advancement of knowledge. It involves the testing and verification of theories.

2. Applied (engineering) research directed toward the practical use of the new theories and involving technology beyond the state of the art, but not the solution of problems associated with a specific project. Theories, devices, or techniques are created or tested.

3. Advanced engineering or development research directed toward the solution of problems associated with specific projects. It involves new applications of existing or tested theories, devices, or techniques; and

4. Development (product engineering) research directed toward the modification of existing products or components created by the engineer in the previous type of research.[7]

The last two steps differ from the previous steps in that they involve in most cases the production of a product and thus entail management problems as much as technical problems. All four steps are required in the research and development process, but a project such as Apollo may only involve the fourth step, because when the decision is made to make the product, the previous three steps have already been accomplished.

This was the case with the Apollo program in 1961 when the decision to go to the moon was made. The technology existed to produce Apollo, but the actual production work still remained to be done. It presented, as Webb suggested, more of a management problem than a scientific problem, in 1961. But the Apollo project was only possible because the other three steps had already been taken. It was Webb's lack of consideration of these other three steps which brought him so many problems when trying to select future objectives, because the objective of the organization became to develop manned space vehicles rather than NASA's mandated objective--to advance aeronautical and space science and applications. Webb quite simply made one of the methods (i.e., manned space flight) of obtaining his actual objective, the objective of the organization. He was thus left without any underlying objective or goal. This is best understood by returning to NACA's experiences.

NACA's leaders' commitment to maintain their rather unique research environment was based not only on their belief that this environment was necessary for the performance of research, but also on a very clear understanding of the purpose of the organization. The purpose of the organization was to advance aviation, and the best method of obtaining this objective was basic and applied research. Faced with demands in its early years for applied research both from the military services and private industry and recognizing Congressional support for basic research was virtually non-existent, its leaders gave up their commitment to basic research and allowed NACA's researchers to focus on applied research, an activity which accomplished their objective of advancing aviation.

The decision to engage in advanced engineering in the 1940s was also made reluctantly, but NACA's leaders were able to argue that it was necessitated by the need to advance aviation and the failure of wind tunnel technology to keep up with the development of the airplane. In the 1950s, when faced with the decision of whether to join the new space program or not, the realization that it was the only way to maintain aeronautical research, given the changes in federal regulations, allowed them to make the necessary change.

These major decisions at important turning points in the organization's history were accepted by the researchers because the researchers accepted the goal of the organization and the authority of its leaders to make decisions about what changes were necessary to achieve this objective. The leadership could use the objective to evaluate the changes they were being asked to make both in research activities and internal management. For example, advanced engineering was necessary to advance aviation, but many of the new federal regulations of the 1940s and 1950s were not acceptable and were to be avoided because they would have made performing applied research difficult.

NASA's leaders, in contrast to this, never appeared to commit themselves to any type of unifying purpose which could guide the organization's decision making and make these decisions acceptable to the various coalitions. Without this underlying purpose, they had no accepted criteria which could be used to evaluate either technical proposals or the types of internal management mechanisms which would be used. They did not have a committee of experts who the researchers felt were qualified to judge their research proposals, nor did they have a history of funding projects devoted strictly to the advancement of space science and development. NACA's leaders when pressured by the Executive Branch or Congress could argue that some of the nation's top scientists and engineers supported the projects and their contribution to the advancement of aviation. NASA's leaders had no criteria accepted by all its internal coalitions or by external actors to make these types of decisions. What they used from the beginning to evaluate various research proposals was their acceptance by Congress or the Executive Branch. Rather than making decisions in terms of the organization's underlying objective, they simply reacted to Congress's decisions. It was Congress, not NASA's leaders, who ended up mediating the conflicts among the various coalitions.

The Impact of the Failure of the Executive Function

The lack of underlying purpose coupled with the belief that a bureaucratic structure was the best organizational structure had an enormous impact on the organization's ability to cope with the increase in competition for funds in the 1960s and the cuts in its appropriations and personnel.

NASA's leaders, by accepting the manned space flight program as the objective of the organization, had no response to the argument that they had succeeded in attaining their objective by the mid-1960s. Except for the Apollo program there was no reason for continuing their high level of funding or even in reality for continuing their existence. NASA's leaders were unable or unwilling to present a convincing argument that the advancement of aeronautical and space research necessitated at least maintaining their appropriations and personnel level.

Once the cuts began they had no what might be called a maintenance objective. NASA's leaders could have accepted the cuts, but made the argument that redistribution of the funds among the various programs was necessary to ensure that the basic and applied research necessary for the nation's leadership in space in the future was accomplished. This would have enabled them to at least maintain the organization and a group of highly qualified scientists and engineers to generate ideas for future projects when funds were more available. Instead they chose to remain committed to the manned space flight program. The result was that they lost the support of external scientific groups, as well as many of the internal scientists and engineers and the opportunity to change their research direction in the future.

They also had no criteria by which they could judge technical proposals and their relationship to the agency's future or one which was accepted by the various coalitions within NASA. Thus, when technical proposals were submitted to them, they could not argue, at least not convincingly, that the decisions were based on any type of criteria. Wernher von Braun's complaint in the late 1960s that all of NASA's problems would be solved if the agency had some type of objective is more understandable in this light. To accept NASA's leaders' decisions as legitimate required that they have this objective. The result was that they simply allowed external actors to make these decisions and further alienated those individuals engaged in basic and applied research. The latter group just assumed that NASA's leaders would not listen to their proposals or be able to judge the importance of them.

Both Webb's management philosophy and the lack of underlying objective played a role in the management problems they were experiencing before and after the cuts. NASA's leaders had no criteria by which to judge decisions about the type of internal management mechanisms they should set up. The fact that the management devices which they did adopt were not satisfactory to certain groups had no impact on the decision to adopt them because there was no recognition that the group was needed in the first place. After 1965 they were left without any way of responding to the civil service regulations, personnel ceilings and budget cuts which were creating so many morale problems. Webb's management philosophy almost forced him to accept decisions of external actors as legitimate requirements in the first place. His failure to understand the importance of scientists and engineers in the research and development process coupled with his inability to understand the importance these individuals attached to evaluations by colleagues made it difficult to argue convincingly about the growing number of controls being exercised over these individuals.

Once the decline started, NASA's leaders had no way to stop the decline. Without a source for new ideas, they could not produce the necessary changes in the organization's research activities to respond to the new environment.

NOTES

1 The discussion of oversight organizations in this study relies on Joseph P. Harris, Congressional Control of Administration (Washington, D.C.: Brookings Institution, 1964); Louis Fisher, Presidential Spending Power (Princeton, N.J.: Princeton University Press, 1975); Richard E. Neustadt, Presidential Power: The Politics of Leadership (New York: The New American Library, 1964); Richard E. Brown, The GAO: Untapped Source of Congressional Power (Knoxville: The University of Tennessee Press, 1970); Frederick C. Mosher, The GAO: The Quest for Accountability in American Government (Boulder, Colo.: Westview Press, 1979); and Larry Berman, The Office of Management and Budget and the Presidency, 1921-1979 (Princeton, N.J.: Princeton University Press, 1979).

2 NACA submitted budget requests and expenditure data in broad categories. Their annual reports to Congress included all the technical reports written in the previous year. Once they received their appropriations, the leaders of the organization made the decision about the allocation within the organization.

3 NASA was rather interestingly one of the first federal agencies required to obtain annual authorization. See chapter 4 for a discussion of the 1959 Johnson Rider to NASA's first Appropriations Bill.

4 See A. Hunter Dupree, Science in the Federal Government: A History of Policies and Activities to 1940 (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1957); and Don K. Price, The Scientific Estate (London: Oxford University Press, 1965).

5 DOD research work is primarily accomplished through small research organizations.

6 Harold G. Moulton to Vannevar Bush, June 3, 1940.

7 These steps with some modifications were obtained from Merton J. Peck and Frederick M. Scherer, The Weapons Acquisition Process (Boston, Mass.: Graduate School of Business Administration, Harvard University, 1962), p. 28.

Chapter 6

OTHER EXPLANATIONS OF NASA'S DECLINE

As I noted in the introductory chapter, there have been a number of explanations given for NASA's decline. Some theorists have suggested that NASA's decline occurred because the power of the manned space flight group precluded the establishment of agency-wide goals.[1] Other analysts have argued that the extensive bureaucratic apparatus established by Webb stifled innovation and made it difficult for the organization to retain scientists and engineers.[2] NASA's leaders, in contrast to this, virtually ignored the events leading up to the decline and argued that external actors prevented them from coping with the personnel and budget cuts in any effective manner. The purpose of this chapter is to examine each of these explanations in the light of the argument presented in the previous chapter. Since the analysts, as I did, based their conclusions on their perceptions of how organizations operate, I will also discuss the assumptions underlying their examinations of NASA.

THE COMPETING GROUPS ARGUMENT

The most popular explanation of NASA's decline, as well as the explanation given for many public organizations' failure to cope effectively with cuts in their resources is what I shall call the competing groups argument.[3] Organizations are composed of coalitions with different objectives. The organization's objectives are developed through bargaining over side payments (i.e., money, authority, power, promotions) among these coalitions. The coalitions vary in the amount of power which they have, and the most powerful group plays the major role in determining the agency's objective. Power is defined as the obverse of dependency. An organization or an individual has power relative to another "(1) in proportion to the organization's [or individual's] need for resources or performances which that element can provide and (2) in inverse proportion to the ability of other elements to provide the same resource or performance."[4]

NASA According to the Competing Groups Argument

In NASA's case, OMSF's (the manned space flight group) objectives became the organization's objectives, because the leadership was dependent on it for the performance of its most important objective, the Apollo program. Its leaders could not turn to any other group for the performance of this research activity, and the lunar landing was considered essential to the organization's survival. OMSF's control over the allocation of resources within NASA was such that its share of the organization's resources allowed it to determine what the organization's future objectives would be. Its strong ties to Congressmen and contractors only improved its power position because they could be called upon whenever NASA's leaders challenged OMSF's authority. A perfect example of this is OMSF's control over the decision about NASA's future objectives. It could hire a private organization, have the proposal packaged so that it appealed to non-technical decision makers, and submit it to both NASA's leaders and Congressmen. Since private contractors gained more from its projects than, say, an advanced engineering project, it could also bring in its supporters from industry.

Other NASA coalitions, from the Office of Space Science and Applications (OSSA) down to the Office of Advanced Research (OART), while varying in the amount of power they exercised over NASA's decision making and the share of the organization's resources they received, never were able to gain enough power to overcome OMSF's control of the decision making process. Competing groups' theorists argued that the problem from NASA's perspective was that the objective of the manned space flight program was only to increase the nation's technical capability or perhaps more accurately, to beat the Russians. Once this had been accomplished with the Mercury program in 1965, there was little, if any, justification for the organization's existence.

Once NASA's resources began to be cut, the imbalance of power within NASA began to have a very noticeable impact on its ability to cope with the decline, according to this group. Its supporters in Congress were asking the agency to provide them with a comprehensive set of future objectives which they could use to justify approval of NASA's appropriations requests and override the Executive Branch's cuts; NASA's leaders could give them little more than ideas for increasingly more expensive manned space flight programs. The other coalitions within NASA simply never had enough power to obtain a hearing for their ideas, some of which may have been more acceptable to Congress.

Competing Groups and the Executive Function Argument

Although the findings from the case study support this explanation of NASA's failure to develop future objectives beyond the manned space program which Congress was no longer willing to support at the levels it did prior to 1965, I cannot agree that the control of OMSF over NASA's objectives necessarily followed from the dependence of NASA's leaders on OMSF's completion of the Apollo project. Webb could have avoided this relationship if he had established an authority structure and underlying agency goal which were accepted as legitimate by the staff and which could have been used as criteria for evaluating the technical proposals of the entire agency. It was the lack of these criteria which made NASA's leaders so vulnerable to the pressures from OMSF and Congress. NASA's leaders could not mediate the claims made by the various coalitions either by arguing that their decisions would result in a mix of programs which would advance aeronautical and space research and development, nor could they argue that they had the expertise to judge the relationship between the technical projects and this objective. In short, I am not saying that the argument is wrong, but that it fails to go far enough in explaining why NASA declined, nor does it adequately explain why the dependency relationship developed in the first place. This can be seen by looking first at NACA's experiences and then by discussing the implications of the argument for organizations trying to change.

NACA's Experiences

If we argue that organizations such as NACA and NASA are composed of competing groups, one of which might control the objectives of the organization and make it impossible for any other group to obtain its objectives or the organization to change research direction, NACA should have had similar problems, and this is difficult to substantiate.

The applied aerodynamical research group who accomplished their research using wind tunnels controlled NACA from 1927 through World War II. It was their failure to understand the need to change to jet and rocket propulsion which led to NACA's crisis period following the discovery of the German research achievements. Their performance failure coupled with the inability to use wind tunnels for testing supersonic airplanes changed NACA's entire mode of operations. The success of the research aircraft program led to NACA's change from an applied research group to an advanced engineering group despite the power of the applied research group and the reluctance of its leaders to engage in advanced engineering. NACA's leaders though did not lose the support of the applied research group even after the agency began to engage in advanced engineering research. Its leaders were able to maintain an environment which met the demands of both groups and could allocate their funds in a manner which satisfied the two. This was accomplished despite the fact that NACA, as did NASA after 1965, experienced financial problems.

NACA's experiences in the 1950s were very similar. The potential creation of a new space agency was threatening to NACA in that it would have come into competition with NACA for funds and would have given Congress even more justification for ending NACA's existence. NACA's leaders again responded in a manner which allowed it to at least maintain the organization at some level. It proposed its inclusion in the space organization and justified this inclusion with ideas for a space flight program.

In neither period did NACA's leaders lose the support of the staff, some of whom strongly disagreed with the changes in research direction. They were able to make the changes when it became necessary to do so both because their authority was accepted and because the changes were seen as necessary to advance aviation.

If we compare NASA's experiences with NACA's, there are some important differences. First, NASA's leaders were not able to make the necessary changes. OMSF, the most powerful group, was able to prevent the organization from changing its research direction despite the fact that whatever the success of the manned space flight program, Congress apparently was not willing to support continuation of the program or to support the rest of the agency's programs if it was continued.

NACA's leaders' ability to control its decision making and change the objectives of the organization even in the face of entrenched power groups should not have been possible if the competing groups' theorists are correct in their assessment, for the simple reason that the explanation leaves no room for a change in coalitions once they have gained power and taken over the decision making of the organization. I am suggesting that in an organization in which the leaders' authority is accepted as legitimate and where the leaders have provided the agency with an agreed-upon purpose, change is possible because the leaders can, whatever the power of the leading group, change the direction of the organization. It was the lack of acceptable authority structure or goal which made NASA's leaders dependent on OMSF, not the fact that they were performing such an important research activity.

Competing Groups and Change

The major problem with viewing organizations from a competing groups perspective is that the theory allows no way for an organization to change. Once a group, such as OMSF, takes control of the decision making process of the organization, no other group would have the resources or power to change the direction of the organization when necessitated by changes in the environment.[5] It does not provide us with any answer as to why NASA's leaders were never able to take the final step and present other alternatives to Congress when it was clear that additional manned space flight projects would not stop the budget and personnel. My argument is that the reason NASA's leaders could not make the necessary changes was not the power of OMSF, but the lack of criteria to evaluate the alternatives presented to them. The manned space flight program was the objective of the organization, not a method of achieving an objective, and once it was completed the organization could not present other alternatives to justify its existence. This occurred not because of the power of OMSF, but because of a failure of the executive function.

NASA AS A BUREAUCRACY

The competing groups argument has primarily been used to explain NASA's inability to go beyond the manned space flight proposals after Congress indicated it was no longer willing to meet NASA's budget requests. The second argument which I will discuss has been used to explain NASA's inability to generate ideas for alternative projects in the first place.[6] Analysts making this argument do not assume that alternative ideas were available. The problem for these theorists is to determine why NASA's scientists and engineers were unable to generate a response to the search for new ideas--a question the competing groups argument does not address. They argue that NASA's failure was one of not establishing an appropriate structure for scientists and engineers. The extensive bureaucratic apparatus which NASA's leaders established was not accepted by the organization's scientists and engineers because it did not provide the discretion necessary for them to accomplish their research. Before discussing the argument in more detail, some note should be made of the assumptions underlying its proponents' assertions.

Organization theorists argue some activities of an organization because of the uncertainty surrounding their performance require that individuals accomplishing the activity be given more discretion than those individuals engaged in routine work and whose performance and outcome can be specified in advance.[7] If an organization develops a structure which is inappropriate for its assigned work, either because too much or too little discretion is allowed, subordinates are not able to perform their work, or at least not able to perform their work at the same level as they could under a more appropriate structure. As discussed in the case study, scientific and applied research are examples of work whose outcome and methods of achieving that outcome are difficult, if not impossible, to specify in advance. NACA's leaders thus argued that the agency's research activities required a great deal of discretion and could not be accomplished within the bureaucratic structure which so many external actors wished it to adopt. NASA's scientists and engineers argued that the organization's bureaucratic structure made it difficult for those engaged in scientific and applied research to accomplish their work because it did not allow enough discretion. The result was that NASA had difficulty retaining and recruiting highly qualified scientists and engineers who were unwilling to accept the numerous rules and regulations governing their performance. In 1965 when NASA's leaders needed new research directions, it was unable to generate new ideas because those individuals responsible for producing the ideas were either no longer willing to propose new projects or had left the organization in frustration.

NASA According to the Bureaucratic Argument

NASA, according to the proponents of this theory, failed to establish an internal management system which allowed enough discretion to its scientists and engineers. They offer as evidence the extensive authorizing and reporting requirements, the lengthy decision-making process as well as the centralization of this process. NASA's decision-making process made innovation and creativity very difficult to accomplish and did not allow the discretion necessary to start or engage in scientific or applied research for which it was difficult to specify the outcome and methods of achieving that outcome prior to the execution of the project. The researchers did not have the discretion to follow interesting leads, but had to obtain approval before engaging in any type of research activity. By the time this approval was obtained, the researcher had already lost interest. The development group also suffered from the increased documentation requirements because the necessity of reporting all activities promoted distrust and an environment in which the interpersonal relationships seen as so necessary for the success of project management were no longer possible.

The cuts in personnel and recruitment, according to these theorists, only exacerbated the situation. NASA's leaders no longer were able to provide those incentives such as promotions, training, and interesting new projects, which are so important in any organization and made it possible in NASA's early years to preserve some semblance of an integrated organization.

The result was that NASA was not able to recruit or retain those individuals who were normally responsible for producing the ideas for new directions in a research organization. Scientists and engineers did not feel that the environment which was provided to them was acceptable in terms of the incentives being offered to them or the amount of discretion they were given to accomplish their research. When NASA's leaders were faced with demands for new research directions, they were unable to respond to those demands because the individuals responsible for generating them were no longer available or were unwilling or unable to bring their ideas to the attention of NASA's leaders.

Inappropriate Structures and the Executive Function Argument

As with the competing groups explanation, this explanation of NASA's decline provides us with a great deal of insight into NASA's problems. What it does not provide is a complete explanation of NASA's decline nor any justification for NASA's leaders' continued adoption of mechanisms which were so unacceptable to its scientists and engineers. The claim that NASA's leaders were not controlling their subordinates in a manner which was conducive to the generation of new ideas is similar to my argument. Where the two arguments differ, and it is an important difference, is why the control was wrong. While I would not disagree with the assertion that the incentives being offered after 1965 were inadequate nor that the reporting requirement was inhibiting creativity, the problem I would suggest was much more pervasive than simply heavy documentation requirements or inadequate incentives. NASA's leaders had not established an authority structure which was considered legitimate by its scientists and engineers nor had they provided the organization with an underlying goal which could guide decisions about management devices. The many bureaucratic mechanisms adopted by NASA's leaders only followed from this lack of acceptable authority structure. The decline after 1965 was exacerbated by the heavy documentation requirements and the poor incentives. The decline itself occurred because of a failure of the executive function, not because the researchers were not given enough discretion. This can best be seen by showing that NASA, whatever the claims of these theorists, did allow adequate discretion for the performance of their assigned research activities.

The Need for Discretion

NASA was responsible for the performance of a number of different research activities. It continued to be responsible for applied and advanced engineering and these activities placed similar constraints on NASA's leaders as they had on NACA's leaders. Since NASA's leaders did not know the specific outcome desired or the method of achieving that outcome, they had to allow the researchers a great deal of discretion. NASA was also responsible for the management of large research and development projects and these projects, while requiring some discretion, also required a great deal of control and coordination if the various subsystems were to be integrated into a final product. NASA's leaders knew what outcome (i.e., lunar landing) they desired and the method (specific spacecraft and launch vehicle) of obtaining that outcome prior to the start of the development phase of any project.[8] In most cases they knew the major technical problems which might arise and thus could allocate additional resources to expected problem areas. While they could not specify exactly how their staff should respond to unexpected technical and management problems, they could establish performance criteria and evaluate the progress of their researchers much more effectively than NACA's leaders could.

The major differences between the applied and advanced engineering research activities and the development projects was the complexity, high costs, and long time-span required for the latter's completion. The major problem which they presented to the organization was not technical, but managerial. Their high costs and long-time frame meant that any commitment to them required intensive study, particularly after 1965 when any commitment to one project meant that other projects could not be funded. Their complexity and the need to integrate the various subsystems made detailed planning and documentation of previous work a necessity if changes were to be made when one subsystem did not perform as expected. This need for control coupled with the fact that the projects required less discretion made NASA's adoption of so many bureaucratic control mechanisms more understandable. NASA's leaders not only had less reason to allow discretion, they also were forced to provide the additional control mechanisms if a final product was to be produced.

It would be difficult to follow the same type of logic with NASA's other two tasks (i.e., applied and basic research) except for one factor. The two tasks were no longer performed in-house at the level they had been during the NACA years. Although the organizations performing these tasks continued to require a great deal of discretion, those individuals within NASA whose task it was to administer the contracts did not require the same amount of discretion. The smallness of these projects both in costs and the amount of time required to perform them, as well as the fact that they were less complex meant they required less rigorous controls than the larger research and development projects, but it is hard to argue that the individuals involved in contract administration of applied or advanced engineering projects required more discretion or that NASA's leaders could not require them to follow certain set procedures when letting contracts or evaluating the performance of these contracts.

The argument that NASA's three research activities required less discretion than these theorists would like us to believe they required is not as convincing as the fact that whatever the discretion required by NASA's research activities, NASA's leaders did recognize the differences among them when establishing control mechanisms. The Office of Manned Space Flight (OMSF) was highly centralized. The Office of Space Science and Application (OSSA) which was responsible for the unmanned space program, while less centralized than OMSF, was a great deal more centralized than the Office of Advanced Research and Technology (OART), which was responsible for the small applied and advanced engineering research projects. OART essentially gave responsibility for its projects to the Center Directors. The differences were particularly evident in the research authorization process. The procedures required for OART projects were less extensive and did not require the detail necessitated by OMSF and OSSA procedures. The fact that OART project managers only had to obtain approval for research areas, not specific projects, made tracking their progress more difficult than for the OMSF and OSSA projects. The tracking mechanisms followed a similar pattern. OART submitted monthly reports on major research areas. OMSF and OSSA projects were tracked down to the working level.

The project management system adopted by NASA actually allowed a great deal of discretion to individuals working with contractors. The tracking and authorization mechanisms provided the control and coordination necessary for the large research and development projects, but NASA's staff was given a great deal of discretion to handle problems which arose. They had to document their solution to the problems, but they were allowed to handle them as they saw fit. NASA's method of directing its research activities toward the agency's objectives, while perhaps requiring more paperwork than was really necessitated by the activities because of Congressional and Executive Branch demands, did not restrict the staff's discretion to the level where they could not perform their jobs, and this is perhaps best indicated by the success of the Apollo project and other major research and development projects after 1965.

Finally, and most important, the heavy documentation demanded by NASA's leaders was not as extensive in the years before 1965 as it was in the following years. Much of it including NASA's centralization in fact was required by Webb after 1965 and in particular following the Apollo fire, before which even Webb admitted the organization was not tightly controlled. The heavy documentation, as were the inadequate incentives, was very much a function of NASA's decline, not the cause of it. The complaints of OART researchers about the lengthy decision making process were undoubtedly valid, but also understandable, given NASA's resource situation.

Lack of Discretion and the Executive Function Argument

The claim that NASA's researchers were not allowed enough discretion suffers from two major problems. First, it is not entirely clear that the researchers were not given enough discretion to perform their assigned responsibilities. Second, many of the heavy documentation requirements and inadequate incentives which its staff complained about were both required by the nature of their work and were implemented after the decline started, not before. Consequently, it is difficult to attribute NASA's failure to generate new ideas to these factors. If instead it is suggested that NASA's authority structure and lack of agency goal led to the first cuts in NASA's budget and personnel levels and that this failure of the executive function started in 1961, not after 1965, NASA's decline is more easily understood. There is some evidence to support this claim.

The fact that the cuts in NASA's budget started in 1965 indicates that it had problems with obtaining new ideas prior to 1965 as well as after. The fact that there were five directors of the Office of Advanced Research and Technology between 1962 and 1968 indicates that its activities were given a lower priority than other Offices and that there was some dissatisfaction about this lack of priority. The complaints of OART Center employees about the low priority of their projects and the requirement that they contract-out more of their work is evidence that there was dissatisfaction among those individuals involved in applied and advanced engineering research activities prior to 1965.

Webb's unsuccessful attempt to centralize NASA in 1961 as well as his appointment of so many non-technical managers shows his lack of understanding of the importance of evaluation by colleagues to scientists and engineers. His unwillingness to place former NACA employees in leadership positions during the first years of his tenure and his dismissal of their method of managing through personal expertise demonstrates that Webb was committed to the change to a new approach to management whatever his scientists and engineers might feel about the change. His lack of understanding of the importance of applied and basic research in the development process is evident in the relatively small increase in personnel and resources at those centers involved in this type of research even during those years when NASA had adequate resources to meet the needs of all of its coalitions.

The unwillingness of researchers to move from their own Centers, many of which continued to be managed in a manner similar to that used prior to Webb's appointment and the inability of NASA's leaders to integrate the various Centers into a unified organization provide evidence that NASA's leaders had problems which were simply ignored during the years its funds were increasing rapidly.

Arguing that the decline was brought about by NASA's leaders' inability to provide a proper authority structure and agency goal not only gives us an explanation of why the decline started in the first place, but also why the heavy documentation continued despite NASA's staff's complaints about it. NASA lost the support of its scientists and engineers before 1965 and thus was unable to generate ideas to maintain its high level of funding. Its leaders' inability to respond to the complaints or to Congress's demand for new research directions occurred because they believed in their method of management and did not understand the importance of this group to the entire research and development process. Even if they had been presented with new ideas, they would have had difficulty determining which to select because they had no criteria which could be used to evaluate the ideas and their contribution to the organization's future.

Arguing that they did not have adequate discretion ignores the fact that NASA's leaders were not even willing to support the in-house research for which that discretion was required and the researchers' unwillingness to accept the authority of non-technical decision makers whatever the discretion they were given.

NASA AND EXTERNAL ACTORS

NASA's leaders, in contrast to the previous two explanations, argued that they were not given enough discretion to cope with the budget and personnel cuts. Bureau of the Budget personnel ceilings coupled with the Civil Service Commission regulations prevented them from developing any type of rational personnel management policies directed toward retaining highly qualified scientists and engineers. Congress and the Bureau of the Budget made decisions about which projects would be supported or completed, not NASA's leaders. Consequently, the poor morale and dissatisfaction of NASA's staff, as well as the loss of support of scientific groups because of decisions about technical projects, was not something NASA's leaders could have prevented.

NASA's leaders' claims are worth addressing because they are indicative of a very genuine problem which faced NASA's leaders during its first ten years, and that is the role of external actors in both its technical and administrative management. The argument that external actors were largely responsible for NASA's continuing decline is not easily dismissed. While NASA's leaders primarily focus on the years following the initial cuts, an argument can be made using the findings from the case study that external actors also played a strong role in the start of the decline. Since the argument places the major blame for the decline on external actors, while mine places it on a failure of the executive function by NASA's leaders as well as the external actors, it is an argument worth addressing. Before discussing the relationship between the two arguments, it is worthwhile to examine the evidence which supports it.

The Role of External Actors in NASA's Decline

Although all federal agencies had to cope with the increasingly larger role of external actors in their administrative and technical activities, NASA's situation was rather unique in a number of ways.

In the first place, Congress was fascinated with the idea of exploring space and showed its fascination by demanding a role not only in NASA's internal management, but also in its technical decision making. Other major research and development organizations, particularly those under the auspices of the Department of Defense, were able to avoid this interference in their internal affairs either by claiming that there would be security problems or because Congress was simply not as interested in them. The amount of discretion which NASA's leaders had was thus limited by the high visibility of its programs.

The impact, as far as NASA was concerned, was that Congress played a larger role in its affairs than other organizations had to endure, and it was this large role which had a major impact on its ability to maintain or increase its resources. Its leaders argued that its discretion regarding projects and their management was largely curtailed because projects had to be approved both by the Bureau of the Budget and Congress. While NASA had the authority to reprogram a small percentage of its funds, any reprogramming had to be justified before Congress. Funds were allocated for specified fund areas, not to the organization to spend as its leaders desired. Congress played a very active role even in the selection of specific launch vehicles. NASA's leaders could not ignore Congress's opinion nor their support of the manned space flight program and their lack of support of scientific programs and any type of in-house research.

Congress's role in NASA's affairs included investigations of technical failures, cost overruns, and schedule slippages. It was not adverse to bringing in technical experts, private contractors, or organizations such as the General Accounting Office whenever its members felt they needed other sources than NASA to help them make decisions.

NASA's leaders argued that they not only had to contend with Congressional demands to be included in technical decision making, but also their demands for improvements in the management of these projects. Technical failure was followed by an investigation and strong suggestions about the deficiencies in NASA management of its technical activities. Congressional interests and demands required the adoption of extensive authorization and tracking mechanisms, if NASA's leaders were to have the capability to justify their budget requests or explain the technical failures which occurred.

NASA's leaders not only faced what they claimed was a greater interference in their internal affairs than other research and development organizations, they also had to respond to these demands with an organization which had a rather unique historical background. It was not a newly created organization, but a conglomeration of existing small research organizations which had a great deal of technical expertise, but very little managerial capabilities. This situation, according to its leaders, was resolved by bringing in individuals with proven management capabilities and using their own staff to provide technical assistance to contractors and accomplish the necessary applied and advanced engineering research. Its leaders argued that the use of private small research organizations to generate new ideas was not necessary because of this in-house expertise. Management had to be emphasized both because of the nature of research and development work and because NASA was weak in this area, but also because of Congressional demands. Relying on personal expertise, as NACA's leaders had, was not possible in an organization the size of NASA nor in one in which there were research and development management responsibilities.

Although NASA's leaders appeared to assume that they were effectively managing the organization, given the external and internal demands being made upon them up to 1965, they admitted to being unable to cope with the requirements and demands of external actors after 1965. As discussed in the case study, oversight agencies had a major impact on their ability to cope with the organization's declining resource base. It was difficult for the organization to plan for the future when Congress or the Bureau of the Budget could arbitrarily refuse their requests for projects or cancel those projects already underway. The Bureau of the Budget's personnel ceilings and the Civil Service Commission's regulations which had to be followed when attempting to meet these personnel ceilings made any type of rational personnel management impossible and played a major role in the dissatisfaction of many of NASA's employees as well as the departure of many highly qualified scientists and engineers. The General Accounting Office's investigations of its activities eliminated the alternative of using contracts to cope with the personnel ceilings.

External Actors and the Executive Function Argument

I have suggested that whatever the role of external actors in NASA's decline, and I do not wish to minimize the importance of this role, the responsibility for NASA's decline still remains with its leaders. It was their responsibility to maintain some type of equilibrium between the demands being made upon them from external actors and the demands being made by their staff, and this they did not do. To confirm that my explanation is more adequate than NASA's leaders' is difficult since any argument making the claim that NASA's leaders had other alternatives whose selection might have prevented the decline is, as NASA's leaders might point out, a counterfactual one and in principle incapable of confirmation. Having made this statement, it does not necessarily follow that making the argument is a wasted effort if for no other reason than the fact that NASA's leaders' argument leaves us in the position of arguing that the leadership of any organization or at least a public organization plays no role in its success or failure. The organization is simply a sponge which reacts to any demand made upon it with little consideration of its impact on the future of the organization. To avoid this conclusion, it is worthwhile to review the executive function argument from NASA's leaders' perspective to determine if there were other alternatives available to NASA's leaders.

I argue that all research and development organizations faced similar demands, and that these organizations had managed to cope with the requirements in a manner which allowed them to survive. The creation of small research organizations owned by the federal government but managed by universities filled the vacuum left by the government's inability to maintain an in-house research staff. These organizations were not only able to provide the research environment which the government was no longer able to provide, but they also met the need for a source of ideas for new research directions so necessary to the research and development organizations. If these organizations could cope with the changes in federal management, NASA's leaders should have been able to respond to them as effectively.

This conclusion from NASA's perspective ignores the unique technical capabilities of its staff which made letting contracts or relying on small research organizations unnecessary. The problem with this claim, I suggest, is that it ignores the fact that NASA's leaders by setting personnel and resource ceilings on Centers engaged in in-house research forced these Centers to let contracts for their research work. Those scientists and engineers who were unwilling to become contract administrators were forced either to leave or if they remained, to begin to let contracts. Although NASA's leaders argued that letting contracts for research work was necessitated by Congress's and the Executive Branch's lack of support for in-house research, this constraint only meant that they should have examined other alternatives for meeting their applied and advanced engineering needs.[9]

Even if we accept NASA's leaders' argument that it did make an effort to maintain an in-house technical staff, we must ask ourselves why they were unwilling to follow NACA's approach to maintaining an acceptable research environment by making sure that its staff was promoted for technical competence and thus ensuring that its staff's demands for evaluations by colleagues was met at some minimal level. Their claim that this was impossible because of the size and responsibilities of NASA's research and development activities seems rather implausible for two reasons. First, NASA's project management system was largely based on the personal expertise of the project managers. This was less true in the case of its program managers, but even at this level personal expertise was an important method of controlling the various groups which were required for the research and development projects. Since neither the project nor program managers had legal authority over the various groups, they had to rely on their own expertise, not their position, to manage the projects. It was at the headquarters level where position and management expertise became so important, but this situation affected the entire organization because it was at the headquarters level that the major technical decisions were being made. NASA's engineers and scientists were thus working under an authority structure based on expertise, but had to depend on the upper levels of NASA's hierarchy at headquarters to make decisions about technical projects, and it was at this level that the authority structure broke down.

NASA's leaders' claims that they could not follow either NACA's or other research and development organizations' examples because of the unique nature of their staff does not appear to be substantiated either by their own actions or by the changes which actually did occur in the organization.

Their second claim that Congress's role in their affairs made their situation different is also difficult to substantiate. Congress only suggested that NASA tighten up its management; it did not direct Webb to make specific changes. While it obviously would have been difficult for Webb to ignore these suggestions completely, as the case study demonstrates, Webb was willing to ignore even specific demands (e.g., Congress's demand for the Phillips Reports after the Apollo fire) when he decided it was in the best interest of the organization to do so. Congress's strong support of NASA at least until 1965 implied that NASA's leaders probably had a great deal more discretion than other organizations as long as they kept Congress aware of what they were doing. Even if we accept Webb's claim, the fact that Congress was primarily interested in the space flight program meant that Webb had a great deal more discretion to deal with the demands of scientists and engineers in other areas. Since these were the individuals from whom the major complaints were coming, Congressional interference is not an adequate explanation for their dissatisfaction.

Perhaps more important, Webb clearly believed that technical failures could be prevented through better management controls. His reaction to the Apollo fire and the centralization throughout the organization following the fire provides evidence of this belief, as does his unsuccessful attempt to centralize the organization in 1961. His distrust of NACA's management style and its focus on personal expertise was evident in his own remarks and his efforts after 1961 to remove the organization from their influence.

NASA's argument that Congress's support of the manned space flight program and lack of support for in-house research prevented them from supporting basic or applied research and forced them to allocate most of their funds to the manned space flight program is also not completely supported by the findings from the case study. Prior to 1965 Congress met NASA's budget requests for new projects with few questions. Their interest was primarily in the space projects, leaving NASA a great deal of discretion with regard to its other projects. Even in decisions involving the manned space flight program, NASA was the one presenting the alternative approaches to them and could set the agenda in the manner it desired. What does seem obvious is that NASA's leaders were the ones who made some of the major decisions which played a role in the projects which the organization would support. The decision to set personnel and resource limitations on the OART Centers was a NASA decision, not a Congressional decision. Congress in the late 1960s even went as far as to question this decision and demand that NASA's leaders provide more funds at least to aeronautical research. The decision to remain committed to the manned space flight program whatever the costs to other programs was also made by NASA's leaders. While this decision was obviously made with Congress in mind, the selection of OMSF's proposal in the late 1960s over proposals submitted by the other program offices and centers was made by NASA's leaders, not Congress.

While the findings from the case study do confirm that the Bureau of the Budget personnel ceilings, Civil Service Commission regulations, and project decisions of both the Bureau of the Budget and Congress did play a major role in NASA's decline after 1965, this must be said with some caution. As I pointed out in my explanation, it was because of previous executive function failures that NASA's leaders were unable to cope with the demands from external actors after 1965.

SUMMARY

The three explanations of NASA's decline discussed in this chapter were found to be inadequate for various reasons. The competing groups argument provided no explanation of NASA's continued dependence on the manned space flight program office after Congress continued to cut NASA's budget. It was suggested that a more complete explanation could be provided if OMSF's power is explained as one of the problems created by NASA's leaders' failure to establish any acceptable authority structure or agency goal. This failure left them with no criteria for evaluating technical proposals or any type of proposed change for the agency. NASA's leaders, thus, were left in the position of simply reacting to demands from outsiders, and since the manned space flight program office had the most outside support and resources to present its views, it continued to control the decision-making process.

The argument that NASA's scientists and engineers were not provided with enough discretion to accomplish their research nor offered enough incentives to accept this lack of discretion was found to be incomplete because it ignored the change to contracting, which required less discretion, as well as the high level of discretion given to NASA's staff. Since NASA's problems started before the decline when many of the extensive documentation requirements had not been adopted, it does not explain NASA's initial failure to produce ideas which would have prevented the decline in the first place. These deficiencies in the argument are avoided if the decline is explained as a failure of the executive function. NASA's scientists and engineers found the authority structure unacceptable and were not willing to accept their leaders' decisions about technical proposals or the manned space flight program as the major objective of the organization.

NASA's leaders' argument that external actors and internal constraints prevented them from coping with the decline effectively as well as precluded some of the alternatives chosen by other organizations to cope with the change in federal management was found to be inadequate both because it ignores NASA's leaders' role in the decline and because the findings from the case study do not support the claims. While external actors did play an important role in NASA's decline, NASA's leaders had other alternatives which might have made it possible to both prevent the decline and cope with it once the cuts started. More importantly, if NASA's leaders would have performed their executive functions more satisfactorily, they could have avoided some of the more dysfunctional effects of the demands being made by external actors after 1965.

NOTES

[1] These studies are discussed in Chapter 1 of this study.

[2] Ibid.

[3] The competing groups explanation of NASA's decline is made by Emmette S. Redford and Orion F. White, "What Manned Space Flight Program after Reaching the Moon? Government Attempts to Decide: 1962-1968." NASA Research Grant NGL 33-022-090. Syracuse / NASA Program, December, 1971; and Raymond A. Bauer, *et al.*, NASA Planning and Decision Making, Final Report, 2 vols. Contract NGR 22-007-163, Harvard Graduate School of Business Administration, 1970. The explanation of it which follows is derived both from these studies and the theoretical literature which underlies the assertions made by these authors. The conception of organizations as composed of competing coalitions is drawn from Herbert A. Simon, Administrative Behavior: A Study of Decision-Making Process in Administrative Organization, 2nd ed. (New York: The Free Press, 1957) and Richard Cyert and James March, A Behavioral Theory of the Firm (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1963). The definition of power and its use in the competing groups argument is derived from Michael Crozier, The Bureaucratic Phenomenon (Chicago: The University of Chicago Press, 1963); James D. Thompson, Organizations in Action (New York: McGraw-Hill Book Co., 1967); Sol Levine and Paul E. White, "Exchange as a Conceptual Framework for the Study of Interorganizational Relationships," A Sociological Reader on Complex Organizations, 2nd ed., Amitai Etzioni (ed.) (New York: Holt, Rinehart & Winston, Inc., 1969); Richard M. Emerson, "Power-Dependence Relations," American Sociological Review 27 (1962), pp. 31-41; and David Jacobs, "Dependence and Vulnerability: An Exchange Approach to the Control of Organizations," Administrative Science Quarterly 19 (1974), pp. 45-59.

A number of theorists have made a similar argument about competing groups in other declining organizations. See Richard M. Cyert, "The Management of Universities of Constant or Decreasing Size," Public Administrative Review, Vol. 38, No. 4 (July / August 1978), pp. 344-350; Irene Rubin, "Politics and Retrenchment in the City: A Case Study," Paper presented at the Mid West Political Science Meetings, April 1979; and John Freeman and Michael T. Hannan, "Growth and Decline Processes in Organizations," American Sociological Review 40 (1975), pp. 215-228.

[4] Thompson, op. cit., p. 30. This conception is based on Emerson, op. cit.

[5] See Cyert and March, op. cit., for a discussion of problemistic search. This will be discussed further in the next chapter.

[6] Richard L. Chapman, Project Management in NASA: The System and the Men (Washington, D.C.: NASA, 1973).

[7] See Thompson, op. cit., and Crozier, op. cit.

[8] See Merton J. Peck and Frederic M. Scherer, The Weapons Acquisition Process: An Economic Analysis (Boston: Graduate School of Business Administration, Harvard University, 1962). They specifically discuss some of NASA's research and development projects and argue that some of them were more closely related to industrial planning projects than to scientific projects.

[9] I might note here that the Jet Propulsion Laboratory was such an organization, but the relationship between it and Headquarters was so poor that any communication from it about new research directions might have been ignored simply because it was coming from JPL. One of the reasons Webb might have been unwilling to establish relationships with other government-owned laboratories is because of his experiences with JPL. See Erasmus H. Kloman, "Surveyor and Lunar Orbiter: Case Studies of Project Management," National Academy of Public Administration, June 30, 1970, and NASA History Office files.

Chapter 7

THEORETICAL IMPLICATIONS

In the preceding chapter I discussed a number of explanations given for NASA's decline. Although the discussion included the relevant theories when appropriate, its primary purpose was to show the inadequacies of existing accounts of NASA's decline. The purpose of this chapter is to discuss how my explanation of what happened within NASA fits into the existing theoretical literature. Its organization follows the major threads of the argument starting with the focus on the executive function. This is followed by a discussion of the conception of change used in the argument and its relationship to two other explanations of change.

THE EXECUTIVE FUNCTION

My argument rests on the assumption that executives, whatever the organization, have certain responsibilities which they must meet if the organization is to survive or at least not decline as NASA did. This assumption has a long history in the organization theories literatures, starting with Chester I. Barnard's formulation in 1938.[1]

Barnard argued that the major function of any executive was to maintain the organization by finding some type of fit between the external environment and the internal management of the organization. Although he focused on private organizations, his conception of executive function is appropriate for public organizations as well if we assume that management regulations are simply another feature of an organization's environment, which must be taken into consideration when the executive attempts to maintain the organization. Thus, the executives of research and development organizations responded to the changes in federal management by establishing government-owned small research organizations which did not have to follow the regulatory policies which were unacceptable to so many scientists and engineers. NACA's leaders responded to the same change by maintaining an authority structure based on expertise, while at the same time overlaying this authority structure with one based on position. Both responses allowed the organizations to continue meeting their objectives within the new federal management structure.

Barnard, as my argument does, argued that the responsibility of executives included, among other things, the establishment of a legitimate authority structure and underlying goal, or what Barnard called purpose. It is only with an accepted purpose that specific actions, or in NASA's case projects, can be agreed upon or evaluated. NASA's failure to establish a purpose for the organization made it difficult to obtain consensus on the specific projects which the organization should perform and to provide Congress with an adequate justification for continuing its high level of funding. It also made it difficult to evaluate any management mechanisms which might be proposed and to gain consensus on those which were adopted.

It is at this point that our two arguments begin to diverge. This is said with some caution because the extent of the divergence is largely a function of what I considered important for understanding NASA's decline. Barnard places a great deal of importance on what he, followed by Simon, called the inducements / contributions contract which defines what subordinates will receive for their contributions to the organization.[2] I discuss the inducements or incentives provided both by NACA and NASA's leaders in the case study and in the presentation of my argument, but my argument does not focus on NASA's leaders' failure to provide adequate incentives. The reason for this deficiency, if it may be called that, is that the type of incentives provided NASA's staff did not become a large problem until after 1965 when its decline had already started. The difference between the two arguments though is one of emphasis, since NASA's leaders' failure to provide an adequate research environment (an incentive used very fruitfully by NACA's leaders) obviously played a role in its decline, but not, I would suggest, the determining role. It was the failure to understand that NASA was a research organization as well as a development organization which led to its failure to establish an authority structure based on expertise and to support those projects which were so important to those individuals who were responsible for producing ideas in most research organizations. NASA's leaders had adequate funds and Congressional support to provide most of its staff with a high level of incentives, and in most cases these incentives were provided. From the researchers' perspective this was not enough. They could not depend on NASA's leaders to make decisions in their best interest.

The second difference involves the importance attached to authority structures and the source of authority. Barnard noted that there are at least two sources of authority--position and personal expertise--but he argued that individuals if they wish to exercise authority must have responsibility or position, and that it is the inducements / contributions contract which defines what is acceptable authority.[3] I have taken a slightly different tack, primarily because the findings from the case study show a relationship between expertise and authority among scientists and engineers that transcends position and has little relationship to the incentives offered. This is not to say that position and the inducements / contributions contract do not play a role in what is acceptable authority, but that the scientists and engineers in the case study were more willing to accept the authority of individuals who had achieved some major breakthrough in their field than they were the authority of a superior who had no technical competence, whatever the incentives offered to them. This attitude toward authority was an important factor in the development of NACA and NASA and was particularly evident in the rejection of government contracts by many scientists and engineers prior to World War II. NACA's continued rejection of the idea that a non-technical administrator could manage a research organization only mirrored the rejection of many scientists and engineers of this idea. Whatever the validity of this belief, scientists' and engineers' strong belief in it defined what was acceptable authority to them, not the position of the individual trying to exercise the authority or the type of incentives offered. Webb's lack of technical competence meant that whatever he attempted to accomplish, he would have had difficulty establishing an acceptable authority structure. This is not to say that Webb's lack of technical competence precluded the establishment of an acceptable authority structure, but that it set the stage. His own belief in position authority, his inability to understand the importance of evaluation by colleagues or the nature of the research and development process, and his failure to provide the organization with a purpose beyond the manned space flight program confirmed the belief and led to the scientists' and engineers' unwillingness to accept his authority. It is only when this, which might be best called an ideology, is taken into consideration that some understanding of NASA's decline can be gained.

To summarize, my argument uses the executive function perspective to lay the groundwork for locating the source of NASA's decline. Its departure from this theory is largely a matter of emphasis and is considered necessary to take into account the nature of research organizations. Having said this, it is necessary to note that using this perspective left me in the position of concluding that NASA declined because its leaders had failed in their executive function of providing an organization purpose and thus were not able to establish an acceptable authority structure or obtain consensus about the projects which the organization should accomplish. To provide a link between this failure and the decline, it is necessary to turn to two other theoretical perspectives.

CHANGE AND ORGANIZATIONS

NASA's decline occurred because it was unable to provide any justification to Congress for continuing its high level of funding in the face of competing demands on the nation's resources in the mid-1960s. Having succeeded in surpassing the Russians by 1965, it was unable to generate any ideas for new research directions which might either increase or maintain its resource levels beyond proposing new manned space flight programs, despite the fact that Congress had indicated its unwillingness to support a continuation of these programs or at least was unwilling to provide funds for both the manned space flight program and other programs sponsored by NASA. NASA's problem, I argue, was at its simplest an inability to change when its environment demanded it. Its failure to change occurred because it did not have an authority structure which was acceptable to its scientists and engineers or any accepted criteria to evaluate solutions to its threatening environment in the late 1960s. These deficiencies which arose because its leaders had not established an organizational goal or purpose beyond the manned space flight program left the organization's leaders subject to the power of the manned space flight program group.

I support my argument by showing how NACA had made changes in the 1940s and 1950s. The conception of change which I use is very similar to that used by one group of organization theorists. Cyert and March, who were the originators of what is called problemistic search, argued that any change in the demand or supply equilibrium established by the organization's leaders will trigger a search for a new equilibrium which will satisfy the various participants.[4] Leaders and other decision makers within the organization do not review all alternatives when selecting a response, but only a limited set of alternatives from which they select that response which meets their minimum criteria.[5] The search is constrained not only by clients, suppliers, and the organization's staff, but also the leaders' own cognitive and language limitations. The organization, according to Cyert and March, follows a number of simple rules in this search. It attempts to find a solution by using standard operating procedures and the department generally responsible for the problem area. Thus NACA responded to the crisis during and after World War II by establishing committees, and NASA responded to the decline in its resources by establishing a number of planning groups. If this is not successful, the organization will turn to other groups or departments which are engaged in related work. The organization, if neither of these two steps is successful, will look in areas which are normally not responsible for the problem. If the third step is successful, the coalition responsible for the success will increase its bargaining position relative to those coalitions which failed. The success of the research aircraft group following World War II made the group responsible for it a major power in the organization. Most searches end in the first two steps, but unless a standard operating procedure can be invoked, some form of change will occur in all the steps. Employment of the third step, since it represents a change in the basic coalition agreements, implies the larger change. Radical change does not occur unless the organization perceives itself as threatened (its survival is at stake) by the changes in its environment.

My conception of how NACA and NASA responded to environmental changes is similar to Cyert and March's explanation in that I agree that both organizations when faced with threatening environments began to search for some type of solution to the problem. In NACA's case the change when the environment was perceived as threatening was a radical one. NASA began the search process, but did not make any radical changes.

Cyert and March argued that what an organization accepts as an adequate solution to the problems in its environment will depend on its perception of the severity of the situation, its goals and decision rules (criteria by which decisions are made), and the order of consideration of alternative solutions. I argue that NACA's successful search involved a group of researchers lobbying for a change in research direction, demands from the environment which could be satisfied by the researchers' ideas, and a threatening environment. The change itself was accompanied by a change in the leadership of the organization.

NACA after World War II had a group of engineers lobbying for a project similar to the research aircraft program. Their initial proposals had been turned down by NACA's leadership and it was not until NACA's leadership changed, its environment became threatening, and the military services began to demand programs similar to what the researchers had originally proposed, that their proposal was accepted. The success of the project left NACA with a new coalition in power. As postulated by Cyert and March, the leadership of NACA first looked to their applied research group to respond to the threatening environment, and it was only when this approach was unsuccessful that they were willing to change research directions. The solution met NACA's goal, the advancement of aeronautical research. It was only adopted after NACA's leaders had established numerous committees in an attempt to become a part of the new supersonic research community and were unable to obtain funding for a new supersonic research laboratory.

I differ from Cyert and March only in the fact that I emphasize the nature of research advancements in the process. I suggest that part of the success of the search process is the existence of that group of scientists and engineers which is lobbying, prior to the start of the search process, for a change in research direction. The environment plays a role in that it defines when the change will be made or at least when the leadership will accept it and what change will be considered acceptable. In short, it forces the most powerful coalition to accept the ideas of the weaker coalition.

I also argue that the change involves the replacement of one group whose ideas had been accepted prior to the change with another group whose ideas had become the accepted ideas. In the process, there was a change in the group whose authority would be accepted. The technological change not only involved a change in research, but also a change in whose authority would be accepted within the organization.

Perhaps more important, I link the change process to NASA's executive function failure. Its failure to establish an organization purpose left it without any acceptable authority structure or any criteria for evaluating technical proposals. It did not have in-place before the start of the search process those mechanisms which would allow it to carry through a successful search. Its leadership's ideas had not been accepted in the first place, and it had no group lobbying for a change in the research direction. This link is important and represents the major difference between my argument and Cyert and March's. I am not as much interested in how the decision making occurred, but the structure of relationships in which it occurred. I would argue that the change process in a research organization has to involve a change in the individuals whose authority is accepted as legitimate and that this authority is based on the success of the ideas of that coalition. This would appear to be essential because if it does not occur there is no individual in power who is responsible for protecting and nurturing the new research direction. NASA since its leadership's authority was based on position, not expertise, and not accepted as legitimate by NASA's scientists and engineers, could not make the essential replacement of one group with another. The weaker coalitions, even if they were willing to submit their ideas, had no way of bringing their ideas to the attention of NASA's leaders, nor even if they had, no way of obtaining a change because of the lack of the criteria with which to judge technical proposals. Even assuming the ideas were successful, they had no guarantee that the leadership would continue to support them after the initial acceptance.

Most important, my emphasis is on the structure of relationships within which the search process occurred. I am not as interested in how specific decisions or changes were made, but in that structure of relationships which made the search process successful or unsuccessful.

ORGANIZATIONS AND CHANGE:
A STRUCTURALIST PERSPECTIVE

Although the focus of my argument is on the executive function, I rely on one other perspective to demonstrate that NASA had other alternatives. My use of this perspective is primarily illustrative, but I make a number of implicit assumptions about organizations and their responses to environmental changes even for this limited use. Consequently, it will be worthwhile to note some of the similarities between the argument of the structuralist perspective and my own.

Before discussing NASA's decline I describe the change in federal management policies and the responses which other organizations had made to these changes, with the assumption that any differences between NASA structure and other research and development organizations' structures might be related to NASA's decline. The assumption that there is one optimal organizational form and organizations without this form will decline is similar to the argument made by theorists who examine organizations over time and focus on the economic and technical conditions which determine the appropriate organizational form for each environmental variation.[6] They argue that "in each distinguishable environmental configuration, one finds, in equilibrium, only that organizational form optimally adapted to the demands of the environment."[7] The configuration of organization forms is isomorphic to the configuration of the environment. Within any historical period, then, organizations will develop according to the specific environmental characteristics of that period.

According to this theory, the change process involves three stages.[8] In the first stage--the occurrence of variation--some type of change (planned or unplanned) occurs in the environment. The change in the federal management policies represents such a change. It is these variations which act as stimuli for organizational change and establish the criteria which determine which organizational form (or structure) will evolve. The second stage involves a process of selection of that organizational form which will "fit" the environment and survive as the major organizational form of that historical period. NACA was representative of the type of organization which was created around 1915. The large research and development organizations which developed during World War II and the government-owned research laboratories which accompanied and followed their establishment replaced the small government research laboratories after World War II. Whether and how many organization forms persist depends on: (1) the "carrying capacity" of the environment; (2) the rate of expansion of the other organizations which are supported by the environment; and (3) whether other organizations have the same resource source or structural characteristics.[9] This is not to say that only one type of structure can exist during any one historical period. For various reasons, including lack of competition for resources and the efficiency of structure for accomplishing the organization's task, organizations with structures from a pervious period remain in existence. These theorists do appear to be arguing that while remaining in existence, the older structures are no longer optimal and thus face decline if resources become scarce or if they come into competition with the new organizations.[10]

Theorists using this framework for their analysis have defined organizational form or structure according to the authority relationships (bureaucratic and professional);[11] size;[12] the formal structure (e.g., organizational table, formal rules and procedures);[13] and national and cultural characteristics.[14] Internal decision making is not examined because environmental constraints determine which structure will fit the environment and any other structure chosen will fail. There is nothing in these theorists' argument to suggest that decision making does not occur since organizational members can obviously choose the wrong structure. They only argue that the leadership of the organization has no alternative as to which structure will fit the environment. The process by which the structure is decided upon then becomes uninteresting to them.[15] An examination of NACA's and NASA's historical development from this perspective leades us to the following conclusions:

First, NACA's committee/ agency structure and its leaders' reliance on evaluation by colleagues to control the output of the staff were internal management structures used during the period in which it was created. NACA in fact was modeled after the British aeronautical research laboratories and was one of a number of research organizations, such as the Bureau of Standards, Bureau of Mines, and the Army Medical Corps, which engaged in applied research to solve problems which private industry was not addressing.[16] Federal management policies during this period provided the leaders of these research organizations with enough discretion to establish a research environment acceptable to the scientists and engineers. There was a need for NACA's product and its creation allowed the federal government to establish ties with the scientific community which was generally unwilling to work for non-technical government groups.

Second, during and after World War II, its environmental configuration began to change in a manner which made maintaining NACA's and other government research laboratories' research environment increasingly more difficult. The development of the large research and development organizations which accomplished their research through government-owned, but university-managed, laboratories, as well as the changes in procurement regulations which made scientists willing to accept contracts from non-technical government agents, made the need for organizations such as NACA increasingly less necessary. NACA by the 1950s was finding it more and more difficult not only to justify its existence, but also to provide the research environment its staff felt was necessary. Quite simply, the fit between NACA and its environmental configuration was no longer ideal, whereas the fit between the new research and development organizations and their environmental configuration was more optimal.

Third, NACA's transformation into a large research and development organization followed a pattern set by other organizations during and after World War II. The small in-house government research organization whose specific output had primarily been determined by scientists and engineers had been replaced by large organizations whose primary activity was to set technical objectives and manage the research and development projects which were designed to meet these objectives. A single director, whose background was more often than not administrative, was responsible to the President for the performance of a centralized administrative organization. In contrast to NACA, the policy of these organizations was to rely on private industry for the development of specified products and universities or small research organizations for the basic and applied research which was required.

Fourth, NASA's decline, according to this group of theorists, occurred because it did not follow the pattern set by other research and development organizations. It did not, as I suggest in my argument, set up small private research laboratories or establish strong ties with the scientific community for its applied and basic research needs. The structure of relationships which it did establish both externally and internally did not fit the environmental configuration of the period in which it existed. By the mid-1960s its failure to establish an optimal structure led to its inability to compete with other organizations when resources became tighter. The carrying capacity of its environment was not large enough to support an organization which did not fit the environmental configuration.

Although this is a rather simplistic example of how the findings from the case study can be interpreted using a structuralist perspective, it does demonstrate that there is little in the argument which contradicts either my argument or the findings from the case study. The problem is that it does not tell us (1) why NASA did not change to fit its new environmental configuration nor (2) why, since it was created after it became clear that maintaining a research environment was becoming extremely difficult, its leaders tried to accomplish applied and basic research in-house. To answer these questions it is necessary to use a different perspective. This is not to say the structuralist theory is inadequate for examining changes over time, only that to answer the questions I was asking required that I look at NASA's internal decision making. The structuralist argument was used to lead me to the differences between NASA's structure of relationships and other organizations'. What it does not tell me is why NASA's leaders failed to establish the structure.

It is only when one uses the executive function perspective that one is able to understand this failure. Its leaders, because of their management ideology and lack of understanding of the research and development process, failed to provide the organization with an acceptable authority structure or organizational purpose. Thus not only was the structure of relationships which its leaders established with external actors not acceptable, but the internal relationships they established were also not acceptable. The result was that NASA's leaders lost two potential sources of ideas at the same time. If I only argue that its leaders did not set up small research organizations without establishing that it did not also set up an alternative source of ideas, my explanation of the decline is only partial and subject to attack by those individuals who argue that NASA had an in-house group which provided it with the same information as external groups provided other research and development organizations.

Perhaps more important, at least for my purposes, it does not leave me in the position of concluding that there was no solution to NASA's problems or any other organization's facing similar situations. There was a reason for the decline.

SUMMARY

NASA's decline can be adequately explained by using existing theories of organizations, but it is difficult to accomplish this task using any one perspective. The executive function argument provides a mechanism for explaining why NASA's leaders failed to maintain the organization or perhaps more accurately provides me with those responsibilities which NASA's leaders failed to perform. To make the link between the executive function failure and NASA's actual decline, it is necessary to examine those theories which attempt to explain how change occurs in organizations. Cyert and March's problemistic search theory provides a mechanism for comparing a successful change process to NASA's unsuccessful search for a solution to its threatening environment. Relating NASA's decline to changes in its environment and to avoid concluding that its leaders had no other alternatives requires a third perspective. The structuralist perspective is used to show how NASA's development differed from other organizations' development. Consequently, while I might argue using the executive function and the problemistic search theories that NASA failed to provide an internal management structure which allowed it to produce ideas for future research directions, the structuralist perspective allows me to say that its leaders also failed to establish an external mechanism for new ideas as other organizations had. Using all three perspectives quite simply allows me to examine the decline from different angles and derive a more complete picture of NASA's decline.

NOTES

[1] See Chester I. Barnard, *Functions of the Executive* (Cambridge: Harvard University Press, 1938).

[2] For a description of the various propositions of the inducements / contributions theory, see James G. March and Herbert A. Simon, *Organizations* (New York: John Wiley & Sons, 1958), p. 84.

[3] Barnard calls the latter leadership authority. Barnard and Simon argue that it is through the inducements / contributions contract that an area in which the subordinate is largely indifferent to certain modes of authority from the superior is established. Barnard calls this the zone of indifference, while Simon calls it the zone of acceptance. See Barnard, loc. cit., and Herbert A. Simon, *Administrative Behavior: A Study of Decision Making Process in Administrative Organization*, 2nd ed. (New York: The Free Press, 1957).

[4] Richard M. Cyert and James G. March, *A Behavioral Theory of the Firm* (Englewood Cliffs, N.J.: Prentice Hall, Inc., 1963).

[5] Simon, loc. cit., uses the term 'satisficing' to describe this type of decision making. Organizations do not look for the best solution, but the solution which is good enough.

[6] See Arthur L. Stinchcombe, "Social Structure and Organizations," *Handbook of Organizations*, ed. James G. March (Chicago: Rand McNally & Co., 1965, pp. 142-193); Howard E. Aldrich and Jeffrey Pfiffer, "Environments of Organizations," *Annual Reviews Inc.*, 1976, pp. 79-105; Joseph A. Schumpeter, *Capitalism, Socialism and Democracy*, 3rd ed. (New York: Harper & Row, Publishers, 1942, 1962).

[7] Michael T. Hannan and John H. Freeman, "The Population Ecology of Organizations," *Environments and Organizations*, eds. Marshall W. Meyer and Associates (San Francisco: Jossey-Bass Publishers, 1978), p. 143.

[8] D. Campbell, "Variation and Selective Retention in Socio-Cultural Evolution," *General Systems*, 16 (1969), pp. 69-85; and Aldrich and Pfiffer, loc. cit.

9 Hannan and Freeman, op. cit., p. 180, define 'carrying capacity' as the "upper limit of the size of the population that can be sustained in a particular system."

10 Stinchcombe, loc. cit., discusses why some organizational forms persist although they are not optimal.

11 Stinchcombe, ibid.; Hannan and Freeman, op. cit.; Schumpeter, loc. cit.; H. H. Gerth and C. Wright Mills (eds. and trans.), From Max Weber: Essays in Sociology (New York: Oxford University Press, 1946, 1973); and Amitai Etzioni, A Comparative Analysis of Complex Organizations (New York: The Free Press, 1961).

12 M. Haire, "Biological Models and Empirical Histories of the Growth of Organizations," Modern Organization Theory, ed. M. Haire (New York: Wiley, 1959), pp. 272-306.

13 Hannan and Freeman, loc. cit.

14 William J. Ouchi and Alfred M. Jaeger, "Social Structures and Organizational Type," Environment and Organizations, eds. Marshall W. Meyer and ASsociates (San Francisco: Jossey-Bass Publishers, 1978), pp. 110-130.

15 See Aldrich and Pfiffer, loc. cit., for a discussion of this issue.

16 A. Hunter Dupree, Science in the Federal Government: A History of Policies and Activities to 1940 (Cambridge, Mass.: The Belknap Press of Harvard University Press, 1957), describes the development of these government research organizations. He argued that "NACA was the capstone of the federal establishment." p. 291.

Chapter 8

CONCLUSIONS

Tracing the historical development of NACA and NASA has proven fruitful not only for explaining NASA's decline, but also for showing the impact of changes in federal management policies on research and development organizations. NASA was in many ways a casualty of these changes, but its decline was not inevitable. Although external actors played a major role in the decline, their demands can be said to have led to NASA's decline only if it is assumed that its leaders had no responsibility for maintaining the organization, or perhaps more accurately, that they were only required to react to demands from outsiders, not to mediate the influences of external actors on the internal management of the organization. There is little evidence even if this assumption is made that Webb was a passive recipient of external requirements. He and other leaders of the organization not only failed to mediate the influences of the environment, they actually believed in the management ideology which was so unacceptable to many of their researchers. Their inability to recognize that research and development projects involved more than a management problem or the development stage of the process lost them the support of the internal and external groups who in most research organizations are responsible for producing the responses to demands from outsiders for a change in research direction. It also left them committed to an objective which even NASA's strongest supporters in Congress had difficulty justifying when decisions about the allocation of federal funds were made.

The findings from the case study because of the nature of the data and the examination of only one organization are only tentative, but they do raise a number of issues about existing organization theory, the management of government organizations and the federal management policies which guide the performance of organizations within the federal establishment.

THEORETICAL IMPLICATIONS

It is perhaps easiest for any theorist to interpret his data from one theoretical perspective and to limit his conclusions to those which can be made using that perspective. The analysis becomes fairly straightforward and one avoids the problem of generating competing interpretations of one's data. The problem, as I have attempted to demonstrate in the last two chapters, is that it also may prevent one from providing an adequate explanation of the data. This study has attempted to go beyond this situation by looking at NASA from a number of different theoretical perspectives. Although this was admittedly accomplished somewhat in a round-about manner by using one perspective to focus the argument and the others to illustrate various central points, even this limited approach showed the utility of at least trying to fit different perspectives together.

The Structuralist Perspective

It seems clear that understanding organizations and their management requires an examination of the historical development of organizations and the relationships between organizations and actors in their environment. NASA's leaders had to contend both with their existing situation and remnants of the organization's past history. This conclusion seems particularly true if one wants to understand why an existing authority structure is not acceptable. Many of NASA's leaders' problems occurred because many of the members of its staff were simply used to a different way of doing things. Examining NASA at one point in time provides no indication of this problem, and one is left arguing that its leaders were simply poor managers.

The most interesting insight gained from taking a historical approach from my perspective was a growing understanding of the changes in federal management and their impact on the management of organizations within the federal structure. Many of the differences between NACA and NASA simply reflected these changes, not any change in their activities or any need for better management.

The structuralist perspective is a very useful tool for uncovering the differences between two organizations with similar environmental configurations. In NASA's case the fact that it didn't establish a permanent mechanism for providing itself with ideas for new research directions is most easily seen by comparing the structure of relationships it established with those established by similar organizations. It also brought into question NASA's leaders' assertion that they had an in-house mechanism for these ideas since it, as other federal organizations, had adopted the bureaucratic structure required by federal regulations. The findings from the case study showed that scientists and engineers had traditionally been unwilling to accept this type of structure, particularly if it involved a complete change to an authority structure based on position. Since this belief was particularly strong among the former NACA employees who were responsible for the basic and applied research of the organization, it was difficult to believe that NASA's leaders were able to attract and retain this group. The answer, of course, was that they didn't. The structuralist approach is ideal for locating those differences which made NASA's structure less than optimal and might have led to its decline.

What it didn't provide was any answer to the question of why NASA was unable to make the necessary changes, and answering this question, while uninteresting to the theory's proponents, seems necessary not only for a complete explanation, but also to provide future leaders of organizations with adequate information to prevent another NASA.

The Executive Function Perspective

The executive function perspective was a useful tool for locating those areas of responsibilities in which NASA's leaders were deficient and providing at least a beginning in my quest for some insight into its leaders' inability to establish the structuralist's optimal structure. My argument that leaders have responsibilities regardless of the demands made upon them by external actors was developed through using this perspective and comparing NASA's leaders' performance of their executive function with NACA's leaders' performance. Although this helped me locate where NASA's leaders were deficient, it did not provide me with much assistance in determining why they failed to establish a goal or acceptable authority structure. It was only by reviewing NASA's history and the history of the major participants that one can explain the deficiencies. Thus, some understanding of Webb's failure to recognize the importance of an authority structure based on expertise can be derived from his background at the Bureau of the Budget and the growing acceptance of individuals in organizations such as the

Bureau of the Budget of the bureaucratic structure as the most efficient method of managing federal agencies whatever the technical activity.

Problemistic Search

The link between the failure of the executive function and the decline was made by comparing the search procedures of NACA and NASA using Cyert and March's conception of problemistic search. The fact that NACA had an acceptable authority structure and goal which allowed it to evaluate technical proposals and obtain consensus about their decisions confirmed my belief that NASA's leaders' executive function failure led to its decline. Without this goal and acceptable authority structure, NASA's staff was either unable or unwilling to communicate its ideas to its superiors.

Rather interestingly, NACA's leaders had a solution available before they started their search. They didn't accept the solution until the environment became threatening and there was a change in leadership, but when the setting was right the solution was accepted. It is hard to determine whether the same situation existed in NASA and NASA's leaders simply turned down ideas for new research directions, or that the ideas were not available from the beginning. What did not exist was those relationships which allowed a successful solution to be found when the organization started its search procedure.

New Research Directions

The findings from the case study do point to a need for further studies of a similar nature, particularly if those studies are undertaken to help future policy makers or executives of organizations. The historical perspective provides more information about the long-term implications of management changes. To conclude that an organization has a bureaucratic structure and that this bureaucratic structure makes the performance of its technical activities very difficult is not a terribly interesting observation. To find that this bureaucratic structure was the result of a systematic effort on the part of organizations, such as the Bureau of the Budget and the Civil Service Commission, to standardize many nonconsequential procedures is very interesting and perhaps something that can be changed. It is only with other historical studies similar to this one that this finding could be confirmed.

The second area in which further research would be valuable is organizational change and how it is accomplished. The structuralist approach provides a description of changes in organization, while the decision-making or problemistic search theory provides a framework from which to describe or predict the process which the organization will go through. Although the latter does describe those factors (e.g., decision rules) which play a role in the search process, its focus on decision making makes it more useful for examining single decisions. What is needed, if NASA is any indication, is an understanding of the relationships within the organization which provide an environment conducive to change. For example, the findings from this study indicate that NASA's bureaucratic structure was one of the relationships which made it difficult for it to change research directions. This finding, though, may only be relevant to NASA or research organizations. If the staff of an organization accepts its bureaucratic structure as legitimate, the fact that it is a bureaucratic one may have no bearing on the organization's ability to change.

Additional attempts to integrate some of our existing theories also seem to be indicated by the study. Even if these attempts consist of examining the data within different theoretical frameworks, it would seem a worthwhile venture. This seems particularly true in those cases where one's argument leads to more questions than it answers. The competing groups theory is particularly relevant here. Concluding that the manned space flight group's power prevented a change in research direction leads one to ask immediately why in an organization supposedly known for its management did this occur, or why did it continue to occur after the decline started and the organization's performance was in question. This is not to say that relying on one framework will provide one with the wrong answer, but that examining data with more than one framework might provide a more complete explanation as well as give others more confidence in the results.

ORGANIZATIONS AND THEIR MANAGEMENT

The findings from the case study, while only tentative and perhaps most applicable to research organizations, do indicate that there are certain minimum requirements if an organization is to maintain itself or at least not decline.

First, its executive should establish some type of general goal for the organization which can be used to evaluate its internal management, selection of projects, and to justify its existence to its suppliers. NACA's leaders' strong conviction that, whatever the project they performed, their goal was to advance aviation, guided them through a number of crisis periods. NASA's leaders' failure to do so left them not only in the situation of not being able to justify their technical proposals, but also unable to understand the importance of maintaining a management system acceptable to scientists and engineers. If NACA's experiences are any indication, both external and internal actors must accept the legitimacy of the goal. NACA used it to justify decisions about projects to its staff and requests for funds, but also to justify its unwillingness to accept demands for changes in its internal management. NASA, in contrast to this, had difficulty justifying its request for funds and its internal technical and management decisions because it had no goal beyond the manned space flight program. Rather interestingly, the establishment of this goal seems to be a function in which external actors can and should play a role. NACA's goal was in its legislative mandate. NASA, while its leaders failed to use it, was also given a general goal, which could have been used to guide the organization's decision making.

Second, it seems particularly important to establish a management system which is related to the organization's goal and to the staff's perception of what is an acceptable method of controlling them. For example, in NASA's case its mandated goal was aeronautical and space research and development. This goal required the performance of basic and applied research, and individuals involved in this type of research may be unwilling to accept a bureaucratic structure. This should be taken into consideration when establishing an internal management system. If an organization's leaders cannot establish an acceptable authority structure, as does seem to be the case within most of the federal government at this time, then some consideration of alternative methods of performing the activity should be made.

Third, the goal should be used as a general guide to evaluate technical proposals or the resources the organization is going to commit to specific projects. I want to be careful here because I am not recommending that an organization's leaders should engage in any type of cost / benefit or planning, programming and budgeting, but that leaders should use the goal as a guideline. NACA's leaders divided their projects into engine, structural and aerodynamical research and allocated a certain percentage of funds to each. Together the projects under each category were supposed to provide the necessary research to advance aviation. The percentage necessary was determined by the main committee and was dependent on the needs of the particular time period. The allocation was undoubtedly subjective, but it was accepted by the staff and external actors as legitimate because both the goal of advancing aviation and the structure in which the decisions were made were accepted as legitimate by the participants.

Fourth, executives should recognize the need to maintain an equilibrium between the demands being made upon them by external and internal actors. NASA's leaders' inability or unwillingness to understand that federal management requirements made establishing an authority structure acceptable by scientists and engineers almost impossible not only precluded any effective response to the problem of maintaining the support of their in-house staff, but also prevented them from seeking an external source which would fill the void left by the loss of support of these individuals.

Fifth, and perhaps most important, some recognition should be given to the fact that there is no ideal management structure for all organizations. Different groups of individuals have different perceptions of what is acceptable authority. They are also motivated by different incentives. The applied and advanced engineering groups within NACA were a perfect example of this. Publishing NACA reports under their own name was a very effective control mechanism for the applied research group. It was not a very effective incentive for the advanced engineering group who were more interested in working on state-of-the-art projects. This would seem to be a self-evident observation, but that apparently isn't the case, if NACA's and NASA's history is any indication. Management systems are evaluated according to their efficiency as a management tool, not according to how they will help the organization perform its technical activities. This seems particularly to be the case with regard to administrative management tools, which appear to be adopted with little consideration of their impact on the internal management of the organization or the performance of the technical task. The most striking example of this is, of course, the personnel regulations which made it so difficult for NASA's leaders to maintain their authority structure. It is also true for management systems which have worked in the past. Thus, NACA's method of controlling its staff worked very well, but to suggest that it might work equally well for a group of individuals involved in an activity such as putting tomatoes into cans just because it worked for NACA's leaders is ludicrous.

ORGANIZATIONS AND EXTERNAL ACTORS

I attempted in the case study to show not only the internal management of the two organizations, but also their relationships with external actors. What came out of this approach was a rather fascinating history of the changes in federal management policies. Two aspects of these policies are worth discussing this point--the growth in power and number of oversight agencies, and the growing role of Congress in the day-to-day operations of federal organizations.

Oversight Agencies

Anyone who becomes familiar with the history of NACA and NASA begins to question the management policies of the federal government. The achievements of the two organizations are to even a non-technical person quite impressive. NACA's committee structure provided a mechanism for obtaining the advice of numerous experts without any cost to the taxpayer. Some of the changes introduced by its researchers remain in use today. Even the General Accounting Office, whose task it is to find performance problems, found the commitment of its staff rather remarkable. The only reasonable argument for the adoption of management policies which essentially ended its existence would seem to be that its product was no longer needed. If NASA's failure to generate new ideas is indeed the reason for its decline, this alone is evidence of a need for an organization such as NACA.

Similar observations can be made about NASA. Although its leaders accepted the management structure which NACA's leaders had tried to avoid, its activities after 1965 became subject to increasingly numerous investigations by various organizations which had regulatory power over federal agencies. The rules and regulations which governed personnel regulations were particularly burdensome. If NASA's various coalitions were in agreement over nothing else, it was that the reductions-in-force were devastating to the organization and its ability to retain highly qualified researchers and managers. The enormous increase in personnel which occurred during its early years suggests that given a great deal of flexibility, its leaders could have brought its personnel complement down to a more acceptable level without the high costs associated with its actual reduction. The organization's inability to plan for what became almost arbitrarily set personnel ceilings, coupled with the Civil Service Commission's regulations concerning who could and could not be fired, made the rapid drop in the staff's morale and the loss of many of its top scientists and engineers almost a certainty. Very few individuals are willing to remain in an organization in which they cannot obtain promotions or are uncertain about their future when they have other alternatives.

The conclusion that NASA's decline occurred because of a failure of the executive function does not preclude the questioning of those management policies which so limited the alternatives open to NASA's leaders and made it so difficult for even an organization as committed to maintaining a research environment as NACA was, to continue in existence. One hesitates to conclude that it is impossible for a federal agency to engage in in-house research activities, but that does seem to be the conclusion that naturally arises from the case study. The continual demands for more and more controls by the oversight agencies coupled with the belief that a bureaucratic structure is more efficient imply that it will become increasingly difficult to attract and retain highly qualified scientists and engineers or any individual who is responsible for an activity which requires a great deal of discretion.

What does seem evident is that there needs to be some consideration of the impact of administrative requirements on the structure of organizations and their capability to accomplish their objectives. The fact that current management policies were adopted with the assumption that there is an ideal structure for all organizations indicates that there is very little understanding of the relationship between tasks and structures--a relationship which is accepted by most individuals who study organizations. The impact of this belief is evident even in the literature. Competing groups, dependency relationships, and other dysfunctional aspects of organizations whose structures do not fit their tasks are accepted not as dysfunctions, but as characteristics common to all organizations. The issue of whether they are a necessary part or only the result of an attempt to control the activities of the federal government should be addressed.

Congress and the Executive Branch

One of the issues which has surfaced repeatedly in the literature on public organizations has been the question of how to justify policy making by non-elected public officials in a democratic nation. The findings from the case study suggest that it may be necessary to address just the opposite issue: Whether it is desirable or necessary for political decision makers to play such a large role in the execution of their own policies or in the internal management of the federal government to ensure accountability.

The answer to the latter issue depends on how one feels about the responsibility of federal administrators toward political decision makers' objectives. Is it necessary in order to make sure that administrators perform as desired to develop as many rules and regulations as NACA and NASA faced? Is it necessary in a democratic nation for Congress and other outside evaluators to not only develop policies, but also the specific means of achieving those policies? Must it be assumed that public administrators will not carry out the objectives set by political decision makers?

The case study would suggest that this assumption of irresponsibility on the part of public administrators is not entirely warranted. NACA's leaders made mistakes, but a review of their records reveals individuals who strongly believed that the advancement of aviation required basic and applied research, a recognition of their limitations in supplying this research, and a rather impressive commitment to providing Congress with full value for the funds they were given. NACA was criticized for its independence and unwillingness to respond to every demand made upon it, not for its lack of performance or its misuse of federal funds.

The same might be noted for NASA, although perhaps less so. Evaluators including Congress blamed Webb for accepting the Executive Branch's decision about NASA's future objectives, not for his failure to implement their demands. Rather interestingly then, and in contrast to

NACA, NASA's leaders were blamed for their not being independent enough.

The case study in many ways points to a different conclusion about organizations and responsibility. NASA and NACA were rather ironically placed in the position of having, if they wished to carry out their objectives, to actually refuse to obey directives of outside evaluators. NACA's leaders spent a great deal of time trying to convince Congress of the need for basic and applied research. That they were able to continue their applied research efforts at any level was undoubtedly due to their decision to provide the military services with the research results they wanted. This enabled them to convince Congress that they were generating practical results. The amount of discretion they were given allowed them to continue their applied research efforts while providing support to the military services.

Even if it is assumed that public employees must be controlled to ensure that public funds are protected, it is not entirely clear that this is the result of current management practices. NACA's and NASA's inability to retain the research environment demanded by highly qualified scientists and engineers meant that the work was either not performed or performed by private parties. In NACA's case the agency's inability to perform scientific research meant that the research had to be performed by outsiders. One of the results of this was of course that the nation fell behind other nations in propulsion research. In other research and development organizations the work was either performed by small research organizations or by private industry. This implies that either an objective set by Congress was not accomplished or that it was performed under the auspices of organizations which Congress had very little control over. The size of research and development contracts, the small number of sources for the type of work which organizations such as NASA require, and the difficulty of changing contractors once the work starts even if they perform poorly means that Congress may have even less control than it did over the researchers who worked for NACA.

Although it is possible to argue that the agency which is responsible for letting the contracts can provide adequate control, this assumes that individuals who have either not had any training in technical areas or who have become managers and therefore have not engaged in research on a continuous basis can adequately evaluate the work of individuals who are engaged in these tasks. What is more likely to occur is that the organization will become dependent on the good will of the contractors for the performance of the work. NASA's attempts to retain its in-house research group so that individuals responsible for research and development projects would not lose contact with what was being accomplished in their fields indicate its unwillingness to accept the assumption that non-technical individuals can oversee the work of technicians.

Perhaps more important, one wonders whether the additional controls have not made federal agencies even less responsible for their work. There was very little incentive for NASA after 1965 to perform well. Its performance made little difference when its budget requests were evaluated. Civil Service regulations implied that individuals who performed poorly could be protected from being fired. NASA's inability to predict its funding level made setting any type of long-term objectives very difficult. There was little incentive to propose interesting projects or even start them if funding could not be obtained for them or if they were subject to cancellation.

The discussion so far has only dealt with the impact on federal organizations' ability to do their jobs, but some note should be made of the fact that Congress's ability to make policy decisions might also be impaired by its concentration on administrative and technical matters. NASA's history is one of continuous discussion in Congress over what type of space vehicle or launch vehicle the nation should produce and very little discussion about what the nation's space policies should be. Its refusal to continue a high level of funding for NASA can perhaps be considered a policy decision, but it is not clear that it recognized the impact of this decision on NASA. Congress continues today to raise the issue of the high average age of NASA's researchers and the effect of the aging staff on the organization's ability to accomplish its research activities. There is little discussion of its role in the aging of the staff. Discussion about the lack of a national space policy is carried on throughout NASA's authorization and appropriation hearings. Numerous agencies produce reports on the enormous need for some type of policy, and little is accomplished. The discussion is left and the hearings continue on the technical aspects of NASA's program. While eliminating Congress's role in technical decision making might not improve the situation, it certainly would save the money spent on technical reports both by NASA and the various legislative and executive agencies responsible for producing them.

What seems more important is that Congress's non-decision making has meant that the nation has begun, as it did in periods of previous radical technical changes, to fall behind other nations in space research and development. During the 1920s and 1940s this type of decision making was easy to remedy. The increasingly time-consuming, complex, and expensive technologies of today imply that catching up is not going to be as easy in the future. It may be that keeping abreast of other nations should not be an objective, but to allow the process to occur by default with little consideration of the consequences is not responsible political behavior.

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APPENDIX A

Personnel and Appropriations Breakdown for NACA and NASA

NACA PERSONNEL DATA

	Headquarters	Field	Total	Total Salaries ($)
1915	1	0	1	1,200
1916	1	0	1	1,200
1917	5	0	5	5,500
1918	37	3	40	62,220
1919	33	11	44	86,650
1920	36	27	63	125,380
1921	22	44	66	123,967
1922	13	56	69	
1923	8	75	83	
1924	23	77	100	204,436
1925	23	107	130	270,192
1926	24	131	145	302,648
1927	24	141	165	341,574
1928	29	156	185	307,372
1929	21	177	198	
1930	38	202	240	532,265
1931	43	240	283	624,931
1932	44	268	312	675,176
1933	44	268	312	671,321
1934	41	266	307	668,640
1935	38	250	288	655,860
1936	50	343	393	861,719
1937	48	398	446	950,415

NACA PERSONNEL DATA
(continued)

	Headquarters	Field	Total	Total Salaries ($)
1938	50	430	480	1,042,510
1939	53	447	500	
1940	64	598	662	1,418,385
1941	80	797	877	1,875,414
1942	132	1,642	1,774	3,492,210
1943	131	2,634	2,765	5,702,099
1944	124	4,370	4,494	9,748,786
1945	119	5,958	6,077	13,999,593
1946	117	5,336	5,453	15,549,016
1947	157	5,773	5,930	19,322,625
1948	125	6,138	6,263	21,438,303
1949	141	6,915	7,056	
1950	157	7,129	7,286	29,061,389
1951	172	7,533	7,705	32,682,192
1952	168	5,540	7,708	35,226,912
1953	168	7,487	7,655	36,365,275
1954	157	7,000	7,157	36,708,193
1955	155	7,415	7,570	39,505,216
1956	163	7,765	7,928	44,586,938
1957	258	7,889	8,147	49,250,032
1958	276	7,765	8,041	

Source: Alex Roland, Research by Committee: A History of the National Advisory Committee for Aeronautics, 1915-1958, Comment Edition, NASA History Office, April, 1980.

NACA

APPROPRIATIONS

	GENERAL PURPOSES	CONSTRUCTION	TOTAL
1915	5,000.00	--	5,000.00
1916	5,000.00	--	5,000.00
1917	18,515.70	69,000.00	87,515.70
1918	82,000.00	40,000.00	112,000.00
1919	167,000.00	38,000.00	205,000.00
1920	169,600.00	5,400.00	175,000.00
1921	192,000.00	8,000.00	200,000.00
1922	197,000.00	3,000.00	200,000.00
1923	215,600.00	10,000.00	225,600.00
1924	307,000.00	--	307,000.00
1925	470,000.00	--	470,000.00
1926	494,000.00	40,000.00	534,000.00
1927	513,000.00	--	513,000.00
1928	525,000.00	25,000.00	550,000.00
1929	623,770.00	213,000.00	836,770.00
1930	745,000.00	555,000.00	1,300,000.00
1931	886,000.00	435,000.00	1,321,000.00
1932	1,051,070.00	--	1,051,070.00
1933	920,000.00	--	920,000.00
1934	705,701.06	247,944.00	953,645.06
1935	777,478.93	478,300.00	1,255,778.93
1936	1,176,884.35	--	1,776,889.35

NACA APPROPRIATIONS (Continued)

	GENERAL PURPOSES	CONSTRUCTION	TOTAL
1937	1,277,550.00	1,720,000.00	2,997,550.00
1938	1,280,850.00	--	1,280,850.00
1939	1,723,980.00	2,340,000.00	4,063,980.00
1940	1,849,020.00	2,330,980.00	4,180.000.00
1941	2,800,000.00	8,400,000.00	11,200,000.00
1942	6,220,465.00	13,645,445.00	19,865,910.00
1943	13,113,736.00	12,315,000.00	25,428,736.00
1944	19,635,415.00	18,756,800.00	38,892,215.00
1945	26,557,330.00	14,385,000.00[a]	40,942,330.00
1946	24,014,393.00	37,267.63	24,051,660.63
1947	27,615,000.00	3,098,000.00[b]	30,713,000.00
1948	33,570,000.00	9,879,000.00	43,449,000.00
1949	38,652,000.00	10,000,000.00	48,652,000.00
1950	43,000,000.00	85,000.000.00	128,000,000.00
1951	45,750,000.00	17,318,000.00	63,068,000.00
1952	50,650,000.00	18,350,000.00	69,000,000.00
1953	48,586,100.00	17,700,000.00	66,296,100.00
1954	51,000,000.00	11,439,000.00	62,439,000.00
1955	51,240,000.00	4,620,000.00	55,860,000.00
1956	60,135,000.00	12,565,000.00	72,700,000.00
1957	62,676,500.00	14,000,000.00	76,676,500.00
1958	76,076,209.00	41,200,000.00	117,276,209.00
1959	78,100,000.00	23,000,000.00	101,100,000.00

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[a] $4,611,330 transferred from the Navy and the Federal Works Administration.

[b] $110,872 transferred from the Navy.

Source: Alex Roland, Research by Committee: A History of the National Advisory Committee for Aeronautics: 1915-1958, Comment Edition, NASA Headquarters History Office, April, 1980.

NACA APPROPRIATIONS

	Headquarters	Langley	Ames	Lewis	Wallops	HSPS
1940	157,946	1,641,150	104,020			
1941	196,935	2,091,889	229,307			
1942	328,979	4,215,736	828,921	421,798		
1943	371,353	6,002,447	1,604,651	4,559,693		
1944	416,586	7,667,537	2,535,386	7,972,423		
1945	407,806	10,832,226	3,050,071	10,455,750		
1946	764,200	13,616,625	4,921,660	13,930,715		
1947	623,612	11,826,315	3,962,356	12,354,438		
1948	1,392,862	13,694,187	5,134,140	12,708,420		
1949	788,356	15,327,202	6,126,230	14,315,302	643,376	326,920
1950	895,124	16,705,748	6,990,932	16,043,756	466,407	685,070
1951	1,081,842	17,631,974	7,535,318	16,416,186	803,904	919,280
1952	1,200,617	19,692,928	8,277,495	18,381,205	777,545	1,208,160
1953	1,137,088	19,261,787	7,794,571	17,292,736	594,371	1,368,000
1954	1,340,524	19,503,862	7,980,951	17,598,976	756,093	1,437,300
1955	1,338,752	20,117,456	8,498,011	18,207,519	687,925	1,705,100
1956	1,541,237	22,083,125	11,269,561	21,996,415	910,217	1,913,100
1957	1,623,981	27,796,270	13,267,350	25,662,580	1,001,005	2,117,600
1958	1,958,201	32,774,912	20,312,089	30,461,848	2,323,465	2,565,300

Sources: 1940-1955, <u>The Budget</u>; 1956-1958, NACA <u>Annual Report</u>; Alex Roland, <u>Research by Committee</u>

Personnel Summary

Onboard at End of Fiscal Year *

INSTALLATION	FY 1978	FY 1977	FY 1976	FY 1975	FY 1974	FY 1973	FY 1972	FY 1971	FY 1970
NASA Headquarters	1,606	1,619	1,708	1,673	1,734	1,747	1,755	1,894	2,187
Ames Research Center	1,691	1,645	1,724	1,754	1,776	1,740	1,844	1,968	2,033
Dryden Flight Center	514	546	566	544	531	509	539	579	583
Goddard Sp. Flt. Ctr.	3,641	3,666	3,808	3,871	3,936	3,852	4,178	4,459	4,487
Kennedy Space Center	2,234	2,270	2,404	2,377	2,408	2,516	2,568	2,704	2,895
Langley Research Ctr.	3,167	3,207	3,407	3,472	3,504	3,389	3,592	3,830	3,970
Lewis Research Center	2,964	3,061	3,168	3,181	3,172	3,368	3,866	4,083	4,240
Johnson Space Center	3,617	3,640	3,796	3,877	3,886	3,896	3,935	4,298	4,539
Marshall Sp. Flt. Ctr.	3,808	4,014	4,336	4,337	4,574	5,287	5,555	6,060	6,325
Space Nuclear Sys. Off.	--	--	--	--	--	--	45	89	103
NASA Pasadena Off.(NAPO)	--	--	--	35	39	39	40	44	72
Wallops Flight Center	429	426	437	441	447	434	465	497	522
Natl.Space Tech. Lab.	108	94	72	76	--	--	--	--	--
NASA TOTAL	23,779[a]	34,188	25,426	25,638	26,007	26,777	28,382	30,506	32,548[b]

* Includes temporary personnel

a Excludes 859 employees in the youth programs

b Includes 592 of ERC which closed 6/30/70

Source: U.S. Congress, House. Committee on Science and Technology, Subcommittee on Space Science and Applications. United States Civilian Space Programs: 1958-1978. 97th Cong., 1st Sess., Committee Print. Washington, D.C.: Government Printing Office, 1981.

NASA PERSONNEL SUMMARY

Onboard at End of Fiscal Year*

INSTALLATION	*FY 1969*	*FY 1968*	*FY 1967*	*FY 1966*	*FY 1965*	*FY 1964*	*FY 1963*	*FY 1962*	*FY 1961*	*FY 1960*	*FY 1959*
NASA Headquarters	2,293	2,310	2,336	2,135	2,135	2,158	2,001	1,477	735	587	492
Ames Research Ctr.	2,117	2,197	2,264	2,310	2,270	2,204	2,116	1,658	1,471	1,421	1,464
Electronics R.Ctr.	951	950	791	555	250	33 b/	25 b/	--	--	--	--
Dryden Flt. R.Ctr.	601	622	642	662	669	619	616	539	447	408	340
Goddard Sp.Flt.Ctr.	4,295	4,073	3,997	3,958	3,774	3,675	3,487	2,755	1,599	1,255	398
Kennedy Sp. Ctr.	3,058	3,044	2,867	2,669	2,464	1,625	1,181	339	--	--	--
Langley R. Ctr.	4,087	4,219	4,405	4,485	4,371	4,330	4,220	3,894	3,338	3,203	3,624
Lewis R. Ctr.	4,339	4,583	4,956	8,047	4,897	4,859	4,697	3,800	2,773	2,722	3,809
Johnson Sp. Ctr.	4,751	4,956	5,407	4,487	4,859	4,277	3,345	1,786	794	In GSFC	--
Marshall Sp.Flt.Ctr.	6,639	6,935	7,602	7,740	7,719	7,679	7,322	6,843	5,948	370	--
Pacific Launch Ops.	--	--	--	d/	21	22	17	--	--	--	--
Sp.Nuclear Sys. Ofc.	104	108	113	115	116	112	96	39	4	--	--
Western Support Ofc.	--	c/	119	294	377	376	308	136	60	37	--
NASA Pasadena Ofc.	80	79	91	85	376	a/	--	--	--	--	--
Wallops Station	554	565	576	563	554	530	493	421	322	220	171
NASA TOTAL	23,929	34,641	35,860	35,708	34,049	32,499	29,934	23,686	17,471	10,232	9,235

a/ Prior years figures included in WSO.

b/ Figures for North Eastern Office.

c/ Effective in 1968 WSO was disestablished and elements merged with NAPO.

* Includes temporary personnel.

d/ Effective in 1966 PLOO activity was merged with KSC.

Source: U.S. Congress, House. Committee on Science and Technology, Subcommittee on Space Science and Applications. United States Civilian Space Programs: 1958-1978. 97th Cong., 1st Sess., Committee Print. Washington, D.C.: Government Printing Office, 1981.

NASA IN-HOUSE AND CONTRACTOR EMPLOYMENT, 1960-1979

YEAR	NASA EMPLOYEES	CONTRACTOR EMPLOYMENT	TOTAL EMPLOYMENT	% CONTRACTOR
1960	10,286	36,500	46,786	78
1961	17,077	57,500	74,577	77
1962	22,156	115,500	137,656	84
1963	27,904	218,400	246,304	89
1964	31,984	347,100	379,084	92
1965	33,200	376,700	409,900	92
1966	33,924	360,000	393,924	91
1967	33,726	273,200	306,926	89
1968	32,471	235,400	267,871	88
1969	31,745	186,600	218,345	86
1970	31,223	136,580	167,803	82
1971	29,479	121,130	149,609	81
1972	27,428	117,540	144,968	81
1973	25,955	108,100	134,055	81
1974	24,854	100,200	125,054	80
1975	24,333	103,400	127,733	81
1976	24,039	108,000	132,039	82
1977	23,569	100,500	124,069	81
1978	23,167	102,800	126,037	82
1979 (est.)	23,237	104,300	127,537	82

* Reflects June statistics for 1960-76; September statistics for 1977-79.

Source: Adapted from NASA. This Is Nasa. Washington, US Government Printing Office, 1979, p. 13. NASA employment for 1978 is corrected here to its actual level (the number used in the cited document was an estimate).

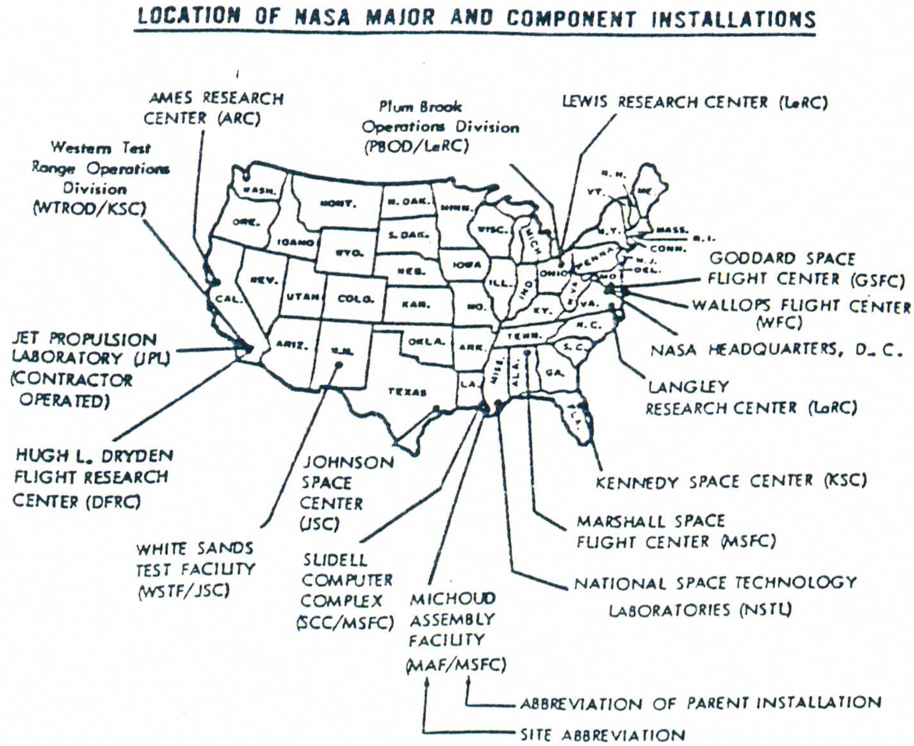
NASA BUDGET, 1959-1979

Fiscal Year	Appropriation	1967 Dollars	GNP Deflator Factor*
1959	184.3	214.9	0.8575
1960	523.6	598.1	0.8754
1961	964.0	1,086.2	0.8855
1962	1,825.3	2,032.6	0.8980
1963	3,674.1	4,024.2	0.9130
1964	5,100.0	5,505.8	0.9263
1965	5,250.0	5,565.6	0.9433
1966	5,175.0	5,341.1	0.9689
1967	4,968.0	4,968.0	1.000
1968	4,588.9	4,429.4	1.036
1969	3,995.3	3,682.3	1.085
1970	3,749.2	3,274.4	1.145
1971	3,312.6	2,751.3	1.204
1972	3,310.1	2,629.2	1.259
1973	3,407.6	2,593.3	1.314
1974	3,039.7	2,142.1	1.419
1975	3,231.2	2,052.8	1.574
1976	3,551.8	2,099.1	1.692
Transition Quarter	932.2	550.9	
1977	3,819.1	2,130.0	1.793
1978	4,063.7	2,112.1	1.924
1979 (est.)	4,566.2	2,226.3	2.051

Source: NASA Budget Office

APPENDIX B

Location of NASA Installations



Source : NASA fiscal year 1980 budget submission.

Figure 6
Location of NASA Installations