MANAGING NASA IN THE APOLLO ERA

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We can lick gravity, but sometimes the paperwork is overwhelming.

Wernher von Braun

Art is I; science is we.

Claude Bernard

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Foreword

Few things can better serve managers undertaking leadership roles in large, complex, technology-based organizations than knowing how other such organizations have coped with the problems that must be solved to achieve success. Yet few studies of the administrative records provide detailed case studies of how very large research and development programs have been managed, or what has worked and why. The same is true of large, nontechnical endeavors. We have Sapolsky's study of Polaris development, Hewlett and Anderson on the origins of the Atomic Energy Commission, Peck and Scherer on the weapons acquisition process, Sayles and Chandler on managing large systems, and with this book, Arnold Levine's *Managing NASA in the Apollo Era.*

Dr. Levine's approach and his large investment of time to study the detailed record of documents and interviews, together with his institutional viewpoint, rather than one that is program-oriented, make this an important book. He takes the entire agency, rather than any single component or program, as the subject of his study, emphasizing those features that NASA shared with other federal agencies in the 1960s and with previous large developmental efforts. In addition, Levine seeks differences from other such efforts in the cause-effect coupling in NASA's approach to management. Specific administrative actions are placed within the context of the larger whole. While documenting and describing NASA's formal organizational structure, Levine concentrates on those key policy decisions that ultimately shaped the agency: reliance on the American industrial establishment, not as vendors, but as research and development partners; sharing decision-making with the centers to the fullest extent possible; avoidance of bureaucratic delays and inertia at headquarters; injection of the profit motive into a traditional cost-plus environment; consciously and continuously striving to retain NASA's freedom of action to move forward with strength in those areas necessary for success in its missions, even when the concurrence of other officials and agencies was delayed; finally, extensive use of the Department of Defense for contract management and launch and of military personnel in key management positions in NASA itself. This book, by implication, shows that NASA found many traditional management axioms do not apply within the large, complex R&D organization—axioms like "well defined areas of authority and responsibility," "unity of command," "one man, one boss," or "centralized operations." These principles often work well in static organizations, but more is needed if dynamic, large-scale endeavors are to succeed. He describes the role of the federal R&D manager as above all a *political* one in the sense that he must find ways for inter-personal and inter-organizational relationships to be a positive, rather than a negative, element in achieving the desired results. If NASA program managers, scientists, engineers, and top officials had not thought of their work in political (personal political and organized units-political) terms, if they had not arranged their activities to gain support from other NASA divisions, Congress, the Bureau of the Budget, the scientific community, etc.—Apollo would not have met its goals.

An important value of this book, I think, is in Dr. Levine's meticulous examination of the record for evidence to demonstrate *why* the NASA structure was adequate to deal with some of the most complex problems any organization has had to face. And increasingly, large organizations confronted with novel technical problems—be they public agencies, multinational corporations, or joint public-private ventures like the civilian space program—will find the NASA approach of a loosely coupled, decentralized organization an effective means of managing such large-scale endeavors. In this regard, Dr. Levine finds, and I believe, that three lessons can be derived from the NASA experience. The first is that political relationships are not (nor can they be) something added on to the work of line managers or program officials as less important than other duties; these relationships are an integral part of their work, inasmuch as personal relationships and a sensitivity to the total environment are essential parts of leadership responsibilities if the system is to work at all.

The second lesson to be derived is that a decentralized organization can be made compatible with precise objectives and timely performance. During the 1960s, Deputy Administrator Hugh Dryden, Associate Administrator Robert Seamans, and I went to considerable lengths both to delegate authority to center directors and project managers whom we had tested by experience or knew from past associations, and to make explicit our reasons for doing so. Levine gives a long list of functions—planning, procurement, launch management, inspection—that could have been, but were not, concentrated at the headquarters level. Our philosophy was to give the field installations and their industrial partners the widest discretion compatible with agency missions. The missions NASA was assigned almost dictated considerable autonomy and freedom to innovate at several levels in the organization, while carefully keeping within the framework provided by the Space Act.

The third lesson follows from the second. NASA could not have accomplished its missions without the ability to adapt to continuous change. By *adapting* I include not only the numerous reorganizations of the 1960s, but also constant attention to the mechanisms introduced to provide senior management with reliable feedback. This is what lay behind the creation of an executive secretariat, the exchange of officials between headquarters and the centers, the development of sophisticated reporting systems, and the constant strengthening of the role of the headquarters program manager as a link between the agency's general manager and the centers. Equally important, Dr. Dryden, Dr. Seamans, and I recognized that reliable feedback requires a flow of information in two directions. Our objective was to ensure that NASA employees, from executives to a point far down the line, understood rather precisely what was to be their role in accomplishing specific missions and that NASA senior officials also understood those factors which most affected the performance of those same executives down the line.

This book, in focusing tightly on issues of organization and governance, to some extent, scants the richness and variety within NASA. I would have liked something about the sustaining university program and the continuing effort to foster interdisciplinary teams at the universities, our international policies, and our attempt to utilize effectively the technologies developed by NASA and its contractors. But these omissions are minor in a work that has much to say to public administrators, managers of large-scale research and development programs, and students of the relation of science and public policy.

At a time when thoughtful observers, including the editors of the *Harvard Business Review,* are asking, "Do the assumptions on which its market economy rests still have meaning for American Society?" and emphasizing such subjects as "The Morality of the Market Place" and "Capitalism and Freedom," I believe students of administration should seek the effect on NASA's success of such policies as the openness of NASA programs, and the fact that we could say to the press and the scientists and engineers of the eighty nations cooperating, "Come and bring your camera." Dr. Dryden, Dr. Seamans, and I, in making the substantive and administrative decisions, constantly and deliberately sought to spread our most difficult problems over the largest possible number of able minds and to develop means to evaluate, from the broadest national and international viewpoints, the concepts and proposals that resulted. We could not know what some of this large number could invent, but we strongly felt many innovative ideas would emerge from a widespread invitation to work on the problems related to an understanding of the solar system and the universe beyond. We constantly sought to develop and employ ways through which all the individuals, organizations, institutions, and government units could build strength for their own purposes while adding to NASA strengths. Our policy was not to draw strength from our partners in such a way as to weaken them, but rather to participate with them in a framework that helped both of us reach our own main objectives.

As to long-range planning, on which Dr. Levine sets down the documentation and finds our efforts inadequate, contrary to many assertions that we had a "blank check," NASA was constantly faced with strong public and private opposition to manned spaceflight. NASA was constantly warned by those political, educational, press, and congressional sources who were most supportive that any evidence of commitment to a large, long-term, expensive program beyond Apollo would lose us the margin of strength needed to finish Apollo. In fact, several near successful efforts were made by influential leaders to cut back on Apollo to the point that we could not assure success. I, myself, and most NASA senior executives were convinced that if Apollo resulted in one or more failures, and was curtailed or eliminated, the monuments to such failure would be visible for a long time in many places—as symbols of U.S. inability to see the project through and master the problems of operating in space. In fact, Apollo and other manned spaceflight projects gave our citizens and those of many other countries tremendous pride and encouragement. Levine summed this up when he wrote: "Webb" (really the senior executive group) "became more determined than ever to salvage Apollo, even if it meant postponing decisions about its sequel." In fact, just as we needed Gemini to guide our work on Apollo, until we had digested the Apollo experience, it was difficult to make fully creditable plans for larger manned missions.

In all the welter of problems and daily immersion of NASA senior executives in both the substantive and administrative issues and actions which Dr. Levine describes, Dr. Dryden, Dr. Seamans, and I never lost sight of the underlying concept that, in our haste, we must not take shortcuts that were not consistent with the basic values on which our democratic society was based.

James E. Webb
June 1982 *NASA Administrator, 1961–1968*

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The research on which this book is based could not have been carried out without the assistance of hundreds of persons within NASA and elsewhere. It is a pleasure to acknowledge the help so cheerfully given by the staff of the NASA History Office and the NASA Technical Library. I would also like to acknowledge the cooperation of the Federal Records Center in Suitland, Maryland, where most of the retired records of NASA Headquarters are stored; the library of the U.S. Department of Transportation; and the Milton Eisenhower Library of The Johns Hopkins University, Baltimore, Maryland, for permission to examine the Hugh Dryden papers.

I am also indebted to those persons whose close readings helped shape this work and improve its content and organization. At the NASA History Office, Dr. Monte Wright, Frank Anderson, Jr., Carrie Karegeannes, Alex Roland, and Lee Saegesser reviewed the manuscript at various stages of its gestation. Other persons who read the complete draft of the manuscript include Richard Hallion of the National Air and Space Museum, Dr. Homer Newell, Dr. Robert Seamans, Willis Shapley, and James Webb. Although I cannot list them individually, I would like to thank the dozens of NASA officials whose explanations clarified many details of the space program. Finally, I would like to thank my wife Stefanie, whose good humor and patience made a somewhat Sisyphean task more bearable. I must add what no one is likely to dispute: Any errors of fact or judgment in this book are my responsibility.

Arnold Levine
Washington, D.C.

November 1979

Introduction

The aim of this book is to describe and analyze the organization of the National Aeronautics and Space Administration during the 1960s and, in so doing, to test certain assumptions about the nature of administrative history. To date, administrative history has been as much the victim of its friends and practitioners as of those who wonder if it exists as a distinct genre. The assumption behind much of the administrative theory that finds its way into such works—that officials and bureaucrats live in a world where rational behavior is conceivable and attainable—has been in question at least since the publication of Herbert Simon's *Administrative Behavior* in 1946.[1] In the real world, Simon argues, a fragmentary knowledge of consequences and the inability to choose among all possible alternatives set severe constraints on the administrator's ability to act rationally. Rationality as a goal—the efficient matching of means to ends—can be described, but for the reasons given, "it is impossible for the behavior of a single isolated individual to reach any high degree of rationality."[2] To these objections may be added two more. One is the tendency of certain key decisions to have cumulative effects throughout the organization, whether such decisions are documented or not. The logic of a particular course of action may bring certain consequences, even (or especially) when these are not consciously intended. The other objection to the view that there is measurable correspondence between intentions and results is that superiors may not know or want to know what their subordinates are doing. Whether the sheer volume of feedback is self-defeating, or subordinates cannot or will not do what their superiors want, the problem remains: Descriptions of formal organization structures may, at best, tell only what the organization was intended to do.[3]

Still, it would be a mistake to substitute for a "formalist" approach to organizations something equally one sided. Statements of intent do matter since they define the boundaries within which the organization must operate. The 1958 act establishing the National Aeronautics and Space Administration (NASA) contains nothing about the manned lunar landing program, yet almost all the powers and authorities needed for the success of Apollo are found there. Thus enabling legislation, formal delegations of authority, and descriptions of powers and functions are important because they determine that the agency shall be this rather than that. Indeed, one can draw no firm line between the procedural and substantive aspects of an agency's work. Rather, one must set the agency in its environment; the historian ought to describe the agency's institutional surroundings, its clients and allies, its budgetary strategies, and the extent to which its functions were competitive with those of other agencies. The defect of treating an agency in purely formal terms is precisely that this approach ignores the surroundings.

The problem of writing about NASA becomes manageable because, given the vast accumulation of documents, by far the greater part consists of paper generated to meet the stringent reporting requirements of the manned spaceflight and space science programs. What is left is documentation that serves to shape agency policy before it hardens into definite programs, to enunciate that policy once it has been ratified, and to record problem areas that come to the attention of general management. Despite advances in communications technology, the primary materials are still written. For policy to be effective it must eventually be issued in written instructions: Policy must be written to reduce the scope of ambiguity, and it must be in the form of instructions to indicate that it is authoritative rather than advisory. However, one must know the written sources and their limitations. For example, the tension between NASA Headquarters and the field centers may run throughout the documentation, but it runs between the lines. It is seldom enunciated. The administrative historian must read between the lines to discern it.

Administrative history, as the account of the interaction between an organization and its environment, is possible and can provide valuable information. An account of NASA is singularly fitted to test this conclusion. Established by Congress in the aftermath of Sputniks 1 and 2, NASA quickly grew by accretion, the incorporation of older installations, and the creation of new capabilities into an agency employing 36 000 persons and owning facilities worth \$3.65 billion by 1965–1966.[4] From 1958 to 1968 NASA launched several dozen unmanned spacecraft that revolutionized communications and meteorological technology on the one hand and electronics on the other, created or fostered new scientific disciplines like bioastronautics and space medicine, and stirred up the field of astronomy. But in the public mind NASA was most closely associated with the manned spaceflight programs—Project Mercury (1958–1963), which tested the ability of one man to function up to several hours in Earth orbit; Gemini (1962–1966), in which two-man crews in one spacecraft were assigned a variety of tasks, including rendezvous and docking in Earth orbit with a target vehicle and moving around outside the spacecraft itself; and Apollo (1960–1972), in which three-man crews were sent on progressively more ambitious missions, culminating in the lunar landing of July 1969. Merely to sketch the civilian program is to indicate the magnitude of NASA's assignments and the scope of its successes. One must take seriously the contention of James E. Webb, NASA Administrator from 1961 to 1968, that the success of NASA was a success in organizing "large-scale endeavors," that is, that the same system of management that made the lunar landing possible may also have been its most important byproduct.[5]

To understand what NASA did, one must begin by considering it as an institution coordinated to achieve certain goals that were neither fixed nor always precisely determined. Coordination had to be achieved on different levels: within the agency among the substantive program offices, the several field installations, and the central functional offices; between NASA and the Executive Office of the President, which determined the funding levels of each item in the NASA budget before congressional review; between NASA and congressional committees that authorized its programs, allocated its funds, and provided continuous oversight; between NASA and the scientific community, which was client, critic, and not-so-loyal opposition; finally, between NASA and other Federal agencies, which might be partners (as in the joint NASA-Atomic Energy Commission Space Nuclear Propulsion Office), rivals (as in the case of the Defense Department's manned programs), or symbiotic (as in the supporting aeronautical research undertaken for the Federal Aviation Agency). Thus the picture of an organization pressing single-mindedly toward its main goal must be replaced by one that recognizes the complexity of the internal and external communities that affected NASA policy. Neither the manned lunar landing nor any other NASA program is quite as straightforward as it may first appear: first, because different officials tended to have different perceptions of the program; second, because the program itself can be seen in different contexts, depending on whether one takes the short-, intermediate, or long-range view; third, because it was not clear whether the lunar landing program (and some others) was an end in itself, designed to give the United States a "total capability" in space, or a diplomatic counter against the Soviet Union.

This book, then, is a study of the development, results, and causes of NASA decisions. It is an attempt to relate administration to the total agency mission, rather than to treat administration as though it were a discrete, closed system. Such a study, to be adequate, should include the following elements.

It should describe the formal authority structure for delegating powers and functions, fund allocation, planning, and relations with and between NASA centers. For the reasons given above, the formal mechanisms are important in themselves as well as for illuminating the way in which informal lines of authority developed. An account of formal structures will not tell if the agency succeeded or failed; it may, however, tell why it succeeded or failed.

It should give some account of the informal structure that developed within the formal one. What were these informal relations, and how did they originate? To what extent did they supplement agency policy, supersede it, or create a new set of procedures in advance of their standardization by senior management?

In this context one should distinguish informal, unwritten operating procedures from the informal relations within program and functional offices and between the centers. In some cases headquarters management did not—or perhaps could not—take official notice of tensions generated by NASA programs until they had become too serious to ignore. Such tensions included, for example, the question of whether the Goddard Space Flight Center in Greenbelt, Maryland, or the Kennedy Space Center at Cape Canaveral, Florida, would have control of the Manned Space Flight network; the conflict between the Marshall Space Flight Center in Huntsville, Alabama, and the Manned Spacecraft Center in Houston, Texas, over the "roles and missions" of Marshall after the production of Saturn rockets ceased; and, within headquarters, the debate over the resources allocated for manned spaceflight and space science. Whether such tensions were inherent in a decentralized civilian space program or not, and whether they resulted in management directives or not, they are among the most important, yet most elusive, topics to be discussed.

An agency history, as distinct from a management history, should concentrate on the senior officials who set NASA's goals, allocated funds, instituted reporting requirements, and set up mechanisms for continuous feedback of information. In short, top management sets the rules of the game; within those rules the centers had to manage approved projects. Thus an administrative history of NASA that attempts, as does this one, to write from the headquarters point of view should analyze the interplay between centralized control and decentralized project management, and it should bring to the forefront those Government-wide policies that determined how NASA got its work done.

Finally, history consists of events situated within a temporal framework. One can "freeze" the action at any point on a continuum, but that point is the result of what has preceded, and from it will flow second- and third-order consequences, not all of which can be foreseen. To cite one example: While the method of managing research and development known as phased project planning was formally instituted in October 1965, something like it had been used in projects from the time of NASA's establishment. The process by which phased project planning was implemented represented a sharper definition, a more emphatic statement of something inherent in the logic of large-scale program management. In like manner, the procedures by which the headquarters program offices set priorities and chose among alternatives were adopted for agencywide long-range planning.

In sum, the question this book seeks to answer is, what can the study of NASA as an organization teach us? This book concentrates on NASA as a going concern, as an organization that, instituted for specific purposes at a specific time, strove to maintain itself, to operate within the terms of its establishment, and to compete with other agencies for the limited resources made available by the White House and Congress. The criteria for the inclusion of a particular subject are the extent to which a problem or issue was agencywide; whether an issue reached the higher levels of management for resolution; whether a program interacted with other programs, internal or external; and the extent to which problems of the kind mentioned above—say, the relations of headquarters to centers or the balance of work done intramurally and that contracted out—recurred. Put somewhat crudely, the principal themes of this book are (1) how a high-technology agency was run in a decade marked by rapid expansion of funds and manpower in the first half and almost as rapid contraction in the second and (2) how NASA combined centralized planning and control with decentralized project execution.[6]

With a subject such as this, a major problem is how to reconcile the narrative with the topical approach. The first chapter is a summary of the key administrative decisions in the early history of NASA; chapter 2 is a narrative account of NASA from its origins to 1969. The intent is to adumbrate the main themes of the book, to sketch the history of the period, and, by a gradual buildup of detail, to prepare the reader for the analytical treatment of the following chapters. Starting with chapter 3, the mode shifts from the narrative to the topical. Separate chapters dealing with contracting, manpower, the budgetary process, headquarters organization, and relations with the Department of Defense carry the reader from the early to the late 1960s. Chapter 9 covers the long-range planning of 1964–1969, when this most mission-oriented of agencies sought a program around which all elements of the organization could unite.

Chapter 1

Key Administrative Decisions of NASA's First Decade

In terms of its proclaimed objectives, the civilian space program in the 1960s was an extraordinary success. The manned lunar landing was achieved on schedule, the record of successful launches improved steadily between 1961 and 1970, and NASA worked steadily and well to develop launch vehicles capable of being produced serially and of accepting a variety of payloads. As far as this book is concerned, the problem is to explain how decisions about NASA's organization accounted for this success—if, indeed, such success occurred because of the organization, not in spite of it. No doubt it is possible to state the reasons for NASA's success in general, straightforward terms. The argument might run along these lines: Congress gave NASA a blank check because the lunar landing had to be managed on a crash basis. Furthermore, by committing itself to extremely precise, measurable, all-or-nothing goals, NASA had powerful incentives not to fail.

All this may be true as far as it goes, but it does not go far enough. Terms such as "crash program" or "decentralization" derive their meaning from a specific context. For example, the 1963 organizational changes discussed in chapter 3 "decentralized" NASA so that lines of authority reverted to what they had been prior to 1961. But one cannot step in the same stream twice; the 1963 decentralization occurred in the context of the vast new lunar landing mission ordained for NASA by President Kennedy in May 1961. These conditions did not recur. Similarly, one should be cautious in applying the term "crash program" to Apollo. If the term is used to denote a program in which "the cost is not the major consideration . . . several parallel approaches are taken for the solution of each major problem, and . . . overtime and multiple shifts are utilized to a very large degree," then Apollo was not a crash program, since the first two criteria, at least, did not apply.[1] Whenever these terms appear in this book, the reader should be aware of their contextual implications.

The salient features of the space program must be sought elsewhere. Among them was the often fruitful tension between applied research and basic research. In the development of a space capability, space applications, supporting technology, and aeronautics, NASA's program was essentially applied research. The manned lunar landing was comparable to the development of a polio vaccine, rather than to a cure for cancer. The latter entails fundamental knowledge about the nature of the cell, whereas the former involves only a more sophisticated use of existing research techniques. On the other hand, space science was accorded a prominent position in NASA's program and organization. Three NASA centers were devoted—two of them almost completely and one of them substantially—to space science.

Other features of the agency's operations may help to explain the success of the space program. There was the ability of the agency to draw on the scientific community for advisors, principal investigators, and consultants; the absence of distinction between the budgetary process and short- and long-range planning; the refusal of NASA officials to enforce a separation between those who built flight hardware and the scientists who designed and developed the experiments to be flown; the ability of the agency to draw on the capabilities of the Department of Defense for launch support, contract administration, program managers, and astronauts; and, finally, the authority vested in the Administrator to waive some civil service requirements in recruiting executives from the outside. But the decisions that made these features possible are not, in a sense, the most important *administrative* decisions. To use Nelson's distinction, these are decisions *within* an organizational structure rather than decisions *about* that organizational structure, which Nelson sees as the major decisions.[2] Decisions about an organization occur when "a given organizational regime is limited in the range of contingencies it can handle effectively. . . . when circumstances evolve outside of this range, the symptom is a growing restiveness (on the part of one group or another) with the routine flow of events and decisions; and . . . successful resolution requires some kind of significant reorganization." It is this kind of administrative decision about the NASA organization that is discussed here.

Anyone who studies the morphology of large organizations is apt to be struck by the power of a few key administrative decisions to set the organization's course. By "administrative" is meant the choices between alternatives that shape the agency from within, not those imposed from without. The peculiarities of such decisions are that they represent choices among alternatives, some of which might have been equally successful; they tend to be cumulative in effect; one such decision requires many others, both to carry it out and to make explicit what was only implied in the original directive; they are at once shaped by and shapers of the agency's terms of reference; and they are not themselves discrete, self-contained decisions as much as they are bundles of administrative acts that gradually rise to the level of agency policy.[3]

Consider, for example, the NASA policy, avowed from the beginning, to contract out research and development rather than do such work entirely in-house.

The decision itself was made before the mechanism needed to make it work—a rational source selection procedure—had been perfected. One might go as far as to say that NASA began with an operating philosophy whose implications took some seven years to work out. In this regard, the decision to contract out stands somewhat apart from other decisions considered here. The others were formally enunciated in a specific directive as internal agency policy, and each contributed greatly to NASA's ability to interpret its mission. In this respect, administrative decisions differ fundamentally from those that establish the mission. The decision to prescribe phased project planning as NASA policy is different in kind from the decision to establish a civilian space agency or President Kennedy's decision to "send a man to the moon and bring him back before the end of the decade." The latter decisions are "organic"; the former, attempts to translate them into day-to-day operating procedure. As with most translations, something is inevitably lost in the process. First, management and line officials will carry out broad goals *as they understand them*. Second, the same communications gap as that between the agency and the executive branch is repeated within the agency itself between the offices that constitute it and the senior officials who act as links between the organization and an environment that may be indifferent or even hostile. No formulation or directive can cover all contingencies; no decision will be seen in precisely the same way by those affected by it; no policy is so impregnable that alternatives are inconceivable.

The decisions that follow were broad formulations; they had to be sold to the center directors, headquarters line officials, and the functional staff. In this respect, technical, political, and management considerations could not be separated for long. The decision to develop the F-1 and J-2 engines for the Saturn rocket stages could not be made in advance of the mechanism for procuring such hardware. Similarly, neither Apollo nor Gemini would have been feasible as agency programs in the absence of a firm policy that established relations between the centers and headquarters.

The decision to rely on private industry, rather than in-house staff, for development of NASA programs has probably been the key internal decision in the history of NASA, yet its genesis is by no means clear. The policy of contracting out was arrived at in gradual stages, each of which made the policy more precise, hence more effective. The Space Act authorized NASA "to enter into and perform such contracts . . . , and on such terms as it may deem appropriate . . . with any person, firm, association, corporation, or educational institution."[4] Except for a proviso concerning small-business set-asides, the act (by its silence) gave NASA the freedom to work out its contracting procedures, the forms of which were borrowed from the armed services procurement regulations, adapted to the needs of a young, rapidly expanding agency. The key steps were as follows:

1. Promulgation of source evaluation procedures in August 1959.
2. Publication in 1960 of the first procedures manual; new edition issued in August 1964.

3. Publication of guidelines for incentive contracting in September 1962; first major incentive contract (with Boeing for the Lunar Orbiter) negotiated in 1963.
4. Promulgation of phased project planning guidelines in October 1965.

These steps made NASA procurement philosophy more precise and flexible, while placing heavy responsibilities on the centers and the line organization to initiate feasibility studies, prepare project guidelines, assist in the evaluation of contractor proposals, and supervise and evaluate work accomplished under contract. Despite its undeniable success, the policy of contracting out—begun by T. Keith Glennan, the first NASA Administrator, and greatly expanded by James E. Webb—raised serious problems that were at once technical and political.

First, there was the question of how large an in-house staff was needed to monitor prime contractors. If the staff was too small, lacked experience in managing large development contracts, or was inclined to favor contractors who had worked for the agency before, NASA would be at the mercy of its contractors. Should the staff be too large, there would be pressure from the centers to do the work in-house. There was always some tension between forcing the centers to learn to deal with contractors and setting aside a certain percentage of funds for small internal projects, without which NASA could not retain its most talented scientists and engineers. As Wernher von Braun, Director of the Marshall Space Flight Center (MSFC), once remarked to a House subcommittee:

> A good engineer gets stale very fast if he doesn't keep his hands dirty. . . . it is for this reason that we are spending about 10 percent of our money in-house; it enables us to really talk competently about what we are doing. This is the only way known to us to retain professional respect on the part of our contractors.[5]

Second, NASA officials had to decide what functions might properly be delegated. The negotiated contract might be for hardware, services, or study reports; the line between what was and was not proper was often exceedingly fine. For example, was it proper for a company to do a feasibility study, recommend that a project be authorized, and then receive a contract to produce hardware for the project? Should a company that offered technical advice to NASA be able to benefit from that advice? What kinds of decisions could not be delegated to private bodies of any kind?

A third problem had to do with contracting for specific services when civil service staff was available to do the job. This was the same problem in another form: What criteria should the Government use in procuring something, be it a launch vehicle, management of a center cafeteria, or test and checkout services? No set of criteria (the Bureau of the Budget issued several sets of guidelines) could meet every contingency.[6] The presumption in favor of a commercial source, save when no such source was available or when using it might somehow disrupt the agency's work, smacked too much of a short-term solution. Excessive dependence on private industry would eventually endanger NASA's ability to determine the kinds of programs it wanted, to estimate reasonable prices, and to evaluate program results. But too much work done in-house would have revived those problems it was the ostensible purpose of the contractual instrument to resolve: a lack of flexibility, the accumulation of a large permanent staff for whom jobs had to be found, and a concomitant vested interest in particular programs. No decision in NASA's history has been fraught with greater consequences than this one. No aspect of NASA organization was left untouched by it.

Another significant decision concerns the reorganization in November 1961, by which responsibility for hardware and responsibility for programs were concentrated in the same program offices. The essence of NASA program planning was organization by goal rather than by hardware. Prior to 1961 a separate Office of Launch Vehicle Programs was responsible for engine and launch vehicle development. If NASA was to be a single agency, rather than a congeries of semi-independent fiefdoms, hardware and programs had to be combined in the headquarters program office and the centers then reporting to them. The catalyst for the change was the decision to give highest priority to the manned lunar landing. What had been discussed for over a year within NASA now became a matter of urgency. The basic changes—omitting the details for now—were (1) that the centers were to report directly to the Associate Administrator, (2) that four new program offices were established in place of the four that had been abolished, and (3) that a new Office of Tracking and Data Acquisition was set up to provide agencywide support.

The reorganization gave the Manned Space Flight (MSF) program the organizational prominence needed to carry out its goal and, in so doing, paved the way for the centers to manage the large development contracts on which the success of the program depended. From these two things—the special freedom of the Office of Manned Space Flight (OMSF) and the doubling and tripling of appropriations and manpower—resulted the most important changes of the next two years: the introduction of incentive contracts and the conversion of older contracts from cost-plus-fixed-fee; the establishment of an Office of Industry Affairs with agencywide responsibility for procurement; and the decision to build a research center dedicated to electronics, the crucial discipline in the refinement of space hardware. The 1961 reorganization, in sum, emphasized the "commonality" of agency objectives. "The manned lunar landing was a NASA objective, not just the objective of the Office of Manned Space Flight. All NASA field installations were to contribute to its accomplishment, not just the centers labelled as manned space flight centers. Agencywide functions . . . were to be performed for the benefit of the entire NASA program, not just one segment of it."[7]

A third decision is that of the November 1963 reorganization, after which the field centers once more reported to the program offices, not to the Associate Administrator. This decision signaled the maturity of the NASA organization. The centers now had the capacity to conceive projects, develop specifications for contractors, supervise contractors, and conduct sufficient in-house work to maintain the excellence of their staffs. The priority of the MSF program was clearly recognized and with it the necessity of shifting the locus of decision making downward from the Associate Administrator to the heads of program offices, center directors, and project managers. Many factors had to converge before such a system could work or be worked. First, there had to be standardized procedures for authorizing projects, tracking resources through the agency, and translating data received into information about ongoing programs. Second, management needed techniques to measure performance, costs, and schedules. Third, NASA needed special scientific and engineering personnel for its research and development programs. It is perhaps truer to call the 1963 reorganization an end rather than a beginning, because without the capabilities listed no such dispersion of authority would have succeeded. In other words, the functions of senior management, i.e., Administrator James E. Webb, Deputy Administrator Hugh L. Dryden, and Associate Administrator Robert C. Seamans, Jr., would be less day-to-day supervision and more long-range planning, handling interagency matters, and attending to the delicate international implications of the U.S. space program. The 1963 reorganization did not change NASA's organizational philosophy; it ratified it.

The fourth major decision was to go to "all-up" flight testing of Saturn vehicles (1963–1966). The all-up philosophy had a rather long history before rising to the level of agency policy. All-up testing means that a vehicle "is as complete as practicable for each flight, so that a maximum amount of test information is obtained with a minimum number of flights."[8] In other words, all three stages of the Saturn V were to be flown with the Apollo command and service modules instead of being tested and flown separately. Unlike the decisions listed so far, it may seem more technical than administrative; again, unlike the others, it was made by George E. Mueller, Associate Administrator (OMSF), and the OMSF Management Council, rather than in the Administrator's office.[9] If the MSF program, by the size of its appropriations and the extent of its resources, was the pacing element of NASA planning, if Apollo was the pacing item for *that* program, and if the lunar landing had to be completed before the end of the decade, then any decision that would decrease the number of test flights would be crucial. In one respect the all-up decision was like the previous decisions discussed: It evolved from earlier decisions and, in turn, presupposed subsequent decisions to implement it. The all-up decision presupposed the July 1962 decision to use lunar orbit rendezvous as the mission mode for Apollo, and it required an ever stricter control of quality and monitoring of contractors, the budgeting of weight within the launch vehicle and spacecraft (itself requiring major advances in electronics and miniaturization), much closer attention to improving some portions of the Apollo program without delaying other portions, and the building in of redundancy wherever possible. All-up testing falls into the category of administrative decisions because it was developed by agency managers and center directors who felt that small incremental development steps would be too time consuming and expensive, and because it did as much as any single decision to establish the allocation of resources and manpower within NASA.

Another significant decision was to strengthen the Office of the Administrator(December 1965–March 1967). Here, too, the decision to create an Office of the Administrator was inextricably involved with prior top management decisions. The year 1965 had been one of intense activity, and the capacity of Webb and Seamans to absorb information, to see the agency as a whole, and to make sense of the welter of reports and issuances generated at the lower levels was stretched very thin. Following Dryden's death on 2 December, Seamans, while remaining general manager, became Deputy Administrator. Webb then moved to tighten his control over the functional management offices. In a 29 December memorandum for agencywide distribution, he announced the establishment of an Office of the Administrator as "a single, uncompartmented entity to afford maximum, direct, personal and informal contact between Dr. Seamans and myself and our associates."[10] In addition to detailing the functions of the secretariat, Webb's memorandum was the most complete expression of his philosophy of the administrative division of labor up to that time. Seamans remained in charge of day-to-day operations; Webb, of protecting NASA from an ever more threatening external environment. The functional staff serving the new office would monitor and assist the program offices.

The second phase of Webb's strategy, begun in early 1967, changed drastically after the Apollo 204 fire of 27 January. The Office of the Administrator had made the division of functions more clear-cut and precise; by itself, this could go only so far to reduce bureaucratic inertia: the delays in reaching decisions, the shifting of decisions upward, the chaotic state of the management issuance system, the real possibility of an Apollo "stretch-out," and so on. Webb appointed Harold B. Finger, manager of the NASA-Atomic Energy Commission Nuclear Propulsion Office (and leader of a task force to study NASA organization) as Associate Administrator for Organization and Management. His functions would include supervising the functional offices, such as Industry Affairs and Administration, and acting as the central point of control within the agency for all project authorizations. Instead of the relatively loose control exercised since 1963, Webb, through Seamans and Finger, worked to bring about much tighter control from above. To many, the Apollo fire was understood to be the failure of North American Aviation, the prime contractor for the Apollo command and service modules, to do what it was supposed to have done. To Webb, it meant more: He had been misinformed by his staff to the point where such an accident had become first possible, then likely, then seemingly inevitable. Finger's mission would be to make sure that the program offices, particularly OMSF, got what they needed and that Webb and Seamans would know it. In effect, the Office of Organization and Management became for NASA what the Bureau of the Budget was for the executive branch.

The decision to establish the project approval document as the single basic device for authorizing and directing NASA programs (1962–1968) marked Webb's final move in controlling agency resources. Phased project planning could break a project into four distinct but related steps, allowing management the option of continuing or terminating at three precise points. What was still needed was a document that could match program costs against agency resources, present and future. The budget, after all, was not just an expression of agency desires; it had to show, line item by line item, the relation between programs, reporting systems, and changes in midcourse. To this end, the system projected by Webb would include an operating budget and the project approval document (PAD), which would contain "the official statement of objectives, technical and management requirements . . . allocated resources . . . and other controlled milestones. . . . An absolute one-for-one . . . relationship would exist at all times between controlled line items . . . in the NASA Operating Budget and the related PAD's, whereby a change in either will require a concomitant change in the other."[11] Although PADs had been the principal mechanism for authorizing the use of appropriated funds since the early 1960s, they were now to be the single device for authorization, with only one or two signatures required for approval.

To a degree, any list of key decisions must partake of the arbitrary. A decision to do one thing is also a decision not to do something else. Indeed, some of the most important NASA decisions for the period under consideration were those *not* to do something: not to ask for the $400 million supplemental appropriation requested by OMSF in 1963, a request that might well have unbalanced the NASA program; not to set up a general advisory committee, as a high-level scientific panel recommended in 1966; not to change the prime contractors for the Apollo spacecraft in the aftermath of the January 1967 fire.

Several more technical decisions could be listed. But at the risk of tautology, the ones listed here are the key decisions because they mattered greatly to the future of the space program. They were not imposed from without, nor were they the result of attempts to placate this or that group through a shift in organizational window dressing. The nature of the decisions does not presuppose one specific organizational theory; the policy analyst may find in any or all of them elements of "disjointed incrementalism," group consensus, participative management, or the theory of organization as problem-solving coalition. The value of the list is that it invites the reader to consider themes, certain of which are latent in the facts presented and others that are reserved for fuller treatment in subsequent chapters. The themes are, first, the *sequence* in which the decisions were made, for example, the way in which program authorization procedures were developed before, just after, and subsequent to the lunar landing decision; second, the way that political, technical, managerial, and administrative considerations came to form a body of decisions; third, the distinction (if any) between gross structural changes in the organization and the many smaller changes whose net effect may be as great; and finally, the contrast between the success of NASA programs and the frequent inefficiency of the agency's administrative housekeeping. The discussion now turns to an account of NASA's founding and the problems and achievements of its first eleven years.

Chapter 2

The Making of NASA Policy, 1958–1969

The organization and management of NASA cannot be understood apart from the circumstances that brought the agency into being. To grasp the relations between headquarters and the centers, one must know what brought the centers into being, how each center's mission related to those of the other centers, and how the missions tended to change over time. Similarly, the agency itself was not created out of whole cloth; it had an ancestry, several research installations, and a nucleus of skilled technicians before there was an entity called the National Aeronautics and Space Administration. The purpose of this chapter is to present a brief survey of the history of NASA and its predecessor agency up to 1969, to do this with a minimum of scholarly apparatus, and, incidentally, to introduce the officials, programs, and installations that recur throughout the book. Readers who are already familiar with the history of NASA may wish to proceed to chapter 3.

The Origins of NASA

The two sources of the U.S. space program were the military services and the National Advisory Committee for Aeronautics (NACA).[1] Chartered by Congress in 1915, NACA was authorized to "supervise and direct the scientific study of the problems of flight with a view to their practical solution . . . to determine the problems which should be experimentally attacked, and to discuss their solution and their application to practical questions."[2] Unlike its successor, NACA was strictly a research, test, and advisory organization. NACA let no major development contracts, owned few airplanes, and manufactured no flight hardware. Its mission, as enunciated by two generations of Committee members, chairmen, and executive directors, was to conduct applied research into the nature of flight to the point where the research could be applied to the production of aircraft.

NACA's research history began with the establishment in 1920 of the Langley Memorial Aeronautical Laboratory near Hampton, Virginia. In 1939 Congress authorized another installation at Moffett Field, California, followed a year later by a flight propulsion laboratory next to the Cleveland Municipal Airport. In time the former was named after Joseph Ames, Main Committee Chairman from 1927 to 1939; the latter after Dr. George W. Lewis, NACA's Director of Aeronautical Research from 1919 to 1947. In 1945–1946 NACA added two more installations: one at Wallops Island on the coast of Virginia and the High Speed Flight Research Station at Edwards Air Force Base, California.* The location of three of the five installations on or near military bases was not accidental. From an early date NACA worked closely with the services, as well as with airframe and engine manufacturers, in its research.

Over the years, NACA compiled a long list of significant achievements in aeronautics. In 1928 it developed the famous NACA cowling, which greatly increased the flight efficiency of air-cooled engines and which won NACA's first Collier Trophy. NACA research on laminar flow and the resulting low-drag wing contributed to the success of the P-51 Mustang in World War II. The research facilities built by NACA, such as the pioneering variable density wind tunnel and the award-winning transonic wind tunnel, not only set the pace for other research laboratories around the world, they also allowed NACA to conduct original and unparalleled research. Although drawn into testing and cleanup work in World War II, NACA returned to fundamental research after the war and developed important concepts in the new fields of supersonic and hypersonic flight: swept wings, the "area rule" of fuselage configuration, and the blunt nose cone for dissipating the heat of atmospheric reentry. By 1954 these achievements had earned NACA an enviable reputation.

Three features of NACA practice may serve to make its success comprehensible. Its mission made it complementary to, not competitive with, the services and industry; its research was only loosely coupled to its users; and its laboratories enjoyed a certain autonomy in the selection of specific research projects and the manner in which research would be conducted. The first of these features should not be taken to mean that NACA did no work to order; most NACA work was to order. Less than half of what the Committee did was the basic, fundamental research it preferred to do. To stay alive it had to keep its customers, industry and the services, happy. The laboratory directors did have considerable flexibility to concentrate on certain fundamental problems that appeared most promising to them, but always they had to do it within the context of job work for industry and the services and the broad guidelines established by headquarters. Incidentally, whatever the reasons for NACA's reputation, the level of salaries was not one of them. The agency's budget was austere; in fiscal year (FY) 1958, its last full operating year, NACA, with just under 8000 employees, had a budget of $117 million.[3]

* The Langley, Ames, and Lewis laboratories were designated "research centers" in 1958, when NASA was formed. Wallops Station became an independent installation in 1959 and was renamed "Wallops Flight Center" in 1974. The High Speed Flight Research Station became the Flight Research Center in 1959 and the Dryden Flight Research Center in 1976.

After World War II and the appointment of Hugh L. Dryden as Director in 1947, NACA began moving into new fields. Spurred on by young engineers who were critical of the agency's conservatism and concerned about the competing research facilities of the Air Force and industry, the Committee authorized work in such new fields as rocket propulsion, nuclear propulsion, hypersonic flight, and exploration of the upper atmosphere. In July 1952 the Main Committee directed its laboratories to begin research into flight beyond the atmosphere. This led in May 1954 to an agreement with the Department of Defense to develop a manned hypersonic rocket plane, later dubbed the X-15. Development work had been eschewed by NACA throughout most of its history, but, once committed, the agency pushed on. In February 1957 NACA established a "Round Three" Steering Committee to study the feasibility of a hypersonic booster-glider, the remote ancestor of what became the space shuttle in the 1970s. One year later NACA Chairman James Doolittle could tell Congress that "4 years ago, about 10 percent of our activities was associated with space; 2 years ago about 25 percent, and in . . . 1959, we will be devoting almost half of our time to missiles, antimissiles, and other space objectives."[4] Thus NACA was well on its way to becoming a space agency even before sputnik.

While NACA was conducting research programs in the upper atmosphere, the services were exploring the military uses of space. The V-1 and V-2 developed by Wernher von Braun and his technical team at Peenemunde had demonstrated the potential of guided missiles; the end of World War II witnessed a flurry of study proposals funded by the services. The Naval Research Laboratory developed the Viking sounding rocket, which later became one of the stages of Vanguard; the Army brought the von Braun team to work first at White Sands, New Mexico, and later at the Redstone Arsenal in Huntsville, Alabama; the Air Force subsidized several projects for air-breathing (cruise) missiles, and one, under contract to Convair, for a ballistic missile, i.e., a missile that expends its fuel in its launch beyond the atmosphere, coasts through near-Earth space, and reenters the atmosphere approaching its target. In 1947 the Air Force canceled that contract, but Convair continued work on its own for several years, until the Cold War atmosphere revived interest in ballistic weapons. Specifically, by 1953 RAND Corporation scientists and an Air Force Strategic Weapons Evaluation Committee chaired by John von Neumann had concluded independently that an intercontinental ballistic missile (ICBM) was technically feasible. In early 1954 the von Neumann committee recommended that the United States undertake an ICBM program on a highest-priority basis. By the end of 1955 all three services had ballistic missile programs: the Air Force was developing Atlas and Titan ICBMs and the Thor intermediate-range ballistic missile (IRBM); the Army's von Braun team was working on the Jupiter rocket; the Navy had initiated what was to become the submarine-launched Polaris IRBM. In addition, in September 1955 the Secretary of Defense authorized the Navy to develop a rocket for launching a small satellite as the U.S. entry for the 1957–1958 International Geophysical Year.

Well before sputnik, the United States had the beginnings of a sophisticated space program. The missiles that would serve as satellite launch vehicles were being designed and built; test facilities existed at NACA laboratories and elsewhere; and a number of proposals had been advanced, several of them by the RAND Corporation, for meteorological, communications, and reconnaisance satellites. All that was lacking was a sense of urgency and coordination. In particular, the future role of NACA was uncertain. The construction of new military facilities with Government funds ended NACA's near monopoly in aeronautical testing. Also, by the mid-1950s NACA was losing some of its best engineers to industry because the salary differential had increased. By 1957 NACA was facing in different directions. It could remain what it had always been, a small agency specializing in advanced aeronautical research, or it could move further into space research, with results that could only be guessed at.

The importance of sputnik to NACA's future was at first overshadowed by the profound blow to the self-esteem of the services, Congress, the White House, and the public. On 4 October 1957, the Soviet announcement of a satellite in near-Earth orbit caught the U.S. military and civilian leadership somewhat offguard. The Soviet Union had announced the intention of orbiting sputnik, but it was the disparity between Soviet and American payloads—sputnik's 83.5 kilograms compared with Vanguard's 1.47 kilograms (Vanguard, the Navy's scientific satellite, was hardly larger than a grapefruit)—and the implication that the Soviet Union had an ICBM capability that surprised and alarmed the public. So far-reaching an event was perceived and acted on in different ways. President Eisenhower advocated a thorough reorganization of the Department of Defense (DOD), coupled with improvement in the quality of scientific advice available to him. On 7 November he announced the appointment of James Killian, Jr., of the Massachusetts Institute of Technology, as Special Assistant to the President for Science and Technology, and on 27 November the transfer of the Science Advisory Committee from the Office of Defense Mobilization to the Executive Office. Reconstituted as the President's Science Advisory Committee (PSAC) and enlarged to a membership of eighteen leading scientists (with hundreds of others consulted for part-time advice), PSAC gave the scientific community greater access to the White House than it had ever had before. With the Special Assistant as the chairman of PSAC and, in 1959, of the newly created Federal Council for Science and Technology (of which the NASA Administrator was a member ex officio), Eisenhower hoped to obtain a body of politically neutral experts to provide disinterested advice at all levels of the Government.

The congressional reaction to sputnik was compounded of apprehension, embarrassment, and the desire to make political capital of the failures of a Republican administration. Should the Administration policy be found seriously wanting, the Democrats would have the opportunity to pose as champions of preparedness and a national space program. Senate Majority Leader Lyndon B. Johnson (D-Tex.) and the Preparedness Investigating Subcommittee of the Armed Service Committee began to probe the weaknesses of U.S. military policy.

Johnson's strategy was to use the subcommittee to question the defense posture of the Eisenhower administration. Johnson, as one student of defense has said, was "clearly able and anxious to take the initiative in policymaking for national security affairs, including space. His choice to do so, more than any other factor, guaranteed that the resolution of the space issue would take place in a broad political arena."[5] Both the Preparedness Subcommittee and the Special Committees on Space and Astronautics, established in both Houses of Congress in February 1958, emphasized the importance of a national space program and an agency—preferably independent and civilian—to administer it.

At the beginning of 1958 several agencies were in the running for the job of managing the U.S. space program, among them NACA, the military services, and the Atomic Energy Commission. The Army and the Air Force were preparing to take the initiative: the Army because its Jupiter program was being developed unofficially as a backup to Vanguard, the Air Force because the development and launching of space vehicles seemed a logical extension of its mission. On the other hand, Defense Secretary Neil McElroy and his staff were preoccupied with bringing the Vanguard program to a successful conclusion and in effecting a division of labor to satisfy the rival services. The humiliation attendant on Sputniks 1 and 2 was compounded by the failure of the early Vanguards on the launch pad. On 8 November 1957 DOD (with President Eisenhower's approval) authorized the Army satellite program as a backup to Vanguard; on 15 November Secretary McElroy announced that he would appoint a new director for advanced weapons development; on 31 January 1958 the von Braun team's Jupiter placed Explorer 1 in orbit, the first successful launch of a U.S. spacecraft; on 7 February McElroy established the Advanced Research Projects Agency (ARPA) to eliminate wasteful duplication of research and development in the services. McElroy hoped to defuse the issue of the military role in space: first, by giving ARPA responsibility for evaluating novel proposals during the earliest planning stages; second, by locating space programs at the level of the Office of the Secretary of Defense (OSD); third, by setting up a research and development arm to deal with programs that were long range and possibly tangential to work in progress.[6] McElroy was no more prepared than the services to leave the field to a new civilian agency. The Air Force might protest the centralization of space programs in OSD, while the Army command might act as if any gain in Air Force funding must somehow be at the Army's expense. But "confronted with a civilian challenge to the freedom to determine what programs were to be considered militarily significant, the services closed ranks with the OSD."[7]

The outcome was a check to DOD. During Johnson's subcommittee hearings, the Administration reviewed the available options. The decision to put the space program in civilian hands was made by a President whose strongest feeling about the space program was that it must be kept from military control, both to keep space activity peaceful and to avoid creating a new, large, and expensive program located in the Pentagon. This left open the question of where to locate the new agency. Should it be placed in an expanded Atomic Energy Commission, a central Department of Science, or a reconstituted NACA? When the Administration decided on 5 March 1958 in favor of NACA, it did so not least because Dryden, Doolittle, and Main Committee members—in speeches, resolutions, and staff papers—had stated that they were willing to take on the job. NACA was already there. It had a specifically technical orientation, a highly trained research staff, a recent history of research on flight in the lower reaches of space, and excellent relations with DOD. Furthermore, NACA had outlived its mission and was in need of a new one. Interestingly, it was the Bureau of the Budget (BOB), not Congress, that proposed NACA as the organizational home of the new agency; the Administration's draft legislation was largely the work of analysts like William Finan of the Office of Management and Organization and Willis H. Shapley of the Military Division. They and Budget Director Maurice Stans preferred single-headed agencies reporting directly to the President, as opposed to independent commissions. The bill's objective, according to Stans, was "to build upon existing institutions and to avoid increasing the total number of Federal agencies involved in aeronautics and space matters."[8]

The Administration bill, introduced on 14 April, modified by Congress, and signed on 29 July, contained two provisions particularly important to this study. First, the act made NACA the nucleus of the new agency, but not NACA as then constituted. Rather than NACA's proposal of a multiheaded executive branch, the act authorized an Administrator with wide powers, including the right to appoint 260 individuals exempt from civil service classification. The new agency would have power to contract out for hardware, support services, and university-sponsored research. Most important, the space agency was empowered to conceive and carry out major development programs, including the development of large launch vehicles.

Second, neither the Administration bill nor the Space Act settled the matter of one national space program or two. Once it became clear that the agency would be civilian controlled, DOD officials dropped overt opposition to NASA, concentrating instead on making it respond to their needs. The Air Force found NASA something it could live with; top officials saw the agency as merely NACA enlarged and somewhat strengthened but still responsive to Air Force interests and a convenient location for noncompetitive military projects. At the same time, the Administration bill contained almost nothing about coordinating military and civilian programs and provided no solution for the jurisdictional conflicts that were bound to arise. It was difficult to find the middle ground; officials like Herbert York, ARPA's chief scientist, argued that space was a region, not a program, and that DOD should be free to operate in any field—including space—that it found interesting.[9] Carried to its logical conclusion, this view would have negated the distinction between civilian and military programs the Administration intended to safeguard. The Space Act represented a compromise. Being civilian, the agency accorded with the views of the Administration, PSAC, and the leaders of both Houses of Congress. At the same time, the new agency would have to depend heavily on DOD for launch vehicles, launch facilities, personnel—many of them officers detailed from the services—and contract administration. To the extent that the Administration bill did not provide for NASA-DOD coordination, the space program would have been somewhat less than national. To remedy this, Congress moved in two directions. First, section 102(b) of the Space Act enjoined the civilian agency to make available to DOD those discoveries having military value or significance. Second, Congress added (sections 201 and 204) two coordinating bodies: the National Aeronautics and Space Council, a high-level policy-making body, chaired by the President, that embraced all Federal agencies with a major interest in space (NASA, DOD, the Atomic Energy Commission, the State Department) and a Civilian-Military Liaison Committee, which was superseded in 1960 by the Aeronautics and Astronautics Coordinating Board.* The success of these bodies would depend entirely on the willingness of agency heads and the President to use them; coordination assumed the existence of a community of interest.

THE TRANSFER OF PROGRAMS TO NASA

Within three weeks of the passage of the Space Act, President Eisenhower nominated and the Senate confirmed T. (Thomas) Keith Glennan, president of the Case Institute of Technology, to be NASA Administrator, with Hugh Dryden as Deputy Administrator. On 30 September NACA went out of existence; the following day, the President signed an executive order transferring to NASA the civilian personnel of the Naval Research Laboratory's Vanguard division; several lunar probes relinquished by ARPA; and the 1.5 million-pound thrust F-1 engine, for which the Air Force had let a study contract to North American Aviation.

In December another executive order transferred to NASA the services of the Jet Propulsion Laboratory (JPL) in Pasadena, California, founded in 1944 and operated by the California Institute of Technology (CalTech) under contract to the Army. In JPL, NASA acquired an institution whose future relations with it could not be precisely defined. Although JPL's facilities were owned by the Government, the laboratory was to be managed by CalTech under contract to NASA. Indeed, NASA created a special Western Operations Office to administer the JPL contract.† As a contractor-operated facility, JPL's status was equivocal: first, because of the contract's "mutuality clause," under which JPL and NASA agreed to undertake projects deemed of "mutual interest"; second, because the role of CalTech had yet to be determined; and third, because JPL was organized to

* The Space Council was reorganized in 1961 under the chairmanship of the Vice President. Although it participated in the lunar landing decision and in the bill that became the 1962 Communications Satellite Act, it never really played the coordinating role that Congress had in mind, and it was abolished by the President's Reorganization Plan No. 1 in 1973.

† It was renamed the Western Support Office in 1966 and abolished in 1968, when its functions were transferred to the NASA Pasadena Office.

do most of its work in-house, including the testing and production of spacecraft. Although JPL was a major acquisition for NASA, its ambiguous status was to lead to serious difficulties over the next six years.

The last major transfer of facilities and programs took place in October 1959, when NASA acquired the Army's Saturn project and the Ballistic Missile Agency's Development Operations Division. The Army reluctantly acquiesced, mainly to prevent the Air Force from taking over the von Braun team, whose transfer to NASA gave the agency a launch vehicle capability it had hitherto lacked. NASA took over a portion of the Redstone Arsenal, renaming it the George C. Marshall Space Flight Center in March 1960, although the transfer was not completed until July.* It should be noted that DOD accepted these transfers because they did not jeopardize military programs and because the Saturn booster had "its primary place in space exploration and not in our missile program."[10] Yet the completion of these transfers raised urgent questions about priorities. First, there were technical questions bearing on future programs. How should NASA choose between liquid- and solid-fuel boosters for first-stage use? Were nuclear-powered upper stages feasible? (NASA and the Atomic Energy Commission established a joint Space Nuclear Propulsion Office in 1960.) How far should NASA go in developing new launch vehicles or in adapting Air Force ballistic missiles for space exploration? Second, what was the proper division of labor between military and civilian programs? To what extent should NASA rely on DOD for launch and ground support or develop its own facilities at the risk of duplicating what was already available? Third, how should the agency plan in respect to manned spaceflight? In October 1958 Glennan had established a Space Task Group† at Langley under Robert Gilruth to work on Project Mercury, the nation's first manned program. By 1960 a headquarters group had recommended that NASA plan a lunar landing for some time after 1970, a prediction soon to be overtaken by events. Mercury was plagued with technical problems, schedule slippages, and doubts about its sequel—if sequel there would be.

Yet it would be worse than misleading to look only at NASA's teething troubles while ignoring its accomplishments. By 1961 it had acquired new installations in addition to those inherited from NACA: JPL, Marshall, and the Goddard Space Flight Center at Beltsville, Maryland, established in 1959 with a nucleus of scientists transferred from the Naval Research Laboratory. In addition, the Office of Space Flight Programs, directed by Abe Silverstein, started work on many of the unmanned programs that flew five to seven years later: Ranger, designed to take photographs of the lunar surface before crash-landing on the

* The center was named in honor of General George C. Marshall, chief of staff during World War II, Secretary of State from 1948 to 1949, and author of the Marshall Plan. As a rule, centers named after individuals will be referred to as Goddard, Langley, Marshall, and so on, to spare the reader an overgrowth of acronyms.

† Not to be confused with the President's Space Task Group established in February 1969 by President Nixon to map out the U.S. space program over the next two decades.

Moon; Surveyor, intended to soft-land on the Moon, take photographs, and analyze soil specimens; the Orbiting Observatories, which were designed to carry a variety of experiment packages; Nimbus, a weather satellite intended as a more advanced system than the Tiros spacecraft transferred from ARPA in 1959; and Syncom, a communications satellite designed (like the Army's Advent) to provide synchronous, twenty-four-hour coverage. What NASA lacked was program direction. But the arrival of new personnel, the accession of new programs, and the dramatic shift in national priorities following the presidential election of John F. Kennedy pushed NASA far indeed from the modestly funded, science-based agency contemplated by President Eisenhower.

The Lunar Landing Decision and Its Aftermath

The decision to go to the Moon was predictable, if not inevitable. Few things seem inevitable until after they have occurred.[11] At the beginning of 1961 the future of NASA's manned program was uncertain. In December 1960 a PSAC committee had reported that a manned lunar landing was feasible but that it would cost between $26 and $38 billion.[12] President Eisenhower refused to approve any manned program beyond Mercury, save for $29.5 million for a spacecraft for Apollo, as NASA's lunar landing program was designated in the summer of 1960. In addition, the Space Council met so seldom and accomplished so little that Eisenhower proposed abolishing it; nor would the Kennedy administration necessarily take a more favorable view. In a report of 10 January 1961, the Ad Hoc Committee on Space chaired by Jerome Wiesner, an engineer at the Massachusetts Institute of Technology, soon to become Kennedy's Science Advisor, had warned the President-elect of grave deficiencies in the national space program: "inadequate planning and direction . . . the lack of outstanding scientists and engineers."[13] The report had further criticized NASA for emphasizing its manned spaceflight programs at the expense of the more scientifically productive unmanned probes. The report argued that Mercury exaggerated "the value of that aspect of space activity where we are less likely to achieve success. . . . *We should stop advertising Mercury as our major objective in space activities.*"[14] While it was hastily prepared and offered the President no new options, the report did make explicit the beliefs of many influential scientists. The worth of the civilian space program, their argument ran, was proportional to the scientific information obtained. This was only another way of saying what NASA officials would not have denied—that a manned program, especially a Moon mission, could not be justified on purely scientific grounds.

Why did President Kennedy commit the nation to a lunar landing as and when he did? The decision was shaped by many considerations: the knowledge that it was possible; the crucial role of Vice President Lyndon Johnson; the humiliating news of Yuri Gagarin's Earth-orbital flight of 12 April and the failure of the Bay of Pigs invasion a week later; and the conviction—strengthened by

NASA Administrator James Webb and Defense Secretary Robert McNamara—that a manned lunar landing was the logical, inevitable way for the United States to demonstrate its superiority in space. Within NASA, the feasibility of lunar landing had been under study since 1959. The Space Task Group had worked out precise guidelines, and a headquarters study committee chaired by George Low had reported in February 1961 that "the manned lunar landing mission could be accomplished during the decade . . . at a cost of just under $7 billion through FY 1969."[15] Moreover, NASA was able to make a better case than the Air Force that it was the agency best equipped to manage such a program. Webb undercut the Air Force's attempt to take over the space program by negotiating jurisdictional agreements with McNamara and Deputy Secretary Roswell Gilpatric, both of whom wished to bring the services under tighter control.

Another ingredient in President Kennedy's decision was the role of Vice President Johnson. As chairman of the Senate Preparedness Investigating Subcommittee, he had been one of the prime movers behind the Space Act, and later of the "Johnson Rider," by which NASA had to seek annual authorizing legislation before requesting appropriations. On 20 April Congress revised the Space Act so that the Space Council, now located in the Executive Office and chaired by the Vice President, would "assist" as well as advise the President. Johnson then installed his own man, Edward Welsh, as the Council's Executive Secretary, rather than have the post filled by a NASA official, as President Eisenhower had done. Johnson was now the ex officio head of the national space effort; indeed, he was quicker than Kennedy to seize the political implications of space exploration. By revitalizing the Space Council and using it to review the space program, persuading Webb to accept the appointment to head NASA, emphasizing the importance of space for national prestige, and drumming up congressional support against the time when it would be needed, Johnson did more than anyone except Kennedy to make the lunar landing decision possible.

When Kennedy came before Congress on 25 May 1961 to request a $549 million supplemental appropriation for NASA, he outlined what were to be the principal features of the civilian space program for the next eight years. He proposed an advance on a broad front: a lunar landing within the decade (this was the language suggested by NASA), scientific investigations, worldwide operational satellite communications and weather prediction systems, and the concurrent development of liquid-fuel boosters (by NASA) and solid-fuel boosters (by the Air Force).

The steps taken by NASA officials were an adequate response to the challenge Kennedy presented. As is the way of organic decisions, this one tended to reorder all NASA's programs with reference to one central, all-important goal. Ranger and Surveyor, originally conceived as open-ended and predominantly scientific programs, were now to do the preliminary scouting of the lunar surface for Apollo. An even more important shift pertained to the role of NASA prime contractors. Instead of the centers doing most of the work in-house and using industry for support services, the roles were to be reversed, with industry handling production and most of the design, while the centers approved or disapproved of changes and checked performance against schedules and cost. Alternatives were dismissed out of hand. It was obvious to Webb that industry and the universities had to be brought in, not only for the urgently practical reason that this was the only way to get the job done, but because it was a way of building support—by geographical area, by political affiliation, by economic interest.

Once Congress had voted the supplemental appropriation Kennedy requested, NASA started to negotiate the prime contracts of the Apollo program. By the end of 1961, NASA had chosen many of the firms with which it would negotiate the most important contracts: the Apollo guidance and navigation contract was awarded to the Massachusetts Institute of Technology Instrumentation Laboratory on 9 August; the contracts for the three stages of Saturn V were negotiated respectively with Boeing, the Rocketdyne Division of North American Aviation, and Douglas in September and December; and the contract for the Apollo command and service modules was awarded to North American by Webb, Dryden, and Seamans on 28 November. The awards were huge. They could not but affect the structure both of NASA and the aerospace industry; the command service module contract was the largest peacetime contract awarded by the U.S. Government up to that time.

Greatly expanded launch facilities, an engine and booster testing facility, and a launch vehicle assembly installation would be required. By December NASA had made the most important decisions: selecting a vehicle fabrication and test site at the Government-owned Michoud plant near New Orleans; choosing Cape Canaveral on the Florida coast as the launch site and the Army Corps of Engineers to build the launch facilities; and announcing the selection of Houston as the site for a Manned Spacecraft Center* to conduct research and development, train astronauts, and manage the flight missions.[16] The core of the new center would be the Space Task Group, which would move from Langley to Houston. Finally, Seamans announced a new program, Gemini, to fill the gap between Mercury and Apollo. It would involve a two-man crew using a more advanced version of the Mercury capsule, and its main purpose would be to develop the capability for a spacecraft to rendezvous with a target vehicle in Earth orbit.

Concurrently, Webb faced the task of restructuring NASA and adapting it to the drastic changes made imperative by Kennedy's decision. To head the Office of Manned Space Flight (OMSF), he appointed D. Brainerd Holmes, an RCA engineer who had been project manager for the Ballistic Missile Early Warning System. In that capacity Holmes had performed the near miracle of finishing on time and within costs. If, in choosing Holmes, Webb had expected a conciliator in an organization rather well supplied with strong personalities, he was to be disappointed. Holmes was masterful, abrasive, and determined to get what he needed to carry out his assignment, even at the expense of other programs. His most pressing task was to build an organization that could handle both launch

* Renamed the Johnson Space Center in 1973 to commemorate former President Lyndon Johnson.

vehicle development and spacecraft design; in Apollo, unlike most NASA programs, the launch vehicle was designed to be integrated with the spacecraft, not the reverse.

Between December 1961 and the end of July 1962, three decisions that were to prove of the utmost importance to OMSF were made: to establish an OMSF Management Council, chaired by Holmes and attended by the Manned Space Flight Center directors; to call in General Electric for testing and checkout services and American Telephone and Telegraph for systems analysis work, in the latter case establishing a separate corporation working solely for NASA; and to select lunar orbit rendezvous as the mission mode for Apollo. At its first meeting on 21 December the Council settled on what was to become the standard configuration of Saturn and assigned to Marshall the responsibility for integrating the three stages of the booster.[17] The Management Council represented an early stage in the quasi-autonomy of OMSF. Within broad limits, the Council had the authority to make the fundamental decisions concerning vehicle and spacecraft configuration, reliability and testing standards, and the mission mode for Apollo.

The choice of lunar orbit rendezvous (LOR) in July 1962 determined the design of the Apollo spacecraft and the Saturn launch vehicles. On strictly technical grounds each of the three proposed modes—direct ascent, Earth orbit rendezvous (EOR), and LOR—was justified by internal task force studies. Direct ascent called for a super booster, the Nova, which NASA was developing concurrently with Saturn. EOR involved many launches into Earth orbit, assembling the lunar vehicle there, and landing it on the Moon. But in 1961 several Langley engineers, led by John Houbolt, argued for a third option: launching the Apollo spacecraft into lunar orbit and detaching a small craft that would land and then return to the parent ship. The OMSF Management Council considered mission mode from February to July 1962, and the decision was made on grounds that were as much political as technical. In its favor, LOR would cost 10 to 15 percent less than EOR and would require only half the payload weight; it was technically feasible with the specified three-man crew, although this was also true of EOR; it called for only one launch from Earth; and it was the only mode to include a lunar landing vehicle that would not have to face Earth reentry problems. This approach assumed that one member of the crew would remain to pilot the command module, while the other two visited the Moon.

The decision to use LOR was first announced by NASA on 11 July. More than two weeks later the PSAC Space Vehicle Panel issued a report criticizing LOR as "extremely ingenious but highly specialized . . . an isolated development" and arguing that "if a two-man crew is adequate for the most difficult part of the LOR mission . . . then it cannot be persuasively argued that *three* men *must* be landed in other modes."[18] The Panel preferred EOR because it seemed to offer a greater margin of safety. The issue was Jerome Wiesner's judgment that NASA could not justify its choice of mode on technical grounds and James Webb's contention that NASA had provided all the justification necessary. Commenting to Holmes on the PSAC report, Webb said that "we [i.e., NASA] were in a process where our top people were considering all of the factors, and their minds moved steadily in the direction of LOR, and that it took some time for the documentation to catch up."[19] Whether the decision was "technical" or something else is a matter of opinion. NASA could not have developed two vehicles as large as Saturn and Nova at the same time. The development of Nova would have rendered Saturn, as well as the existing contractor structure, useless, and called for drastic alterations at Michoud. Furthermore, a decision could not have been postponed much longer. With NASA officials hinting at the possibility of a landing in 1967, the choice of mission mode came at the last possible moment.

Although the 11 July announcement was described as "tentative," its confirmation in November, when the Grumman Company was awarded the contract for designing and producing the lunar excursion module (later shortened to lunar module) surprised no one. In July 1962 NASA announced two more decisions that froze the design of Apollo. One, announced ten days after the LOR press conference, was to assemble the advanced Saturn vehicle and spacecraft inside a large building at the Cape, and to transport the assembled vehicle in a vertical attitude on a crawler-transporter, a sort of monster tractor, to the launch pad. The second, announced at the LOR press conference, was to produce an improved or "uprated" two-stage Saturn I, consisting of the modified first stage of the Saturn I and the third stage of the advanced Saturn, to test the Apollo spacecraft in Earth orbit. Early in 1963 the advanced Saturn was renamed Saturn V, and the uprated Saturn I became Saturn IB. Their configurations and the prime contractors for each stage are shown in figure 2–1.

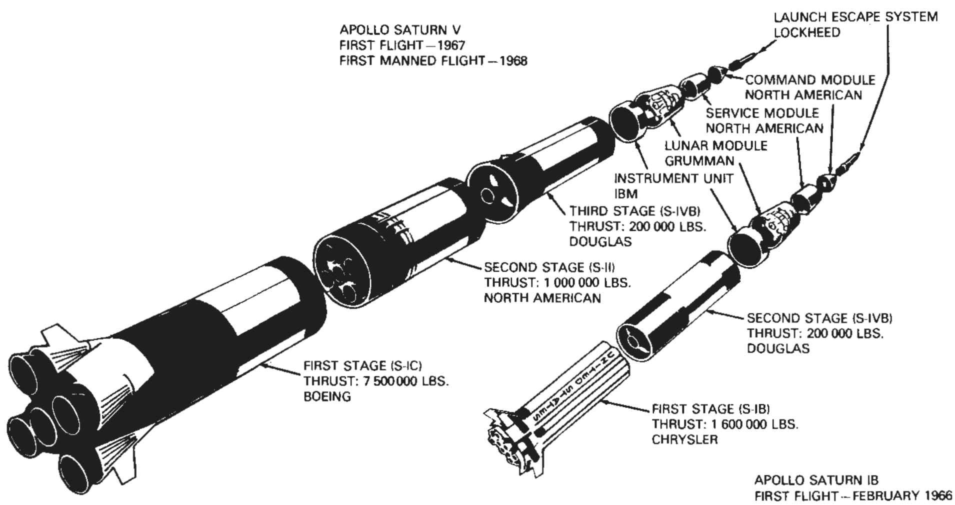


Figure 2–1. — Apollo launch vehicles.

THE INITIAL PAYOFF, 1963–1966

The decisions of July 1962 marked the end of NASA's shakedown period. An account of subsequent program developments would go beyond the scope of a summary narrative, nor is such an account necessary. It will suffice to mention only a few of the most important events and to select several organizational problems for review.

In manned flight, NASA went from strength to strength. After unpromising beginnings, Mercury met all its goals with a steady increase in the scope of each mission, from Alan Shepard's suborbital flight of 5 May 1961 to John Glenn's three-orbit flight of 20 February 1962 to Gordon Cooper's twenty-two-orbit flight of 15–16 May 1963, which brought the series to a close. Gemini, with a similar start (and even greater cost and design problems), had similar results. In 1966 there were five Gemini launches, all successful. From its first manned flight in March 1965 to its last in November 1966, the program achieved its purposes:

> Demonstration of ability to rendezvous and dock with target vehicle; demonstration of value of manned spacecraft for scientific and technological experimentation; performance of work by astronauts in space; use of powered, fueled satellite to provide primary and secondary propulsion for docked spacecraft; long-duration space flights without ill effect on astronauts; and precision landing of spacecraft.[20]

In a way, the most remarkable thing about Gemini was that it remained a NASA program in the face of attempts by DOD to make it either a joint program or one under de facto Pentagon management. The NASA-DOD agreement of January 1963 recognized Gemini as a NASA program, but one that would fly military experiments and respond to DOD's needs. A few days earlier DOD had recognized the land acquired by NASA at Cape Canaveral in 1961–1962 as a NASA installation. That facility, renamed the Kennedy Space Center in honor of the slain President, became NASA's spaceport on the East Coast. During 1964 and 1965 the Army Corps of Engineers continued to build at a furious pace, constructing launch pads 39A and B, the vehicle assembly building (166 by 220 meters) where the Saturn Vs would be assembled, and the 4.4-kilometer roadway along which a crawler would carry the assembled vehicle to the pad.

The unmanned science and applications programs were equally successful, nowhere more so than with the three lunar probes—Ranger, Surveyor, and Lunar Orbiter. After six consecutive failures, the last three Ranger flights in 1964–1965 returned thousands of accurate pictures of the lunar surface, with resolution to 30 centimeters. The success of the Surveyor program was even more surprising, what with two congressional investigations, the inexorable climb in the weight of the spacecraft, the difficulties with the second-stage Centaur vehicle that was to launch it, and the transfer of Centaur project management from Marshall to Lewis in October 1962. Yet Surveyor 1, launched on 30 May 1966, worked perfectly, as did four of the remaining six spacecraft. As for Lunar Orbiter, which had originally been a part of the Surveyor program, all five spacecraft in the series were successful. It is interesting that the project manager for Lunar Orbiter was the Langley Research Center, a former NACA installation taking on development work.

One of the incidental effects of Ranger and Surveyor was to bring about changes in the relation between JPL, which managed both programs, and NASA Headquarters. The failures of Rangers 5 and 6 were galling, the latter especially so; everything went perfectly until a few minutes before the programmed crash landing, when the TV cameras failed to turn on. Ranger 6 led to a NASA board of inquiry, an investigation by a House subcommittee, and a change in the contract with CalTech. NASA officials considered annexing JPL but preferred retaining it as an independent contractor. Yet JPL did become more like a NASA center. In particular, Surveyor was drastically reorganized; engineers who had worked on Ranger joined the Surveyor team, and most of them served full-time; the majority of the team was relocated in one building; and NASA instituted much more rigorous design reviews.[21] Under pressure, JPL hired a general manager and began to assign an increasing number of employees full-time to individual projects.[22] Finally, the December 1964 contract extension made two important changes. It superseded the mutuality clause with a proviso that NASA could assign tasks unilaterally and replaced the annual lump-sum fee with award fees based on performance.[23]

All the while, NASA management sought that elusive entity, a balanced program. Although manned spaceflight accounted for nearly 70 percent of NASA outlays, there was an understanding that a limit existed beyond which it could not interfere with other programs. When Holmes asked Webb late in 1962 for an additional $400 million for the lunar landing program, Webb refused outright. The money could be obtained only by going to Congress for a supplemental appropriation, which Webb believed was inexpedient, or by reprogramming funds from other areas, such as space science. Webb was even more opposed to this course, since no reprogramming could be carried out "without decimating NASA's other vital programs by abandonment of projects well along in hardware development and extensive cancellation of contracts."[24] Webb and Holmes took their case to President Kennedy, who backed Webb. The Administration did not request a supplemental, no funds were reprogrammed, and Holmes returned to industry in the summer of 1963, to be succeeded by George E. Mueller.*

By the mid-1960s NASA officials had refined certain concepts for managing the space program. First, they stressed the concept of a balanced program, although, as one political scientist has observed, where you stand is where you sit. Second, they declined to overextend NASA beyond its existing commitments. As early as June 1961, NASA, DOD, and the Federal Aviation Agency had entered into an agreement to conduct feasibility studies on a civilian supersonic transport. But NASA managers, at Dryden's suggestion, refused to commit themselves

* Pronounced "Miller." By coincidence, the chairman of the House Science and Astronautics Committee, which authorized the NASA budget, from 1961 to 1972 was Congressman George P. Miller (D-Calif.).

beyond the traditional NACA role of supporting research when President Kennedy in June 1963 asked Congress to authorize a supersonic transport program. Similarly, NASA entered into agreements with various user agencies that would transfer responsibility for managing certain applications satellites once they became operational. NASA was and would remain a research and development agency. In its 1964 agreement with the U.S. Weather Bureau, NASA undertook to procure a new weather satellite system, the Tiros Operational Satellite, launch it, and check it out in orbit. For its part, the Weather Bureau would finance the system, provide overall management, and be responsible for its operation.

Finally, top management delegated to the program offices and field installations the authority to get the job done. This was the rationale behind the reorganization of November 1963, when the centers were placed under the program offices, instead of reporting directly to Associate Administrator Seamans. In addition, NASA officials decided not to build up capabilities where the private sector could fill the need. The one partial exception was the decision to create an Electronics Research Center near Boston. This proposal was broached in the fall of 1962, introduced into the NASA budget in January 1963, authorized (after an intensive site survey by NASA) by Congress in July 1964, and formally implemented when NASA accepted the offer of a site in Cambridge in August 1964. With this exception, the NASA organization at the end of 1963 changed comparatively little during the next seven years.

FROM APOLLO 204 TO APOLLO 11

This record of success was brutally cut short by the Apollo fire. On 27 January 1967 three astronauts—Virgil Grissom, Edward White, and Roger Chaffee—were killed when a fire broke out in the Apollo 204* command module as it sat on a launch pad at the Cape for preflight testing. Although a NASA board of inquiry could not determine the precise cause of the fire, certain flaws in the spacecraft were revealed, especially in the number of combustible materials in the spacecraft at the time of the fire. Subsequent investigations by the House and Senate space committees uncovered two aspects of the history of the Apollo spacecraft not generally known outside NASA: first, that Apollo program manager Gen. Samuel Phillips had visited the North American Aviation plant late in 1965 and had discovered evidence of schedule slippage, bad workmanship, and a lack of direction from the senior management of North American; and second, that North American had been awarded the command service module contract despite a report by the NASA source evaluation board rating the Martin Company higher on technical performance. For several weeks Webb and Seamans (Dryden died in

* Each Saturn IB and Saturn V vehicle had a code number, indicating its sequence. Thus Apollo 204 was intended as the fourth launch of the Saturn IB, the first three having been in 1966.

December 1965) grappled inconclusively with the congressional committees, the latter demanding that NASA release the so-called "Phillips report," a collection of notes prepared by Phillips during his tour of inspection, while Webb and Seamans insisted that to do so would be a breach of faith with a NASA contractor.[25] In the end, the essential facts about the circumstances surrounding the fire became public knowledge. Errors had been made, but the design of the spacecraft was fundamentally sound. At a cost of an extra $410 million, a reorganization of North American's Space Division (carried out under pressure from NASA), and a slip of eighteen months in the launch schedule, NASA redesigned the block II Apollo spacecraft, removed combustible materials, brought in Boeing to integrate the spacecraft with the Saturn V, and made Grumman tighten up its management of the lunar module.

There were to be few failures thereafter. On 9 November 1967 Saturn V was launched, unmanned, for the first time. This marked the beginning of a sequence of launches designed to culminate in the lunar landing: Apollo 7 (October 1968), the first flight of the three-man crew (Saturn IB); Apollo 8 (December), the first flight to take astronauts out of the Earth's gravitational pull and place them in lunar orbit; the Apollo 9 launch in March 1969, which tested the lunar module in Earth orbit; and Apollo 10 in May, which accomplished every stage of the lunar landing except the landing itself. When Neil Armstrong and Edwin "Buzz" Aldrin set foot on the Moon on 20 July 1969, it was the culmination of more than eight years of plans and organization. The mission that President Kennedy assigned to NASA had been accomplished on time and within Webb's estimate of about $20 billion as the cost of the manned program.[26]

Yet the future of NASA in 1969 was nearly as uncertain as it had been in the fall of 1960. Where would the agency go after the first landing? Would there be an extended program of lunar exploration, manned missions to the near planets, or a manned Earth-orbital space station serviced by a low-cost, reusable transportation system? When Apollo 11 was launched, planning groups at headquarters were considering all three possibilities. But in 1969 and for two years after, very little about the agency's long-term prospects was certain. Thomas O. Paine, who succeeded Webb as Administrator in October 1968, favored an ambitious long-range program with movement on all fronts: a manned mission to Mars, a new generation of automated spacecraft, and new programs in advanced research and technology. However, in 1969 the problem was less one of starting up new programs than of holding the agency together. At that time, NASA was in the middle of its third consecutive fiscal year of budget cuts and employee layoffs—cuts that eliminated the Voyager spacecraft for the exploration of Mars, the NERVA II nuclear rocket, a substantial portion of NASA's request for Apollo Applications (as the sequel to Apollo was called) and to the announcement at the end of 1969 that the Electronics Research Center would close, even as work on the unfinished complex continued. For NASA, the key problem of the 1970s would be to move from Apollo toward a program that the agency could sell to the Executive Office, Congress, and the American public.

Chapter 3

Headquarters Organization, or the View From the Seventh Floor*

The internal administrative history of NASA is much more difficult to write about than its external affairs. Bureaus rose and fell; functions performed in one were parceled out among several and vice versa. Bureaus with imposing titles sometimes had little real power, while others with little formal authority had much say in making and carrying out management decisions. Furthermore, the larger the organization and the greater the rate of change, the more complex internal relations became, with more opportunity for jurisdictional conflict and a greater need for specialized units to prepare and enforce agencywide rules. A final reason for the complexity of the relations (and the difficulty in explaining them) is that many agency practices were worked out through informal unwritten understandings. Such agreements might appear because of the tendency for institutional reality to outrun its formal documentation, or perhaps because officials preferred that certain relations not be formalized, for fear that it might prove impossible to draft a management statement acceptable to everyone.[1]

These features—the complexity of jurisdictions, the network of informal relations, the shifting of functions between offices, the blurring of the lines of authority—highlight the problem of understanding and explaining NASA management. A logical way to begin is with an account of headquarters organization in general and of "top management" in particular—that is, the three or four officials at the top of the hierarchy. This approach is attractive because top management was the only group who could represent the entire agency to the outside world. The peculiar decentralized structure of NASA is best understood as a series of delegations of authority from top management to the program offices and from

* The location in Federal Office Building No. 6 (FOB-6) in Washington, D.C., to which NASA Headquarters moved in the summer of 1961.

headquarters to the centers, and the major reorganizations of the 1960s, while they affected all of NASA, began as changes at headquarters in its relations with the field installations. In this chapter headquarters administration is analyzed as it changed from 1961 to the resignation of NASA Administrator James E. Webb in October 1968. The next year, ending with the presentation of the report of the President's Space Task Group in September 1969, is discussed in chapter 9. The discussion begins with a summary account of the problems confronting management in organizing headquarters functions. Then the four cycles of reorganization of the 1960s are examined—why they occurred and what they effected—and the discussion concludes with an analysis of the functions top management performed.

Creating a Headquarters Organization, October 1958–January 1961

When NASA began its official existence on 1 October 1958, Administrator T. Keith Glennan and his deputy, former NACA Director Hugh L. Dryden, faced the problem of pulling together the programs inherited from NACA and those to be transferred from DOD. Dryden had at first seemed the logical choice to head the agency. Before coming to NACA in 1947, he had done notable work in aeronautical research at the National Bureau of Standards, where he rose to the position of Deputy Director. At NACA, as later at NASA, Dryden had earned almost as much respect for his ability as an administrator as he had earlier for his research on boundary-layer flow. But he was no manager in the sense that Glennan and Webb were. As one colleague remarked, "he really wasn't the guy to bang away morning, noon, and night on keeping programs and projects going on schedule and within funds and that kind of thing. What he was, rather, was a man with very good judgment on what objectives we ought to have in NASA, on what relationships were really important. . . . He had a very good understanding of how things got done or might get snarled up in the Government."[2] Yet the same firmness, methodical approach, and caution that were respected by those who knew him well were not likely to appeal to Congress—still less were his remarks about setting the pace of the space program that seemed to betoken a lack of aggressiveness. What made Glennan acceptable was his combination of experience and political loyalties. He was an engineer, not a scientist; before World War II he had worked as a sound system engineer in the motion picture industry, and during the war he had been in charge of the Navy's Underwater Sound Laboratories. His Republican politics made him acceptable to the White House, while his manifest success in making the Case Institute of Technology, of which he was president, a leading technical institute, and his experience as a member of the Atomic Energy Commission, the National Science Foundation, and the Institute for Defense Analyses implied that he understood the problems involved in managing a science-based agency.

Between them, Glennan and Dryden had the mixture of scientific and administrative experience to preside over the transition from an agency doing most of its work in-house to one expected to contract out for most of its research and development. Nevertheless, the transition proved so difficult that it was not completely effected until the end of 1963. In truth, the problems they faced in 1958–1959 were manifold and interrelated: to plan for an extended period of growth in funding and manpower, not as though these were grafted onto a preexisting agency but as the foundation for a national space program; to maintain a proper balance between in-house and contractor capabilities, since in-house work would be necessary both to attract and retain the most talented scientists and keep them available to furnish management with objective technical advice, or at least not advice biased in favor of the corporations with which NASA might do business. They had to (1) develop and update a long-range plan that could justify the agency program internally and before Congress, (2) run the agency on a day-to-day basis, (3) refine the systems management reporting techniques used in the development of Polaris and Atlas and transfer them to the fabrication of launch vehicles and spacecraft, and (4) strike a balance between headquarters and centers—neither too rigidly structured nor too decentralized. Their work was further complicated by the way in which one problem impinged on all the others. For example, the perfecting of management reporting systems depended on the authorization of projects ambitious enough and complex enough to justify their use.

What was inseparable in fact may profitably be dissociated for analysis. The problem of headquarters organization logically preceded the resolution of the other major problems. This was so for three reasons: first, because Glennan and Dryden had to decide which functions to reserve for themselves and which to delegate to the centers; second, because they needed expert staff work to assist them in formulating policy; and third, because agencywide functions like procurement and financial management might best be handled by central offices. While not a blank check, the Space Act had nonetheless given the Administrator considerable freedom to decide NASA's structure. Starting from scratch, Glennan had more reason than his successor to turn to outside consultants and committees to study management problems. It was not that he actually hired more consultants than Webb, who sometimes seemed to have signed up half the country to consult and advise. Rather, Glennan used them specifically to set up the entire headquarters structure. At a time when NASA was tending toward something very different from what its predecessor had been, the last thing he needed was an internal task force that would recommend the establishment of an agency modeled on NACA. For this reason, Glennan called in outside experts. He hired a consulting firm, McKinsey and Company, as early as October 1958 to assist in organizing headquarters functions and again in 1960 to study contracting systems and to provide staff for the Advisory Committee on Organization. Glennan's choice of outside consultants was also influenced by the lack of NASA personnel skilled in management analysis and by his knowledge of the potential advantages of forming ad hoc study committees whenever substantial changes had to be made. A committee legitimized open discussion of the fact that a problem did exist, created an arena for bargaining, and served as a conduit for ideas and policy suggestions. The specific advantage of a committee external to the agency was that members could raise issues and suggest improvements without fear of jeopardizing their positions. On the other hand, the danger existed that such committees would simply rubber stamp what had been decided; that, in searching for consensus, the members would rub away the sharp edges of their differences, leaving only smooth rounded surfaces of agreement; and that, by being outside the organization, they had no real stake in whatever conclusions they might reach. The committees appointed by Glennan certainly did justify decisions already taken; that is, they rationalized Glennan's intuitive ideas. This may well have been their principal contribution and the reason why Glennan used them.[3]

Early in his tenure, Glennan started to tackle a problem inherent in the administration of an organization such as NASA. To make the best use of his time as head of an agency that was about to expand greatly, Glennan had to subdivide the duties of management. To Dryden fell the responsibility for dealing with the universities and the national and international scientific communities; to Glennan, attending to those matters of planning and budgeting and interagency coordination that affected the totality of NASA. In his first year as Administrator, Glennan put forward the notion of a general manager (somewhat along the lines of the Atomic Energy Commission) to handle agency routine, freeing himself and Dryden to formulate policy and conduct the external relations of the agency. Having carried his point in the teeth of considerable opposition, Glennan named Richard Horner, Assistant Air Force Secretary (Research and Development), as Associate Administrator in April 1959. This office was of fundamental importance in the development of NASA policy; the organizational history of the next decade can be charted to a degree by the extent of the Associate Administrator's responsibility for program planning, monitoring the centers, and, through his management of daily operations, freeing the Administrator for long-range planning.

The essential problem in establishing the position of Associate Administrator was that it set up a layer between the line organization and the two top officials. A conflict of roles was unavoidable given that the organization antedated the office. "The top program and administrative directors . . . were powerful individuals in their own right. All were on the scene several months before the position of Associate Administrator was filled . . . the former NACA laboratories had had a history of partial autonomy and resistance to central controls."[4] To prevent the laboratories and program offices from breaking off and becoming semiautonomous, certain changes were called for: a staff located in the Associate Administrator's office to enable him to pull the agency's programs together, especially in submitting the annual budget requirements; a standard procedure for authorizing specific programs, updating these authorizations, and integrating them with the long-range plan; and a procedure whereby program managers could be brought face to face with top management to discuss areas that concerned both groups. None of these had been fully achieved prior to 1961. There were, to be sure, formal meetings for bringing agencywide problems to light: a semiannual management conference usually held at one of the centers, biweekly meetings chaired by the Associate Administrator and attended by officials from the major program development offices, and a Space Exploration Program Council that, attended by high-level officials, served as a kind of agency supercouncil. All these reviews and committees represented steps in the right direction, but none went very far. Their effectiveness was directly proportional to the frequency with which they met, the precision with which the agenda could be prepared, and the authority that those attending could exert in enforcing whatever decisions were reached. Where meetings were infrequent and where problems were so general and broad that nothing emerged beyond a vague sense of the meeting, little of consequence resulted. This was largely the case with the semiannual conferences and the Space Exploration Program Council.

Program authorization was yet another problem that took several years to work out. Before 1961 "some projects had been approved verbally only, some had been in the budget but no formal approval action could be found, some were contracts implying some type of formal approval, some were commitments made in letters to outside organizations, some had appeared in a variety of places . . . and could be presumed to have been approved."[5] There is no mystery about the lack of a standard project approval procedure, attributable in part to the number and variety of programs inherited or started up, ranging in size from the development of the F-1 engine for the Saturn rocket to small-scale Explorer spacecraft. No one procedure covered them all. Developing a standard authorization procedure presupposed agreement on official definitions of "program," "project," "system," "systems integration," and so on. NASA also had to recruit a staff capable of matching programs against budgets and extrapolating future programs from present resources; indeed, it was essential that NASA adopt or develop data processing systems to track resources from their appropriation by Congress to completion of the programs.

There had to be standardized procedures for promulgating management directives; few procedures were more useful for the establishment of a headquarters organization than the development of a NASA Management Manual that would distinguish between ad hoc circulars, directives that stated policy in a general way, handbooks of detailed procedure, and instructions intended as standard descriptions of powers and authorities for the time being. (The extent to which the Manual actually made policy or lagged behind is discussed separately.) Ultimately, the success with which NASA created a uniform authorization procedure would depend on having a single official, a final point of contact, responsible for approving project plans. That official, as will be seen, was the Associate Administrator, the key figure around whom all agency programs would ultimately pivot.

Glennan and Dryden worked quickly and effectively to build an agency capable of handling large, complex programs. By the summer of 1960 NASA had acquired many of the people and facilities that would prove indispensable to a greatly expanded mission one year later. In the Jet Propulsion Laboratory NASA

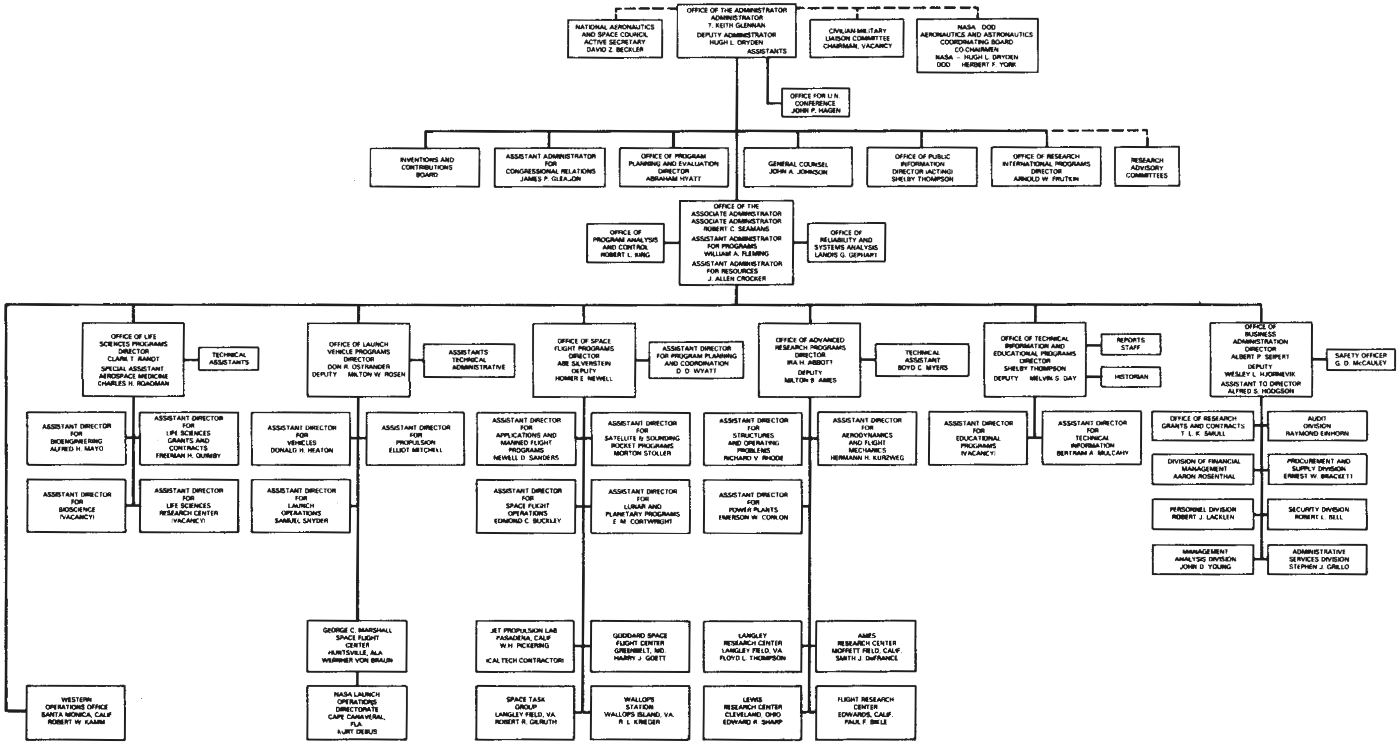


Figure 3–1. — NASA organization chart, 17 January 1961.

had a research installation superbly equipped to design and track deep-space and lunar probes such as the Ranger and Surveyor series; in Marshall, a team with a long in-house tradition and competence in the development of large launch vehicles; in the Naval Research Laboratory, scientists who formed the nucleus of the space science program, a pool of capabilities with few rivals in other Government laboratories; finally, in the Space Task Group, located at Langley but an autonomous subdivision of Goddard, the core of what would become in 1962 the Manned Spacecraft Center in Houston. In fact, by the end of 1960 almost all of NASA's programs for the next decade had either begun or were under study.

The failure of Dryden and Glennan to go still further in establishing a stronger headquarters organization was only partly administrative; it was political as well. Glennan, appointed well into Eisenhower's second term, had taken a leave of absence from the Case Institute of Technology. He had neither the authority nor the inclination to lock his successor into organizational arrangements established in NASA's formative period. Moreover, he had to contend with the uncertainties dogging the very concept of a national space program at a time when there were no manned spaceflight projects approved beyond Mercury, the overlapping spheres of NASA and the Air Force had yet to be defined, and the mechanism for placing and supervising large research and development (R&D) contracts still had to be worked out. Until NASA's mission in space had been enunciated, there was only so much that Glennan could do to mold the organization at headquarters (figure 3–1).

Nevertheless, Glennan established the Associate Administrator as the agency's general manager for day-to-day operations. He set up an Office of Plans and Program Evaluation to prepare and revise an official Ten-Year Plan, issued, as one of his last official acts, a management instruction that provided a uniform mode of project authorization, and established an Office of Launch Vehicle Programs that separated the fabrication of launch vehicles from their ultimate use. Finally, in March 1960 he appointed an Advisory Committee on Organization to evaluate NASA on the assumption that "the opportunity to make comprehensive changes in NASA's organization and procedures would not exist too much longer."[6]

The committee, chaired by Lawrence Kimpton, former chancellor of the University of Chicago, consisted of corporate and foundation executives, men of Glennan's type; this fact almost automatically deprived the committee of any influence in NASA below the highest level. That the Kimpton committee's conclusions were bland, that its report had few original ideas, should not seem too surprising. Perhaps the lesson of the Kimpton committee was that the problems it was invited to address—the proportion of work that should be done in-house, the functions of the Associate Administrator, the responsibilities of headquarters staff for monitoring the centers—went too deep to be disposed of on the basis of an ad hoc committee's recommendations. Significant structural changes would be determined by the content of NASA programs, which in turn would be determined from the outside, by the executive branch and by Congress.[7]

TURN AND COUNTERTURN, 1961–1963

When Glennan left Washington on the day President Kennedy was inaugurated, the nature, the scope, and even the future of the NASA mission were in doubt. Nor did Kennedy's belated appointment on 7 February 1961 of James E. Webb to succeed Glennan resolve these questions. While the President's advisors had recommended that he name a scientist to head NASA, the President had wanted someone with experience in the political rough-and-tumble of Washington, someone who could handle Congress, the Bureau of the Budget, and those elements in DOD that wished NASA to be essentially a supporting agency for the Air Force. As former Director of the Bureau of the Budget and as Under Secretary of State, Webb had the experience and the energy—if not at first the desire—for the job. He demanded, on being offered the job, the authority to run the agency as he saw fit, without altering everything at once. He insisted that Dryden remain as Deputy Administrator and that both Dryden and Associate Administrator Robert C. Seamans, Jr., who had succeeded Richard Horner in September 1960, serve with Webb as a multiple executive, making the most important decisions together and otherwise working in those spheres for which each was best qualified. This arrangement lasted until Dryden's death in December 1965. As Administrator, Webb represented NASA to other agencies, to Congress, and to the White House; Dryden kept open the lines of communication to the international scientific community and to the National Academy of Sciences, of which he was home secretary; while Seamans, as general manager, prescribed internal policy, served as co-chairman of the Aeronautics and Astronautics Coordinating Board, and until 1967 was the official to whom most of the so-called "functional" offices reported.[8]

Very soon after Webb's appointment was confirmed, it became apparent within NASA that headquarters structure, especially as it pertained to the centers, would have to be changed. As an outsider, Webb had no stake in any existing arrangements. Like his predecessor, he might have decided to call in an outside group to evaluate NASA as a whole. Instead, he began by working with a very small group of insiders, none of whom had been part of NACA: the Director of Business Administration, Albert Siepert, who had come to NASA from the National Institutes of Health; Alfred Hodgson, Siepert's special assistant; and Jack Young, who had earlier been involved in the McKinsey studies of NASA before becoming Deputy Director of the Office of Administration. Without any management instruction or directive, the settled practice became, in Siepert's words, to reserve to NASA officials rather than to outside consultants "the continuous study of our management policies." Appearing before a House committee in 1962, he explained that one of the conclusions of the Kimpton report had been that "NASA has reached a period of maturity in its young life where it should definitely strengthen its management analysis staff. It ought to be able to appraise with its own in-house competence most of the operating problems as they develop."[9] This shift, prior to the major changes that it helped to effect, remained standard procedure during the next seven years.

Between February and August 1961 these men carefully laid the groundwork for the October reorganization in a series of staff papers that set forth the available options.[10] The campaign of self-evaluation, which began with a "Summary Look" in February, went on to a 14 April staff study (on the eve of the lunar landing decision) and culminated in a 12 June paper on "Reappraising NASA's Organizational Structure to Achieve the Objectives of an Accelerated Program." Each paper represented an advance toward the eventual solution. Whereas the February paper analyzed problems and listed alternatives without recommendations, the subsequent papers began by recommending procedural changes—the way in which decisions were implemented—as a means of making substantive decisions.

Undoubtedly the most important procedural change was the establishment—proposed in April and made in June—of a "programming" office as a staff arm of the Associate Administrator, which would be charged with responsibility for budget preparation, management reporting, and the preparation of budgetary guidelines for the program offices. "Its loyalty would be to the Associate Administrator rather than to any program or group of programs, or to any combination of field installations or program offices."[11] The new office's responsibilities would be agencywide; its staff, several of whom were recruited from Abe Silverstein's Office of Space Flight Programs, would check the tendency of any single headquarters bureau to become semiautonomous or to grow at the expense of all the others. The head of the new Office of Programs,* DeMarquis Wyatt, who had worked for many years at Lewis before coming to Washington, had most recently been in charge of program planning and coordination in Silverstein's office. Wyatt was quick to grasp the possibilities of the new office, namely, that there had to be some single person or office to ensure that "on-going actions, new actions, and future plans were fitted into an identifiable work plan." The basic premise of the Office of Programs was that "a simultaneous technical and fiscal evaluation must be made of plans and actions in order to best accomplish the objectives of [the] program."[12]

Wyatt's office became the bureau where all NASA planning converged, and its four divisions—facilities coordination, which oversaw all NASA construction; management reporting, which supplied data for scheduling and reporting to all levels of management; resources programming, which prepared the data for NASA's budget; and project review, which would evaluate requests for new projects or changes in old ones—provided the staff services that Seamans needed as the agency's general manager.[13] A danger was that the new office might become something more than a staff arm, interposing itself between the program directors and the Administrator. This seldom happened. For several years the Office of Programs served principally to expedite decisions reached at the program office level; following the organizational changes of 1967 the Office of Programs, under

* The Office of Programs became the Office of Programming in 1963 and the Office of Program Plans and Analysis in 1967.

a different name, surrendered its budgetary functions to prepare those studies on which (it was hoped) long-range planning was intended to be based.

The full-scale reorganization of headquarters announced on 1 November 1961 was both procedural and substantive (figure 3–2). That is, it prescribed what the program offices were to do as well as how they were to do it. The principal change, under which the center directors were to report to the Associate Administrator, was the most difficult to carry out; it was dropped two years later, and its importance may easily be overestimated. Under the interim arrangement, the program directors at headquarters remained responsible for program budgeting and funding. They set up the technical guidelines, established milestones for reporting progress on a monthly basis, and retained the authority to reprogram funds to the centers. The 1961 reorganization purported to provide Seamans with direct observation of the centers, to bring the center directors into the planning process, and to guarantee control of the $2–3 billion in capital investment anticipated for center facilities. It was not aimed primarily at bringing about a mechanical smoothness of functioning. Rather, this change was made in frank recognition that the lunar landing decision had made manned spaceflight the dominant activity within the agency; that the lunar landing mission was something to which all the centers would have to contribute directly; and that—because all the centers had responsibilities in space science, applications, and advanced research—there ought to be one official with agencywide responsibilities to whom they should report.

The second major change was the realignment of headquarters program offices. The previous four were abolished,* and four new ones were created: Space Science under Homer Newell, Advanced Research and Technology (OART) under Ira Abbott, Manned Space Flight (OMSF) under D. Brainerd Holmes, and Applications under Morton J. Stoller.[14] An Office of Tracking and Data Acquisition (OTDA) headed by Edmund C. Buckley was established for agencywide support in telemetry and automatic data processing. The responsibilities for developing and using hardware were once again united. The tendency of these changes was to separate the broad areas of the space program that required greater autonomy. In particular, by stressing the importance of advanced research and technology, the 1961 reorganization marked a recrudescence of the NACA concept of research in fundamental aspects of aeronautical and space vehicle design and systematic testing "to obtain data for aeronautical and space vehicles of the future."[15] But OART was now required to go beyond this, and, by reducing theory to design, it was to produce real prototypes of advanced subsystems, whether or not that hardware would ever be used. OART would stand in relation to NASA very much as NACA had stood in relation to the services. OART would have to anticipate problems, do preliminary studies, and carry investigations to the

*The program offices abolished were Advanced Research Programs, Space Flight Programs, Launch Vehicle Programs, and Life Science Programs. Abe Silverstein, previously the Director for Space Flight Programs, returned to Cleveland in November to head the Lewis Center.

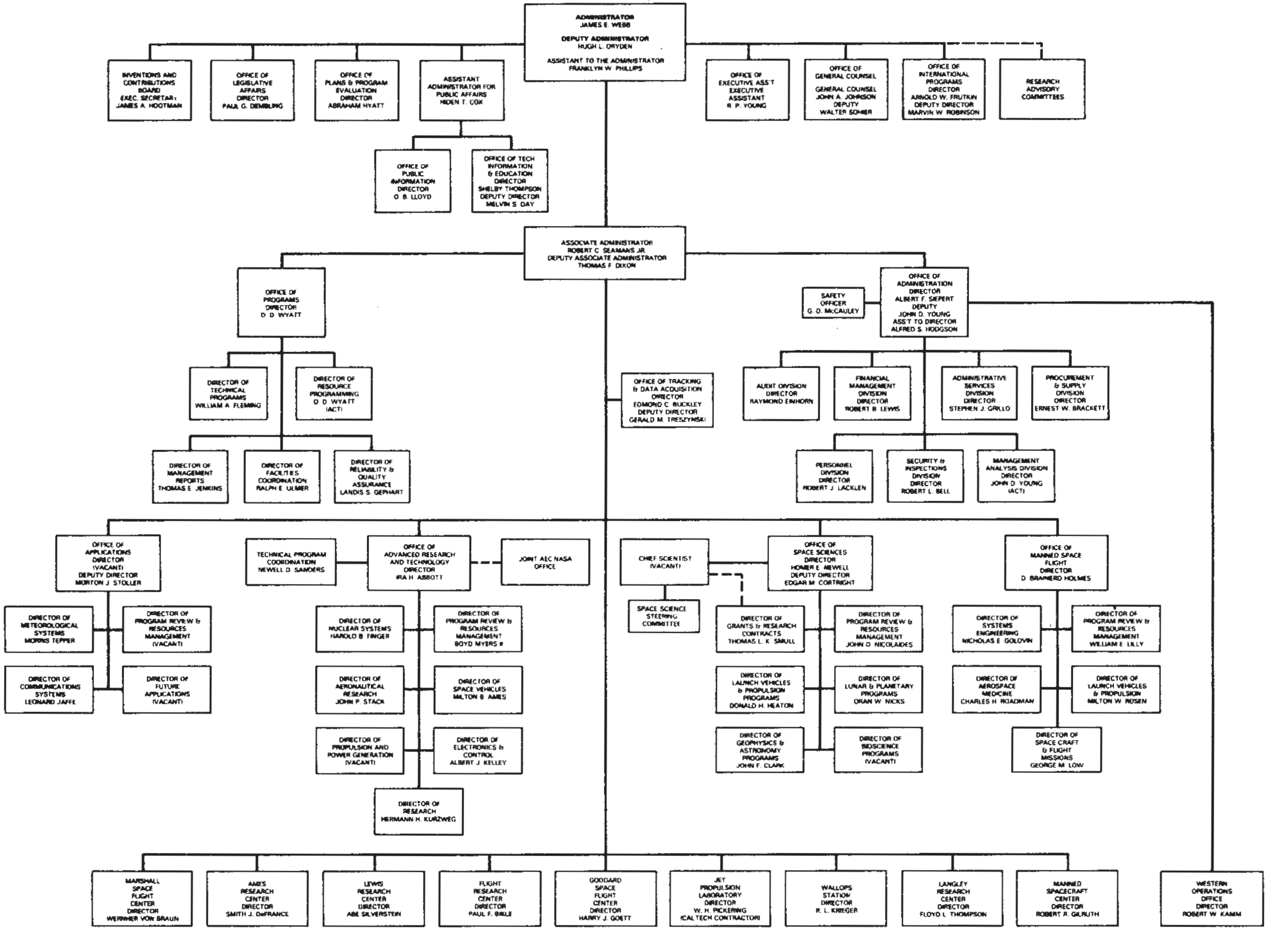


Figure 3–2. — NASA organization chart, 1 November 1961.

point at which the research could be usefully applied—in this case, by NASA itself.

In sum, the 1961 reorganization was a response to problems, certain of which stemmed from the circumstances of NASA's establishment, others from the prominence of the manned space program, while still others existed by virtue of NASA's status as a large organization involved in research and development. The changes discussed so far bound the headquarters offices and the centers more tightly together and at least temporarily checked the tendency of both to become quasi-autonomous. The changes confirmed the role of the Associate Administrator as the official responsible for authorizing projects and approving budgets and provided him with a staff to review and evaluate all NASA programs—those in progress and those for which approval was sought. Nevertheless, the reorganization left certain problems in abeyance and created new ones. The role of the Office of Programs reduced that of the Office of Plans and Program Evaluation, with its Ten-Year Plan, to something of a fifth wheel. The substance of planning, top management came to believe, lay less in stating new objectives than in getting the maximum return on the total dollars invested in programs already approved. The Ten-Year Plan, as it stood, provided no real guidance. Moreover, the budgetary process, for NASA as for any other Federal agency, required that funds be sought on a year-to-year basis, with later years always being treated as less important. By 1962 relatively few new projects were being started; the funds requested were for work in progress. The cancelation of the Ten-Year Plan early in 1963 resulted from the logic of the situation: Planning had to be integrated into the budgetary process, not superimposed on it. The budgetary process became, in Seamans' words, "the mechanism by which new projects, or major reorientation of current projects, may be proposed."[16]

One difficulty occasioned by the reorganization was that neither the centers nor headquarters was really prepared for it. Holmes and the other program directors complained that they could not "task" the centers effectively enough for the work in hand. Many of the directives required to spell out the details of the changes were a long time aborning; the crucial instructions on the responsibilities of the program directors and the functions of the Office of Administration (responsible for financial management, personnel, security, and the like) were first drafted in July 1961, issued in "informational" form in June 1962, and promulgated authoritatively only in June 1963. But the most serious problem was that neither center directors nor headquarters program directors were quite certain of their functions and responsibilities. The management instruction on "Planning and Implementation of NASA Projects," issued by Glennan in January 1961, was already out of date.[17] By September 1962 the situation had deteriorated to the point at which one official wrote to Seamans to complain of "gross inadequacies in major management systems . . . [and] confusion over the respective authorities of the Associate Administrator and Program Director. . . . The situation ranges from a lack of systems to duplicative systems and in some instances conflicts or disregard of established systems." He was especially disturbed because

Figure 3–3. — T. Keith Glennan, NASA Administrator from August 1958 to January 1961.

Figure 3–4. — James E. Webb, NASA Administrator from February 1961 to October 1968.

Figure 3–5. —Thomas O. Paine, NASA Administrator from March 1969 to October 1970.

Figure 3–6. — Hugh L. Dryden, NASA Deputy Administrator from October 1958 to December 1965.

Figure 3–7. — (Left to right) Robert C. Seamans, Jr., Smith DeFrance, and James E. Webb.

Figure 3–8. — Wernher von Braun (left) and Raymond Bisplinghoff.

Figure 3–9. — (Left to right) Homer E. Newell, James E. Webb, and Abe Silverstein.

> Center officials feel that the Agency may be working toward a "bureau" type of organization and are uncertain about how they should act and react to their different and multiple "bosses," and the extent to which they may be held responsible by Program Directors vis-a-vis top management. . . . Waste is inevitable . . . if Program Directors can delegate or withdraw program authorizations to Centers without serious consideration of the related impact such actions may have on manpower, facility, and related general resource requirements.[18]

At bottom, the problem was a management structure that was "inadequate and unrealistic."

At the semiannual management conference held that October at Langley, several center directors, especially those under the Office of Space Sciences, complained that the various organizational changes had made their work much more difficult. While the centers under Holmes had been given much greater operating authority, Goddard and JPL found their positions worse than before. The internal communications problem cut across all other organizational levels: It affected relations among headquarters and the centers, the program and functional offices, and the centers themselves. As Harry J. Goett, Director of Goddard, pointed out, five centers were engaged in designing and fabricating spacecraft with almost no exchange of information between them.[19] Headquarters was too eager to involve itself in relations with contractors, too slow to approve projects submitted by the centers, and too reluctant to encourage intercenter coordination. Furthermore, the center directors had almost no direct contact with Seamans, although the ostensible reason for having the centers report to him was precisely to foster such contact. Changes in organization inevitably affected the ways in which programs were carried out—whether the approval of contracted advanced studies, the management of approved projects, or the center negotiations with contractors.

In summary, the 1961 changes failed for three reasons. They tended to create a "free for all" between the program offices at headquarters and the centers. The headquarters program director had authority only over specific, discrete projects.[20] "Often a center was working on projects in several program areas. Any one field center could be involved in projects under the supervision of all five Headquarters program offices."[21] This tended to obliterate each center's orientation toward its specific mission. Moreover, the role assigned to Seamans was extremely demanding; it left him little time to visit the centers, confer with project managers, or grasp what was going on in the field. The problem was how to relieve him of part of this crushing workload and free him to take a broader view of his responsibilities. Reducing the scope of his office might be too drastic; delegating his authority, although less disruptive, would be easier to recommend than accomplish.[22] Finally, until 1963 there was no set pattern for top management to meet with the program directors and functional staff to discuss operating problems as they arose. To be sure, there were semiannual conferences organized around some central theme, staff meetings chaired by Webb, and program reviews chaired, from time to time, by Seamans. But no real format had evolved by which Webb, Dryden, and Seamans could grasp and evaluate program developments before they advanced so far that change directed from above would be difficult to carry out.

Yet it would be too facile to interpret the 1961 changes as part of an experiment that could not be made to work. The arrangement under which the centers reported to Seamans rather than to the program directors was probably never intended as a lasting solution. Seamans would later remark—although he may have been wise after the fact—that "we realized that it would not be desirable to maintain this structure as a lasting arrangement."[23] It had served its purpose reasonably well in reminding the centers that NASA had a single mission to which all local interests must remain subordinate. The 1963 reorganization was in no sense a return to the pre-1961 state of affairs, although the centers once more reported to the heads of the program offices. That NASA was once more "decentralized" signifies almost nothing, unless one adds that there were now central functional offices for Defense Affairs, Public Affairs, and Industry Affairs, to which NASA's Procurement and Supply Division (once part of the Office of Administration) was moved; for the first time a Technology Utilization Division reporting to Webb was set up to work out means by which the technical byproducts of space research and development—"spin-off," "fall-out," "second-order consequences," or "technology transfer"—could be disseminated most effectively to private industry and other users. In itself this was a major undertaking, involving identification of useful technology, evaluation of its potential, support of research on technology transfer (often through grants to universities and research institutes), and matching of data collected with potential users.[24]

The 1963 changes marked NASA's arrival at organizational maturity (figure 3–10). The significant change, under which the centers once again reported back to the program offices, had been anticipated in October 1962 when Holmes was named Deputy Associate Administrator for Manned Space Flight Centers. What was new was the role envisaged for the program directors, now the associate administrators for their several offices. As Webb put it several years later, the purpose of the reorganization was to emphasize that the director "was a guy running his show as an Associate Administrator, and that he ought to think of himself as nearly as possible doing the total job. He had to present his program to Congress—he wasn't just an internal manager. . . . It was the idea that for his area he had almost as broad responsibility as the Administrator, subject to supervision and . . . to evolving his own relationships with functional staff and line staff."[25]

As it turned out, this never occurred—at least not to Webb's satisfaction—and it is worth considering why. The enhanced power of the program directors was, for Webb, only one side of the equation. The other side was the concept of "functional management," which, although not formulated in a comprehensive policy statement until 1966, had been official NASA policy since the 1961 reorganization.[26] Basically, Webb tended to distinguish between program and functional offices, between those who prepared and carried out substantive programs and those who provided centralized, agencywide services in a specific professional discipline. The functional staff offices, most of which reported to Seamans, had two responsibilities: to serve as a central staff for the three top officials and "to emphasize the agency-wide importance of a particular area of specialization," that is, to check the tendency of the program offices to create their own supporting groups with their own parochial interests.[27] But this never worked out. Five years later, Webb was complaining that the heads of the program offices had not reached up to use the central staff; that each of the three program associate administrators—as of 1963 George Mueller in OMSF, Homer Newell in the Office of Space Science and Applications (OSSA), Raymond Bisplinghoff in OART—tended to work in isolation from the other two; and that while the three were to have been "associated with the triumvirate at the top to serve as an overall group devoted to getting the total NASA job done," this (he immediately added) "never really happened."[28] The program offices tended to build up their own functional staffs at the same time that the central staff offices were discovering the limits within which they could impose uniform policy, especially at the center level.

Three other features of the 1963 reorganization should be noted. The first entailed a shift in emphasis, a return to the NACA concept (in a very different context) of giving the field installation responsibility for technical decision making. Top management stressed, then and afterward, that project management was the responsibility of the centers. For all flight projects except Apollo, there was to

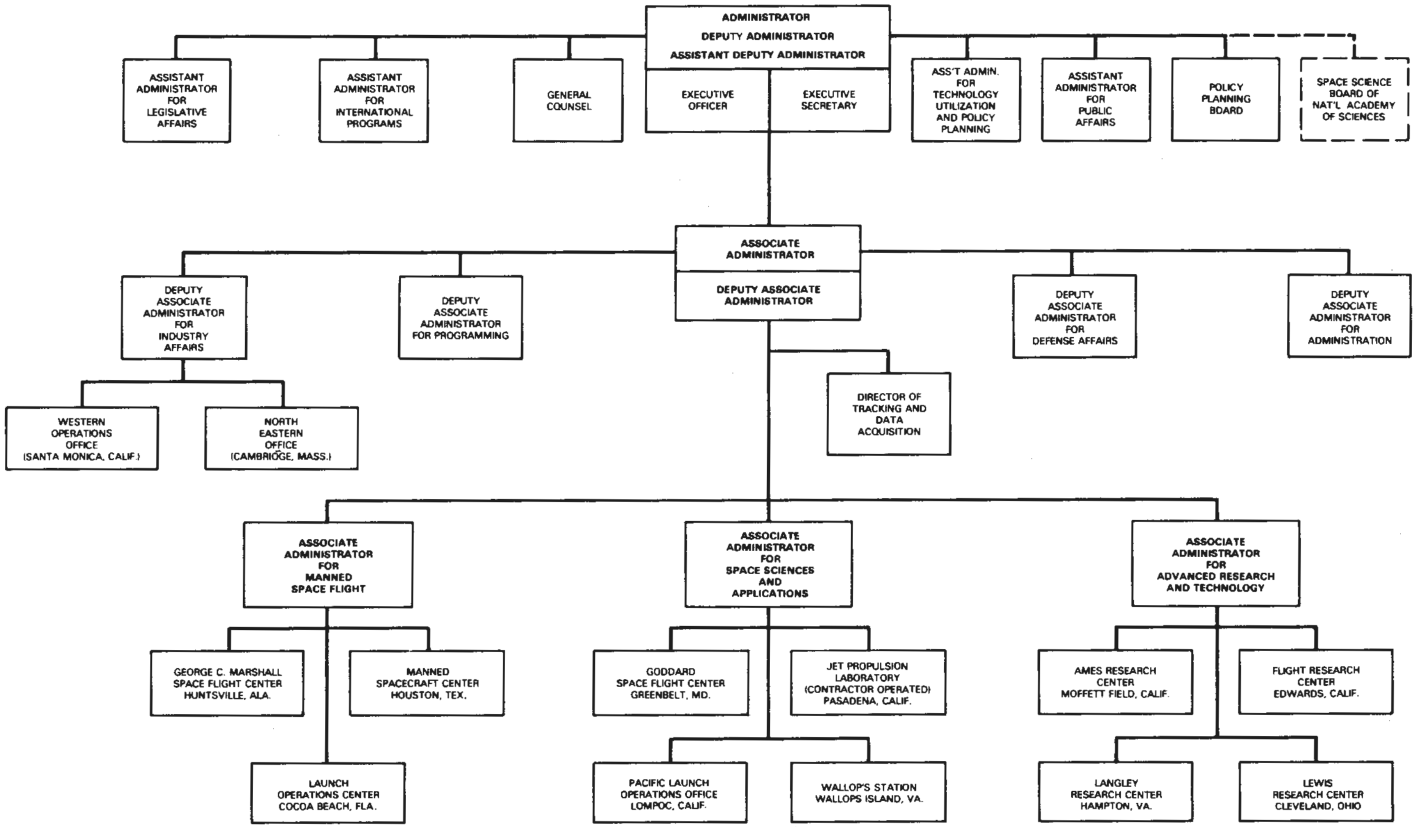


Figure 3–10. — NASA organization chart, 1 November 1963.

be one lead center, regardless of how many installations actually participated. In the case of Apollo, the major elements were given to lead centers: for example, the spacecraft to Houston, the launch vehicle to Marshall, and the tracking system to Goddard. The tools for getting the job done had to be grouped in a related fashion; thus Applications, which used the same launch vehicles and centers as Space Sciences, merged with the latter in 1963. This meant that a particular center had (or was assumed to have) the capacity to manage large development contracts, the skills to integrate the subsystems of a project parceled out among two or three different centers, and the ability to draw on the resources of other centers instead of needlessly duplicating them. In 1963 even more than in 1961, there was an agency "program" instead of "programs," hence the need for the cross-servicing of one center by another center. (Only in 1963 was NASA able to establish a unified Launch Operations Center at the Eastern Test Range, where previously each center had its representatives—a Goddard team, a Marshall team, a JPL team. The Launch Operations Center, headed by Kurt Debus, was renamed the Kennedy Space Center in December 1963.)[29]

This system was not self-regulating. It depended on a mixture of formal delegations of authority and a network of informal relations too subtle to be put on paper; neither was fully understood throughout the agency. Under these circumstances the general manager really had to be prepared to manage. He had to know what was going on before problems got out of control. He had to make himself visible to the heads of the program offices, and he had to be able to say, "'Well, we need more data on this,' [or] 'this is something we can't decide here, it must go to the Administrator.'"[30]

The second feature of the 1963 reorganization was to create a mechanism that enabled the general manager to do this. The NASA Management Committee, which met for the first time in October 1963, was chaired by Seamans and comprised nine key headquarters staff officials reporting to him. Its terms of reference extended to the discussion and resolution of management problems—relations with the centers, procurement policy, the format for project authorization, and so on.[31]

At the same time, Seamans instituted an intensive "monthly status review" at which he would sit down in turn with each of the program associate administrators for a searching examination of each project for which he was responsible. Such reviews would cover all substantive and administrative aspects: planned versus actual manpower allocations at the centers and at contractor plants, planned versus actual expenditures, key milestones in program and procurement schedules, and advanced studies prior to their completion. Each review was to be preceded by staff discussions, and the preparation of a formal agenda by the Office of Programming would be followed by presentations to Seamans. The drift of Seamans' thinking was to make short-range planning more realistic by seeing that the program offices provided him with the information on which key decisions had to be made. Consider for example the official monthly launch schedule, which was the Associate Administrator's responsibility to update. The changes made in 1963 were in the direction of greater realism and precision. All launches scheduled within thirty days of a Management Committee meeting were to be scheduled by day, those within the ensuing year were to be specified by month, and launches planned for the following year were to be specified by quarter. Seamans wanted to eliminate unnecessary reporting, while insisting that the program offices assist him in making launch dates as realistic as possible.[32]

On balance, the system of status reviews worked well. The principal recurring meetings—the monthly status reviews chaired by Seamans, the internal reviews of the program offices themselves, the annual program reviews attended by Webb—did aid in bringing problems to the surface. In the annual reviews, for example, specific program areas were reviewed in depth from the standpoint of their overall objectives, scientific and technical content, organizational structure, and interrelationships with other Government agencies. The meetings were held on Saturday and lasted all day; the following Monday the presentation was repeated for NASA staff and senior officials of other departments. But shortcomings remained. The monthly status reviews covered only substantive programs, omitting the work of functional management, and the presentations for Webb outlined each program in a fragmentary way, since the programs could only be covered a segment at a time. Still, the 1963 reforms were a definite improvement over their predecessors. The Management Committee, the monthly reviews, and the annual reviews of each program gave Webb and Seamans access to information and views that had scarcely been tapped earlier. The meetings enabled top officials to use overlapping sources of information, hear all points of view, eliminate some middlemen in channeling information upward, and define the purpose of each meeting so that those attending would know precisely why they were there.[33]

Finally, long-range planning continued to be a vexation and a burden to top management. By early 1963 Webb had decided not to update the Ten-Year Plan; in October the Office of Plans and Program Evaluation, which had played an equivocal role—not being quite in on decision making nor entirely out of it—was abolished, to be replaced by a Policy Planning Board reporting to Webb and a Planning Review Panel attached to Seamans' office.[34] Neither had effective authority, presumably because top management preferred not to give them any. It was one thing to bring officials together to discuss NASA programs in a general way; it was another, much more serious step to empower them to speak authoritatively for NASA. Planning could be no more effective than its organizational location and status allowed. Webb was reluctant to propose a long-range plan, not solely from a conviction that NASA's long-range mission could only be spelled out in the political arena, but also because he did not want to declare preferences that could set one part of the agency against another. The so-called plans of 1965–1968 were more in the nature of shopping lists (most of them prepared by OMSF or OSSA staffs) than actual outlines of what NASA intended to do; the Policy Planning Board was abolished in 1965 because, as Webb disingenuously explained, nobody was using it.

The Situation at the End of 1966

The years from November 1963 to November 1965 were not marked by changes as sweeping as those already discussed. Top management, the heads of the line and functional offices, and the center directors had worked out a system they could live with. Two successive reorganizations had shaken up the agency, spotlighted the values top management deemed important, and reduced the inertial forces of custom—"this is the way things have always been done around here"—that might form in an organization that had inherited so much from its predecessor. But it was not part of Webb's philosophy to keep NASA in a state of, as it were, permanent revolution. Smaller (although not small) changes would serve just as well. As he explained to one official, top management consciously decided "to make relatively small changes on a fairly frequent basis. Thus we . . . have used our decisions on incremental improvements to teach the organization to expect change rather than contemplate static periods after a series of major changes."[35] In his view the 1963 changes, if carried to their logical conclusion, would free himself and Dryden to concentrate on the major issues, particularly where they impinged on other agencies, Congress, and the White House. But it was absolutely essential that NASA officials understand their roles in what Webb called "the total milieu." As a matter of policy he believed in transferring headquarters officials to the centers and vice versa, assigning executives jobs outside their experience and beyond their area of proven competence, and using NASA officials to present their programs before congressional subcommittees. For all the shifts and turns of the NASA organization during Webb's tenure, there is a definite consistency of intent toward reducing the layering of authority so that fewer officials and fewer documents would be needed to authorize projects, and toward bringing as many senior officials as possible into decision making. The goal being posited, the means of attaining it had to be worked out on the basis of periodic reviews, staff meetings, and presentations to senior officials—a system at once more rigorous but less formal than a Ten-Year Plan.

Two examples of "relatively small" changes at headquarters are the revision of the system of management instructions and the formal establishment of the executive secretariat, both begun in 1964 and extending over several years, both closely tied to the major changes of the previous October. The so-called issuance system had been a longstanding grievance.[36] The Management Manual instituted in 1959 could not adequately document the changes taking place in NASA. Often, there were no instructions (or occasionally, conflicting instructions) covering a subject area. Instructions tended to lose relevance within two or three years of publication but not to the point of becoming totally obsolete. Added to this, the coding scheme was inadequate, there was no indexing or cross-referencing, and definitive instructions took too long to prepare. These problems, recognized by 1962, had become acute following the 1963 reorganization that, in delegating maximum authority to the program offices and the centers, called attention to the gap between the directives and the purposes they were intended to serve.

One of the first steps in revising the Manual was taken early in 1963, when the Division of Management Analysis (Office of Administration) conducted a study based on an earlier report prepared by the General Services Administration at NASA's request. These two studies, the former of which was discussed by the Management Committee in April 1964, served as the basis for subsequent revisions, but converting from the old Management Manual to the new directives system—entailing as it did the rewriting and converting of current directives, canceling others, and updating the remainder—took another two years to complete.[37] The job of revision included several sorts of change: eliminating what was extraneous, issuing a new coding system to distinguish ad hoc notices from policy directives and the management instructions that supplemented them, and the preparation of a checklist to make cross-referencing possible. A particularly important step related to these reforms was the publication of "NASA Basic Administrative Processes" in February 1964.[38] This manual, complete with flow charts, official definitions, and enumeration of basic policies and principles, established the guidelines to be followed by agency officials and, as such, was the substratum from which the issuance system was supposed to develop.

The history of the management documentation problem is interesting, less for its own sake than for what it reveals of the workings of the NASA management process. For brevity's sake, the important points may be summarized as follows. First, the changes of 1964 through 1966 followed logically from the decentralizing tendencies of 1963. In line with management's policy of delegating and dispersing authority, the new system authorized all officials reporting to top management (and, of course, top management itself) to prepare and to sign directives outlining their powers and responsibilities. It gave the functional offices the authority to determine the content, prepare the format, and coordinate drafts with other offices. Second, while this relieved general management of the responsibility of preparing all the detailed instructions, the functional offices were given the onerous burden of preparing directives that might affect nine or ten other offices, as well as the centers.

Finally, the new system failed in its purpose almost as much as its predecessor. NASA did not stand still, and no set of instructions or directives could possibly serve as a contemporary record of operating procedures. At the Office of Administration, Young tried in vain to satisfy Webb's demand for precise, up-to-date descriptions of every responsible person's job.[39] "Basic Administrative Processes" was already out of date by the end of 1966; it could not be replaced until it had been studied by one task group, worked over by the Office of Organization and Management (see below), discussed by the NASA Management Council in January 1968, and subsequently coordinated between Organization and Management and the newly revived Office of Management Development. In the end, agency officials found it impossible to summarize the processes between the covers of a small handbook. The compromise effected was to replace the handbook one chapter at a time—a process that was never brought to a formal conclusion.

The creation of an executive secretariat was as much the result of the 1963 reorganization as the enhanced authority of the program offices was. Although discussed for some years prior to its establishment, the concept of a central secretariat for handling communications made little headway prior to 1963.[40] It was not mentioned in the December 1958 McKinsey report on establishing headquarters functions, nor in the Kimpton report of October 1960. The 1961 staff papers prepared by Deputy Associate Administrator Jack Young did mention and elaborate on a "Central Secretariat," but no such staff office was included in the changes that followed. The real catalyst for change—another staff study supervised by Young—came toward the end of 1963, and the management instruction establishing the secretariat was only issued on 1 February 1964.[41] Why it should have taken so long to recognize the need for a secretariat function in NASA is unclear. Prior to 1964 the responsibility for handling communications between top management and the rest of the agency had been delegated to an "Executive Officer," usually an officer detailed to NASA from the Army Corps of Engineers.*[42]

The creation of a secretariat did not immediately resolve the several administrative problems that had led to its creation. It was by no means clear whether the executive officer would be inside or outside the secretariat (ultimately inside); whether the secretariat would serve the Administrator alone, or the Deputy and Associate Administrators as well (with qualifications, the latter); whether its function was completed when the Secretary informed the Administrator of what he needed to know, or whether the secretariat had an additional responsibility to see that decisions made by the Administrator were carried out promptly (the office became responsible for both). The functions of a secretariat really depended on the Administrator's view of his own position vis-à-vis the rest of NASA. To a degree, Webb's concept of a secretariat was not radically different from the one held by the heads of other large Federal agencies, particularly the State Department and DOD. Webb needed and wanted a staff to handle all materials coming to his office, sparing him matters that did not require his personal attention, while placing before him everything that he had to know to meet his responsibilities. Webb's knowledge of secretariat functions was strongly influenced by his experience as Under Secretary of State; the State Department secretariat was manned by officials who frequently reported directly to the Secretary or Deputy Secretary of State.[43] Webb envisaged a NASA secretariat that would assist in the making of—more precisely, in the implementation of—agency policy, but it still remained to be seen how it would act in following up decisions and in working with and through the headquarters offices and field installations.[44]

At the end of 1965 the secretariat's charter was conspicuously enlarged as part of the much broader changes brought about by Dryden's death on 2 December. In failing health since 1961, Dryden had nevertheless managed to carry on with few interruptions for the next three years. By late 1964, however, he had

*By selecting officers detailed to NASA, Webb hoped to keep the position "above politics."

become incapacitated to the point that his resignation or death was anticipated. Before Dryden's death, it had been informally decided that Seamans would succeed him as Deputy Administrator. What this would mean did not become clear for several months. During 1964–1965 Webb had started moving toward a more precise definition of his and Seamans' respective spheres. With Dryden gone, Webb decided to pull together into one unit functions and offices that had hitherto remained separate. In a memorandum of 29 December, which Seamans discussed with all top headquarters officials the next day, Webb announced the creation of the Office of the Administrator as a "single, uncompartmented entity to afford maximum, direct . . . contact between Dr. Seamans and myself and our associates."[45] However, Seamans cautioned, this concept was "experimental in nature" and was designed to "assist in eliminating functional delays."[46] But the creation of the Office of the Administrator was intended to do more than this, and it would be well to summarize here the kind of organization Webb had in mind.

First, Seamans remained general manager. That is, he retained his function of overseeing the agency daily. He would continue to chair the monthly status reviews, update the NASA flight schedule, sign project authorization documents, and so on. But his role as general manager did not exhaust his responsibilities. Webb wanted him to move into several of Dryden's functions, for example, to involve himself in international scientific programs. He especially wanted Seamans to work closely with the Offices of Legislative Affairs and Public Affairs in preparing NASA's congressional statements and in meeting with those Congressmen who had most to say in determining NASA authorizations and appropriations. Seamans had been doing much of this before; he was now expected to carry it to the fullest extent. All staff and program offices (with certain exceptions shown in figure 3–11) would report directly to Seamans.

Second, Webb intended to make the secretariat visible throughout the agency. As the staff arm of the Office of the Administrator, it became responsible not only for reviewing incoming correspondence but for establishing and maintaining "a need-to-know reporting system of items of significance to general management . . . a Critical Reports and Correspondence Review System to keep general management currently informed of significant matters covered in written reports and communications by the heads of Headquarters offices" and "a Codified Policy Reference that will provide for recording policy directives . . . and for making them available to appropriate officials."[47] By what he said and did, it is clear that Webb intended the secretariat to have a de facto role in policy making. It became the Secretary's responsibility to prepare the agenda for management reviews, to attend major staff meetings (for example, those attended by Mueller, Seamans, and Webb) and to prepare a memorandum for the record afterward, and, through his assistants, to obtain copies of the internal papers of all the program offices (including OTDA, which was elevated to program office status in December 1965). But the secretariat could assist in policy making in more direct ways. The Executive Secretary could, for instance, remind each of the program offices to coordinate an impending action with the functional offices; he could say in so many

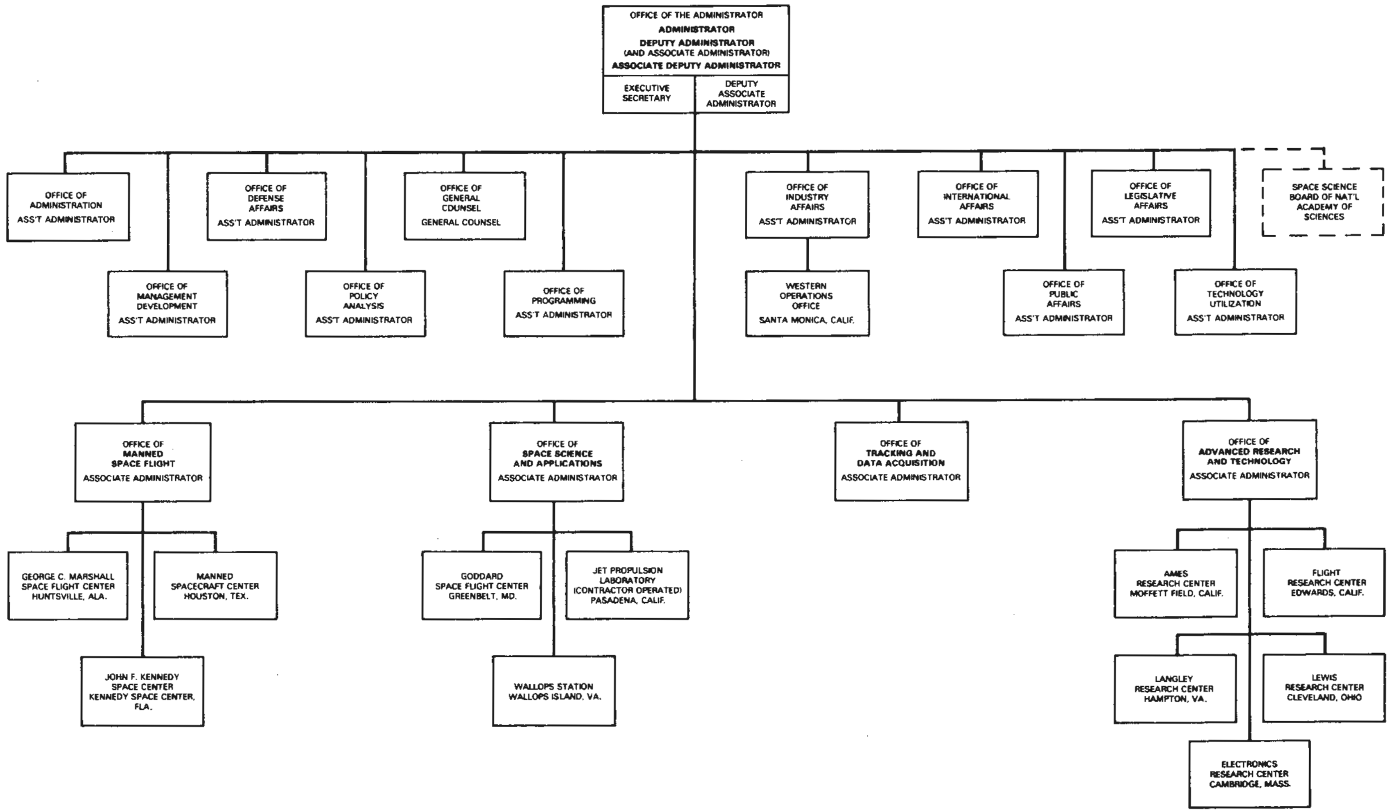


Figure 3–11. — NASA organization chart, 2 January 1966.

words, "Have you seen the General Counsel? Have you talked with Procurement?" And he could coordinate the policies of the program offices with each other. It sometimes happened that two offices, ignorant of what the other was doing, would prepare separate policy statements on the same matter. The different approaches of OSSA and OMSF on the quarantine of outbound spacecraft converged only at the level of the Executive Secretary, who intervened to bring the matter to Seamans' attention and to gain a final resolution.[48] Obviously, a great deal depended on the program offices' willingness to cooperate, for example, to provide the secretariat with copies of internal correspondence, to allow assistant executive secretaries to sit in on their staff meetings, and to tolerate another level between themselves and general management.

These changes were meant to reduce still further Webb's burden of routine business. Seamans was now completely responsible for the internal management of NASA and for many of its external relations as well. Moreover, even those groups lodged in the Office of the Administrator did not always report directly to Webb. The Executive Secretary, for example, reported to Willis H. Shapley, who had joined NASA in September 1965 as Associate Deputy Administrator. Shapley came to NASA from the military division of the Bureau of the Budget, where he had been involved in space policy making since NACA days. He was one of the drafters of the Space Act and had worked closely with Seamans to resolve issues between NASA and DOD. Arriving just before Dryden died, Shapley had first been assigned responsibility for interagency relations. But following the December reorganization, it was Seamans' notion to work out a three- or four-way division of labor among himself, Webb, Shapley, and Earl D. Hilburn, the Deputy Associate Administrator. In the broadest terms, Webb and Seamans would be the top two officials running NASA, and Shapley and Hilburn were to run the agency on a day-to-day basis. According to Seamans, "Mr. Webb and I would have available to us two senior people, and you wouldn't have a very definite rule as to what Shapley did or what Hilburn did, but a general area defined, and then I would work very closely with both of them."[49] In that sense, Seamans' plan never got off the ground. Webb would not buy it, preferring to have one person responsible for a given area. He saw to it that Shapley was placed in immediate charge of the secretariat, with a kind of overall responsibility for the "policy planning" function, to which the entire agency would be expected to contribute. In sum, Webb was delegating his authority for daily operations in the hope that he could totally involve himself in the key problems facing NASA.

This account rather understates the complexity of what Webb had in mind. At one end, he would delegate authority to Seamans and Shapley (Hilburn having left in the summer of 1966) to run NASA on a daily basis; at the other end, he was delineating a sphere of policy planning that would be his own bailiwick. This division of authority could never be laid down with any finality because no one knew precisely where "management" gave way to "policy planning" or "policy analysis." Either might be used to mean the determination of whether previously established policies were being carried out, the documentation of specific policy decisions, or the study of how "programs are put together year by year, not only for the 5 year future, but 10 years and beyond." [50] Lack of definition was only one of Webb's problems. Another was that the key officials were not—nor did Webb intend them to be—just one thing or the other. In his view, Seamans was not just the general manager any more than Shapley was just the chief of staff or Mueller was just the Associate Administrator for Manned Space Flight. They had to be able to grasp the "total milieu," to understand what the agency would be years later, when the compartmentalization of manned and unmanned programs had broken down, when NASA was developing a technical capability that would enable its officials to "know enough to know what ought to be done in the world," and when Webb or his successor would be involved as "exponent[s] of advanced technology and advanced scientific thrust and the combining of the two for everything from agriculture to economics and military." [51] To the engineer or program manager working full-time on Apollo Applications or Voyager, Webb's demand that he see the total picture was a very tall order indeed.

On balance, the changes of 1965–1966 accomplished a great deal without disrupting the existing roles of the program line management. Webb had introduced the concept of a central staff to serve the Office of the Administrator, whose chief of staff was Willis Shapley, had created an executive secretariat to handle internal communications flowing up to his office and policy directives moving downward, and had delegated to Seamans most of the authority for running NASA. None of these changes had anything final about them; rather, Webb was attempting to develop an agency that could run itself on a daily basis, while he, Seamans, Shapley, and the four program directors worked to extend NASA's influence into economic and political spheres hitherto untouched by the space program. The question was, would the agency accept this interpretation of NASA's mission? For that matter, would Congress understand it? And finally, how far was it within NASA's competence to determine its mission, since it had to go outside for the funds to sponsor it?

Organizational Changes, 1967–1968

James Webb:	What I want you to realize is that you are not on a nice ship steaming across the ocean at a high speed with the flags flying. You are sort of on a raft that is partly at the mercy of the currents and . . . you are going to keep your feet wet and have a real hard time getting all of it done, but you must consider the total environment within which you operate.
Edgar Cortright:	I don't think that is quite a fair analysis.
James Webb:	It isn't. I agree with you. It is exaggerated for effect.[52]

The year 1967 was probably the most eventful for NASA since 1961. Although the Apollo fire and its aftermath was the dominating factor for months, that year also marked the completion of Gemini, the first launching of the Saturn V, the cancelation of the Voyager program for the exploration of Mars, further reductions in the NASA budget, a Civil Service Commission report that was highly critical of NASA personnel management, and a General Accounting Office investigation of NASA support service contracts. Even without the Apollo fire and the ensuing publicity, NASA officials would have had reason to worry about the future. Questions asked at congressional hearings had a disturbing way of recurring. What was NASA doing about post-Apollo planning? Why did NASA spend comparatively little on aeronautics and applications on the one hand and so much on manned spaceflight on the other? How could NASA guarantee that it could handle its contractors instead of becoming their captive? By the end of 1966—one month before the fire—Webb and Seamans were sufficiently worried about the NASA management structure to ask Harold B. Finger to head a task force to study the full spectrum of functional management with a view to restructuring it. He was invited to recommend how changes might best be implemented, how they would affect the program offices and the centers reporting to them, and whether they should be phased over time.[53] By February, Finger was preparing the charter for an "Office of Management," and on 15 March Webb named him the Associate Administrator for Organization and Management—ushering in the last major reorganization of the 1960s.

Webb chose Finger because he had succeeded as a research and development manager; he was the very type of line operator Webb wanted to bring from the field to headquarters to understand the agency as a prelude to running it. As director of the NASA-Atomic Energy Commission Nuclear Propulsion Office since its establishment in 1960, Finger had done remarkably well in handling not only the usual range of project management problems but the added burden of working with another agency, with the Joint Committee on Atomic Energy, as well as with Senator Clinton Anderson (D-New Mex.), a member of the Joint Committee and chairman of the Aeronautical and Space Sciences Committee, which authorized the NASA budget. Finger had the experience and the ability to win the respect of those program offices with which he would have to work to restructure the agency in the aftermath of the Apollo fire.

The changes of 15 March can only be summarized here. As figure 3–12 indicates, the following functional offices would now report directly to Finger: the Office of Administration headed by William E. Lilly; the Office of Industry Affairs under Bernhardt L. Dorman; and the Offices of Technology Utilization and University Affairs headed, respectively, by Richard Lesher and Francis B. Smith. The other major change, by which Wyatt (who reported to Seamans) became Assistant Administrator for Program Plans and Analysis, was perhaps just as significant; in the process, the budgeting and programming functions previously under him were transferred to the Office of Administration (which reported to Finger) as part of an agencywide system "for resources management, including programming, budgeting, personnel management, and financial reporting."[54] Within the year several more offices were brought within Finger's control: the Office for Special Contracts Negotiation and Review, established in May to monitor certain important contracts, particularly the North American Aviation contracts for the S-II stage of the Saturn launch vehicle and for the Apollo command and service modules; the Audit Division; the Inspections Division; and the Headquarters Administration Office. By the spring of 1968, the role of management and supervision had passed from Seamans, who left NASA at the beginning of January, to Finger (figure 3–12).

In certain crucial respects, however, Finger's assignment differed from Seamans'. Finger was brought in because self-policing had not worked and because, in Webb's view, there had been too much emphasis on programs and not enough on administration. In the past, he argued, nobody minded how the job was done so long as it got done. The Apollo fire and the attacks by Congressmen hitherto favorable to NASA changed all that. The agency had been caught unprepared. Webb wanted the job done, but done properly and through the approved chains of command. The management instruction that established Finger's office stated that "all officials with leadership and executive responsibility are expected to accomplish agency programs . . . within the prescribed systems and procedures." Furthermore, it would be Finger's responsibility to develop criteria "for selection upward of R&D personnel who also demonstrate administrative competence . . . and the transfer to non-administrative specialties of those who cannot grow in both program and administrative areas."[55]

In private Webb was even blunter. Finger's office would be to the rest of NASA what the Bureau of the Budget was to the Federal structure.

> 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." . . . I am giving them real teeth. I am saying to Harry [Finger], "If these fellows don't satisfy you with respect to the components to the system, cut off the water. Don't give them any money." He's got the authority to allocate the money, he's got authority to issue in his own right a modification of a project approval document and say, "Boys, you used to think you're going to do it this way, and even when you don't like what I'm proposing, here it is—signed. Go do it this way."[56]

Along with the Office of Program Plans and Analysis and the secretariat, the Office of Organization and Management would provide Webb with multiple layers of feedback; under Finger's leadership it was expected to penetrate almost every facet of administration. Now the heads of the program offices had to work through Finger in preparing and seeking approval for their project approval documents (PADs); that is, Finger was expected to certify to the Administrator that a draft PAD was sound—for example, that it not only had an updated launch schedule attached but also a reference to the research and ongoing projects that should feed the project. But Finger and his assistants were expected to do more than this. During 1967 and 1968 they planned and carried out several important studies of NASA management processes: an April 1967 report on the "functional review process," that is, the self-evaluations and internal reviews of the functional offices themselves; a task force review of those "action and decision processes" leading to mission assignments and approved PADs; and the preparation of detailed guidelines for phased project planning. The power to review, inspect,

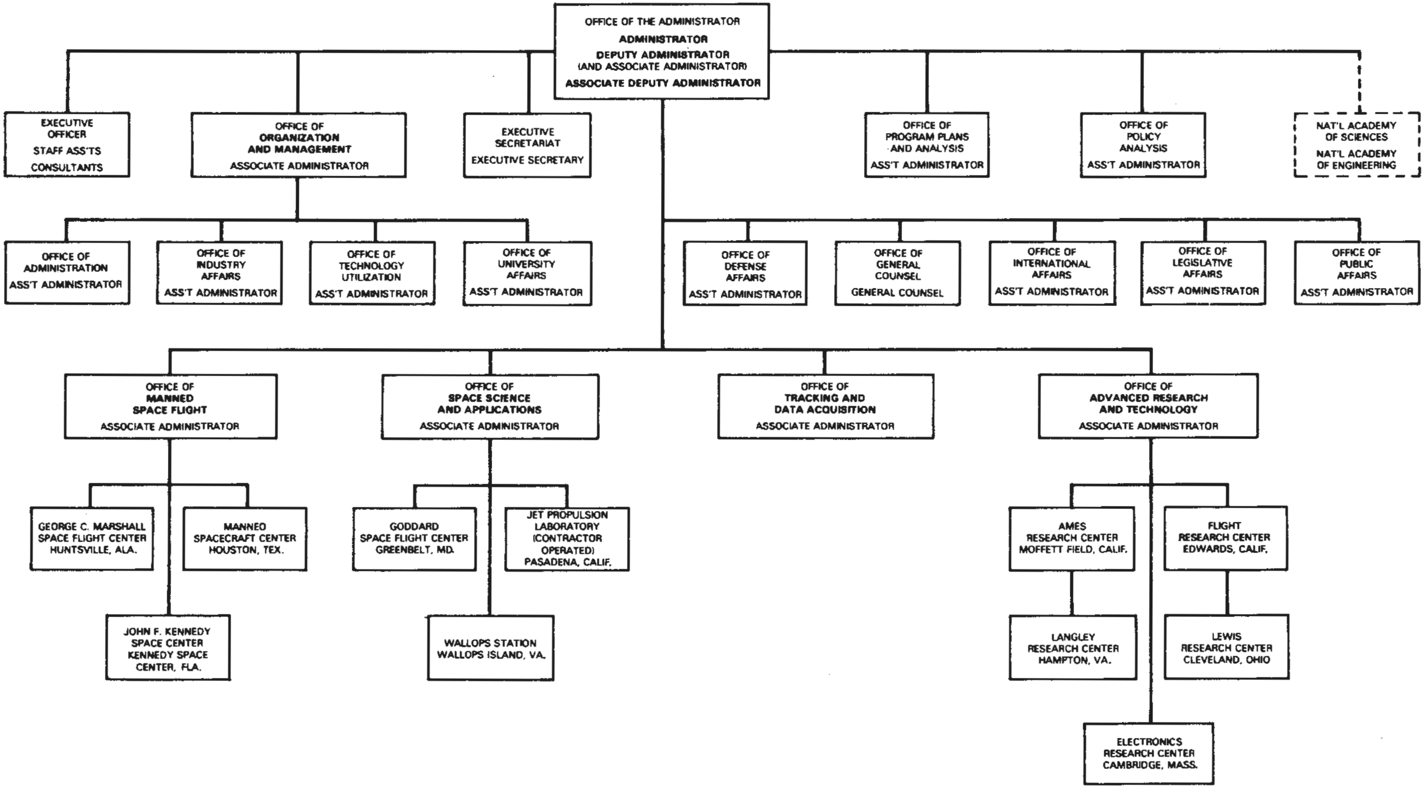


Figure 3–12. — NASA organization chart, 15 March 1967.

establish management systems, deal with the General Accounting Office, and allocate resources for research and development made Finger the most powerful staff official at headquarters. Reporting directly to Webb, a member of the NASA Management Council (see below), and the conduit through which all PADs had to pass before arriving on Webb's desk, Finger was both line and staff.

The creation of the Office of Organization and Management was only part of a larger strategy, a wider frame of reference. It assumes importance only in relation to the other functions and roles that comprised "NASA management." Where the three top officials of 1961–1965 had been able to substitute freely for each other, the key officials at headquarters after 1967 were charged with broad functional responsibilities delegated by the Administrator. Finger was, so to speak, both inspector-general and administrative housekeeper. Shapley, whose office was "subject to the overall administrative system established . . . by Mr. Finger," was once more in charge of the offices clustered around external affairs, especially relations with Congress and DOD.[57] Newell, who became Associate Administrator in September 1967, was charged with organizing and coordinating NASA's long-range planning.[58] At the same time, the heads of the program offices were expected to become more like group vice presidents; the more they had to deal with one or two officials like Finger and Shapley, the more they were to shoulder responsibilities for getting their work done. And that work was principally coordination: coordinating their long-range planning with Newell, their project planning with Finger, their congressional presentations with Shapley, and their review of management processes with each other, "as if each were the Administrator having to make decisions concerning and affecting all areas of the Agency's program and operations."[59]

The nature of the administrative changes in NASA from the beginning of 1967 to Webb's resignation on 7 October 1968 may be summarized as follows. First, Webb had a penchant for pouring new wine into old bottles—he liked to retain the name while changing the format. Thus the Office of Management Development, established in 1964 to enable one of his consultants to do some troubleshooting, was revived in February 1968 for the totally different purpose of reviewing all NASA management documentation.[60] Similarly, the Office of Programming became the Office of Program Plans and Analysis and shifted from the preparation and validation of the NASA budget to long-range studies (see figure 3–13 for the NASA organization as of 1968). Such changes tended to emphasize continuity within the NASA administrative system. Indeed, most of the changes at headquarters after 1965 represented a shift in the functions of existing units rather than the addition of new ones.

Second, the changes of 1967–1968 were supposed to lead to group participation in decision making. One of the ways of effecting this was to have the top officials at headquarters meet together periodically for discussion and task assignment. The concept was nothing new: Seamans' monthly status reviews and Webb's attendance at an annual review of each program have already been mentioned. There were also various in-house reviews by the program offices (and

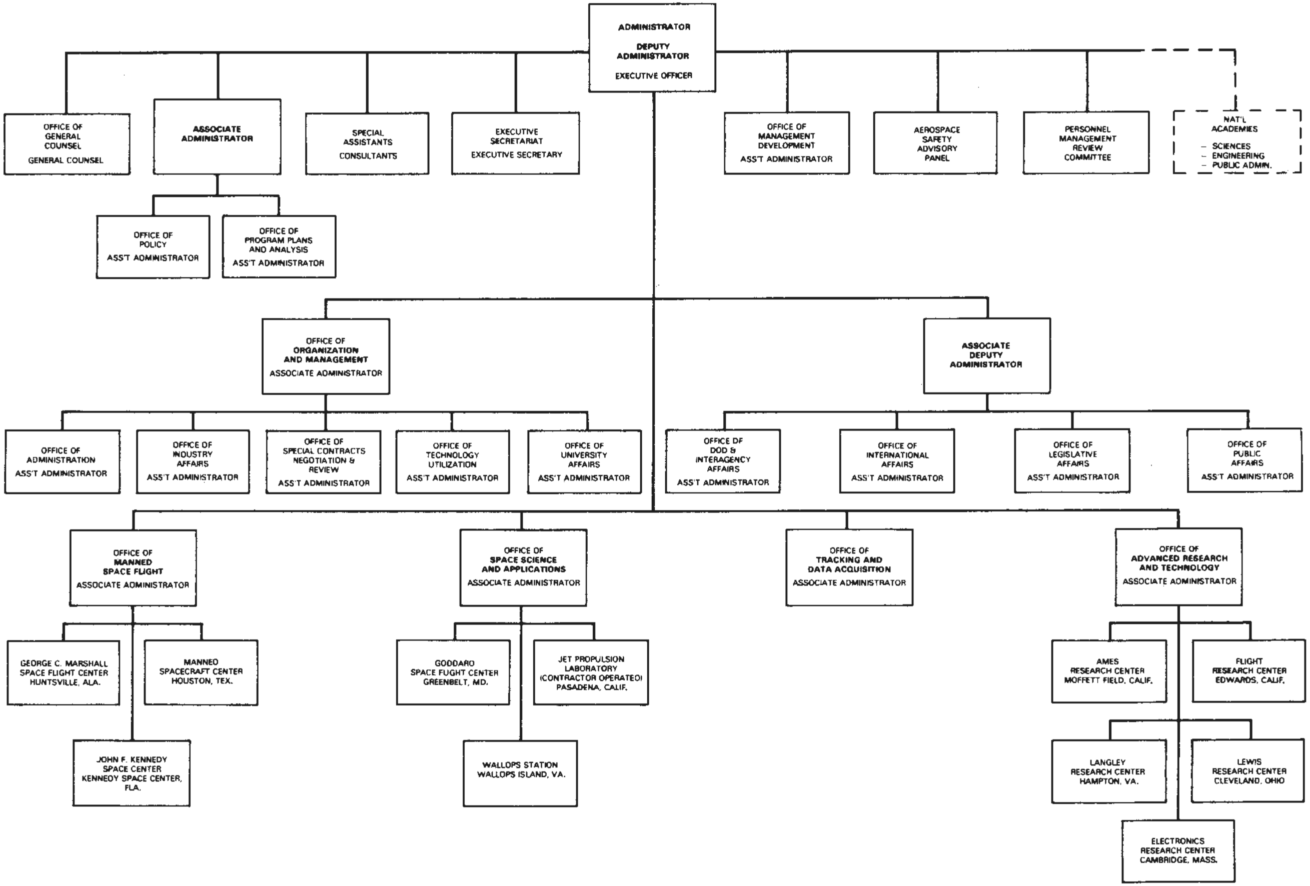


Figure 3-13. — NASA organization chart, 1 May 1968.

often attended by DOD representatives) and, from 1964, annual reviews of advanced mission studies in which each program office discussed its study plans for the upcoming fiscal year. But in line with the administrative fragmentation of 1967–1968, new panels, committees, and councils were set up to focus on NASA-wide problems. Webb established a Management Advisory Panel composed of NASA officials and part-time consultants to serve as a link with the public administration community.[61] As Associate Administrator, Newell chaired the NASA Management Council, which, established in January 1968 and attended by representatives of all the program and functional offices, was supposed to evolve into a top management team sharing responsibility, that is, to assume the functions of a general manager like Seamans.

But the most interesting changes were those involving the program reviews. Each of the reviews suffered from serious flaws. The Administrator's reviews presented each program a segment at a time, and the monthly status reviews mainly covered substantive programs, although Seamans did attempt to include functional managers within the system. Neither considered programs as entities. Worse, none of the meetings made it possible to take a hard look at the total NASA program; none distinguished between program office reviews, which would naturally concentrate on the technical aspects of each project, and top-level reviews, which would examine a broader range of management problems. Such shortcomings in the review system had been aired at several meetings, notably one chaired by Seamans in November 1967. On 11 March 1968 Newell announced that the "'project status reviews" would become "general management reviews" to be attended by all key headquarters officials. The important change was that, instead of dealing with one program at a time, the reviews would "provide a regular forum for the presentation of issues, problems, and policy questions" involving more than one element of "the General Management team." This was not to be an arena for decision making as such. Rather, policy would be discussed "in such a manner that when formal approval channels are used on that particular item, there is a clear understanding by all organizations involved of the nature and substance of that particular issue."[62] The emphasis had shifted from the predictable to the unexpected, from what concerned one office to what affected all. The NASA Management Council would stress the responsibility that officials had both to make policy and to justify what they had done.

Third, the changes only intensified the fragmentation of authority at headquarters. No one below the Administrator's level could even pretend to see the agency as a whole. In particular, the responsibilities for planning and general management were now parceled out to separate officials. The three-man team, each member of which was prepared to substitute for the others, had been succeeded by interlocking councils and panels and by units like Organization and Management that were not so much "offices" as conglomerates of smaller units. Take, for example, the way in which policy planning was handled from 1967 on. Earlier, "policy planning" and "policy analysis" were shown to be thoroughly ambiguous terms. If they were understood to include long-range planning, then no office and no official could really claim full responsibility for that activity. This was as true of the Planning Coordination Steering Groups over which Newell presided as it was of the analytical staffs within the program offices, the Office of Policy reporting to Newell, or Wyatt's Office of Program Plans and Analysis, which pulled together the so-called program memoranda and special analytical studies required by the Bureau of the Budget as part of the annual budget submission. Long-range planning admittedly represents a rather extreme case, and the difficulties in preparing a long-range plan were not only the result of fragmentation. Both the separation of planning from operations and the incomprehension of NASA officials as to the kind of plan to be drafted stemmed from the same source: The key officials, each preoccupied in his own sphere, could not be the general managers that Webb demanded they become.

Fourth, functional management tended to run counter to broader interests in two ways, one relating to the contact between the functional offices and the centers; the other, to the use of the central functional staff by the program offices. In the former case, functional offices like Procurement or Administration tended to work directly through their counterparts at the centers without first consulting with the program offices. As to the latter case, there is evidence showing that the program offices did not use the functional offices to anything like the extent that Webb had anticipated. At a meeting of the Management Advisory Panel in the spring of 1968, he complained that the program directors "didn't reach upward to use the general staff and functional staff in the way that those of us at the top reached down to use them . . . each one began to have around him his own people . . . [and] tended to be autonomous, run things his own way, and you didn't find him reticent to come up when he had a problem with a Senator or Congressman to get help at the top."[63]

Finally, the new organizational philosophy failed to "take," as new men and problems appeared. Seamans left the agency at the beginning of 1968; Webb resigned that October, to be succeeded by Thomas O. Paine who had been appointed Deputy Administrator a few months earlier; and Finger became Assistant Secretary of the Department of Housing and Urban Development in April 1969. A number of new faces appeared at the end of 1969: George Mueller, the Associate Administrator for Manned Space Flight since 1963, returned to private industry, to be succeeded by Dale D. Myers, general manager of North American Rockwell's space shuttle program; George M. Low, the Apollo spacecraft manager since April 1967, became NASA's Deputy Administrator.

By 1970–1971 the organization painstakingly created by NASA general management during the 1960s was changing into something else. The various offices—Industry Affairs, University Affairs, Administration—no longer reported to Organization and Management, which would be dissolved in 1975. Similarly, the various "policy" offices and panels kept going with ad hoc assignments and played no central role in agencywide planning. As a third example, phased project planning, by which each project was broken into discrete sequential steps, was drastically modified in 1972 to permit the program offices to determine procedure on a case-by-case basis. In sum, the concept of group management, which was the heart of Webb's philosophy, was never widely shared by the program offices, the functional offices, or the centers.

CONCLUSION: WHAT DID TOP MANAGEMENT DO?

This account of headquarters organization may seem to have answered every question but one: What did top management *do*? To answer this without having first reviewed the organizational cycles within headquarters did not seem very useful. But having reviewed the organizational changes, what seemed simple and definable is now hedged with qualifications, and the clear patterns of the organization chart must be replaced by complex interlocking networks of formal and informal relationships. Even to assert that the Administrator was responsible, for example, for representing NASA to the rest of the Federal community ignores the fact that the program associate administrators were as much NASA spokesmen in their areas as the Administrator was for the agency as a whole. One must also be aware of the extent to which any top official could act for the others; that Seamans, first as Associate Administrator and then as Deputy Administrator, assisted in making the policies that he carried out; or that Webb insisted on bringing in Dryden and Seamans on the most important management decisions, such as the review of all source evaluation board recommendations involving contracts of $5 million or more. Further, the way in which a function changes or evolves is as important as its official definition at the outset. Much depended on the ways in which officials came to understand their assignments: whether they chose to concentrate or delegate their powers and to increase or narrow their span of control; or whether a function empowered the official to initiate action himself or to review actions taken on some other level.

The role of top management was complicated immensely by the tension between headquarters and the field centers that was built into NASA almost from the start. Each side had its characteristic viewpoint. Headquarters, itself almost a kind of rival installation, had certain key functions that were well understood: to prepare and defend the agency budget; to allocate funds for "research and development," "construction of facilities," and "administrative operations"; and to act as a central point of control. Beyond this, there were problems that senior management could not resolve in the short term. One was whether the centers should report to the agency's general manager, the Associate Administrator, or to the heads of the program offices. The former would appear to be the logical solution when the centers were involved in a variety of projects; the latter, when each center had carefully defined tasks distinct from those of other centers. Another problem was how centers reporting to one headquarters office could work with those reporting to another. A third was the problem of project assignment: whether to give the entire management to one center; to split it between a number of centers and, if so, how to select one as "lead"; or whether to put the entire project management team in headquarters. A fourth problem was how to convert the older research-oriented centers into managers of large development contracts. All these problems were compounded by the necessity, for top management, of taking an agencywide perspective and considering NASA in relation to variables that, in a technological sense, were extraneous to the successful pursuit of the agency mission. If a program was canceled or shifted from one center to another, project managers and center directors might be excused for seeing politics at work. Just as agency management had to defend the NASA budget as if every penny counted, so each center director would see his programs as vital to agency needs. The problem in part was one of communications. The greater the pressures of time, the faster the rate of significant change in the environment, the more interrelated the various programs, the more difficult and necessary adequate communications would be.[64]

So much for any simple, straightforward explanation of administrative behavior. The question of what top management did remains open. This is best answered by describing not discrete functions but broad areas of functional activities, none of which was completely distinct from the others, and all of which served to form the structure of the organization and to settle some of the more important policy issues. These activities are the establishment of uniform organizational procedures; resource allocation; review and control; and the maintenance of intra-agency checks and balances.

Establishment of Uniform Organizational Procedures

Top management, particularly the Administrator, had the prerogative of establishing the organization and procedures most useful to carry out the NASA mission. When Webb came on the scene, he found an organization young enough not to be hidebound by tradition and small enough to be changed with relative ease. This chapter has listed some of Webb's organizational changes: the creation of bureaus with agencywide functional responsibilities for procurement, budget preparation, management development, public affairs, and the like; the use of internal task forces rather than outside consultants for management studies; the establishment of the Office of the Administrator with a supporting executive secretariat; the inauguration of annual reviews of each program area; the location of long-range planning in the line organization; and the invention of stereotyped formats for management instructions, delegations of authority, and (though Glennan had done some of the preparatory work) project authorization. Because of the work of Webb and his associates, there was no need to set up an informal organization to bypass an inherited and cumbersome formal bureaucracy.

Webb's freedom to maneuver in no way minimized the problem faced by top management in selling its philosophy to the rest of the agency—a problem compounded by the changing nature of the NASA mission. In the early 1960s NASA expanded prodigiously to develop its capabilities for manned spaceflight and space science; toward the end of the decade NASA was becoming an aging research and development organization where emphasis had shifted from "the development of capabilities to that of using capabilities already created to meet established needs."[65] The task of organization building thus had a dual aspect: The organization had to be able to get the job done, but it also had to be sufficiently detached from the immediate task to weather any sudden expansion or contraction in its resources. In any case, the top officials had to persuade the rest of NASA to accept their concept of how the agency should be managed. One way of doing this was to handpick key line and functional officials and to make it clear to those already on board that they must either "sign on" or look for jobs elsewhere. A second way to achieve consensus was through face-to-face encounters with other NASA officials. Unlike Glennan, Webb preferred small recurring meetings with heads of program and functional offices. These gave him the flexibility to explain policy, to get feedback from the staff, to discuss unresolved problems, and to decide whether to take immediate action or to table an item for subsequent resolution.

Webb went to great lengths to enunciate the concepts behind organizational changes. Among those mentioned thus far are the concepts of functional management, the role of program associate administrators as group vice presidents, and making major top management decisions jointly. In essence, these concepts could be reduced to the basic principles of management by exception and collegiality. The former principle means that the higher levels of management were called on for decisions "only when something extraordinary occurred in the process of executing approved projects."[66] According to the latter principle, Webb accepted full responsibility for his agency, while delegating his functions and authority piecemeal to officials further down the line. Paradoxically, the option of decentralized decision making was available only to managers strong enough to delegate responsibility.

Resource Allocation

NASA management had the responsibility for (1) allocating resources, that is, determining how much of the agency funds should go for one program rather than another; (2) reviewing proposals and providing the resources for implementing them; and (3) continually evaluating goals, programs, and the allocations themselves. What this meant was that headquarters officials—from the general manager down—worked toward a system in which each program had its place in the NASA mission and in which all programs were covered by documentation sufficient to track them from preliminary studies to formal termination. The history of NASA project authorization policies in the 1960s demonstrates that top management basically wanted two things: the ability to intervene at all key decision points in the life of a project (phased project planning) and the use of the project approval document to control the authorization and funding of every item in the operating budget. In the last analysis, the power of the purse, whether exercised by Seamans or delegated to Finger, was one of the most important internal constraints in determining the character and scope of NASA programs.

Also note that the power to allocate resources was also the power to say no, for example, to deny Holmes the additional $400 million for Apollo that would have had to come out of unmanned space science programs.

Review and Control

NASA management was responsible for control, defined by Sayles and Chandler as "the measurement, *primarily after the fact,* of the extent to which funds are being spent wisely; schedules are likely to be met; and whether all federal personnel, contracting and other policies are being adhered to by both program offices and centers."[67] But to exercise control without knowing what agency units were doing was meaningless. Hence the stress placed by Webb on means of gathering, screening, and disseminating information: the establishment of an executive secretariat for internal communications; Webb's appointment of consultants as links to the Departments of Defense and State and to the intelligence community; the institutionalization of monthly status reviews and annual program reviews; and the creation of the Office of Organization and Management, one of whose functions was to police the agency and to see that each unit was measuring up to agencywide and Government-wide standards.

Maintaining Intra-agency Checks and Balances

Webb and Seamans sought to preserve a system of checks and balances within NASA. Thus program offices such as OSSA and OART forwarded mission concepts different from those of OMSF, while functional management served, supposedly, as a check on the freedom of program offices and centers to pursue their ends at the expense of the overall NASA program. Webb's policy of management by exception meant that tradeoffs between one program office and another or between headquarters and the centers had to be built into the system itself. Hence the freedom of program directors to transfer funds between projects, subject to their ability to justify the transfers at management reviews. Hence the overlapping responsibilities of the program offices, the "space science" component within OMSF, the "manned" element within OSSA, and their joint responsibility for coordinating their supporting research and technology with OART. Each office also had agencywide responsibilities over and above its specific task: OART for aeronautics and supporting research and technology, OSSA for university grants, OMSF for the development of large launch vehicles. Much overlapping and duplication was deliberate. Officials were able to report to two or more superiors if necessary; program associate administrators had "line" and "staff" functions; and certain functions, for example, those of an inspector general, were dispersed among four or five offices instead of being concentrated in one.[68] Such overlapping forced each program or functional manager to undertake responsibilities in an agencywide context.

Chapter 4

The NASA Acquisition Process: Contracting for Research and Development

A Summary of NASA Contracting Philosophy

From its establishment to the present, NASA has contracted with the private sector for most of the products and services it uses. Compared with the organizational changes discussed in chapter 3, changes in this area have been slight. Between 1958 and 1965 NASA developed procedures at once internally consistent and politically acceptable, and which would spread NASA funds widely through the economy. The greater part of the acquisition process is traditionally called *procurement*, but that term is not used in this chapter title for three reasons: it sets too sharp a division between the preaward phase of the contract and its postaward administration; it implies that responsibility for contracts was concentrated in a particular headquarters office, when in fact there was scarcely a key official who was not involved; and something is needed to link procurement and contracting with the planning of NASA projects. Project planning (including listing mission objectives and their rationale, preliminary estimates of schedules and costs, and risk assessment) and procurement were the elements of a double-stranded process. The more general term *acquisition process* covers what is meant by procurement and has been used within NASA to signify "an orderly progression of Agency programs from early concept through the development and operation of hardware . . . and [provision of] the best sources . . . in the execution of projects and the performance of supporting services."[1] A basic feature of the process is that the program sets the contracting philosophy, not the reverse.

What sort of programs are we talking about? The official NASA source evaluation board manual has enumerated those special features that bear on the process, including "technological complexity, tight time schedules, unusual reliability requirements, a general absence of quantity, and little follow-on production."[2] As of March 1969 NASA had bought twenty Mercury, thirteen Gemini, and thirty-eight Apollo (command service module) spacecraft, including "boilerplate" (test) models and spacecraft modified for changed mission objectives.[3] Furthermore, NASA often had to contract for products whose main features could not be precisely defined in advance, so there was no clear-cut basis on which the bidder could estimate costs. In such cases NASA could not use formal advertising and turned to negotiated procurement.

With important exceptions, NASA scientists and engineers have not built flight hardware. Rather, they have planned the program, drafted the guidelines, and established the parameters within which the product is to be developed. Viewed in this light, the rationale for an in-house staff has largely been to enable NASA to perform those functions that no government agency has the right to contract out, functions enumerated by a former Director of the Bureau of the Budget as "the decisions on what work is to be done, what objectives are to be set for the work, what time period and what costs are to be associated with the work, what the results expected are to be . . . the evaluation and the responsibilities for knowing whether the work has gone as it was supposed to go, and if it has not, what went wrong, and how it can be corrected on subsequent occasions."[4] Without the experience of actually building a spacecraft or performing experiments, center personnel could not effectively select industrial contractors or supervise flight projects running to many millions of dollars. The in-house work in advanced and supporting research and technology at Lewis, Langley, or Goddard was done less for its own sake than because, without it, Government personnel would have had no prospect of keeping contractors at arm's length. Nor could a center attract and keep the best people unless they had the opportunity, as Wernher von Braun put it, "to keep in touch with the hardware and its problems."[5]

By separating evaluation and production, NASA acquisition philosophy has had three especially important long-range consequences: the delegation of technical direction and monitoring to the centers, the refusal to set up a production capacity already existing in the private sector, and the refusal to create operating divisions intermediate between public and private sectors.

NASA has generally preferred to stand in relation to private organizations as buyer to seller and not to establish captive research centers like the RAND Corporation, the Aerospace Corporation, and the Institute for Defense Analyses. Exceptions such as Bellcomm and the Jet Propulsion Laboratory (JPL) are more apparent than real, although, like genuine Federal contract research centers, they worked for a single sponsor who guaranteed stable annual funding.[6] Bellcomm, NASA's one experiment in sponsoring an adjunct trouble-shooting organization, differed in two respects from most captive groups: it was established as a profit-making corporation, and it was dissolved when its ostensible reason for being ended. As for JPL, it performed a variety of functions, and work was assigned as though it were a NASA center. The reasons for NASA's aversion to captive organizations were complex, but they stemmed mainly from top management's desire to keep NASA's suppliers at a healthy distance, rather than (in Webb's words) "to create some new kind of organism which we would then be responsible for monitoring and which would in some way become dependent on us for support . . . and where we would have to evaluate their work not only on the projects assigned, but as to continued support."[7] When NASA contracted for analytical or advanced mission studies it did so ad hoc, and it was not averse to using those same Federal contract research centers it was loath to establish in its own organization.[8]

NASA has generally preferred not to manufacture items available from private firms, even where it had the capacity to do so. Consider the choices posed by the problem of how best to develop automatic data processing (ADP) equipment, which was essential for mission control, data reduction, flight simulation, information retrieval, financial management, and image processing of data returned by remote sensors. NASA management chose not to build an ADP capability similar to what it was developing in space electronics. The computer was a tool, not an end product, and the research and development work of IBM, Control Data, and Minneapolis-Honeywell obviated the need to match the private sector strength for strength.[9] Instead, the Office of Tracking and Data Acquisition compiled an annual ADP plan based on individual plans submitted by the centers. The plan served as the basis for reports required by the Bureau of the Budget and the General Services Administration, as a point of departure for negotiations with commercial suppliers, and as a yardstick for future planning.[10] This approach served NASA well. By 1967 NASA had gone from first-generation equipment based on vacuum tubes to second-generation (transistors), and third-generation (integrated circuitry) equipment in less than ten years.[11] And by letting contracts for the installation, programming, and maintenance of computers—generally for one or three years with an option to renew—NASA escaped heavy fixed costs for manpower and equipment.

NASA's ADP planning also demonstrates the agency's policy of assigning the acquisition process to the field installations where engineers and procurement specialists had the competence to decide the feasibility of negotiated competition in any given instance, prepared the initial procurement plan that served as the basis for a request for proposal (RFP), and made awards up to a dollar level that was raised from time to time by headquarters.[12] Even in cases where headquarters made the award—where the bidding was noncompetitive or the action involved a competitively negotiated procurement of an amount more than the centers were authorized to handle—most of the preliminary steps were taken by center employees who wrote the procurement plan or served on the source evaluation boards reporting to the Administrator. Since the technical expertise to evaluate and the management skills to select were heavily concentrated at the centers, any other course would have been less efficient.

However, a word of caution seems in order. Drawing the line between evaluation as an internal function and design and production carried out by firms under contract was not easy. The private sector has been called on to define the major systems of most large programs; to integrate the interrelated parts of a system, such as the stages of a launch vehicle or the vehicle and the payload it was intended to place in orbit; or to do checkout analysis that required the inspection of other companies' performance. In addition, the selection of the most qualified bidder depended on the qualifications sought. Agency officials had to decide, for example, whether to negotiate only with the most technically competent source or to encourage limited competition to obviate NASA's becoming captive to any single contractor; whether to select one firm to integrate all the systems in a complex flight project like Apollo, to have the work done by several companies under NASA technical direction, or to have it done by NASA employees; and to what extent one or more contractors could share in the early planning stages of approved programs. None of these problems was purely technical. In choosing a source, NASA had to consider not only the contractor's skills but also how the selection would affect NASA's relations with Congress, other Federal agencies, and the aerospace community.

So much by way of summary. To analyze the contracting cycle without being swamped in complexities, the remainder of this chapter deals with the questions such a process raises:

1. How did the procurement (contracting) process develop to subserve the ends for which NASA was constituted?
2. To what extent did NASA staff retain full control of program planning and management? Alternatively, what was perceived within NASA to be the dividing line between functions that could and could not be delegated to outsiders, whether firms, not-for-profit research centers, or universities?
3. To what extent did NASA's acquisition polices achieve such goals as "maximum competition consistent with the nature of the procurement," providing "the best sources to participate in the execution of projects and the performance of supporting services" and other formal expressions of policy? [13] In short, how well did the acquisition process work on its own terms?

Origins of Government by Contract

As one student of Federal contracting has observed, the shift from work done in-house to contracting out was the result "not so much of explicit congressional direction as of agency decisions, in which Congress acquiesced, to seek the important advantages believed to be gained from close contacts with the capabilities of the private sector in R&D." [14] One could trace the American bias in favor of private enterprise to at least the late 18th century; but for our purposes, we need not go as far back as Hamilton's *Report on Manufactures.* After World War II, three circumstances conspired to increase enormously the volume and dollar value of work done for the Federal service under contract and to change the character of that work: the virtues of contracting out to the private sector, the limitations of formal advertising, and the demand for special skills in the management and integration of complex weapons systems. The advantages of contracting, especially for management and consulting services, were readily apparent. The Government could tap experience and capabilities already available in the private sector; it was not bound by civil service regulations pertaining to hiring, dismissal, salaries, or work termination; persons who would not work for the Government because of red tape could be hired under these conditions; and the use of contractors probably allowed a much more rapid buildup of a large work force where such manpower was needed.

At the same time, many Federal agencies, especially the Department of Defense (DOD), found the limitations of formal advertising irksome. The 1947 Armed Services Procurement Act reaffirmed that advertising would remain the norm, and other modes "exceptions," for Government contracting.[15] Yet advertising had only limited application for defense and, later, for space research and development. To advertise for bids, one must usually be specific about the item required, the design must remain fixed over a long period, and the lowest bid must normally be accepted by the contracting officer. In practice, formal advertising did not lead to more competition; a 1966 RAND study showed that of some 2300 procurements studied, 45 percent resulted in three bids or less, 32 percent in two bids or less, and 8 percent in only one bid.[16] Increasingly, agencies with long-lead-time programs began to waive formal advertising—as the Armed Services Procurement Act allowed them to—in favor of negotiation because it allowed them much greater scope in exploring their bidders' proposals and cost data.

The only programs since the Manhattan Project comparable to the NASA mission were the weapon systems programs managed by the Air Force since 1954. Problems that became characteristic of civilian space research and development—the difficulty of estimating costs, the general uncertainties of the process, the long lead times—had already been faced by the Air Force in the management of the Atlas and Titan intercontinental ballistic missiles. In 1954 the Air Force established a Western Development Division of the Air Research and Development Command under Gen. Bernard Schriever to direct and coordinate its ballistic missile programs. The similarity between Western Development and NASA need not be pushed too far. The former was a blank-check outfit set up to run a crash program to close the missile gap. Under Schriever's philosophy of concurrency, production and operations were telescoped together, even while research and development were proceeding. Concurrency meant "simultaneous work on basic and applied research, vehicle design, component design, test facility design and construction, component and system testing, the creation of production facilities, and the design, proof, and test of launch site facilities without which the missile would be impotent."[17]

Schriever's approach to program management was equally radical. The case for hiring systems contractors to manufacture and integrate the components was not open and shut. The Army, at its Huntsville Arsenal, was as capable of developing weapon systems (e.g., Jupiter) as complex as the Air Force's Thor intermediate-range ballistic missile. In essence, the Air Force turned to private contractors because it had neither the depth of competence found in Army laboratories nor the time to recruit engineers. For various reasons, including politics, the Air Force preferred to foster a civilian aerospace industry in peacetime. The research and development capabilities were there, ready to be exploited. Moreover, many Air Force weapons managers were convinced that, in contrast to the Army's arsenal system, "intimate relations with industry did promote a significant shortening of the long period of weapons gestation."[18] While retaining ultimate responsibility for its programs, the Air Force delegated to civilians every aspect of the research and development cycle. In several cases the Air Force selected a prime contractor for technical integration, testing, assembly, subcontracting, and the like; this was how the Bomarc missile and the B-58 bomber were developed.[19] In its ballistic missile programs, the Air Force worked through several associated contractors for components and subsystems and hired a separate organization, the Ramo-Wooldridge Corporation, to serve as technical director of the program. Ramo-Wooldridge, excluded from production of hardware, was both "line" and "staff"; the former insofar as it did systems engineering and provided technical direction for the Western Development Division, and the latter inasmuch as it also did long-range planning studies for the Air Force.[20]

The Army's arsenal system and the Air Force's use of independent contractors for systems engineering might be considered two extremes in the Government's management of its R&D programs. Yet there is a point at which extremes meet. At the Huntsville Arsenal "as much or as little in-house production was possible as was compatible with the objective of keeping the technical team on the fringes of research and development work, or assuring the most rapid development of a specific item."[21] On the other hand, the Air Force, in hiring Ramo-Wooldridge and, later, the Aerospace Corporation to provide technical direction for its missile programs, was creating its parallel to the arsenal system. NASA could use features of both approaches without duplicating either. From the beginning it was NASA policy to contract out for items that could not be procured off the shelf (table 4–1).

How far NASA was prepared to go in hiring a contractor to do integration work is less clear. Some centers, like Goddard, occasionally integrated their own flight projects. In the case of the largest projects, especially Apollo, it is not even certain that there was a single contractor or center to integrate all the systems. Rather, each center delegated its responsibility to an industrial contractor, for example, Marshall's Saturn IB and Saturn V integration to Chrysler and Boeing, respectively. With NACA laboratories, the Vanguard Division of the Naval Research Laboratory, and the von Braun team, NASA had the competence to perform those functions in-house that the Air Force had delegated to Ramo-Wooldridge and the Aerospace Corporation. The following section examines how NASA developed and refined its policies for acquiring and launching complex space systems.

Table 4–1. — Distribution of direct NASA procurements, FY 1960–1968.

Type	FY 1959[1]	FY 1960	FY 1961	FY 1962	FY 1963	FY 1964	FY 1965	FY 1966	FY 1967	FY 1968
					Net Value of Awards (Millions)					
Total	*$212.5*	*$336.7*	*$755.5*	*$1 550.6*	*$3 230.5*	*$4 593.9*	*$5 187.4*	*$5 031.6*	*$4 650.9*	*$4 132.7*
Business firms	87.8	174.0	423.3	1 030.1	2 261.7	3 521.1	4 141.4	4 087.7	3 864.1	3 446.7
Educational	5.8	17.0	24.5	50.2	86.9	112.9	139.5	150.0	132.9	131.5
Nonprofit					15.3	29.1	25.3	27.7	39.6	33.6
JPL	22.4	38.3	86.0	148.5	230.2	226.2	247.2	230.3	222.2	207.2
Government	96.5	107.4	221.7	321.8	628.5	692.6	622.8	512.5	366.9	287.0
Outside U.S.	([2])	([2])	([2])	([2])	7.9	12.0	11.2	23.4	25.2	26.7
					Percent of Total					
Total	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
Business firms	41	52	56	66	70	77	79	81	83	83
Educational	3	5	3	3	3	2	3	3	3	3
Nonprofit					([3])	1	1	1	1	1
JPL	11	11	12	10	7	5	5	5	5	5
Government	45	32	29	21	20	15	12	10	8	7
Outside U.S.	([2])	([2])	([2])	([2])	([3])	([3])	([3])	([3])	([3])	1

[1] Nine months operation.
[2] Included in Government.
[3] Less than 0.5 percent.
Source: NASA Procurement Office, *Annual Procurement Report, Fiscal Year 1968,* p. 70.

How NASA Learned To Deal With Its Contractors, 1958–1962

The management of the acquisition process may be considered as a set of subsidiary, interrelated problems: providing a legal framework, creating a source selection procedure, safeguarding the privileged nature of source selection documents, and finding the right organizational location for the procurement function. With modifications, NASA adopted the Armed Services Procurement Regulations of 1947, which had been extended to civilian agencies in 1949 by delegation to the General Services Administration (GSA). The procurement regulations, which listed seventeen categories exempted from the rule of awarding to the lowest responsible bidder, including "services for which competition was impracticable" and "services for experimental or developmental work," enabled NASA to negotiate R&D contracts and even go to a company on a sole-source basis.[22] In an exchange of letters in 1959, GSA permitted NASA to follow the armed services regulations in those cases where they differed from GSA's Federal procurement regulations, otherwise binding on all civilian agencies.

Under Glennan, officials adopted and modified the DOD source evaluation procedure for proposals on large prime contracts—those of $1 million or more. When NASA negotiated in such cases, the usual procedure was to set up a source evaluation board (SEB). By 1961 the procedure had been elaborated to comprise the following stages: preparing a procurement request by the responsible division or center; drafting a procurement plan by the appropriate contracting officer, in which was outlined the proposed procurement, the funding, the sources to be solicited, the type of contract to be used, the schedule for completing the procurement, and the negotiation determination and findings; preparing a request for proposal if the contract was to be negotiated; and awarding the contract by the Administrator whenever the contract was for $5 million or more. Each stage of the process had its own difficulties—the precision with which procurement plans could be drawn, the decision to advertise or to negotiate, and fixing the particular stage of the R&D cycle at which to request proposals. The development of a standard selection procedure took several years, but Glennan took two key steps. The first, announced in August 1959, was the promulgation of guidelines for awarding very large contracts; this was to be done by the Administrator, assisted by ad hoc boards responsible for establishing the selection criteria for each contract. The second, determined in late 1960, clarified the role of the boards in source selection. "Instead of the [source evaluation board] selecting contractor sources, or making *recommendations*, it became the primary SEB function only to *evaluate* potential sources and *order rank* their findings. The selection decision rested solely with the Administrator."[23]

Yet it would be misleading to assert that NASA had a uniform selection procedure, even in 1961. There was no single evaluation process. "There had been almost as many approaches . . . as there had been NASA programs. . . . NASA Headquarters had provided only the broadest guidelines for source evaluation practices . . . thereby permitting the Centers wide latitude and flexibility . . . in this area."[24] Moreover, there was a real danger that the formal selection process might become so cumbersome as to defeat its own ends by increasing rather than lowering the cost of R&D.

In addition, Glennan and later Webb had to come to terms with the supposedly privileged nature of source selection documents. They would both insist that certain records of contract negotiations, such as the SEB report, should not be available to congressional committees; that their disclosure could only damage relations between NASA and its contractors, jeopardizing the mode by which both sides transacted business; and that, in any case, nothing essential was omitted in those documents that NASA chose to make public. This issue, which first surfaced in 1959 when the U.S. Comptroller General and later the House Science and Astronautics Committee demanded the records of NASA's negotiations with the Rocketdyne Corporation for the F-1 engine, was to become the basis of serious criticism in 1967 when Webb refused to produce certain key documents pertaining to the North American Aviation contract for the Apollo command and service modules.[25] In a very real sense, the "production of documents" controversy was part of the larger question of how far NASA was willing to go in riding herd on its prime contractors: whether, for example, it was prepared to terminate a contract in midcourse because of the contractor's incompetence or go to a second source when a contractor was unable to fulfill its responsibilities; whether NASA was willing to disallow costs and penalize contractors for overruns; finally, whether NASA had a sufficient depth of in-house skills to prevent the agency from becoming captive to its contractors.

The question facing Webb, Dryden, and Seamans in mid-1961 was how well such a contracting system would serve to organize the manned lunar landing program. In general, they accepted, while improving on, the procedures instituted by Glennan. The principle of contracting out for R&D was reaffirmed; the role of in-house staff in technical direction was stressed; and headquarters officials took it upon themselves to make procurement policy more uniform yet flexible enough for NASA to obtain space hardware whose main features could not be specified in advance. The key organizational change was the establishment of an Office of Industry Affairs in March 1963, with NASA's Procurement Division placed directly under it.* " . . . instead of being one of several divisions in the Office of Administration, the Procurement Division became the all-important division under a Deputy Associate Administrator."[26] Procurement Director Ernest Brackett and his deputy, George J. Vecchietti, who succeeded him in February 1964, laid down the general rules of the process: to advise the head of the Office of Industry Affairs on procurement matters, to publish and coordinate agencywide procurement policies, to make determinations respecting procurement matters, and to serve as liaison with other agencies, especially DOD's office of Installations and Logistics.[27] Brackett's powers did not extend *directly* to the substantive nature

* An autonomous Headquarters Procurement Branch was established in July 1961.

of NASA contracting. It was the center employees' responsibility to draw up the procurement plan, draft technical specifications, and develop realistic cost and budget estimates.

The other important changes of 1961–1963 focused on two closely related problems: how to structure the contract to the work desired and how to draw the line between functions that could or could not be delegated to contractors. For its largest R&D contracts NASA had to go to negotiation; and while negotiation did not automatically preclude competition, attaining competition became more difficult. There were also two situations in which competition was not feasible, and the contracting officer recommended that NASA negotiate with a single firm. The first case is represented by the contracts for the Gemini spacecraft and for ten improved Delta launch vehicles, both of which were awarded to the McDonnell-Douglas Corporation. McDonnell-Douglas had been prime contractor for the Mercury spacecraft. The Mercury and Gemini designs were similar, the second program was intended to follow closely on the first, and the technical experience gained in Mercury gave McDonnell-Douglas a decided advantage over other potential suppliers. The justification for negotiating with McDonnell-Douglas for the Delta vehicles was similar. The firm had the experience and proven capability to do the work, going to a new source would cost an additional $10–20 million and delay launch schedules by eighteen to thirty months, and without McDonnell-Douglas experience, it would be difficult even to prepare definitive specifications outlining the scope of the work.[28] The second case was one in which, as Brackett explained,

> the nature and scope of the work is such that very special technical, management, and organizational capabilities are required. In such situations, while it cannot be said that there is only one company capable of performing the work, a particular company nevertheless stands out among all others as possessing a superior combination of the requisite, and sometimes unique, skills.[29]

In the same category were the contracts involving the creation of Bellcomm and commissioning General Electric to perform test and checkout services in support of Apollo.

But the difficulty in working such a system was that it tended to weaken NASA's bargaining position vis-à-vis its suppliers. NASA officials wanted as many alternatives as were available, and they wanted to bring about a state of affairs where the contractor also stood to lose. In 1961 the majority of NASA R&D contracts provided for paying a contractor for all acceptable costs plus a fixed amount of fee as profit, or simply cost-plus-fixed-fee (CPFF).* Whatever their value in attracting bidders, CPFF contracts could scarcely be considered efficient even by the most liberal definition. In a "cost-plus" contract, the contractor was not penalized sufficiently for underbidding or for inadequate performance. Nor did the contractor have any real incentive to economize. Quite the

* See appendix D for definitions of contracts authorized by NASA.

contrary; while the fee was fixed, cost overruns would be profitable to the contractor.

In effect, the problems plaguing NASA contract policy ran the gamut from heavy cost overruns to the expense of preparing proposals (an expense borne almost entirely by the Government), to the excessive time spent by NASA employees in judging proposals, to firms' reliance on "brochuresmanship" to win NASA contracts. For each contract, several questions had to be resolved. For example, should the contractor use Government-furnished equipment or provide its own facilities, and how much should be allowed for research and development undertaken at the contractor's discretion, so-called independent research and development? Such problems were closely related and had to be attacked from many angles, from program definition to postaward administration. The principles that NASA officials enunciated were the ones behind the major reforms of 1962–1965: developing realistic specifications before proposals were solicited, including in the RFP as many of the definitive contract terms as possible, strengthening in-house capabilities for technical direction, and screening proposals to eliminate companies with no reasonable chance of receiving a contract.

THE BELL REPORT AND ITS AFTERMATH, 1962–1963

The NASA acquisition system was not solely a technical response to technical problems of managing the space program. NASA, DOD, and the Atomic Energy Commission, the three Federal agencies that spent 90 percent of the Government's R&D dollars, had to come to terms with a blurring of the public and private sectors in the late 1950s.[30] When the facilities of the Atomic Energy Commission were operated under contract, when many of the leading aerospace firms did essentially all their business with the Federal Government, when a very large share of university research was funded with Federal grants—the line between private and public was no longer clear. Of all the studies devoted to the problem, one of the most searching and influential was the report to the President submitted by Budget Director David Bell on 30 April 1962.[31] The task force that Bell chaired included Webb, Defense Secretary Robert McNamara, Presidential Science Advisor Jerome Wiesner, the chairmen of the Atomic Energy Commission and Civil Service Commission, and the director of the National Science Foundation. The Bell report did not set guidelines applicable to every circumstance or draft rules broad enough to cover all contingencies, but it did lay down a general rule:

> There are certain functions which should under no circumstances be contracted out. The management and control of the Federal research and development effort must be firmly in the hands of full-time Government officials clearly responsible to the President and Congress. . . . decisions concerning the types of work to be undertaken, when, by whom, and what cost . . . must be made by full-time Government officials.[32]

The report also concluded that the effects of contracting out Federal R&D work "on the Government's own ability to execute research and development work had been deleterious"; and the report's principal recommendation—that Federal agencies use their laboratories to maintain knowledge of the most advanced science and technology—was put forward as a means of making Government a more sophisticated buyer.[33] The Bell report accepted as settled the need for science-based agencies to go outside Government for scarce and valuable skills; it defended the profit motive as often the most effective way to get the job done; and it strongly dismissed any notion that the Government provide hardware or services that were available from the general economy.

What effects did the Bell report have on the Federal structure in general and on NASA in particular? One of its recommendations, that pay scales for Federal scientific personnel should be made "comparable" to those in the private sector, was partially met by the 1962 Federal Salary Reform Act, which also abolished the quota on the number of supergrade positions allotted for scientists and engineers. The report had also warned the Government that its contractors or employees were too often placing themselves in situations where conflicts of interest became unavoidable; here, tentative guidelines were set forth in a Presidential memorandum of 2 May 1963.[34] Most important, the report recommended broader use both of fixed-price contracts and contracts with incentive provisions. In this case, some of the pressure for change came from those agencies, especially DOD, that were represented on the Bell task force. Prior to the report's publication, DOD officials had addressed some of the problems that led to the task force's creation by (1) publishing jointly with NASA a guide to stiffen the reporting requirements imposed on their prime contractors; (2) introducing the concept of program budgeting, whereby the Defense budget, force requirements, and alternative methods of meeting them were combined on a multiyear basis; (3) strengthening the "hardware ban" so that no firm could act as general systems engineer and produce components for the same project; (4) tightening contract administration; and (5) revising in March 1962 the armed services procurement regulations to make the fixed-price contract the preferred type or (where this was impracticable) to include incentive provisions with fees up to 15 percent.[35]

Not all DOD management procedures could be transferred wholly to NASA, if only because NASA contracted for some products that were much more specialized than anything the military needed. In fact, the contracting styles of the two agencies differed. Unlike DOD, NASA took title to all inventions resulting from the performance of R&D contracts, as required by section 305 of the Space Act. As of 1962, NASA had no "excess profits" clause in its contracts and was not bound by DOD's statutory requirement to terminate a contract if the contractor offered or gave a gratuity to secure favored treatment.[36] Further, program budgeting, which came to be almost synonymous with Defense Secretary McNamara's method of working, was only reluctantly accepted at NASA when it was extended to civilian agencies in 1965. All the same, the innovations at DOD were bound to have repercussions within NASA. The Space Act required both agencies to coordinate their programs, they shared many of the same prime contractors, and since its establishment NASA had used contract administration services supplied by DOD. The 1963 changes in NASA procurement were due essentially to the example set by DOD, combined with technical problems intrinsic to the space program.[37] But whatever limited steps NASA took before the summer of 1962 to reduce the cost of doing business with industry, the Bell report made it politic to intensify such changes. The first, middle, and last steps involved improving the definition of specific programs, which NASA did by revising its contracting structure: using fixed-price contracts where possible, eliminating letter contracts, and rewarding contractors for detailed, accurate estimates and for selecting their subcontractors competitively.

The sequence of changes in NASA's contracting system can be stated briefly. On 29 May 1962 Webb appointed a study group chaired by Walter Sohier, the NASA General Counsel, to review the source evaluation procedure and various methods of improving contractor performance.[38] Between the establishment of the Special Procurement Study and its final report in February 1963, NASA moved toward wider use of incentive contracts. In September a NASA circular announced that the agency would favor "procurements that lend themselves to the use of contract incentive provisions" while avoiding their use where they were unsuitable. In the same month Webb named Robert H. Charles, a McDonnell executive, as his special assistant with responsibility for procurement. Before he left NASA in November 1963 to become Assistant Air Force Secretary (Installations and Logistics), Charles wrote several reports whose main conclusion—that "significant improvement in product quality . . . timeliness and cost can be achieved if the procurement process is saturated with competition before contract execution, and with performance and cost reduction incentives thereafter"—became the cornerstone of NASA contracting policy.[39] The events of the following year represented the unfolding of this principle: the final report of the study group, recommending that NASA improve its handling of incentive contracts and compel its contractors to prepare better work statements; the January 1963 budget request, which provided for the establishment of an Electronics Research Center; Seamans' memorandums of 25 February and 22 March to all center directors, suggesting that the RFP, including the incentive clause, "contain the precise language of the *definitive* contract terms"; and the directive of November 1963, ordering that CPFF contracts be reduced substantially and that incentives be considered for all.[40]

The Bell report was less the effective cause of these changes than their catalyst. The report, signed by Webb, did not go beyond NASA practice or the 1960 report of the Kimpton committee. NASA had always accepted in principle the division between in-house and contracted work. Years later, Webb asserted that he had "made sure that the things I considered important either could or would be incorporated in the final report. . . . It may be that on certain of the most important matters, I played one of the more decisive roles."[41] By endorsing the existing system the Bell report made it easier for NASA and DOD to make some changes that would go down well with Congress. Any policy intended to save tax money by rewarding a contractor for good performance and penalizing it for a bad one would be welcome there. To act in the spirit of the Bell report was good public relations, and it was cited explicitly before congressional committees as justification for establishing an Electronics Research Center or writing incentive provisions into new contracts.[42]

To repeat, the real basis for the 1962–1963 changes must be sought in the risk-bearing features of NASA programs. It is easy enough to assume that the risks were almost entirely on NASA's side. But from the standpoint of those companies that NASA invited to bid, the risk might not seem worth taking. Why, for instance, should a business organization invest enormous capital in building a plant to produce liquid hydrogen with no guarantee that it would be needed beyond a few missions? Contracts also tended to change as the systems did. For R&D of this sort, NASA used CPFF rather than competitive bidding or fixed-price contracts. But the great, the fatal, defects of CPFF were that profit was not tied to performance and that for all intents and purposes the contractor could not lose. The firm was not penalized for overruns nor rewarded for administrative efficiency. The firm had more reason to concentrate on getting the contract—often by bidding low—than on managing it.

The difficulties with incentives were of a different order, depending on whether a new contract or conversion from CPFF was involved. Incentives were tricky: Often little hard data were available to determine the relative importance of performing on time, within cost, and to specifications. These difficulties were compounded when converting an existing contract. The problem had a five-fold aspect:

1. Seeking to make the buyer more sophisticated in defining the mission design and the standards for successful performance.
2. Determining the proper weight and scoring for such performance.
3. Avoiding unrealistic cost estimates.
4. Persuading the contractor to adjust risk and convert voluntarily.
5. Reducing the number of cases of sole-source procurement without returning to competitive bidding and its disadvantages.

These goals were not easily attained. To convert the North American Aviation and McDonnell contracts for the Apollo and Gemini spacecraft took from 1962 through 1965. Few systems were as simple as the Early Bird communications satellite, which was "well-defined, requiring little or no development, operating with little or no technical direction, and procuring an essentially off-the-shelf item."[43] Others, like the J-2 engine, were difficult to manage, let alone convert, because the programs themselves were changing. Originally designed for a two-stage vehicle, this engine had to be modified for the S-II stage of the Saturn V, and its firing time extended from 250 to 350 to 400 and eventually to more than 500 seconds. When the contract had been negotiated, no firm requirement existed for such an engine, and it involved "a minimum of facilities, a minimum of tests, and an engine which is considerably short of the present performance."[44] In such cases, the variables affecting NASA's ability to convert a contract from CPFF to some form of incentive were the technical complexity of the project, the contractor's attitude toward conversion, the technical competence of the NASA contracting officer, and the objective desired—whether cost control, prompt delivery, or improvement in performance. All these criteria were tied to the source evaluation procedure by which the contractor was selected. As we shall see, there was often less competition than the system promised because some companies were so clearly superior for a given system that NASA had to resort to sole-source procurement. Moreover, while the SEBs only "evaluated," rarely did headquarters select someone not in effect recommended by the evaluation.[45] Indeed, one official complained that in certain contracts for support services Webb and Seamans concluded "that they could do nothing else than to accept the judgment of the source evaluation board."[46]

NASA Contract Administration

By the end of 1964 NASA had revised its contracting structure within the management system established by the 1963 reorganization. In general, NASA had brought its contracting policies into line with those of DOD and had delegated to the Defense Supply Agency and the Defense Contract Audit Agency much of the responsibility for administering its contracts, a development foreshadowed by DOD's Project 60 study, begun in May 1962. In August 1963 the Project 60 policy committee, which included NASA representatives, recommended consolidating NASA and DOD field contract administration in a single agency under the Office of the Secretary of Defense, a recommendation first carried out as a pilot project in the five-State Philadelphia region beginning in April 1964.[47] That June DOD consolidated its field administration service into eleven Contract Administration Service regions, which handled the vast bulk of NASA contracts, and the transition period was largely over by 1966.

In substance, NASA delegated many contract functions to Defense agencies, that is, the authority to handle property administration or to consent to smaller subcontracts. NASA retained the authority to change the terms of the contract. At the beginning of FY 1967 DOD was administering approximately 1700 NASA contracts totaling $11.7 billion; 1500 of these, worth $4.2 billion, were handled by the Defense Contract Administration Service (DCAS), set up as a result of Project 60, while another 200, worth $7.5 billion, were managed by that military department having "cognizance" of all contracts in one plant.* The Air Force, for

* In one case NASA departed from the principle of using DOD capability. From 1962 to 1967 NASA maintained a contract management unit at North American Aviation's plant in Downey, California, to represent NASA on plantwide matters and to provide day-to-day support for the Apollo command and service modules and the second stage of the Saturn V.

example, had cognizance of Boeing (Seattle), Rocketdyne, and Douglas, while the Navy handled Grumman. Where NASA let a contract that would not be performed at a cognizant assigned plant, it was sent to the DCAS regional office where the contractor was located. The great advantages of this arrangement were that it allowed NASA to work through a single Government agency, DCAS, for field administration; it avoided a wasteful duplication of services; and it enabled NASA to make maximum effective use of DOD, while reserving to itself those functions that it could not delegate.

The Hilburn Task Force and the Origins of Phased Project Planning (1964–1965)

If 1964 was the year in which NASA attained organizational maturity, it also marked the stage at which some of its largest projects ran into serious trouble. By September the delays, particularly in Apollo, had become so grave that Seamans warned Mueller "if present trends continue we will not achieve a lunar landing in this decade and the cost of the program will be in excess of twenty billion dollars."[48] Why was the situation worse than it had been a year earlier? The answer lies partly in the peculiar technical difficulties connected with Apollo, requiring as it did the simultaneous development of a launch vehicle, three spacecraft modules, and ground support equipment at the Cape. Many components operated satisfactorily when tested alone but failed when incorporated into a system, for example, the automatic checkout equipment for the Apollo spacecraft.[49]

The difficulty that became increasingly evident to Seamans and his staff was that the contractor's organization was not structurally adequate to the demands made upon it. North American Aviation, the prime contractor for the command and service modules, was also responsible (through its Rocketdyne Division) for the S-II stage of the Saturn V and for the F-1 and J-2 engines that would power all three stages. Top management was entirely aware that "when you let the contract, all you've done is started a process that with the greatest of care, and ability, and drive will produce a bird. All you've done is put in motion forces that have the capability but which could fail at any point along the line."[50] There were no easy solutions to the problems generated by Apollo or, in lesser degree, of Surveyor, Ranger, Nimbus, and the Orbiting Observatories. In the case of Apollo, management could go to a second source for the propulsion system and actually considered doing this.[51] NASA could stick with North American Aviation and tighten the reins by more careful definition of the work to be done or by more frequent visits by the Apollo program manager. Finally, another corporation could be hired to integrate the three stages of the Saturn V with each other and with the spacecraft. Clearly, turning a program around in midcourse is more difficult than precisely defining a program at the beginning.

However, new methods like phased project planning were not introduced simply because of drastic schedule slippages. The problem facing NASA was more simple and more complex than one of slippages: simpler because the causes of the delays could probably be dealt with by improved management techniques that already existed—incentive contracts, projectized management, and closer control by headquarters; more complex because both the Bureau of the Budget and the President could be expected to "go to a greater level of detail [than before] and examine all deviations in program content, delays in launch schedules, and other factors which affect total program costs."[52] Failures that might have been excusable in a new agency would be of more concern now that NASA had the experience, the manpower, and the funds to get things done. In NASA's first three years, more than half its launches failed, but it received little criticism. However, after the failure of Ranger 6 in February 1964, Congress made it clear to NASA that no more would be tolerated. Hence the tone of Webb's letter to Seamans quoted above, a letter remarkable for its frankness and realism. Management would have to "learn to predict future costs more accurately" and to reduce them "to an absolute minimum," a task that would involve "*timely reexaminations of some of our basic operating practices.*"

Then Webb explained what he had in mind:

> We must, for example, find an effective means to take all actions necessary to terminate developmental costs when developmental tasks are completed before the time when we can incorporate them in a test system, and not have to continue underwriting a . . . team to protect ourselves against the eventuality that the production articles intended for later consumptions may encounter difficulties. . . . [Otherwise] we will find ourselves continually on the defensive with respect to the management and budgeting of the program, even though the flight missions succeed. Those who are opposed to this program will take advantage of every opportunity in these areas to discredit the agency and the program.

Phased project planning was only one method among several that NASA management used to bring programs under greater control. Others included the revision of NASA's contract with JPL, pressure on the centers to tighten their monitoring of flight projects, and a series of task force studies by the Office of Programming on NASA cost and schedule estimating that were carried out in the summer of 1963. The most important of these studies was conducted at Marshall and led to the conclusions that "nobody knew anything beyond his specific area of responsibility," and that more advanced planning was essential—a policy that the task force sold to Seamans and, through him, to Webb.[53] That NASA officials were considering the phasing of projects long before they issued guidelines is evident from a July 1964 memorandum by Seamans, recommending that

> any new projects should be planned on a phased basis with successive contracts for advanced studies, program definition, prototype design, and flight hardware and operations. This will permit the work statements, including development engineering, to evolve in an orderly manner with maximum realism.[54]

At the same time Seamans assigned Deputy Associate Administrator Earl Hilburn to study current methods of scheduling and estimating the cost of projects.

Table 4-2. — Average schedule slippage factor for various classes of projects.

Project	Launched											
	Successful		Unsuccessful		All Flights		Canceled		Future Flight Articles		Overall	
	No.	Average	No.	Average	No.	Average	No.	Average	No.	Average	No.	Average
Total	*75*	*1.74*	*28*	*1.58*	*103*	*1.70*	*38*	*2.25*	*134*	*2.25*	*312*	*2.02*
Communications	10	1.65	2	1.46	12	1.61	5	1.51	–	–	17	1.58
Lunar	1	1.79	6	1.24	7	1.32	–	–	15	1.86	22	1.69
Planetary	1	1.05	2	1.00	3	1.01	2	1.00	1	1.00	6	1.01
OART	5	1.96	5	1.75	10	1.85	1	2.44	5	1.83	16	1.88
Meteorology	9	1.69	0	–	9	1.69	2	1.84	3	3.18	14	2.18
Observatories	1	2.07	1	1.67	2	1.87	–	–	7	3.97	9	3.50
Simple scientific satellites	16	1.70	7	1.63	25	1.68	4	1.58	10	2.76	39	1.95
Manned spacecraft (S/C) and all systems	9	2.27	1	1.93	10	2.24	17	2.44	66	2.23	93	2.27
Launch vehicle development	11	1.60	1	1.64	12	1.60	2	5.25	12	1.93	26	2.03
Engines	–	–	–	–	–	–	2	2.20	–	–	8	1.98
Boilerplate S/C	10	1.60	3	1.72	13	1.72	3	2.38	9	1.95	56	1.88
Biosatellite	–	–	–	–	–	–	–	+	6	1.44	6	1.44

Source: *Second Interim Report to the Associate Administrator on Studies Relating to Management Effectiveness in Scheduling and Cost Estimating* (15 Dec. 1964), p. 2.

Table 4–3. — Average schedule slippage factor by center.

Center	Launched											
	Successful		Unsuccessful		All Flights		Canceled		Future Flight Activities		Overall	
	No.	Average	No.	Average	No.	Average	No.	Average	No.	Average	No.	Average
Total	*75*	*1.74*	*28*	*1.38*	*103*	*1.70*	*38*	*2.25*	*134*	*2.25*	*311*	*2.02*
Manned Spacecraft Center[1]	19	1.92	5	1.94	24	1.92	14	2.71	61	2.30[3]	130	2.17
Marshall	9	1.34	3	1.54	12	1.39	9	1.86	24	1.65	49	1.61
Goddard	33	1.72	4	1.63	37	1.71	6	1.67	14	3.34	57	2.11
Jet Propulsion Laboratory	2	1.42	8	1.18	10	1.23	4	3.12	11	1.98	25	1.86
Langley	9	1.79	7	1.74	16	1.77	4	1.48	9	1.67	29	1.70
Lewis[2]	3	2.28	1	1.04	4	2.08	1	2.44	5	2.52	11	2.46
Ames	–	–	–	–	–	–	–	–	10	2.56	10	2.56

[1] Includes all Mercury flights.
[2] Includes all Centaur vehicles.
[3] Lunar module and command service module for the same flight are listed separately, as are Agena Target Vehicles and Gemini launches.
Source: *Second Interim Report to the Associate Administrator on Studies Relating to Management Effectiveness in Scheduling and Cost Estimating* (15 Dec. 1964), p. 3.

In two reports submitted in September and December 1964, Hilburn laid the basis for many subsequent changes. He concluded that slippages were greatest in propulsion systems and in launch vehicles requiring new engine development; that, on the whole, slippages were greatest in the newer centers; that the largest cost increases were due to incomplete definition of the work at the start; and that delays in one mission impinged on all future missions in that series (tables 4–2 and 4–3).[55] Most significantly, Hilburn concluded "that NASA's project control can be improved; that slippages and overruns are not inevitable . . . it is felt that sweeping changes in organization or procedures are neither necessary nor desirable."[56] NASA already had the remedies in hand; all that was needed was to intensify their use. Align all projects on a "vertical" basis and see that all contractors do the same; conduct project reviews to identify all areas of dubious ("soft") planning; wherever possible, put contracts on a multiple incentive basis, with special weighting for costs and schedules.[57]

By January 1965, agency policy was to define all programs as explicitly as possible. Phased project planning (PPP) was only one method of attack and perhaps not even the most important. Reserving to chapter 6 a detailed account of NASA program planning, several features of PPP nevertheless deserve emphasis here. First, the guidelines of October 1965 applied specifically to *new* projects at a time when very few new projects were starting and several that had reached the advanced study phase had to be canceled. Second, the concept, if not the name, was certainly not new. To cite one example, the construction of the 64-meter radio antenna at Goldstone, California, as part of the Deep Space Network was mentioned by Seamans as "almost a textbook case of phased project planning."[58] What he did single out as new was "the agency's ability at this point to assure that all new projects can be undertaken in this manner."[59] Third, as a major benefit, NASA would be able to keep all options open as long as possible. Here, the language of the relevant policy directive is significant. PPP was "not an end in itself"; it was introduced only to ensure that research and development would now be conducted in "an appropriate number of sequential phases" with maximum competition characterizing the "phase-by-phase increments of project execution," and each phase allowing for "the fundamental concept of agency top management participation at all major decision points."[60] Fourth, the exceedingly gradual way in which the details of PPP took shape is also noteworthy. Only after more than a year—from the appointment of the Hilburn task force—of studies and consultations with the directors of the program offices did senior management take the first tentative steps toward a goal that would require another three years to attain. Some reasons for the delay appear in chapter 6, in which it also becomes apparent that the goal of fostering maximum competition at every stage of the R&D cycle was inherently unworkable.

The NASA Acquisition Process Evaluated

Phased project planning was predicated on the assumption that NASA employees would be responsible primarily for defining programs and providing technical direction to agency contractors. The separation of evaluation and production was the key to the NASA acquisition process, and that process was central to the way NASA worked. Any assessment of the agency must therefore try to measure the success of the acquisition process.

Before proceeding with this argument, however, some preliminary remarks are in order. First, "success" is an ambiguous term, both in NASA and DOD parlance. Was the Air Force's C-5A transport plane a failure because of cost overruns or a success because it resulted in "a substantial reduction in the cost of Airlift capability"?[61] In NASA, was the Syncom I communications satellite a success because it was placed in synchronous orbit or a failure because it returned no data? In such cases, even cost-effectiveness is not a reliable criterion. The C-5A experienced overruns of 60 percent, yet this was low compared with the 200–300 percent overruns of earlier weapon systems uncovered by Peck and Scherer in the early 1960s. Moreover, "the early ballistic missile programs incurred large cost overruns and their initial performance was deficient. Yet, these early programs were not counted as failures but, rather, successes, because the goals perceived during the 'missile gap' era put overriding emphasis on early deployment of some kind of deterrent capability."[62]

Second, NASA and DOD acquisition procedures were directed to the production of very different systems. Compared with DOD, remarkably few NASA programs have been canceled because they were beyond the state of the art or because their costs clearly outweighed any possible benefits.*[63] The difference is not to be sought in the quality of management or the techniques used for reporting and control. Program evaluation and review techniques (PERT) could be used for weapon systems and spacecraft alike, and some of NASA's most important projects were managed by military detailees who were trained in PERT. The question, rather, is what such canceled programs as the Skybolt missile, the nuclear-powered airplane, the Cheyenne armed helicopter, and the B-70 supersonic bomber had in common that Apollo, the Orbiting Observatories, and Viking did not. The former were all planned as extensions of capabilities already existing; no one could build a "better" supersonic manned bomber unless there was already a bomber to serve as a yardstick for technological change and hence for cost-effectiveness and cost-benefit studies. With Apollo and other very large NASA programs, there was nothing to serve as a measure of each program's *relative* success. No one had landed on the Moon before the crew of Apollo 11 did, nor had anyone successfully soft-landed on Mars prior to Viking.

To put the matter differently, the question here is less one of effectiveness than it is of efficiency. Granted that NASA did accomplish its lunar landing mission within the time specified, the Apollo program cannot be compared to

* NASA programs *were* canceled or delayed for budgetary reasons, either because the Bureau of the Budget disallowed them, Congress would not fund them, or NASA sacrificed them on the altar of Apollo. Examples include Voyager, a Mars mission canceled in 1968, the Advanced Orbiting Solar Observatory, and the large solid motor.

alternate approaches that were never adopted. But the acquisition process can be evaluated in terms of what NASA management claimed on its behalf. Thus, if the role of in-house staff was to do advance planning and to provide technical direction, how well was this accomplished? How well did the source evaluation procedure succeed in promoting the avowed aim of fostering maximum competition? What benefits resulted from the extensive use of contracts with incentive provisions? The following sections are intended to provide tentative answers to these questions.

The Integrity of the NASA Civil Service Staff

What distinguished NASA employees from contractor employees was the complex of responsibilities subsumed under technical direction and supervision. But between the fabrication of flight hardware and the in-house capacity to plan programs was the broad grey area of contracting for nonpersonal services. Such contracts, by reason of the issues they raised, serve as a test case of NASA's ability to make explicit its criteria for contracting out.[64] No one expected NASA personnel to fabricate either the Saturn launch vehicles or the Apollo spacecraft. Less clear was the course to be followed in staffing the three main tracking networks, writing computer programs at NASA installations, and operating test facilities for simulating the space environment. A case could be made for doing such work internally or for hiring a contractor.

Within NASA, the Bureau of the Budget, the U.S. General Accounting Office (GAO), and interested congressional committees, there was no consensus as to what "support services" were, the extent of the practice, or the guidelines for contracting to the private sector. There was agreement that support services were ancillary to the agency's functions, could be performed in-house if staff were available, and were more temporary and intermittent than those usually performed by civil service employees. Beyond this, agreement broke down over costing formulas, the questions of whether and to what extent support service contracts were being used to evade agency personnel ceilings, and whether an agency was delegating functions that should be retained to exercise technical direction. Furthermore, drawing a fine distinction between one kind of service contract and another was difficult, if not impossible. As Finger remarked in congressional testimony:

> Some of these services require little contractor capital investment; others require substantial investment. Some of them require little skilled labor; others require special training and highly specialized skills. In some cases the function is separate and distinct; in others it is intimately related to the whole process of successful system development and flight mission operations. In some cases it is a service to the Government organization; in others it is a direct support of a development contractor's responsibility. Some of these functions are performed at a Government installation; others . . . at a contractor's plant. . . . In some cases there are many customers for the services; in others the Government may be the only customer. In some cases the operation is a continuing and stable one; in others it is so closely related to program or project requirements that it requires continuing adjustment in numbers and skills of people assigned.[65]

Finger stressed the special and urgent nature of the task that he and other officials were expected to manage. Given the target date for Apollo and the extraordinary buildup in required manpower and facilities, NASA had perforce to turn outside for many kinds of services.

NASA's position was complicated by the tendency of officials to argue as if service contracts were only occasional departures from the general norm that Government provide such services in-house. Prior to 1967, NASA guidelines specified that the agency was to contract for support services only if the capability for doing the work already existed, industry itself normally contracted for similar work, the nature of the work made full-time employment of Government employees impracticable, or skills not readily available within the Government were required.[66] On the face of it, this position seemed opposed to that of the Bureau of the Budget, which since 1959 had asserted the general policy that Government should rely on private enterprise to supply its needs;[67] but the difference was superficial. NASA officials argued that in a period during which the space budget had doubled and then tripled over what it had been in 1960, the agency had to go outside for certain rare and valuable skills—whether these involved performing analytical studies in support of the Apollo landing, operating the mission control center at Houston, or providing technical services at the Kennedy Space Center. Over and over they argued that it was impracticable to graft these skills onto a Government operation when abundant capacity for such work existed in the private sector. NASA, so their argument ran, did not contract for end products when it awarded a service contract; simply by virtue of being services, items such as those listed were purely means to obtain an end product designed by NASA employees. The reverse of this argument was that once the space program began to shrink, it might be necessary for NASA to build up in-house those skills for which it had contracted in the past. It may be significant that the strongest criticism of these practices—beginning with a June 1967 GAO report concerning service contracts at Goddard and Marshall—occurred just as NASA budgets and manpower were beginning to decline.[68]

In the area of launch operations, NASA deliberately assigned responsibility to the flight contractor from the design phase through checkout, launch, and performance in flight. Whatever the benefits of a purely abstract cost analysis, NASA deemed it impossible either to employ civil service personnel for the job or to impose a moratorium on flight operations until the contractor work force could be converted to civil service positions. In any case, NASA did not make the mistake of trying to justify its contractor policies on the basis of cost alone—a position that would have left the agency vulnerable indeed. One official at Goddard said that "cost is not the prime determinant in decisions to contract. To accept such a premise would have . . . deleterious impact on current and future contracting operations of this Center and all of NASA."[69] Where even the Bureau of the Budget could not adduce uniform cost criteria to justify contracting out, NASA officials could regard their own policies as being well within Bureau standards that were unclear to begin with. Cost was a consideration, but not the only one.

Sometimes, as Finger explained, "there was a strong feeling that the function ought to be performed in-house and, therefore, even though for some functions the cost differences would be within the 10 percent [stipulated by the Bureau as the differential for contracting out] or less than 10 percent, the function could still be moved in-house if it was felt that the function ought to be performed that way."[70]

All these arguments assumed that support contracts did not impair NASA's control of its own operations. Time and again, in congressional testimony and in correspondence with GAO, Finger and Webb emphasized the safeguards for maintaining the integrity of NASA programs: the "clear separation" of Government and contractor responsibilities, maximum practical competition among qualified firms, the physical separation of Government and contractor employees to avoid the supervision of the latter by the former, the imposition of a hardware ban on major support contractors like Bellcomm and General Electric, and the "recompeting" of support contracts—seeking new competitive bids instead of automatic extensions—so that industrial firms could never become too complaisant.[71]

But how effective, really, were these safeguards? The issue was not whether this or that center might hire firms to remove the garbage, mow the lawns, or provide guard service, even if Government unions were inclined to argue that a multiplicity of such contracts might subtly erode NASA's ability to distance itself from its contractors. The real test cases were those contracts for engineering support services that seemed directly to threaten NASA's ability to control and monitor its own programs. To examine the issues at stake, three such contracts will be described: the Bellcomm, General Electric (GE), and Boeing Technical Integration and Evaluation (TIE) contracts.* Other than their large size, these contracts had little in common with other support contracts or even with each other. The Bellcomm and GE contracts were negotiated early in the Apollo program to anticipate or forestall problems; the TIE contract was let in the aftermath of the Apollo 204 fire. Bellcomm was a profit-making subsidiary of American Telephone and Telegraph that worked solely for NASA, while the GE and Boeing contracts were carried out by existing divisions within the parent companies. Bellcomm went out of business in May 1972 when its last contract extension expired; the Boeing TIE contract was phased out in 1970.[72] In the same year, NASA gave each OMSF center the option of extending its portion of the GE contract separately. Yet each contract met one of the criteria of a support contract, in that the work "could have been done by our hardware prime contractors or in-house if sufficient . . . capacity were available."[73] The questions are, why did NASA decide to contract in these cases, and how did each decision affect the role of in-house staff.

* From March 1962 to its termination in May 1972, the Bellcomm contract (NASW-417) and its extensions cost NASA about $91 million. At the end of FY 1968, the GE (NASW-410) and TIE (NASW-1650) contracts had run to $670 million and $52 million respectively.

Bellcomm was established in March 1962 at NASA's request to do analytical studies in support of the Apollo landing. Unlike the GE and Boeing contracts, it was strictly a Washington, D.C., operation on behalf of OMSF. Bellcomm manufactured nothing. Among the specified tasks were preparing specifications for the Apollo Program Office, indicating Apollo requirements for data from Surveyor and Lunar Orbiter, evaluating proposed manned spaceflight experiments, and defining scientific objectives for lunar missions after the first landing.[74]

As an Apollo Program Office report stated, the situation was unusual "because NASA was attempting to use a contractor organization as its line engineering directorate."[75] The justification for creating Bellcomm proceeded at several levels: the oft-repeated "unique capability" argument,* NASA's general practice of contracting to private industry, and the impossibility of NASA's assembling civil service manpower in a brief period, only to disperse it within six to eight years. Moreover, Apollo differed radically from the Mercury and Gemini programs that preceded it. The earlier programs used the Atlas and Titan launch vehicles developed by the Air Force, with essentially only one center (the Manned Spacecraft Center and the Space Task Group that was its nucleus) involved. Apollo, however, involved all three OMSF centers and required totally new launch vehicles, a new spacecraft, and new ground test and launch facilities—all of which had to be integrated into a functional system reliable enough for manned flight. "Management of the program require[d] a strong program office at Headquarters with a strong systems engineering capability not then in existence."[76] This was NASA's principal justification for turning to the Bell System; indeed, it was argued that the creation of Bellcomm would also enable NASA to tap the capabilities of Bell Laboratories and Western Electric.

Although linked with Bellcomm in congressional testimony, the GE contract was otherwise distinct.[77] Bellcomm was involved in systems engineering; GE, in "the implementation of standards to assure proper integration, reliability, and checkout of hardware" at Houston, Marshall, and the Cape.[78] GE would eventually design and manage fourteen sets of Apollo Spacecraft Automatic Checkout Equipment rather than the three originally specified, support the investigation of the Apollo 204 fire, and operate the Mississippi Test Facility for Marshall. As with Bellcomm, NASA wrote a hardware ban into the GE contract, forbidding the company to participate as a prime contractor or first-tier subcontractor for Apollo launch vehicle or spacecraft stages or as a supplier of nonstandard components for launch vehicles or spacecraft, save at the discretion of the Administrator or Deputy Administrator. However, this restriction did not prevent GE from manufacturing much of its own checkout equipment, did not apply to existing contracts, and did not bar GE from bidding on "standard" items in managing the Mississippi Test Facility.[79]

* However, in a personal communication to the author, Dr. Seamans has noted that "we originally planned to carry this effort out primarily within NASA as part of the Apollo office. When we had difficulty recruiting the caliber of people we wanted and obtaining sufficient manpower slots from the Office of Management and Budget (sic), we went to AT&T and asked them to set up a dedicated organization, which became Bellcomm."

Each of these contracts involved some kind of "service." Systems engineering requires that the environment within which systems operate be known, that the objectives for which the systems are designed be understood, and that the resources available for the system be adequate to meet its goals. Integration, on the other hand, means fitting things together, whether components into a subsystem, subsystems into systems, and the system—for example, the first stage of a launch vehicle—into the total launch vehicle.

But "integration" and "evaluation" are not synonymous.

> Technical integration is the act of making two or more elements, such as a launch vehicle and a spacecraft, fit and work together. . . . Technical integration must be performed between the elements for which an organization is responsible, as well as the major elements between different organizations.
> Technical evaluation consists of examining the mission requirements specifications and the hardware capabilities . . . to determine that the hardware will work . . . to accomplish its role in the performance of the pre-established mission.[80]

Boeing, which already had the contract for the first stage of Saturn V as well as for integrating all three stages of the booster, was now being asked (according to Webb) to certify that "the whole unit, vehicle and payload, does function together, is compatible, and is ready for flight."[81] Boeing was called in because there was no time to build an in-house capability; in any case, the company's role was "advisory." NASA's original intention—to award the contract to North American Aviation—was dropped after the Apollo fire. Boeing was chosen although the contract, first announced by Webb in congressional testimony on 9 May 1967, was not made definitive until 30 May 1968. NASA settled on Boeing because of the company's experience in the Saturn and Minuteman programs, its management of Lunar Orbiter, and the management abilities of senior Boeing officials.[82] Also important, although unmentioned, was the familiarity of OMSF staff, several of whom had worked for Boeing, with the company's mode of operations.[83]

Bellcomm and TIE were the "upstream" and "downstream" sides of Apollo systems engineering. Put simply, Bellcomm mapped the requirements for lunar missions; Boeing implemented the requirements in many ways—by evaluating the adequacy of hardware, analyzing proposed changes in flight equipment, and preparing backup material for the flight readiness reviews held a month prior to each Apollo launch. The TIE contract was as significant for what it forbade as for what it sanctioned. Boeing personnel would not supervise other NASA or contractor personnel and would only perform work that was not being handled by a specific Apollo prime contractor. Again and again, NASA management insisted that the TIE organization was to "assist," "advise," "recommend," and "support" Apollo.[84] Like those with Bellcomm and GE, the Boeing contract was established in response to a program whose complexity and urgency precluded a gradual buildup of the needed skills.

Now to return to the earlier question, to what extent did the three contractor organizations assume functions that NASA should not have delegated? This question is distinct from inquiring into the contractors' effectiveness. In fact, they made substantial contributions to Apollo. When Finger visited Houston in August 1968, Manned Spacecraft Center Director Robert Gilruth told him that "the best return MSC could get from the [TIE] contract was additional engineering support which was sorely needed in many areas of the Apollo program . . . spacecraft sneak circuit analyses* were a major Boeing contribution. It was felt all along that these analyses should be made, *but personnel had not been available to do so*."[85] Another example of work done under the TIE contract was the analysis of the "pogo" problem, the oscillations of Saturn V after lift-off, and its effect on the Apollo spacecraft. Similarly, Bellcomm's work in systems engineering was more than satisfactory, judging by the extensions of the original contract.[86]

These contracts violated neither Government policy nor the spirit of the Bell report, but they tended to compound the confusion between public and private sectors that the Bell task force had tried to dispel. NASA managers could respond, with considerable justice, that their policy of using support contracts was fully disclosed, that the agency had no alternative to contracting out most of its development work to industry, and that the final word in policy matters remained with civil service employees.

One can also acquit NASA of the charge that, by allowing contractors such as Bellcomm to define problems, the contractors set the terms on which decisions were made. The charge made by one critic of NASA, that Bellcomm in effect provided the rationale for the decision to make lunar orbit rendezvous the Apollo mission mode, does not bear close analysis.[87] A significant portion of the NASA community, including the entire Space Task Group, had come to favor lunar orbit rendezvous by the end of 1961, almost three months before the Bellcomm contract was let.[88] Also, the decision of the Manned Space Flight Management Council in June 1962 to adopt lunar orbit rendezvous was heavily influenced by nontechnical influences—for example, the desire for unanimity and the consensus that the Saturn vehicle should be used—that were peripheral to Bellcomm's assignment.

The problems generated by these contracts were more subtle. In all three cases, there was a tendency for support contractors to continue working for NASA after their original reason for being had ended. Bellcomm, which had been set up to do systems engineering for Apollo, went on to do studies for Apollo Applications and the space shuttle, and in 1968–1969 evolved into an in-house entity like the RAND Corporation for OMSF; it had the manpower and the budget to prepare a post-Apollo plan for NASA and to participate intensively in the planning review sessions held throughout 1969.[89] Moreover, the very functions of evaluation and review for which Bellcomm was created and TIE was negotiated were those for which, it could be argued, an in-house force was needed. Support contractors were used for three reasons: direct support, "added assurance that all possible problems have been identified and solved," and to provide checks and balances, that is, to check on the centers before the commitment to fabricate was made.[90] These

* Sneak circuits are inadvertent electrical paths.

reasons, particularly the latter two, might seem to apply with greater force to headquarters, both to top management and the program offices.

In addition, hiring contractors to do what might have been done in-house was welcomed neither by other prime contractors nor by the centers. According to the official history of Apollo, the GE contract "was seen in some circles as a matter of GE telling government officials how to do their jobs." And one GE official conceded that at Houston "they didn't want us. There were two things against us down there . . . it was a Headquarters contract, and it was decreed that the centers shall use GE for certain things; and . . . they considered us Headquarters spies."[91]

The most serious charge against support contracts was that they caused NASA to depend on industry for what could have been done by agency employees. When Mueller wrote to his center directors at the end of 1968 to ask their opinion on phasing out engineering support contracts, the three directors were unanimous. Gilruth put the matter with special force:

> 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 agree that the most effective management of future programs calls for greater in-house engineering capability. 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 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.[92]

By 1969 NASA was faced with declining personnel ceilings. Thus the attempt to strengthen the in-house staff meant, paradoxically, that service contractors would remain indispensable for several more years (table 4–4).

The case for service contracts rested on one powerful argument that was never adequately refuted: An agency with such urgent and unique assignments could not have done the job with its in-house staff alone. That case was not always well-presented, as indicated by continued skirmishing between NASA and the House Government Operations Committee as to whether TIE was or was not a support contract, whether the Boeing personnel ceiling at headquarters was 75 or 300 persons, whether these figures were for "direct" or "indirect" personnel, and whether or not Boeing was being paid twice for its work on Apollo.[93] Even those like Gilruth who thought that support contracting had gone entirely too far conceded that Apollo had made such contracts unavoidable. Nor need one conclude that NASA abdicated its responsibility to manage. In the Apollo program, NASA possessed a far greater depth of experience and talent than the Air Force's Western Development Division or the Special Projects Office that developed the Navy's Polaris.[94] NASA acted to control its programs in the following ways:

Table 4-4. — Nonpersonal service contracts: Number of Government and contract personnel, 30 June 1962–31 May 1968.

Date	Government	Contractor
30 June 1962	23 511	3 525
30 June 1963	29 488	6 758
30 June 1964	31 957	10 200
30 June 1965	34 049	Not Available
30 June 1966	35 708	26 962
30 June 1967	35 860	29 267
1 Nov. 1967	34 281	33 768
31 May 1968	33 202	31 511

Sources: 1964 and 1966 program reviews, *Procurement Programs* (27 Oct. 1964, fig. 26; 31 Oct. 1966, fig. 48); and hearing of House Science and Astronautics Committee, Subcommittee on NASA Oversight, 90th Cong., 2d sess. (11 July 1968), p. 9.

1. By determining the conditions under which contracting would be necessary.
2. By anticipating problems before the contractor did, who would then do whatever detailed engineering was necessary.
3. By conducting enough of the effort internally to acquire the expertise to judge and evaluate contract performance and, if required, to provide support or actually take over contractor work in order to complete the program.
4. By terminating or phasing out the contract, although this was as much a managerial as a technical decision.

In sum, several of the most controversial NASA contracts were for work that might have been performed in-house, but the contractor's involvement gave assurance that everything had been double and triple checked. Faced with ambiguous guidelines, NASA officials believed that resort to the private sector was inevitable and that the question of whether a task was covered in-house or by contract was less important than the knowledge that the capability would be there when needed.

Selection Criteria and Their Effectiveness

Before turning to NASA's source selection procedure, something must be added about the agency's policy of fostering maximum competition in the selection of contractors. This must be understood in a highly qualified sense. For NASA, competition was strictly a means to an end. The nature of the products for which NASA sought suppliers precluded competition in the classical sense for several reasons: Only a small number of firms were able to compete for major R&D contracts because of the prohibitive cost of entry; the firms were concentrated in certain geographic areas; and, most of all, unique uncertainties are inherent in the development of sophisticated space and weapon systems. As Peck and Scherer observed in their study of the weapons acquisition process, in soliciting for R&D work "the seller does not offer a finished product which the buyer can either accept or reject. Rather, the government pays development costs before it knows what the ultimate performance of the product or its desirability relative to other products will be."[95] Two additional considerations that affected the NASA acquisition process were the absence of follow-on production and the uncertainties of the future of the space program in 1960–1961 and again in 1967, when funding for most NASA programs, especially the newer ones, had begun to decline.

Thus NASA had to take its suppliers where it could find them. Despite pressure from regional associations and from Congress—year after year, NASA authorization acts included a clause urging NASA to distribute research funds on a wider geographical basis—NASA placed most of its prime contracts in those areas where the capability already existed. The NASA position, as stated by Webb and Hilburn, was that

> to base the award of contracts on geographical considerations, rather than on competition for all companies regardless of location, would be inconsistent with the statutory procurement authority currently applicable to NASA. Moreover, limiting competition to geographical areas might mean that the company with the best capability for a project of importance would not be awarded a contract because of its location.[96]

In fact, NASA prime contracts were concentrated in a few regions. Between fiscal years 1962 and 1969, 60 percent of NASA R&D dollars were placed in only three States: California (42.7 percent), New York (10.2 percent), and Louisiana (7.2 percent).[97] However, the sheer scope of NASA contracting activity led to a substantial dispersal of funds, principally because 40–50 percent of NASA procurement dollars for major R&D contracts were subcontracted. For example, in FY 1969 subcontracts on fifty-eight major prime contracts amounted to $418 million. Of this amount, only $120 million (29 percent) remained with the States to which the prime contracts were awarded, while the remainder was redistributed elsewhere. A further breakdown illustrates how extensive this redistribution really was. Twelve States received more in subcontracts than they did in prime contracts, while seventeen of eighteen States with NASA prime contracts transferred some work to other States. Indeed, many subcontracts were awarded to companies that were probably incapable of becoming prime contractors themselves. Thus, while the dispersal of contract dollars was incidental to its mission, NASA did encourage its prime contractors to award subcontracts on a broad geographical basis.

Analysis of the source selection procedure is in terms of the following questions. First, what did NASA mean by "competition," and what was the actual degree of competition in bidding on NASA prime contracts? Second, how much weight did officials attach to the various criteria for source selection? Third, how efficient was the selection process itself? Finally, how did NASA management regard the procedure; in particular, how far did they believe it was necessary to revise, overhaul, or do away with it entirely? For NASA, competition was between firms rather than between regions, and its function was to provide the agency with a service, component, or major system. It was in NASA's interest to promote competition because the more competition there was, the less NASA would have to depend on any single contractor; the more entries there were into the aerospace industry, the more likely the industry was to generate technical and managerial innovations; and by spreading NASA funds as widely as possible—as far as this was compatible with its mission—the agency would secure a nationwide base of support for its programs. The extent of competition in NASA procurements is shown in table 4-5.

The entire purpose of NASA's selection process was to procure the best source, one that would be compatible with the agency's budget, the armed services procurement regulations, and external forces that impinged on the agency's selection procedures, such as Congress, industry associations, the Executive Office, the President's Committee on Equal Employment Opportunity, the Small Business Administration, and the like. The criteria NASA used to evaluate potential sources varied depending on the size and complexity of the system to be developed, the point in NASA's history when it issued requests for proposals, and the agency's desire to build a capability rather than to see it concentrated in one or two firms. At the risk of oversimplification, it can be said that NASA officials weighted selection criteria according to the context. One consideration in many early procurements was the need to attract competition in a specific area. This was the justification given by NASA for awarding the contract for the S-II stage of Saturn to North American Aviation rather than to Douglas, which already had the contract to design and build the S-IV stage.[98] By placing the S-II contract with North American, NASA would have available three firms—North American, Douglas, and the Convair division of General Dynamics—capable of advancing the state of the art in liquid-hydrogen technology.

The data reveal that NASA chose competitively more frequently in the late 1950s and early 1960s than it was to do later. Between 1958 and 1960 NASA held source selection competitions for eighteen of twenty-one major programs, including Rover, Ranger, Surveyor, Mercury, Nimbus, and the Orbiting Astronomical Observatory.[99] But during the period 1958-1965, in sixteen of seventy-six cases involving contracts of $5 million and over, a source evaluation board was not convened, either because there was only one firm with the requisite capability or because the action was a follow-on to an existing contract (table 4-6). Indeed, by the end of 1965, non-SEB actions constituted almost one-third of all contracts for $5 million and over.[100] It may be that there were fewer new programs on which to bid or that the high cost of entry served to discourage prospective contractors.

It also seems likely that there was less competition in the mid-1970s than there had been a decade earlier for at least three reasons. First, while it was

Table 4-5. — Competition in NASA awards to business firms, FY 1961–1968.

Award	1961	1962	1963	1964	1965	1966	1967	1968
Total (in billions)	*$0.423*	*$1.030*	*$2.261*	*$3.521*	*$4.141*	*$4.088*	*$3.864*	*$3.447*
Competitive—Total	*0.276*	*0.565*	*1.302*	*2.119*	*2.630*	*2.693*	*2.698*	*2.308*
Advertised	0.038	0.064	0.106	0.134	0.169	0.111	0.081	0.057
Negotiated	0.238	0.501	1.195	1.985	2.461	2.582	2.617	2.251
Noncompetitive—Total	*0.146*	*0.464*	*0.959*	*1.401*	*1.511*	*1.395*	*1.166*	*1.139*
Follow-on after competition	([1])	([1])	0.255[2]	0.495[2]	0.504	0.373	0.347	0.336
Other noncompetitive	0.146	0.464	0.704	0.906	1.007	1.022	0.819	0.803

[1] Data not compiled, included in other noncompetitive.
[2] Follow-on after competitive procurements of less than $25 000 are included in other noncompetitive procurements.
Sources: NASA *Procurement Reports* for 1964, p. 4–2, and for 1968, p. 14.

Table 4–6. — Breakdown of SEB and non-SEB cases, 1958–1965.

Time Period	SEB	Non-SEB	Percentage	Total
12/58–2/61	10	1	9	11
3/61–2/62	10	2	17	12
3/62–3/64	19	3	14	22
4/64–12/65	21	10	32	31

Source: Joseph Fernandez, "The Origin, Evolution, and Operation of the NASA Contractor Source Evaluation Board Process," unpublished M.Sc. thesis (Massachusetts Institute of Technology, June 1966), p. 23.

expensive to enter the space business, it was even more costly to stay in. Thus Grumman, which was NASA's number two prime contractor during the late 1960s, virtually withdrew from space systems after completing its work on the Orbiting Astronomical Observatory and the lunar module, both of which were plagued with overruns and technical difficulties. Second, if a company supplied a recurring service or standardized items such as the stages of a launch vehicle, then it was generally more expensive for NASA to go to an alternate source. This, as indicated above, was the justification given by NASA for negotiating only with McDonnell-Douglas for ten improved Delta vehicles, but the same rationale applied to the Centaur stages supplied by General Dynamics or the GE Apollo engineering support contract, which Houston extended to cover the Skylab and Apollo-Soyuz missions. Third, the structure of the aerospace industry changed in the 1960s in ways that tended to reduce competition further. McDonnell Aircraft and Douglas Aircraft, two of NASA's biggest contractors, merged in 1967. Similarly, companies like TRW or North American Aviation, which merged with Rockwell-Standard in 1967, were able to remain and thrive in the space business because they were large and diversified corporations that were not overly dependent on NASA contracts. Under these conditions, newer and smaller firms could enter the space industry only (if at all) as subcontractors—a situation not without danger for NASA's bargaining position.

On the whole, NASA did not give preponderant weight to any single criterion in the selection process. Cost estimates, for example, were apt to mislead either because of underbidding by the contractor or because neither side had realistically appraised the costs involved. Nor was straight technical competence sufficient by itself. In the mid-1960s many top officials concluded that a company could not take on a complex, difficult program without at least demonstrating by past performance that its organization had adequate managerial skills to get the work done. The cost overruns and slippages that plagued so many projects in 1962–1964—the Centaur launch vehicle (whose prime contractor was General Dynamics), the RL-10 engine (Pratt and Whitney), Gemini (McDonnell), and the S-IV and S-IVB stages of Saturn (Douglas)—were problems of managerial as much as technical competence. And it was largely as a byproduct of management failures that NASA, in 1964–1965, moved to the principle that

> greater emphasis should be placed on company management flexibility and its ability to marshall the management *plus* technical competence necessary to perform the contract rather than accept a simple technical proposal and evaluate it on technical merits with only secondary evaluation of the organizational factors involved in getting the job done.[101]

All things being equal—which they seldom were—NASA officials would give as much weight to business as to technical criteria: availability of manpower and facilities, preparation of a detailed management plan, understanding of the project management approach, and understanding of the form of the contract that NASA desired to write.[102]

A proposal that was both technically and managerially sound and that widened the scope of competition stood a better chance of being accepted than one whose only virtue was a low bid. Douglas, for example, won the S-IV contract although its proposal was $5.44 million higher than Convair's. In this case, at least, Douglas won because of Glennan's desire to promote "at least limited competition as we start off this new technology . . . [otherwise] it might well be the case that subsequent competitions for the other stages of Saturn would become quite one-sided."[103] The history of the Lunar Orbiter contract is a more straightforward case of a contract awarded for managerial as well as technical criteria. Boeing, which received the contract, submitted the highest bid of all five proposals. Aside from the considerable technical merits of its proposal, Boeing impressed the selecting officials because of (1) its past experience with Minuteman, the B-52, and Bomarc, and its willingness to use developed components; (2) its ability to assemble a strong project management team, owing, in part, to the phasing out or termination of the Bomarc and Dyna-Soar programs; (3) Boeing's link with Eastman-Kodak and RCA as subcontractors; and (4) the desire of NASA management to encourage Boeing's entry into the design of spacecraft systems. In such cases, what counted in the final evaluation was less the offeror's actual experience in NASA programs than the potential revealed by its handling of other kinds of major systems work.[104]

As selection procedures became more elaborate, they tended to slow down the entire acquisition process. The matter was thought serious enough to prompt a "procurement lead-time" study in 1968–1969, whose principal finding was the existence of major delays in contracts processing. It took an average of 420 days to process a contract involving a procurement plan, 3 months for headquarters to review the plan, and 47 days for headquarters to approve a negotiated contract.[105] It may be that all this merely signified the advent of bureaucracy and red tape. Or it may have reflected the learning process NASA had undergone during the preceding decade in negotiating with its prime contractors. Or, finally, what seemed to be a delay in the acquisition process may have really masked delays in the decision to fund new programs. As Finger observed, NASA had gone from "a large, fast-moving program aimed at a clearly identified national objective to a situation in which reductions have been made in our program budget and, therefore, to a requirement for a very detailed examination of every element of our program before final approval is given to proceed. There is no question . . . that the uncertainty of the AAP [Apollo Applications] program scope and schedule and the delay in making firm AAP program decisions were reflected in long procurement lead times."[106] In addition, the NASA budget was tied to the planning-programming-budgeting cycle introduced by McNamara at DOD in 1961 and imposed on many civilian agencies in 1965. One effect of the new system was that it required that NASA submit its projected cost estimates to Congress earlier than good estimates could be produced. By 1969 NASA was some six years beyond the time when Congress had, so to speak, agreed to hand the agency a blank check. The uncertainty as to the future of NASA programs, the parceling of the NASA budget for review by many congressional committees, and the elaborate reporting requirements engendered by planning-programming-budgeting meant that NASA could not let contracts on the assumption that a program funded for one year would automatically be funded thereafter. Program planning and the acquisition cycle were inextricably linked. As one changed, so did the other.

But there was another, more technical, reason for the protraction of the acquisition process. As a large research and development organization, NASA had good reasons to make its regulations as specific and as uniform as possible. Kaufman's observation concerning organizational change applies here.

> The more experience an organization acquires, the more numerous it discovers the complexities and the ambiguities of its work to be, and the more its leaders feel obliged to clarify policies and refine procedures. . . . In quest of the best and most up-to-date technical performance, organizations in this way generate still more sets of specifications governing the actions of their members.[107]

By about 1966 the procurement cycle showed signs of becoming a lengthy procedure, owing to requirements imposed on NASA from within the agency and by other Federal agencies. NASA procurement regulations stipulated that all contracts negotiated by the centers above a specified dollar value (as well as contracts for individual facilities) had to be reviewed and approved by headquarters. Contractors were encouraged (or required) to submit cost reduction plans, identify new technology, and comply with the Government's equal employment opportunity (EEO) program. Requirements imposed on NASA from outside multiplied throughout the 1960s. NASA was designated a "predominant interest agency" for investigating EEO complaints against more than 200 prime contractors and subcontractors at some 450 facilities.[108] The agency was also assigned full responsibility for setting aside (i.e., reserving) competitions for small business, rather than determining them jointly with the Small Business Administration. In fact, there was a substantial area of public policy that NASA, along with all other Federal agencies, was required to implement through the procurement process: the Buy American Act, the Fair Labor Standards Act, the Work Hours Standard

Act of 1962, the Copeland Anti-Kickback Act, the rulings of the U.S. Comptroller General, the National Environmental Policy Act of 1969, and the like. The lengthening of the procurement cycle was the sum total of forces at work not only within NASA but throughout the Federal community. There was the proliferation of forms and review procedures that are one sign of Parkinson's law at work. More significantly, perhaps, the cycle lengthened because, in the course of planning programs, NASA program managers had come to understand the acquisition process better and to know what to expect of their contractors.

At the end of the 1960s NASA management looked at its selection process and found it to be good despite complaints that procurement lead time was too great; that losers in competition did not know why they had lost or winners why they had won: that requests for proposals were poorly drawn, in part because they were prepared by different people, "so that the need for all the material is seldom evident to one person"; and that a severe case of "echelonitis" existed between the program offices and senior management.[109] These were defects in a system that most of NASA considered to be basically sound. NASA officials dismissed out of hand the fundamental criticism of the process—that it was essentially noncompetitive. This thesis, forcefully stated by Prof. Edward B. Roberts of the Massachusetts Institute of Technology, was that the process underlying R&D awards was "informal and highly selective" and that the formal acquisition process succeeded only "in increasing the costs of research and development, adding time delays, and producing other damaging effects on government-sponsored research and development."[110] Part of this critique was only a more forceful restatement of what NASA procurement officers were saying privately. But they were not prepared to go the whole route and concede with Roberts that many large R&D contracts were in effect preselected and that the weightings given to proposals only amounted to "after-the-fact representations of general agreements . . . justifications for decisions, rather than causes."[111]

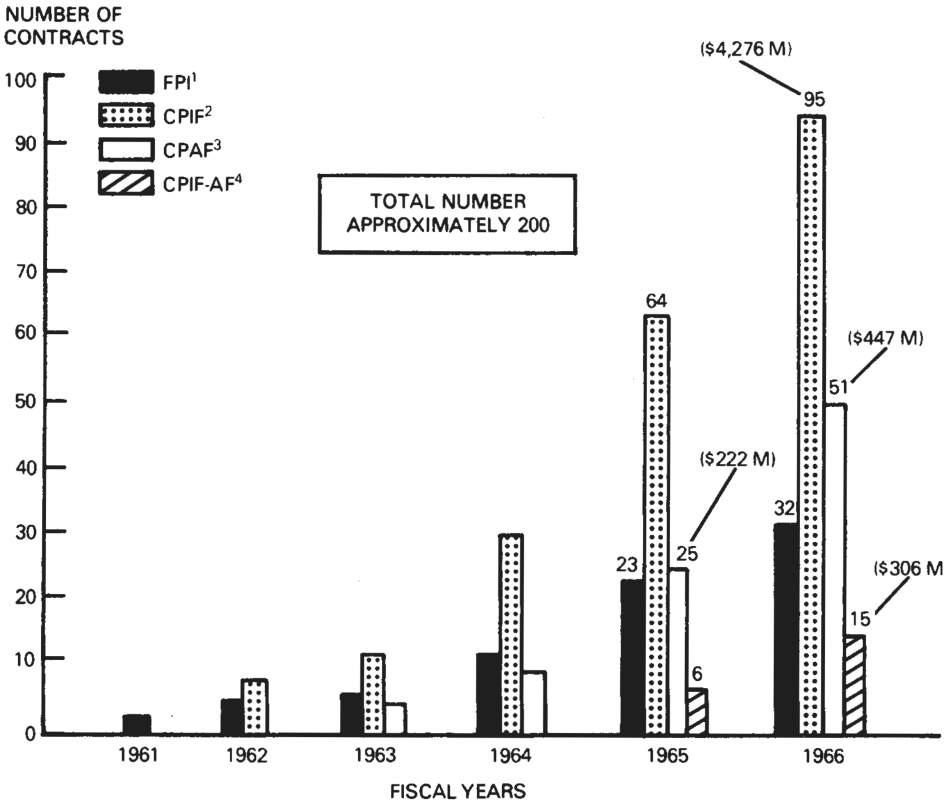
NASA's position may be summarized as follows. The NASA task force that studied the NASA acquisition process in 1970–1971 concluded that it "sufficiently met NASA's needs and objectives."[112] The task force preferred to judge by results. NASA had tapped—to a degree had created—an industrial capacity adequate to carry out its programs. It had created safeguards, such as the recompetition of support contracts and phased project planning, to prevent the agency from becoming captive to its contractors. NASA would concede the delays, the vague criteria, the unnecessary review levels, and the tendency to use technical criteria when the contractor as a whole was to be judged. But to abandon formal source solicitation would have been politically undesirable, not calculated to promote the agency's goals, and more likely to leave particular firms in sole-source positions for given areas than would otherwise be the case.

Use of Incentive Provisions

NASA introduced incentive provisions into its procurement system when the entire subject of R&D contracting was under review by Congress and the Bureau of the Budget. The time was ripe, judging from the circumstances that led to the introduction of incentives: the notorious inefficiencies of CPFF contracts, with cost prediction errors sometimes mounting to more than 200 percent; the recommendations of the Bell report; the March 1962 revisions of the armed services procurement regulations that authorized DOD to make more use of incentives; the pressures within NASA to use incentives, especially in the development phases of large systems contracts; and a series of meetings in December 1961 involving Webb, the chairman of the Atomic Energy Commission, and contractor representatives, in which they discussed the rationale for the cost-plus-award-fee (CPAF) concept. Once the decision was made to write incentive provisions for new contracts and to convert older ones from CPFF, NASA moved quickly. NASA issued one incentive contract in FY 1961, six in 1962, ten in 1963, and thirty-four in 1964. By the beginning of FY 1967 NASA was managing some 200 incentive contracts (figure 4–1).[113] The selection of contracts for conversion was made by top management, the program offices, and the staff offices, especially the Office of Procurement. However, the criteria for applying incentive arrangements in each situation had to be developed within the centers.

The basic criterion in applying incentives was to not use them before both sides had arrived at a clear definition of requirements. In other words, project definition and contract negotiation went hand in hand. As a corollary, most of the centers, when questioned by headquarters procurement officials in 1964, recommended that NASA use a phased approach to R&D contracts. Even before the introduction of phased project planning, center officials had instituted a phased contracting cycle. They began with a CPFF contract for research and initial development, converted to cost-plus-incentive-fee as requirements became firmer, and to fixed-price-incentive as cost prediction became more accurate. It was essential, however, that both NASA and its contractors understand how incentives worked. Or, what amounted to the same thing, "you've got to negotiate the contract all the way through or you're hung."[114] It was the lack of experience in handling incentives that led to most of the problems, such as placing incentives on final mission performance without including incentives for important technical subgoals.

Granted that early definition was imperative, what improvements did NASA program managers have in mind? Consider, for example, the Office of Manned Space Flight (OMSF), which was spending more than two-thirds of NASA funds obligated for R&D. Meeting in executive session, the OMSF Management Council resolved to give primary emphasis to schedule, then to cost, and third, to performance.[115] In the opinion of Council members, emphasis on schedule was the best or even the only way to force both parties to define the end product because there would be "a premium on getting the specifications correctly written in the first place, because the Government personnel realize that the contractor is going to insist that they accept the hardware based on these specifications in order to earn the schedule incentive fee."[116] For OMSF, there was good reason to stress schedule over costs. Schedule and cost control were very closely related; Mueller



[1]Fixed-price incentive
[2]Cost-plus-incentive-fee
[3]Cost-plus-award-fee
[4]Cost-plus-incentive-fee/award-fee

Source: *Procurement Program* (31 Oct. 1966), p. 17.

Figure 4–1. — Number of incentive contracts under administration by type of contract, FY 1961–1966.

believed that the only way to keep costs down was to keep on schedule. The use of schedule incentives worked better than any other means to create "hard" communications between the project manager and the hardware producer, to get the contractor to deliver its hardware in order that NASA might conduct early ground testing, and to give OMSF added insurance against unforeseen difficulties. Not that schedule and performance were identical; as one program manager put it, "There's no point in delivering a product that's unsatisfactory on time."[117] To improve performance NASA and the contractor had to define the discrete tasks, or work packages, into which the work was divided; without such definition neither side could communicate with the other.

Almost as soon as NASA introduced incentives, it began to study their effectiveness. Just before the Hilburn task force submitted its reports on schedule slippages, the Office of Procurement asked the centers to report on their experience with incentives and subsequently contracted with the management consulting firm of Booz, Allen and Hamilton to study the effectiveness of NASA incentive contracts. The final report was submitted in August 1966, and it furnished a detailed balance sheet of the benefits and disadvantages of incentives.[118] It did not, perhaps, provide conclusive evidence on their long-term results. But it was based on a study of fifteen contracts that totaled $1.5 billion, or 62 percent by dollar value of NASA incentive contracts at the time the study began in July 1965.[119]

The task force discovered that, properly applied, incentives were more effective than CPFF in improving delivery on schedule and performance according to specifications. Incentives did not cost more to administer than CPFF and reduced the need for day-to-day surveillance of contractor operations. Finally, incentives led to better program definition, although more as a byproduct than as a stated objective.[120] On the other hand, there was little apparent relation between the intensity of contractor motivation and the use of incentives. Typically, the contractor was under pressure to secure new business or follow-on work or, in the case of the Manned Space Flight programs, to perform well in the face of the publicity that these programs, above all others, engendered.

The task force also concluded that in at least four cases incentives were introduced under pressure from headquarters and that in three cases incentives were used to control cost growth. The center personnel had not been enthusiastic about incentives. They believed incentives required more controls, not less, and lengthened, rather than shortened, the overall procurement cycle. Incentives placed a heavier administrative burden on the technical staff. And by increasing the element of risk, incentives prompted the contractor to ask for higher fees—say, 8 percent rather than 7 percent. Only recognition that incentives had improved contractor performance in a number of cases caused center employees to change their minds. Also, by the end of FY 1964 almost 700 center personnel had received some training in the management of incentives. By then—and certainly by the conclusion of the Booz, Allen and Hamilton study—NASA procurement policy had moved beyond the experimental stage. By 1966 NASA was able to define with some precision four "desired conditions" to be considered in designing incentive contracts: the procurement should require no significant technological breakthroughs; there should be no overriding need for intensive technical direction during the life of the contract; it should be possible to estimate the cost of getting the job done; and, within constraints, the contractor should be given almost complete freedom to perform.*[121] Moreover, NASA had at its disposal a variety

*One former NASA official gave an example of the sort of freedom that NASA gave to its prime contractors. One year NASA found that Boeing needed $10 million for Lunar Orbiter that was not programmed in the budget. To keep from breaking the contract and, more importantly, from upsetting Boeing's management plans, NASA reprogrammed the $10 million from other projects.

of techniques that ranged from incentives directed to a single variable (cost, schedule, performance), to multiple incentives, to contracts employing interdependency, that is, "the amount of penalty or reward . . . under any one incentive element in a multiple-incentive contract will vary according to the achievements under the other incentive elements."[122]

And yet, while NASA had learned much in handling incentives, it had not reaped the full benefit of their use. NASA employees continued to monitor contracts even when incentives made such surveillance unnecessary. Also, while NASA had improved its method for processing contract changes, it had not done enough to reduce the number of changes. The Booz, Allen and Hamilton team concluded that the benefits of incentives were not yet well understood within NASA. Incentives were used, so to speak, to communicate NASA objectives, but not to convey the *relative* importance of cost, performance, and schedule. On the other hand, the task force members were well aware that the structure of NASA contracts could go only so far to eliminate bottlenecks. As they put it, "certain objectives . . . appear to be largely beyond the control or 'influence' of the contract structure," especially cost growth.[123] Incentives might reduce but they could not eliminate the technical uncertainties dogging most R&D programs. Nor was the sort of technical definition required by incentives already in use available when it was needed most—at the beginning of the program. A contract designed to cover everything from early development phases to small-quantity production was not flexible enough for the kind of program (which covered most of NASA's R&D work) where the end item itself changed over the life of the program. The contradiction between fixed targets and changing programs remained insoluble.[124]

In sum, the recommendations of the Booz, Allen and Hamilton study group were directed toward attainable goals. Incentives were not to be used as a cure for unavoidable uncertainties, nor could they compensate for the lack of program definition that their use presupposed. Within these assumptions, the study group recommended continued use of incentive contracts for R&D and support services; use of a phased approach in contracting, in which the final fee would reflect the contractor's accomplishment in all phases; introduction of "steeper" (higher) incentives as technical definition improved; and NASA's implementation of additional case studies on recent contracts.[125] The basic conclusion, however, was that NASA's use of incentives had been justified by the results. And though the study group did not say so explicitly, its drift was that incentives were the most effective way in which NASA could simulate market conditions in what was essentially a nonmarket environment.

The conclusions of the Booz, Allen and Hamilton report suggest a final observation. In the mid-1960s NASA was moving toward more rather than less technical direction of programs. The introduction of incentives and their widespread use influenced and was affected by the establishment of phased project planning guidelines. It was the essence of phased project planning that it kept open many technical options, allowing management to intervene at almost any point before the final developmental phase. And by recommending that incentives be phased to stress those subgoals that collectively made up the program objective, Booz, Allen and Hamilton clarified what has been implicit throughout this discussion: While procurement and program planning were two ways of regarding a unified acquisition process, the latter was logically prior to the former.

Chapter 5

NASA Manpower Policy

INTRODUCTION

No matter how brilliant NASA planning might have been, it would have come to nought without the manpower to implement it. The success of NASA management in transforming a small research organization into one of the largest Federal agencies within five years of its creation depended on the assembly of scientists, engineers, and managers who made the transition possible. That NASA grew rapidly is undeniable. Starting its official life with the nucleus of engineers inherited from NACA, the new agency soon added personnel transferred from the Vanguard program and the Army Ballistic Missile Agency. But after acquiring the von Braun team in July 1960, NASA had to recruit manpower directly, a problem made even more onerous by President Kennedy's commitment of the nation to a lunar landing before the end of the decade. The 1960s began with a tremendous increase in the agency's manpower, followed by a contraction as marked as the expansion that preceded it. The number of contractor employees alone doubled in 1961–1962 and again in the following year [1] to the point where 420 000 persons (contractor and civil service) were working directly or indirectly for NASA at the beginning of 1966.[2] This marked the turning point; from a total of 396 000 employees at the end of June 1966, agency employment fell to 307 000 in 1967, to 268 000 in 1968, and to 218 000 in 1969.[3]

But these figures alone do not explain the mix of skills the agency needed, the reasons for using so high a proportion of contractor employees, or the problems created by Government-wide standards to which the agency must conform. NASA officials had to meet internal requirements while conforming to the policies of four other agencies: the Bureau of the Budget, which approved or took exception to NASA personnel ceilings; the U.S. Civil Service Commission, which established Federal standards for personnel management and position classification; the U.S. General Accounting Office, which, as the watchdog for Congress, was frequently to investigate NASA's use of support service contracts (and by extension, its conduct of research and development programs) in the later 1960s; and the Department of Defense, which supplied NASA with military detailees experienced in managing complex development programs.

The questions addressed in this chapter include the following: How did the agency's manpower policies contribute to the success of NASA programs? What specific features of NASA manpower management would account for the success it had in building the agency's work force? Where and by whom was personnel policy made? Was NASA as successful in scaling down as it has been in "tooling up"? Finally, were NASA installations aggregations of manpower and equipment that were to be dispersed once the mission for which they were assembled was completed, or were the centers organized to take on scientific work other than the kind for which they were created? Each of these questions is considered before arriving at more general conclusions.

The Making of NASA Manpower Policy

How was NASA manpower policy made? Given the decentralized structure of the agency, there could be no uniform policy imposed from above. Instead, there were competing interest "nodes" with various conceptions of the problem and various preferred solutions. Below the level of top management, the Personnel Division was charged with developing and administering NASA's personnel program within the framework of civil service regulations. Established as a division of the Office of Administration following the 1961 reorganization, the Personnel Division had two Directors during the period under consideration: Robert J. Lacklen, who served from October 1958 to the end of 1964, and Grove Webster, who was Acting Director and then permanent Director from January 1965 until his death in 1972.* In line with Webb's concept of functional management, the Director of Personnel was authorized to "establish standards, procedures and operating guidelines . . . review and advise on proposed allocations of personnel . . . participate with Headquarters and Field officials in the selection of key personnel."[4] But the Division's powers were sharply limited in several ways. It had relatively little visibility since it was only part of a larger functional office and lacked the quasi-autonomy of Procurement within the Office of Industry Affairs. In the gritty bureaucratic prose of one internal report, Personnel was not in a position

> to participate in formulation of policy and high-level implementation in critical matters, such as salary, budgets [and] allocation of top positions. . . . the organizational placement of Personnel is too low in the NASA organization to deal with total personnel management problems on an agency-wide basis. The . . . Director of Personnel is apparently able to discuss personnel matters with a Deputy or Assistant Director at a Center level but not with the Center Director himself.[5]

* Before the 1961 reorganization, Personnel was a division of the Office of Business Administration headed by Albert Siepert.

Headquarters Personnel Division did not manage and had little control over personnel offices at the centers. In effect, each center worked out its own problems in its own way. Not the least of Personnel's problems was due to the program offices' practice of dealing directly with the centers rather than working through the functional offices. The great and evident success of NASA personnel management owed something to the fact that headquarters did not interfere with what the centers wanted to do.

To the extent that there were uniform personnel guidelines, they were due to the logic of NASA programs and to periodic investigations by the Civil Service Commission and the General Accounting Office. Policy was made at headquarters not only by the Personnel Division, but also by standing committees of which the Director was a member ex officio, by ad hoc task forces, by the NASA Management Committee, and by Webb's intervention from time to time. Webb's interest in recruiting executive managers was well known, and he was prepared to take exception to any policy proposal that went counter to his experience in private industry, at the State Department, and at the Bureau of the Budget. He disagreed, for example, with a 1964 report of the Committee for Economic Development recommending that the task of improving executive management in the Federal Government should be assigned to a separate office within the White House.[6] Webb thought that management "must always find a way to marry substance and administration at each level and . . . the senior leaders in the departments and agencies are the focal points to which the President must look to get this done."

One example of Webb's interest in personnel management illustrates how policy at NASA was *not* made, and the example applies beyond the personnel issue. A recurring problem in most large organizations is how to select skilled executives: how to strike a balance between promotion from within and recruitment from without, how to determine the characteristics sought in executive managers, how to persuade prospects to join, and how to screen candidates for positions. This problem has arisen from time to time since NASA's establishment and has been resolved in several ways, ranging from informal recruitment by the first Administrator Glennan and later by Webb, to systems developed by the program offices and centers on the basis of their experience and needs. In 1965 NASA introduced a system for recruiting executives from outside the agency and later adapted it to cover internal selection. The system, regarded as comparable to the one used for selecting astronauts, was used to fill vacancies at the Electronics Research Center and at Goddard. In March 1965 Deputy Associate Administrator Jack Young, after clearing the matter with Associate Administrator Seamans and his deputy Hilburn, authorized a task force to study NASA executive personnel administration, and this group, headed by Young's executive assistant John Cole, issued a report on 29 November. The Cole report was an example of complete staff work down to the draft NASA Management Instructions provided to carry out its recommendations. But nothing came of the report, chiefly, it would seem, because Webb shot it down. The task force had neither sought his guidance nor solicited his views, and its principal recommendation—that the executive personnel administration function be organized directly under the Associate Administrator—seemed to fly in the face of all that Webb believed. He was reported to have asked, "Where would this leave the Personnel Director? If he is to be a high level official he needs this function. This tends to go against the concept of joining . . . substance and administration at each level." The report did not recognize what Webb and Seamans had done to bring talent into NASA: "How could we have done more in . . . recruitment of George Mueller—where did his people come from? Who got Mueller? Newell? Bisplinghoff? Adams? Promoted Newell? What we want to do is teach them how to do what they do not know—change when a Goett or Holmes stops the kind of management responsiveness we want."[7] Cole's recommendations would have placed more reliance on a system than on the judgment of senior management.

In short, the moral of this story seems to be that no important changes in personnel policy could be made without involving top management. No agencywide personnel policy could succeed without being a mixture of systematic and informal recruitment; and functional officials had to do their staff work and submit their findings without, as it were, presenting top management with accomplished facts.

NASA Excepted and Supergrade Positions, 1958–1968

Any account of the role of top management in making policy must examine excepted and supergrade positions because they were among the most potent means by which the Administrator shaped the agency.[8] To understand the importance of the excepted position, one must consider NACA's position vis-à-vis private industry at the end of World War II. Along with other Government laboratories, NACA found that it could no longer compete with industry for the best engineers; the situation was such that it threatened NACA's ability to operate effectively, if at all. In 1947 and 1949, Congress enacted legislation of the utmost significance to NACA/NASA. The act of 1 August 1947 (Public Law 80–313) authorized the Secretary of Defense to fill forty-five scientific and professional positions at salaries from $10 000 to $13 000, a range equivalent to that of the highest ranking Government officials; this authority was extended to NACA in 1949 when it was allotted ten "Public Law 313" positions. Congress intended the positions to be used for recruitment rather than retention. They were to be filled by the head of the agency with the concurrence of the Civil Service Commission (CSC). Moreover, the agency head was empowered to determine the appropriate salary within the bounds set by legislation. In a word, the 1947 act was intended to give certain agencies, especially those doing R&D, a flexibility within the bounds of the civil service system. Public Law 313 was in no way intended as a blank check, and such positions were not to be filled as a matter of course. Each expansion of Public Law 313 positions was the result of tough bargaining between NACA and CSC.

The 1949 Classification Act served to bring civil service salaries in line with those in the private sector. As the first major reform in classification since 1923, it established the job classification system that prevailed until the civil service reorganization of 1978. Briefly, the 1949 act accomplished four things. It consolidated the old "professional and scientific" and "clerical-administrative-fiscal" categories into one common structure, added three new grades popularly known as "supergrades", (GS-16 through GS-18), established numerical limits on the number of supergrades that could be established by CSC (the so-called "general quota"), and authorized the Commission to set standards for supergrade positions as well as the right to withdraw allocations from agencies not conforming to those standards. The supergrades established in 1949 were an addition to, not a replacement of, the Public Law 313 positions created two years earlier. However, with each increase in salaries in the supergrade range, Public Law 313 positions have been more or less reduced to those in the GS-16 to GS-18 range.

These two measures alleviated but did not resolve the problem of competitive salaries. From 1950 to 1958 Director Dryden and Jerome Hunsaker, chairman of NACA's Main Committee, urged Congress to extend its allotment of Public Law 313 positions. In 1956 Congress authorized thirty such positions (NACA had requested sixty), and on 20 June 1958 it authorized a ceiling of ninety Public Law 313 positions in anticipation of the creation of the new space agency. But in a curious way, this legislation only accentuated the problem. In 1949–1950 Dryden, Hunsaker, and the members of the Main Committee had decided that these positions ought to be filled from within. They had reasoned that the persons they might recruit would probably not be as qualified as the branch chiefs in the research divisions of the laboratories, "and that to bring such men of lesser quality into the agency under P.L.-313 appointments, while leaving the deputy laboratory directors and chiefs of major research divisions at 'P-8' would be indefensible and would precipitate numerous resignations."[9]

But this consideration did not arise when NACA asked for further extensions of Public Law 313 authority. By 1956 "the salary crisis was so critical that NACA was seeking any measures to retain its key personnel . . . from 1951 through 1958 NACA fought steadily for higher grades, P.L. 313 authority—any measures by which it could retain its staff through recognition and the prestige that the new supergrades and the P.L.-313 positions afforded."[10] Yet none of this stemmed the inexorable leakage of top personnel to industry. Between January 1955 and early 1960, NACA/NASA lost more than 250 GS-11 through GS-16 personnel with a median service of 11 years, 73 of them to 3 companies. The median salary increase for NACA executives moving to industry was $1,000–$3,000.[11] Such losses made it more difficult for the agency to perform its mission. As one author, assessing the problem in 1961, observed, "the government [was] indirectly paying these people what it [would] not pay them directly."[12]

Such was NASA's position from its establishment to mid-1961. Congress sought to give NASA a much greater flexibility in filling science and engineering positions. Section 203(b)(2) of the Space Act provided that the officers and employees of NASA

> shall be compensated in accordance with the civil-service laws and their compensation fixed in accordance with the Classification Act of 1949, except that (A) to the extent the Administrator deems such action necessary to the discharge of his responsibilities, he may appoint and fix the compensation (up to a limit of $19,000 a year, or up to a limit of $21,000 a year for a maximum of ten positions) of not more than two hundred and sixty of the scientific, engineering, and administrative personnel of the Administration without regard to such laws.

Unfortunately, the intent of this clause was partially nullified by a ruling of the U.S. Comptroller General on the day that NASA began its official life: NACA's Public Law 313 positions were included in, not an addition to, the 260 positions authorized by the Space Act. Nevertheless, NASA managed to have the ceiling raised twice within the next 3 years, from 260 to 290 in June 1960 and to 425 in October 1961. The first increase was needed to accommodate the top-level personnel transferred from the Army Ballistic Missile Agency to the new Marshall Space Flight Center. In addition, twelve Public Law 313 positions were transferred from DOD to NASA—the so-called "German positions"—and the number of all positions permitted above $19 000 was raised from ten to thirteen. The second increase, from 290 to 425, was in response to the imperatives of the manned lunar landing; included was a proviso that not more than 355 were to be established prior to 1 March 1962 and not more than 390 prior to 1 July 1962.

To understand how NASA used its supergrades and excepted positions, it is well to round out the picture with a brief account of the 1962 Salary Reform Act. Earlier it was shown that lack of comparability, or equal pay for equal work, had been one of the problems NASA inherited from its predecessor agency. By 1960 one of the major problems within the Federal structure was how to retain, let alone attract, executives who could make considerably more money for comparable work in the private sector. Over the next two years, pressure for change built up within the Government, beginning with a March 1961 CSC report showing just how large the discrepancies between the public and private sectors really were.* This was followed by a Bureau of Labor Statistics report in November 1961 to much the same effect. These reports, along with that of an Advisory Panel on Federal Pay Systems, were the bases for the legislation introduced by President Kennedy on 20 February 1962.† The 1962 act further enhanced NASA's ability to get the job done; indeed, it was the one major piece of legislation during the 1960s to allow NASA the increases in executive positions that top management believed to be essential. The act increased the rate for GS-18 positions from $18 500 to $20 000; identified the earlier $19 000 limit for all but thirty excepted positions (the number having been raised) with "the highest rate for grade GS-18"; and, while raising the quota of supergrade positions in the Government to

* The results were so startling "that the White House established a special committee of consultants to review the 'matches' made, to assure that the findings were valid." Among the consultants was James Webb, then a member of the board of several companies, including McDonnell Aircraft. Braithwaite, "The Executive Personnel Program, 1958–1962" (Jan. 1967), p. 48.

† Note also that the Bell report (pp. 75–78) appeared at the *right* time in May 1962.

2400, established a nonquota category of scientific and research positions to be filled by agencies with approval by CSC. The act did not remove all numerical limitations nor did it fully accomplish making Federal salaries above grade GS-15 really comparable to the private sector. But for NASA in particular, it afforded an opportunity to recruit executives in the face of the continued denial to NASA of higher excepted position ceilings. In October 1962, for example, Webb requested the Bureau of the Budget to increase the number of such positions from 425 to 750. In July 1963 the Bureau denied the request, suggesting that NASA meet its requirements through applying to CSC for nonquota positions. This is what NASA had perforce to do; thus by the beginning of FY 1967, NASA had just over 700 supergrade personnel on board.[13]

One of the difficulties in evaluating so complex and technical an area as NASA's use of supergrade and nonquota positions is the lack of precision with which these terms were used. A GS-16 position could be supergrade, excepted, nonquota, or Public Law 313, depending on the context. Another potential pitfall is to make too much of NASA's uniqueness. In seeking to attract the most highly qualified engineers and administrators, NASA was doing no more than any other R&D agency. When Webb and Dryden tried unsuccessfully to raise the excepted position ceiling to 750, they coordinated their program with the Director of Defense Research and Engineering and the Director of the National Institutes of Health.[14]

With these caveats, the question remains: What difference did the availability of excepted and nonquota positions make to NASA? The most important *administrative* result was the leverage gained by Glennan and then Webb for structuring the agency. Only the Administrator could "establish an Excepted Position, change the assignment of an incumbent, change his title, or his rate of compensation."[15] Glennan and Webb thought of these positions as a resource personal to themselves, a resource that might be used to structure the agency at the higher levels without the need to seek congressional approval. But from about 1962, a number of constraints began to restrict the Administrator's ability to allot excepted positions. Within the agency there was pressure from the program offices and the centers to retain the excepted positions they already had. The centers and program directors would, as it were, "associate their 'total' . . . as a 'quota' guaranteed to them, so that with loss of any one individual, they felt free to 'replace him' with some other position."[16] From being the Administrator's personal resource, the excepted position became a budgetary resource to be divided within the agency. In effect, every such position tended to be committed once CSC authorized it.

The real threat to NASA's use of excepted slots came from outside. First the number of excepted positions was frozen at 425; then the Administrator lost authority to place certain top-level positions in the excepted category; finally CSC began to approve fewer nonquota positions, even though the number of such positions was unrestricted by law. The Federal Executive Salary Act of 1964, for the first time, named those positions beyond the $21 000 limit (raised from

$19 000 in 1962) that the Administrator could fill; these were the positions just below the level of the Administrator and Deputy Administrator. In the view of one official,

> The limit of $21,000 for "not more than 30" of the Excepted Positions had permitted the Administrator to re-establish the major program offices of NASA as he deemed necessary. . . . With the top positions in the Agency now set forth by precise title in the Exeuctive Salary Act, he must seek prior approval of further major changes through formal legislative proposal and debate. The element of "flexibility" and quick response to new management concepts and strcutures was lost.[17]

As NASA manpower and funding peaked, the agency was under much greater pressure from CSC to justify its nonquota positions. In October 1966, for example, CSC advised the heads of executive agencies that further requests for positions at grade GS-16 and above "must show how the needed positions are essential to the accomplishment of Great Society objectives."[18] It would not suffice for NASA to claim that it supported the "Great Society" in some general but undefinable way. Agency heads now had to cite specific legislative or executive authority for the programs for which they sought new positions. Nor were such positions, even if approved, to become in any sense the property of the agency requesting them; whenever a slot was no longer required for an approved position, the Commission would consider Government-wide needs in deciding what to do with it.

The more NASA sought an increased number of nonquota positions, the more chary the Commission became in granting them. In August 1966 CSC Chairman John W. Macy, Jr. wrote to Webb:

> It is very difficult for us to rationalize the increase in the number of high-level positions in an agency when the program of the agency is not changing significantly. . . . it appears questionable that the increases since 1962 fully support the increase which has taken place in the number of high-level positions. . . . I am afraid that you and we will be subject to severe criticism from the Congress if the number of high-level positions continues to increase at the rate at which it has been increasing for the past several years.[19]

Unfortunately for NASA, the dollar level of its programs was not a reliable index of its requirements. NASA spent comparatively little on salaries; the bulk of its funds went for contracted hardware systems. This meant that as NASA's capital equipment increased, the agency would continue to need highly trained personnel for the kinds of scientific programs that such equipment made possible. In 1966–1967 NASA programs continued to grow beyond the capabilities envisaged by CSC and the Bureau of the Budget in 1962–1963. The new Electronics Research Center was still only partially staffed, and planning for Voyager and Apollo Applications was under way, while in October 1965 the transfer to the Kennedy Space Center of responsibility for unmanned launches meant that a new block of positions would be needed there. The upshot of the matter was a compromise. NASA agreed not to seek more GS-16 personnel; instead it would use some of its forty excepted slots on the understanding that they would be converted to grade GS-16 at the beginning of FY 1968. However, the majority of these excepted slots had not been utilized when Seamans, who had handled negotiations with CSC, left NASA at the end of 1967.

If this account of NASA's authority to fill excepted positions shows anything, it is the great importance that top management attached to them. Webb, Dryden, and Seamans fought hard to extend that authority by persuading Congress to raise the level of excepted positions, hiring nonquota personnel where excepted personnel were unavailable, reserving as far as possible a certain number of excepted positions for "quick hires" of executives from outside the agency, and doing what they could to keep the center directors and program associate administrators at the highest levels authorized by the various salary acts. In some ways, NASA's record in justifying its supergrade positions was outstanding. One ranking CSC staff member advised Macy that, of all the supergrade positions, those from NASA had "the least water in them, of any of the agencies and departments."[20] Yet the success of NASA's use of excepted personnel mostly depended on a balance of forces outside the agency—principally the willingness of Congress to raise the salary structure in order to attract engineers and administrators on whose talents the future of NASA would depend.

Characteristics of the NASA Work Force

Despite their significance for top management, excepted positions comprised a small fraction of the NASA work force, seldom more than 2 percent. One must turn elsewhere to derive some useful generalizations about NASA employees as a whole and to consider the more general features of agency personnel policy. Four features seem noteworthy: the generous allotment of supergrade and excepted positions for the agency's top managers; the unusually high proportion of scientists and engineers in relation to the total work force; the use of military detailees as project managers, support staff, and, of course, astronauts; and NASA's extensive use of support service contracts at its newer centers. The first and last features have already been discussed; the next section considers the ways in which centers like Marshall Space Flight Center and Manned Spacecraft Center (or program offices like Tracking and Data Acquisition) made use of support contract personnel. This section considers the makeup of in-house personnel.

A high proportion of NASA personnel were scientists and engineers, a higher proportion, perhaps, than in any other Federal agency doing research and development work.[21] Between 1960 and 1968 their share of the total NASA work force was fairly constant, ranging between one-third in 1961 and two-fifths in 1967 (table 5–1). Moreover, if the figures for in-house and contractor scientists and engineers are combined, the total was a constant one-fourth throughout the period.

But these figures must be examined before their significance becomes apparent. First of all, who are scientists and engineers? Are statisticians and computer

Table 5-1. — NASA scientists and engineers as a percentage of NASA employment, 1960–1968.
(30 June approximations)

Characteristic	1960	1961	1962	1963	1964	1965	1966	1967	1968
Contractor scientists and engineers	7 300	12 600	25 000	48 200	68 800	72 600	77 400	64 800	51 350
Percentage of contractor employment	20.0%	21.9%	21.6%	22.1%	19.8%	19.3%	21.5%	23.7%	24.3%
NASA scientists and engineers	3 500	5 800	8 200	11 000	12 400	13 500	14 300	14 500	13 715
Percentage of NASA employment	34.3%	33.1%	34.6%	36.8%	38.2%	39.4%	39.7%	40.1%	39.2%
Total scientists and engineers	10 800	18 400	33 200	59 200	81 200	86 100	91 700	79 300	65 065
Percentage of total employment	23.1%	24.5%	23.9%	23.8%	21.4%	20.9%	23.2%	25.7%	26.4%
Distribution of total scientists and engineers									
By employer (100%)									
Contractors	67.6%	68.5%	75.3%	81.4%	84.7%	84.3%	84.4%	81.7%	78.9%
NASA	32.4	31.5	24.7	18.6	15.3	15.7	15.6	18.3	21.1
By appropriation (100%)									
Administrative operations					15.5	16.6	16.5	18.5	21.7
Research and development					82.8	81.8	82.5	81.1	78.5
Construction of facilities					1.7	1.6	1.0	0.4	0.2
By program office (100%)									
University affairs					–	–	–	0.5	–
Technology utilization					0.1	0.3	0.3	0.2	–
Tracking and data acquisition					4.6	4.7	6.5	6.8	6.6
Advanced research and technology					14.3	12.5	10.2	11.5	13.3
Space sciences and applications					19.0	17.2	14.6	16.8	14.3
Manned space flight					62.0	65.3	68.4	64.2	65.4
By sector (100%)									
Government					15.3	15.7	15.6	18.3	21.1
Industry					81.9	81.2	81.8	78.3	77.1
University and nonprofit					2.8	3.1	2.6	3.4	1.8
Other characteristics (100%)									
Prime and subcontractors-R&D					71.8	70.7	67.2	64.8	68.2
Prime and subcontractors-COF					1.7	1.6	0.5	0.4	0.2
Service contractors-R&D					–	–	5.5	5.1	–
Service contractors-AO					0.2	0.9	0.9	0.2	0.2
Materials and supplies-R&D					8.1	7.9	7.3	5.6	8.5
University and nonprofit-R&D					2.8	3.1	2.6	3.4	1.8
NASA employees-AO					15.3	15.7	15.6	18.3	21.1

Source: *NASA Data Book,* table 3–27.

programmers included in this category; are persons trained in science or engineering who were employed in positions that did not require such training included? The lack of widely accepted definitions may be one reason why statistical breakdowns that would compare NASA employment of scientists and engineers with other R&D agencies are so hard to come by. The matter is further complicated because scientists and engineers were grouped by NASA under three separate occupational codes. NASA defined scientists and engineers as "all persons primarily engaged in the performance or direction of scientific, engineering, mathematical, or other technical professional work requiring a 4-year college major . . . in engineering or in physical, life, or mathematical science."[22] This would exclude persons trained in the social sciences, include statisticians, and leave open the occupational group to which computer programmers belong. Of the total, all but an insignificant number of scientists and engineers were grouped under occupational code 700 (scientific and engineering positions), a classification that included persons with aerospace technology qualifications. This qualification was important chiefly because of the special examination that CSC authorized NASA to employ, beginning in 1962. This examination was for NASA's use alone; and part C, "for work in Research and Development Administration," was hailed by NASA officials as an "advance in selective examination and recruitment." What made the examination, especially part C, unique, was that the applicant, in addition to the required educational background, had to demonstrate "understanding of research and development organizations and their specialized problems, organizational structures, functions, operations, and characteristics."[23] The beauty of this requirement was its openendedness: NASA could add specialties, give the examiner discretion in interpreting requirements, and generally make use of a hiring freedom unmatched by any other agency. NASA personnel controlled the examination at the critical points: they administered it, they rated it, and they gave it much of its specific content. The aerospace technology examination "provided a means for NASA to fill almost all of what could be termed its 'professional' positions. This, combined with the power of the Administrator to make 'excepted' appointments, gave NASA almost complete control over whom it hired."[24]

Where did NASA obtain its newly hired scientists and engineers? The major hiring campaigns occurred in 1961–1962 and 1962–1963; the results are shown in table 5–2. Approximately 70 percent of newly hired scientists and engineers came from either industry or Government. In 1963–1964 the source of new technical hires shifted significantly from Government to industry, while recruitment from colleges and universities stayed constant at 23 percent. All this was in marked contrast to contractor experience: Most of their new hires came from other industrial organizations or other plants and divisions of the same company, with an insignificant percentage recruited from Government.

Where were in-house and contractor scientists and engineers employed? Table 5–3, which gives the essential figures as of 30 June 1964, reveals that 85 percent of the scientists and engineers in the NASA work force were employed by

Table 5-2. — Organizational sources of NASA in-house scientists and engineers.

Source	1961–62	1963–64	Difference
Total	*100.0%*	*100.0%*	–
Industry	32.4%	40.8%	+8.4
Federal Government	40.1%	28.9%	−11.2
College or university[1]	23.8%	23.3%	−0.5
Other[2]	3.7%	7.0%	+3.3

[1] Graduating students account for 20.8% in 1963–64 and 22.1% in 1961–62.
[2] Includes Nonprofit organizations, unemployed, and other.
Source: *Reply to Sen. Gaylord Nelson,* table III-A. NASA Staff Study of Recruitment Sources and Selected Characteristics of Scientists and Engineers Hired by NASA (1 Oct. 1962–30 Sept. 1964).

private industry, including JPL; 83 percent were working on NASA programs funded by the research and development appropriation; 62 percent were employed under the direct supervision of OMSF and that, of these, 10.8 percent (5450) were NASA employees. These figures also show that while 38.2 percent of total NASA civil service employees were scientists and engineers, only 19.8 percent of contractor employees were.[25] Contractors performed a major share of NASA work, and NASA required qualified persons to direct and monitor these activities. At the same time, each NASA scientist or engineer had more contractor employees to supervise: where there was 1 NASA scientist or engineer for 1.5 contractor scientists and engineers in 1960, there was only 1 for every 5 in 1964, and 1 for every 5.5 in 1966.[26]

How did NASA requirements for scientists and engineers compare with national requirements in the same categories? Table 5–4 shows that NASA manpower requirements were 4.6 percent of national requirements in 1964, rising to only 5.4 percent in 1965. The issue of national manpower requirements for specialists was a source of some confusion during the mid-1960s. Journalists, scientists, and Congressmen who criticized the space program accused NASA, among other things, of siphoning off scientific manpower from areas with greater need, of possessing a disproportionate share of the nation's scientific manpower, and of attracting to itself a greater number of scientists and engineers than its programs warranted. But such criticisms simply ignored the lack of a national policy to coordinate the distribution of scientists and engineers. To be sure, the NASA Administrator was a member of the Federal Council for Science and Technology, established in 1959 to act as such a coordinating body. There were also congressional committees in abundance, ad hoc panels of the National Academy of Sciences, and various coordinating mechanisms involving NASA and DOD. Nevertheless, there was no formal agency to coordinate or to make a unified national science policy; therefore, each agency was free to recruit personnel to meet its own needs, subject only to budgetary restrictions. In the absence of

Table 5–3. — Total scientists and engineers on NASA work by program office, 30 June 1964.

Program Office	Total	Research and Development			Construction of Facilities		Administrative Operations	
		Prime and Sub	University and Nonprofit	Materials	Prime and Sub	Materials	Service Contractor	NASA Employees
Total	*81 200*	*58 300*	*2 300*	*6 600*	*1 400*	-	*200*	*12 400*
Office of Manned Space Flight	50 350	39 100	60	4 570	1 040	-	130	5 450
Office of Advanced Research and Technology	11 600	5 560	460	930	180	-	40	4 430
Office of Space Science and Applications	15 420	10 800	1 620	840	130	-	30	2 000
Office of Tracking and Data Acquisition	3 720	2 800	100	260	50	-	0	510
Office of Technology Utilization and Policy Planning	110	40	60	-	-	-	-	10

Source: NASA Management Information Systems Division (Office of Administration), *Scientists and Engineers and Total Employment on NASA Programs as of June 30, 1964*, table IV. 15 Dec. 1964.

Table 5-4. — NASA requirements for scientists and engineers compared with national requirements, 1960-1970.

Year (1 Jan.)	National Requirements[1]	NASA Requirements[2]	NASA Requirements as a Percent of National Requirements
1960	1 185 000	8 400	.7
1961	1 260 000	14 700	1.2
1962	1 340 000	22 000	1.6
1963	1 415 000	43 500	3.1
1964	1 495 000	68 600	4.6
1965	1 570 000	84 500	5.4
1966	1 645 000	87 900	5.3
1967	1 725 000	87 900	5.1
1968	1 800 000	87 900	4.8
1969	1 880 000	87 900	4.7
1970	1 955 000	87 900	4.4

[1] The data on national requirements are from preliminary estimates prepared by the Department of Labor, published in *The Manpower Report of the President* (Mar. 1963), pp. 100, 125, as follows: total scientists, 1960, 335 000; total engineers, 1960, 850 000; total scientists, 1970, 580 000; total engineers, 1970, 1 375 000. This table presents a linear interpolation between the key dates of 1960 and 1970. For 1960 through 1964, these data are estimates of persons employed in existing positions. For 1965 through 1970, the data are projections of *requirements*, not *supply*.
[2] The estimates of NASA requirements for 1967 through 1970 are projected at a constant level assuming a budget program of approximately $5.2 billion annually.
Source: NASA Management Information Systems Division (Office of Administration), *Scientists and Engineers and Total Employment on NASA Programs as of June 30, 1964*, table IV. 15 Dec. 1964.

yardsticks to determine "how much is enough," no one could say that a certain percentage of scientists in an R&D agency was enough or too much. Projections by the Bureau of Labor Statistics or by NASA had to reckon on the existence of variables external to the system. For what they are worth, the figures in table 5-4 show that NASA requirements were neither as great as its critics feared nor as small as its defenders anticipated.

One feature that the tables do not indicate is that in the 1960s the NASA work force was mostly white and male, especially at the higher levels. The issue of equal employment opportunity (EEO) was not yet the source of difficulty it would later become, when the imperative (for NASA) of recruiting and retaining highly trained personnel collided with the demands of blacks and women for a greater share of Federal jobs. EEO, as a challenge and as a battle cry, originated with President Johnson's Executive Order 11246 (24 September 1965).* This

* Extended by Executive Order 11375 (13 October 1967) to cover women.

declared the policy of prohibiting discrimination in Federal employment, and it enjoined the head of each executive agency to "establish and maintain a positive program of equal employment opportunity for all civilian employees and applicants for employment within his jurisdiction."[27] In addition, each agency became responsible for ensuring that its contractors took "affirmative action" to promote equal employment opportunity.

This and subsequent executive orders were ambiguous in a crucial sense. It was not enough for NASA to show that it did not discriminate against its employees nor that it permitted its contractors to do so. The burden of proof was now on the agency to show that minorities and women were adequately *represented* as a percentage of full-time employees. But there was no basis for arguing that one group was or was not represented adequately until one answered the question, "compared to what?" In 1973, 3.4 percent of all NASA scientists and engineers were black, while the Government-wide average for black employees was about 20 percent. On the other hand, since 3.5 percent of scientists and engineers in the United States were of minority groups, the NASA figure was very close to the average. Many of the difficulties faced by NASA in implementing EEO were not, of course, of the agency's making. The procedures could not be worked all at once but only on the basis of accrued experience. Moreover, NASA faced the problem of comparable pay in hiring the relatively few black scientists and engineers who were coming on the market in the early 1970s; most of them could go into industry at salaries considerably higher than NASA was authorized to pay. In any case, NASA had all it could do to keep the engineers it already had, much less hire new ones.

In a sense, NASA's problem was how to give EEO proper organizational location and visibility. Until 1971, EEO was handled by two separate divisions on a part-time basis. The Director of Personnel was responsible for handling internal EEO policy, while the Office of Procurement enforced compliance of contractors operating at or near NASA centers. Since both offices had many other responsibilities, EEO was relatively low on their list of priorities. Furthermore, there were genuine difficulties in coordinating these programs on a Government-wide basis. On the one hand, CSC was charged with implementing EEO in the Federal Government, and the Labor Department was charged with establishing rules for contractor compliance. On the other hand, each agency was responsible for establishing and maintaining its own program. Thus the potential overlap between NASA, CSC and the Labor Department created a zone of uncertainty. In September 1971 NASA consolidated its EEO activities by establishing an Equal Employment Opportunity Office that reported to the Associate Administrator for Organization and Management.

NASA policy has always been to make the maximum use of DOD capabilities. Thus NASA used DOD support in contract administration, procurement of launch vehicles like the Titan II, and tracking and capsule recovery in the Mercury, Gemini, and Apollo programs. One of the more important of these services was the detailing of military officers to NASA for extended tours of duty—usually for three years with a one-year renewal option. When NASA was established, the only persons with experience in the kinds of projects the agency was expected to implement were officers involved in weapon systems development. A short list of military detailees form the Air Force makes its own point: Lt. Gen. Samuel Phillips, Apollo Program Manager from 1964 to 1969; Maj. Gen. James W. Humphreys, Jr., Director of Space Medicine, Office of Manned Space Flight; Brig. Gen. Edmund O'Connor, Director of Industrial Operations at Marshall; and Brig. Gen. C. H. Bolender, Program Director for the lunar module. An incidental advantage of using detailees was that they did not count against the numerical ceiling imposed by the Bureau of the Budget on personnel.[29]

The detailee system was governed by agreements between NASA and DOD, especially the agreement approved by President Eisenhower in April 1959. This established a procedure for coordinating NASA requests with what DOD was prepared to furnish; set the tour of duty at three years, although either agency could terminate an assignment earlier; stipulated that NASA supervisors prepare military effectiveness reports; and required that NASA reimburse the military departments for pay and allowances. The increase in the number of detailees assigned to NASA coincided closely with changes in the scope of NASA's manned spaceflight programs. There were 77 detailees with NASA at the end of 1960, 161 at the end of 1962, and 323 at the end of 1966, after which the number gradually leveled off.[30] The number declined after NASA had developed a pool of experienced managers capable of taking over many of the jobs to which officers had been assigned. Many detailees resigned their commissions after completing their tours of duty to take jobs with industry, and it was considered common knowledge in the services that "when they detail an outstanding [flag] officer to NASA, that is the last they see of him."[31] Not the least of NASA's worries was that there might be a sudden withdrawal of officers for urgent military needs, as in Southeast Asia. While NASA continued to call on the services for manpower, from 1966 on positions were not filled with detailees until a reasonable effort had been made to obtain a civilian.

The selection of the astronauts deserves fuller treatment than the brief summary offered here, but a paragraph must suffice.[32] Millions who could not have identified the NASA Administrator or the Associate Administrator for Manned Space Flight knew who John Glenn and Neil Armstrong were. Between 1959 and 1969 NASA selected seven groups for astronautic training. Over the decade, there was a trend from military detailees to civilian recruits and a shift toward the utilization of scientists in addition to test pilots. In this sense, the history of astronaut selection reflects the changing nature of the manned spaceflight program. In the beginning what counted was the physical and mental stamina of the candidates, as well as their coordination and reaction time. Manned spaceflight first had to be shown to be feasible before the later Apollo missions, whose main purpose was scientific investigation, could proceed. Astronauts were also expected to assist in developing future spacecraft and advanced flight simulators, and their experience and judgment were essential in changing or freezing the design of existing flight equipment. The recruitment and training of the astronauts was, without doubt, the most taxing and successful of NASA's personnel development programs.

SUPPORT SERVICE CONTRACTS AND THE GENERAL ACCOUNTING OFFICE

The reader might suppose that since NASA was committed to contracting out for most of its operations, all the centers (and program offices) used contractor personnel in the same way and to the same degree. This was not the way support contracting worked. In 1968 Langley, with 4200 civil service personnel, had only 450 support contractors actually working at the center. Lewis, with 4600 civil service employees, had about 350 support contractors, almost all of whom were at the center's Plum Brook Station.[33] In general, the newer centers made the most extensive use of support services, but even they followed no set policy from above, save for the vague formulas of the NASA circular (NPC 401), "Contracting for Nonpersonal Services." The three Office of Manned Space Flight (OMSF) centers, for example, had individual contracting patterns.[34] Following the August 1963 reorganization, Marshall consolidated its contracts into two groups. In the first were the "mission support" contracts negotiated for each of the center's nine laboratories; these were in research, test, design, and "special maintenance and operation." Marshall then planned two master contracts—one for technical services and one for management services—each of which was designed to support the center across all organizational lines. At Marshall (and also at Goddard) there was one prime contractor for each laboratory or division for which support was provided, each contract covered one or two years with an option for renewal, and the contract was normally cost-plus-award-fee. A noteworthy point, and one that distinguished Marshall from the older centers, was that most contract personnel were stationed on-site in such a way that they were not always segregated from civil service employees.

The contracting patterns at Kennedy Space Center (KSC) and Manned Spacecraft Center (MSC) were slightly different. At Kennedy there were five master contracts that supported the center across the board: (1) launch support (including advance storage, shop operations, and Complex 39); (2) instrumentation support; (3) base communications (operation and maintenance of all communications except administrative telephones); (4) administrative service (including printing, photographic support, and automatic data equipment operation); and (5) base operations (including guard, janitorial, and motor pool services), which, under a consolidated contract, was provided by Trans-World Airlines. Incidentally, NASA's multicontractor approach was the opposite of that used by the Air Force at the Eastern Test Range, where Pan American World Airways was prime contractor for operation and maintenance. As a congressional study noted,

> NASA deliberately avoided the single-contractor approach used on the Eastern Test Range because it did not want to get "locked" into a situation where it had to rely on one contractor. The agency was convinced that several contractors . . . would provide more competition and thus lower costs. . . . NASA also contended that a multicontractor pattern minimizes labor problems by not risking the totality of the operation to a single contractor who might be struck.[35]

At MSC the pattern was midway between Marshall's "one contract per laboratory" approach and Kennedy's five master contracts. MSC used six master contracts for the same number of functions; within the mission support contract there were subsidiary contracts, one per laboratory.

Since the policy issues in contracting for support services are fully discussed in chapter 4, only the main points need be summarized here. NASA defended contracts for nonpersonal services for the following reasons: (1) the rapid buildup of the Gemini and Apollo programs precluded reliance on civil servants alone, (2) it was NASA policy not to develop in-house capabilities that were already available in the private sector, (3) NASA employees were needed for technical direction rather than for hardware fabrication or routine chores, (4) NASA had developed safeguards for policing its contractors, (5) it was better to let the up-and-down swings in manpower take place in the contractor, rather than the civil service, work force, and (6) the practice of using support service contractors had been fully disclosed to Congress and the Bureau of the Budget. However, these contracts were not in the same category as the Bellcomm and Boeing TIE contracts. Support service contracts were for functions that were repetitive, continuous, and routine, such as computer programming, data processing, and general maintenance. The Bellcomm and Boeing TIE contracts were for engineering support that, some Congressmen held, NASA had no right to contract out. But relying so heavily on the private sector for maintenance services laid NASA open to all sorts of criticism. First, there were no cost studies to prove that contracting for services was less expensive than doing the work in-house. Second, because many contractor employees were located on-site, there was the danger that they would be intermingled with the civil service work force and that NASA employees might find themselves supervising contract labor, which was illegal. Third, some Government labor union officials suspected that NASA was using support contracts to circumvent personnel ceilings imposed by the Bureau of the Budget. And this suspicion might have drawn support from Webb's correspondence with Budget Director Kermit Gordon, in which Webb protested manpower restrictions imposed by Gordon. Webb flatly stated that NASA was using support contracts because NASA, with its limited manpower, had to turn outside for certain kinds of work.[36]

Outside the Federal Government, most of the opposition to support contracts came from organized labor, especially the American Federation of Government Employees. Within the Government, NASA manpower and contracting policies were closely watched by several agencies, notably the U.S. General Accounting Office (GAO). Established by the 1921 Budget and Accounting Act, and headed by the U.S. Comptroller General, GAO is an independent agency of the legislative branch. Its principal function and the reason for its importance is the authority vested in it "to examine the manner in which Government agencies discharge their financial responsibilities and to make reports to the Congress on the financial operations of the Federal agencies."[37] The reports are normally of two kinds: survey reports, which serve as the basis either for a draft report or a decision not to proceed further; and draft reports, which are submitted to the whole Congress, individual members or committees (especially the congressional Government Operations committees), or officials of the agency being reviewed.[38] Much of GAO's influence rests on its authority to approve agencywide accounting systems, to audit and settle the accounts of executive officers, and to make comprehensive reviews, in which "emphasis is not on the individual transactions but on the soundness of the agency's accounting and financial management system and *the efficiency of its operations generally.*"[39] In other words, the Comptroller General has construed GAO's authority to inspect an agency's records as one of general oversight, comparable to that enjoyed by the legislative committees of Congress.

NASA's relations with GAO have followed a well-defined pattern. During NASA's early years GAO paid it comparatively little attention, save for the "production of documents" controversy in 1959. As late as FY 1964, when GAO made 147 audit reports to Congress on DOD management, it made only 3 on NASA.[40] But inevitably GAO would turn more of its attention to NASA; the agency was simply too visible, and its contracting practices were too much like those of DOD. When Elmer Staats became Comptroller General in March 1966, the processes of audit and comprehensive review were intensified. Moreover, GAO has two specific powers that were bound to affect its relations with NASA. It is authorized to consider protests by unsuccessful bidders on Government contracts, and it has the right to audit the records of contractors having Government contracts negotiated without advertising, an authority whose significance for NASA is obvious.[41] GAO interpreted these powers broadly as authorization to review R&D activities, including complete programs. Thus GAO reviewed supposed cost overruns on the development of scientific instruments for Surveyor, the management of the S-II program by North American Aviation, and the same company's management of its Apollo command and service module contract (drawing on excerpts from the Phillips report); undertook to examine the Orbiting Astronomical Observatory program at the request of the chairman of the House Committee on Science and Astronautics; and reviewed scheduling practices related to the development of the Nimbus spacecraft.[42]

The effects of GAO audit reports varied. In some cases Congress took no action; in others GAO terminated a report, either because of inadequate manpower to handle the study or because the study itself did not seem worth pursuing. And in a surprising number of cases, GAO canceled or modified draft reports because of NASA comments.[43] This probably owes less to the innate reasonableness of NASA's position than to the experience gained by officials in constant touch with GAO. It has been NASA policy since the early 1960s not to invoke executive privilege in response to GAO requests for documents; this had been the issue between Glennan and the Comptroller General when the latter reviewed the negotiations leading to the Rocketdyne contract for the F-1 engine (see p. 73). It was consistent with NASA policy that relations with GAO should not degenerate into adversary proceedings. More important, NASA took steps to coordinate its replies to GAO draft reports. Prior to 1967 agency replies were normally prepared and dispatched by the "cognizant" official or program office; a report on Surveyor would be answered by the Associate Administrator for Space Science and Applications or his deputy. Under the 1967 reorganization, all replies had to go through the Office of Organization and Management, which coordinated the facts and memorandums comprising NASA's position. In this way, the agency could speak with one voice.

Yet it is undeniable that, starting in the mid-1960s, GAO began to take a close, hard look at NASA. By 1975 it was reviewing NASA activities like the space shuttle almost on a "real time" basis. The review of R&D programs was by no means the only area to which GAO's audit powers extended. It intensified its review of NASA financial management systems, including the planning-programming-budgeting system mandated for executive agencies in 1965. It continued to review Government-wide use of automatic data processing equipment, especially the rental versus purchase issue. It began to address more of its audit reports to agency officials than to Congress. Finally—and this is where the discussion began—it turned to NASA's use of contracts for nonpersonal services, from bid proposal expenses to contracts for base support at NASA laboratories and installations.[44] Basically, GAO found such contracts suspect, either because they set up what appeared to be an employer-employee relation or were costing the Government more money than the use of civil service personnel would have. And here NASA was vulnerable because it could not readily show that such contracts *were* less expensive and because NASA had few criteria to determine whether certain kinds of work should be done in-house or contracted out.

One such GAO report on contracts at Marshall and Goddard in June 1967 helped to touch off an evaluation and overhaul of NASA personnel policies. To be precise, the GAO report was the first in a chain of events that included reductions in the NASA budget, which led to program cancelations and concomitant layoffs of personnel; a Civil Service Commission "Evaluation of Personnel Management," which criticized the ways in which NASA used its manpower; and a decision in October by a CSC administrative judge that most NASA support contracts were illegal. All these factors led to a NASA-wide review. This combination of budget cuts, reductions in force (RIFs, or dismissing personnel) and across-the-board reviews had an effect on top management that may be called tonic by some and purgative by others. The next section examines the changes that review, reduction, and RIFs forced on NASA.

Personnel Management Policy, 1967–1969

Review, reduction, and RIFs must be understood in terms of a broad context. NASA had its interests to defend, but so did GAO, CSC, and the Executive Office.

For the reasons given above, GAO eventually was bound to pay more attention to NASA contracting and manpower practices. CSC had to mediate between an agency that needed (but could not easily request) more nonquota positions and a Congress that was inclined to question the number already on hand. As for relations with the Executive Office, Webb summed them up with his usual frankness at a meeting with center directors in September 1966. Referring to President Johnson, he said that

> we are not dealing with the guy who said, I am your champion, I will go out there and fight your battles, I will get Kennedy and his 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 me out, you didn't do it.

At the Bureau of the Budget,

> Elmer Staats is gone, even Kermit Gordon is gone and the guys that are there now are interested in this cost-effectiveness program. . . . It is the byword over there. . . . I must say that all I get is a cold, stony demand that we act like the Post Office when I go over there.[45]

Webb and the others conceded that there would have to be changes, but the meeting broke up without consensus on the nature of the changes.

In the area of manpower management the agency already had begun a blueprint for the future. Three weeks before Webb's meeting with his center directors, a NASA task force submitted its "Considerations in the Management of Manpower in NASA." This task force, established by Seamans and chaired by Wesley Hjornevik, the Director for Administration at MSC, included representatives from other NASA centers; its report provided a penetrating analysis of the agency's manpower problems and some recommendations for resolving them.* The task force gave special attention to "possible methods by which Center complements could be adjusted by management to meet the needs of changing roles and missions."[46] This adjustment problem existed in two forms. One was the relation between space sciences and manned spaceflight and the changes in center roles that this relation would bring about. The other was the so-called "Marshall problem," the belief throughout NASA that Marshall "was the source for manpower needed elsewhere and the place where surplus manpower would occur as the Apollo Program phased down."[47] The Marshall problem extended beyond the future of Marshall itself to embrace a host of other questions: What should be done with centers whose primary role and mission (in Marshall's case, booster development) was changing or disappearing? How could headquarters mediate between two centers reporting to the same program office—like Marshall and MSC—with different attitudes toward this problem? Was manpower a resource available to the entire agency, one that could be shifted freely between centers? And was there any method by which NASA could determine how its work force

* The Hjornevik report was submitted on 8 September 1966. Besides Hjornevik, the task force included Henry Barnett (Lewis), T. Melvin Butler (Langley), Harry Gorman (Marshall), Samuel Keller (Goddard), and Merrill Mead (Ames).

was utilized, the nature of that work force, and its availability as programs were terminated and others were begun? The last question is logically anterior to the others since, without accurate figures, no agency manpower plan could be realistic.

The Hjornevik task force found that existing techniques for tracking manpower were inadequate, whether because headquarters ignored them, or because the program offices only presented their needs one year at a time, or because the various manpower reports did not match excess manpower with new programs. The task force report emphasized that this was not enough and that "a continuing effort should be made . . . to formalize and . . . standardize methods of justifying and validating manpower requirements at all levels."[48] This could be done by making three-to-five-year projections based on actual and proposed future programs and the requirements for new starts being considered at each center. Such a system might tell NASA management how manpower was really used. More to the point, such a system could be effective only in proportion as it related each center and program to the other centers and programs comprising the total NASA effort.

To use such information, the agency needed techniques for matching manpower with program requirements. In turn, their usefulness involved two assumptions: that each center's manpower complement would remain stable and that contractor manpower would remain available to free civil service employees for more important tasks. Granted these assumptions (both of which were overtaken by events), the task force identified seven ways to match manpower with programs: functional transfer of groups (e.g., the transfer of the Space Task Group from Langley to Houston); individual transfers; RIFs in one area coupled with increased hiring in another; attrition either among organizations or skill groups; retraining personnel; reassigning work from an overloaded to an underloaded area; and use of the vacant-position "float," that is, the gap between authorized and filled positions.[49] These options were available to NASA but not all to the same degree. The task force dismissed out of hand the possibility of mass transfers; the conditions that had led to the transfer of the Space Task Group to Houston or the Naval Research Laboratory scientists to Goddard no longer existed. Transfers of individuals were even less likely to succeed because of the morale problems such moves usually created. Reductions in force were to be viewed as a last resort, "where a function, office, or discrete facility is being eliminated . . . its results are usually unsatisfactory."[50] Retraining personnel was valuable as a means of "changing the skill mix or enabling a Center to move from one step in technology to the next." But the task force rejected retraining as a way of redistributing manpower for the same reason that it viewed personnel transfers as impractical. In the end, the Hjornevik report endorsed three methods of matching personnel to programs. It very cautiously approved the concept of assigning tasks where the manpower was available. Such endorsement had to be cautious because each center had developed its own special capability and because "the prime interest of a center can properly change only very gradually."[51] The task force also approved of using attrition to move slots between centers and the "float" of unfilled positions to handle emergency requirements.

In sum, the Hjornevik report provided NASA with three things. First, it diagnosed the agency's manpower problems: the lack of reporting systems to determine the agency's needs as related to present and future planning, the absence of tradeoff studies to establish how far personnel at one center were available to another, and the failure of officials to coordinate manpower information with the budget and programming cycle. Second, it made specific recommendations for the short term; recommendations that on the one hand called for the assembly of information needed by management for an agencywide view of civil service manpower, and on the other hand, for the centers' participation in the kind of planning that would have to cross institutional and program office lines. Third, the report attempted to demonstrate that attrition and reassignment of work between centers were the two basic methods for matching civil service manpower to program changes. All these recommendations assumed that NASA could maintain its in-house work force at a fairly stable level.

The Hjornevik report was a warning that NASA would have to prepare for major changes within the near future. Yet the events of 1967 seem to have taken the agency almost unawares. The GAO report of June 1967 on support contracts at Goddard and Marshall concluded that NASA could have achieved additional savings by using civil service employees.[52] At Marshall, GAO auditors reviewed three contracts at three laboratories and concluded that NASA could have realized savings of 19 percent; at Goddard, of 7.4 percent.* The thrust of this and other GAO reports of 1967–1968 was that NASA had not developed adequate costing standards to justify contracting for support services, whether for engineering support at Goddard or guard and fire protection services at KSC. Besides GAO's failure to recognize the pressure from Congress to maintain personnel strength below authorized levels, what especially troubled NASA officials was the report's conclusion that the principal rationale for such contracts no longer applied: "in contrast to its past rate of growth, NASA has now achieved a relative degree of stability and should be able to better consider relative costs in assessing the extent to which it should continue to rely on the use of support service contracts."[53]

The GAO reports did not go the whole route and conclude that support contracts *as such* were illegal. But following its review of six Goddard contracts, GAO turned them over to CSC for further study. And it was the CSC decision, based on a study of two of these contracts, that NASA's use of contractor personnel was illegal. This decision, handed down in October 1967 by General Counsel Leo Pellerzi, threatened NASA with serious disruption at a time when it was already reducing its own work force. Pellerzi ruled that the contracts were illegal because they involved on-site performance by contractors, because they set up an employer-employee relation between Government and contractor personnel, and

* These were *aggregate* percentages. On Marshall's contract for servicing its Computation Laboratory, the report estimated savings of up to 27 percent.

because "contract personnel are performing the regular work of the agency. . . . It seems clear that what Goddard has done in this situation is to create federal positions."[54] The question then was not whether NASA would have to lay off contractor personnel, only how soon.

Coming on the heels of the GAO report, the Pellerzi decision was enormously troubling to NASA officials. Yet neither had any dramatic effect—not immediately, anyway. On the eve of the Pellerzi decision, NASA employment was down more than 100 000 from what it had been at the beginning of 1966. Furthermore, the practice of support contracting was so widespread, in DOD as in NASA, that it was unrealistic to suppose that it could have been eliminated. In any case, neither CSC, GAO, nor the Bureau of the Budget wanted to force a showdown. Rather, they began to work with the Office of Organization and Management, which became NASA's liaison with these agencies, to hammer out a uniform policy on support contracts. Between the announcement of the Pellerzi decision and the spring of 1968, Finger issued guidelines that, taken together, signaled a move to bring such contracts under much tighter central control. No function then performed by civil servants could be converted to contract, all new support contracts and extensions of old ones over $100 000 had to be approved in advance by Finger, requests for contract approval would have to include cost comparisons for all functions where cost was a consideration in contracting for services, and service contracts were to be limited to one year. Also, support contract manpower was to be reduced at a rate at least twice as great as that for Government employees. These guidelines were in addition to a joint study that NASA conducted with CSC, GAO, and the Bureau of the Budget to develop a mutually acceptable cost model for support services. The issue was so fraught with uncertainty that NASA had perforce to remain in a holding pattern until clear Government-wide standards could be brought into play.[55]

In fact, it is surprising that so much sound and fury should have led to such inconclusive, short-term results. NASA developed tighter central control and took steps to provide for periodic recompetition of such contracts. As for the reviews that led to the GAO reports and the Pellerzi decision, the outcome was neither simple nor final. After more than a year of negotiations, NASA announced at the end of 1968 that it would convert 810 contractor positions at Goddard to civil service status.[56] At KSC, NASA modified certain practices in contracting for fire protection and photographic support, as recommended by GAO.[57] The center consolidated its photographic work with that done at the Air Force Eastern Test Range, reduced the expenses involved in having its prime support contractor (Trans-World Airlines) subcontract for guard and fire protection service, and (at KSC and Marshall) consolidated many engineering support contracts into large master contracts. The result of all the pressure from GAO and CSC was that NASA developed more rigorous costing standards and, in general, used such contracts much more selectively. But as long as NASA was committed to spending most of its procurement dollars in the private sector, support contracts would remain essential to the conduct of its operations.

In the long run, NASA's view of its authority to enter into support service contracts prevailed in the Federal courts. When NASA ordered a reduction in force at Marshall in 1967 (see p. 134), a Federal district court found twenty-two support service contracts invalid and declared the RIF null and void. This led to an eleven-year legal battle between NASA and the American Federation of Government Employees, which ended in October 1978 when the U.S. Supreme Court refused to hear a challenge to a decision by the U.S. Court of Appeals for the District of Columbia reversing the 1967 decision. In its decision the court of appeals construed the Space Act broadly to give the agency maximum flexibility in contracting for and administering support services. The implications, not only for NASA but for other Government agencies, are immense. NASA's position, that Federal agencies have open-ended authority to contract for services, has been sustained; and it now seems that these agencies will use their contract authority to circumvent any hiring freezes imposed by the White House.

However, in the summer of 1967 this outcome was more than a decade away. NASA officials faced the immediate prospect of defending the agency on two fronts. Not only did they have to justify support contracts to a Congress that was increasingly sceptical about their current use and future necessity, they had to justify their in-house personnel management as well. The Hjornevik report had made several recommendations, but it had been an in-house report. Although management authorized followup studies and began to implement some recommendations in piecemeal fashion, there was not the same urgency that would have resulted from a review by an outside body. This was precisely what befell NASA when CSC submitted its "Evaluation of Personnel Management" to Webb in October 1967. The Commission's earlier review of NASA in 1962 had disclosed certain deficiencies—in merit promotion, position classification, and lack of definite agencywide policies—but that report itself had not been made public. The Commission, it seems, was prepared to make allowances for a new agency assigned an enormously demanding mission. Consequently, CSC seems to have given NASA the benefit of the doubt.[58]

The 1967 report went further in identifying the successes and failures of NASA personnel management. It gave NASA credit for progress in many areas since 1962, notably in recruiting outstanding research and engineering personnel. But the report pointed to four problem areas that NASA would have to set in order. The first problem was that many supervisors did not understand their personnel management responsibilities in areas such as merit promotion and employee-management cooperation. The second problem was that "employees are uninformed about and lack confidence in . . . personnel practices such as merit promotion, career development, and position classification that operate differently than described in NASA publications and include criteria which have never been called to their attention."[59] The third problem was the lack of management support for equal opportunity programs or for increased hiring of women; the fourth problem was the lack of headquarters leadership in areas such as supervisory training and promotions.

This kind of outside review placed NASA in an awkward position. While NASA officials criticized the conclusions as too sweeping, they conceded privately that the report was correct in many details. As head of the agency, Webb had to hold a middle-ground—accepting the thrust of the report without alienating center directors and program managers. CSC, he argued, did not "wish to be punitive in their reports unless it is absolutely essential." If NASA could develop an effective personnel management program during the next five years, CSC "will gladly forget the sins of the past." What bothered him more than the report itself was the role that CSC was assuming. Instead of "detailed policing of agency personnel matters," CSC's role should have been one of "promulgating broad policies and then auditing the agencies to assure that these policies are properly carried out."[60] NASA had to convince CSC—and Congress—that it took its problems seriously and was doing something to correct them.

The first and principal step was Webb's establishment of a Personnel Management Review Committee on 21 November 1967.* There is good reason to stress the importance of this step. Unlike a flight program, which usually has a definite beginning and end, personnel management is a continuing function. To be effective, a review panel must be a standing committee whose members have a stake in the matters they are inspecting. Through the Committee NASA management tried to shift from "policies" to "policy" and to end the lack of coordination between headquarters and the centers. In 1968, for example, there were installations with high separation and low accession rates (Ames, MSC), high separation and high accession rates (Electronics Research Center, headquarters), and low accession and low separation rates (Langley, Lewis).[61] The problem was to create an agencywide personnel management policy without imposing a spurious uniformity.

The Personnel Management Review Committee was charged to review NASA's personnel management process, identify problems, and "recommend to the Administrator any changes considered appropriate . . . and provide feedback to the Administrator as to the efficiency of . . . policies and practices throughout NASA."[62] Authority of the standing committee cut across the normal program and functional lines. Its immediate business was to respond to the CSC report, but over the next two years it carried out a very thorough survey of the agency's personnel structure. To Webb, the Committee was something more. It was of a piece with the other management changes he made to bring problems to his attention: the creation of the NASA Management Council, the revival of the Office of Management Development to prepare agency management issuances, and the establishment of a group to develop a catalogue of agency policies. Webb was

* It was formally established by NMI 1152.26 (3 Jan. 1968). The chairman was Harry Gorman (Deputy Director, Administrative, at Marshall), who had served on the Hjornevik Committee. Other members were Grove Webster, NASA Director of Personnel; Bernard Moritz, Assistant Administrator for Special Contracts Negotiation and Review; and John Townsend, Deputy Director of Goddard.

especially anxious to bring in R&D managers from the centers for a tour of duty with the Committee to give them an overall view of the agency.

What did the Committee accomplish? Merely by its establishment, Webb advertised the importance he attached to personnel management. And by recruiting managers from the centers to serve on the Committee, he hoped to bring about a consensus in favor of uniform policy—a consensus not to be achieved by executive fiat. The Committee began its work by visiting six centers and talking to key functional and program officials, discussions that were to be the basis of the Committee's April 1968 report. In the report the Committee agreed with CSC's analysis to the extent that "its conclusions can . . . be supported by a careful and sometimes isolated selection of substandard performance cited in one . . . of the individual NASA installation reports."[63] But the Committee denied that what might hold for one center in one area could be extended to the whole of NASA. Instead, the report recommended certain steps that, applied over the long term, would tend to bring NASA more into line with CSC demands. The Committee found that personnel management needed to be made visible at the headquarters level, and it recommended that the function "be elevated organizationally" within Finger's office.[64] It also recommended that NASA continue to review its use of support service contracts and to define precisely what such a contract was; that NASA adopt a ranking system, which would enable the agency to retain the top 25 percent of its professional staff in the event of a reduction in force; that NASA lower entrance-level standards in certain cases to recruit minority employees; and that more attention be given to improving employee-management relations.[65] Finally, the members recommended that the Committee be continued in order to effect "greater involvement of top officials in personnel management."[66]

This last phrase explains why the Committee was relatively successful. It was not a panel of outside consultants with no responsibility for the problems on its agenda. By bringing in officials from the centers and by staggering Committee appointments, a nice balance was struck between the two bureaucratic concepts of flexibility and continuity. The Committee worked closely with Finger and Webster, the latter of whom was a member ex officio. It established subcommittees to tackle such problems as career trainee programs and reductions in force. Its blend of line and functional officials was in keeping with the agency's way of getting things done; that is, it provided for maximum delegation of powers to officials who would have to carry out the policies they helped to make.

Personnel Retrenchments, 1967–1969

Ultimately, the issues of personnel management were those of long-range planning. But in 1967 NASA had no formal agencywide long-range plan. Without it, NASA could produce no justification for keeping agency manpower at the 30 000-plus level, where it had been since 1963. Webb believed that an agency had to be able to phase down as well as to "tool up." One week before he left NASA in 1968, he delivered the Diebold Lecture at Harvard and said that

> in the project-type endeavor, acceleration would have to be followed by deceleration and that many operations involving both governmental and nongovernmental manpower and facilities would have only a limited usefulness. We have accepted the need to end these after their purposes have been met. . . .
> We have already . . . reduced the scale of our total activities to about one-half the peak level, which was attained three years ago. . . . We are in a position to operate at this level or to increase or decrease as decisions generate either trend.[67]

But the phasedown was neither as orderly nor as well planned as this statement would indicate. The dismissals and hiring freezes that began in FY 1968 signaled a reduction in manpower that continued well into the 1970s. The reductions shaped and were shaped by the absence of some long-range plan for NASA to place before Congress. The initial reductions did not merely have a ripple effect on the NASA work force; they also set the terms on which future programs, if approved, would have to be carried out.

The reductions in permanent civil service employees (FY 1968–1970) are shown in table 5–5. However, the figures conceal the variations between centers, where there was no single pattern of accessions and separations. Rather than discuss them all, it is more useful to concentrate on one center to understand what a reduction in force is, how it worked at NASA in the late 1960s, how the center adjusted to its losses, and how skills lost in one area might (or might not) be replaced in another.

Except for the Electronics Research Center, which closed on 30 June 1970, no center was more severely affected by manpower reductions than Marshall. Mention was made earlier of the "Marshall problem"—the widely held conviction that there was a manpower surplus at Huntsville that might be tapped by the rest of NASA. By 1966 Associate Administrator for Manned Space Flight Mueller was reducing manpower at Marshall in order to increase it at MSC and KSC and still remain within his personnel ceiling.[68] At the same time a debate was going on within OMSF on the future of Marshall, a debate hinted at in the Hjornevik report.[69] Basically, MSC officials wanted Marshall to develop the new booster systems that they believed would be needed for manned missions in the 1970s. Marshall officials disagreed, feeling constrained by their lack of manpower in advanced research, compared with that for hardware development and testing. Further, Lewis had already staked out a role in advanced propulsion technology that Marshall could not expect to emulate. In short, Marshall had to cope with three closely related problems: commitment to a program that was about to taper off, a high proportion of facilities designed to serve specific programs rather than institutional needs, and what was perceived at Houston, the Cape, and headquarters as an excess of manpower in relation to future assignments.

At the end of October 1967 it became apparent that Marshall would have to reduce its manpower considerably. Congress passed and the President signed an appropriations bill that eliminated the Voyager and Advanced Missions programs, reduced most other non-Apollo programs, and cut back the administrative operations appropriations request by $43.3 million. This meant that Marshall

Installation	Peak Employment 7/31/67	Change in FY 1968	Actual 6/30/68	Change in FY 1969	Actual 6/30/69	Planned Change in FY 1970		Planned 6/30/70
						Increase	Decrease	
Headquarters (including NASA Pasadena Office)	2 332	−178	2 154	−61	2 093	+37		2 130
Kennedy	2 739	+178	2 917	−40	2 877	+4		2 881
Manned	4 862	−258	4 604	−220	4 384		−77	4 303
Marshall	7 272	−832	6 440	−291	6 149		−298	5 851
OMSF	14 873	−912	13 961	−551	13 410	+4	−375	13 035
Ames	2 176	−93	2 083	−91	1 992		−36	1 956
Electronics	738	+56	794	+6	802	+98		900
Flight	598	−32	566	−27	539		−5	534
Langley	4 251	−214	4 037	−125	3 912		−63	3 849
Lewis	4 703	−251	4 452	−184	4 268		−71	4 197
SNPO[1]	115	−7	108	−4	104		−5	99
OART	12 581	−541	12 040	−423	11 617	+98	−180	11 535
Goddard:								
Base	3 828	−133	3 695	−166	3 529		−82	3 447
Contractor conversion	-	+127	127	+473	600	+365		965
Wallops	512	−18	494	−10	484	+4		488
OSSA	4 340	−24	4 316	+297	4 613	+369	−82	4 900
Undistributed reduction	-	-	-	-	-	-	−100	−100
NASA	34 126	−1 655	32 471	−738	31 733	+508	−741	31 500
Recapitulation:								
Base	34 126	−1 782	32 344	−1 211	31 133	+143	−741	30 535
Contractor conversion[2]	-	+127	127	+473	600	+365	-	965

[1] Space Nuclear Propulsion Office.
[2] Contractor conversions are treated as decreases in NASA employment.
Source: Thomas O. Paine to Robert P. Mayo, Director, U.S. Bureau of the Budget, 18 Aug. 1969, tabie I.

would have to reduce its personnel by 700, a move that was successfully challenged in the Federal courts by the American Federation of Government Employees.* When the injunction against the RIF was lifted in April 1968, the careful phasedown planned by center officials was no longer possible. The RIF procedures led to an extremely high turnover of personnel, even of those who were not affected directly. The turnover of R&D personnel was three times higher than it had been at the same time in 1967. And those losses were especially heavy among the younger scientists and engineers, possibly because there were job opportunities at the Huntsville Arsenal nearby. The worst effect of the RIF, as it appeared to von Braun, was that it disrupted work teams that had taken years to develop.[70] The damage wrought by such procedures reached beyond their short-term effects to more profound second- and third-order consequences. Managers and supervisors were "bumped" into nonsupervisory positions and found themselves "relegated to the ranks of the workers they [had] been supervising."[71] The average age of employees rose as younger people were dismissed or left to seek work elsewhere. And as the average age of scientists and engineers rose, it became much less likely that the advanced research then taught at the universities would be reflected in NASA laboratories.[72]

In sum, RIFs and hiring freezes affected the NASA centers in many ways; some were obvious and immediate, and others were more subtle, although in the long run even more devastating. On the whole, NASA was unable to implement the orderly phasedown that Webb described in the Diebold Lecture. It was too much to ask NASA or any other agency to make unilateral reductions in funding and manpower. But in the name of economy, the Great Society, and the war in Vietnam, the Bureau of the Budget turned what might have been an orderly retreat into something resembling a rout. Between NASA's peak (in-house) employment in July 1967 and the end of FY 1969, NASA abolished 2850 permanent positions. In the FY 1970 budget cycle alone, the agency sustained *four* separate reductions: initially 370 positions were abolished; under pressure from the Bureau of the Budget that number escalated to 452, then to 552, and finally to 1052 positions.[73] These gross figures only hint at the consequences of continued large-scale reductions. First, NASA was given very limited authority to replace personnel who had been separated. In FY 1968 NASA replaced only one out of two separated and in 1969 about two out of five. At some centers the replacement ratios were much smaller: one in five at Langley, one in fourteen at Marshall.[74] By 1969 the "critical mass" at these centers was getting dangerously low. At Ames there was no longer "any remaining flexibility to take reductions in manpower. . . . Any pro rata share of manpower reduction at Ames appears improper in view of the small size of that installation."[75]

* A former NASA official observed that Marshall officials "carried out a rather extensive modeling exercise by means of computers in which they attempted to take into account the bumping rights of the Civil Service personnel. In this way they hoped to carry out their reductions in force at the designated levels and at the same time separate those individuals who were felt to be the least qualified. Since a shift of one individual usually involves three or four job changes in an organization, this effort was complex indeed."

Second, the effects of mass separations went far beyond the number of those actually dismissed. The long-range consequences included the departure of many younger professionals to look for greater job security and the concomitant rise in the average age of those who remained; a sharp drop in the number of college students hired from 925 in FY 1966 to less than 200 four years later;[76] and a rise in Federal employee union membership, especially at Marshall and MSC. The success of the American Federation of Government Employees (AFGE) in temporarily blocking the RIF imposed on Marshall convinced many employees that AFGE might be able in 1969 to repeat what it had done in 1968. In the long term, center officials had to deal with unions that were a good deal larger, more militant, and better organized than in the halcyon days of the space program. The actual number of persons separated might be only a fraction of the work force, but the ripple effect touched every center employee. As an internal MSC report observed,

> A RIF is a symbol to all employees that the Center or the Agency have serious problems. . . . Although by far the vast majority of employees . . . were not in any way touched by the proposed RIF, many of them viewed it as another symptom of an uncertain future. It should be pointed out, however, that the RIF did not create uncertainties, it merely reinforced them.[77]

Finally, this pattern of reductions and low replacement rates seems to have convinced top management that agency manpower must be defended and justified as a national asset. If all these skills had been assembled simply to get a job done, there was no cause for complaint if they were to be dispersed once that job was completed. Obviously, this was not how Webb, Paine, or Finger viewed the agency. In principle, they conceded that a "less-than-best" laboratory might be closed if it had served its initial purpose, if there was no likelihood that a new role for the laboratory could be found, or if closing the laboratory would not leave a significant gap in the national capability to perform R&D. But, they maintained, there was no reason why a center with a capacity for research in aeronautics or propulsion systems could not expand to cross-service other Government agencies, as NASA had been doing for DOD for many years. Furthermore, the centers were more flexible than was generally realized. At Lewis, for example, the altitude wind tunnel used to test the B-29 during World War II had been converted into a space environmental test facility during the 1960s. The same center shifted emphasis and manpower from propulsion systems to aeronautics following the cutbacks of 1967–1968. Even Marshall had been able to make the transition from one kind of development work to another; the Apollo Telescope Mount, assigned to the center in the summer of 1966, was very different from the launch vehicle development work for which Marshall was known.[78]

With no coordinating agency or advisory body to establish national priorities for the use of scientific manpower, the issue of which agencies were allocated such manpower had to be fought out in the political arena. This had been the case even during the relatively prosperous days of Presidents Eisenhower and Kennedy, when Presidential advisors like Killian and Wiesner had the power to make science policy rather than serve as more-or-less neutral umpires among competing agencies. By 1970 research priorities were established almost exclusively by the President working through the Bureau of the Budget. NASA priorities had to compete not only with other scientific priorities but with the priorities of other Federal programs generally. And such a process could only be inimical to the long-term interests of NASA R&D programs.

Some Conclusions

This chapter has examined some of the reasons for NASA's successes—as well as its problems—in attracting the mixture of scientific, engineering, and managerial talent that it needed. NASA's success was neither complete nor permanent, but it was adequate to the need. NASA in the 1960s had the kind of mission that attracted some of the best engineers in the country; it had a large block of excepted and nonquota positions, which the Administrator consciously used to structure the agency; and it was given an initial period of grace by CSC to work out its manpower policies to fit its programs. But none of these things would have availed much without the continued interest of top management to recruit the best talent from outside, ensure rapid promotion for those within, and involve the most capable engineers and project managers in running the agency. Management's interest in personnel matters can be illustrated by the history of the NASA Management Committee from October 1963, when it was established, to November 1965, when Seamans dissolved it. Of the sixty-six meetings held by the Committee, two-thirds had at least one personnel item on the agenda, ranging from the use of military detailees, to a consideration of employee-management relations at the centers, to security waivers for summer employees.[79]

This interest in personnel policy revealed itself differently at the level of top management, at the program offices, and at the centers. Webb's interest centered on selecting the best men for executive training. During the early 1960s he had perforce to find executives on the outside, and there was always a need to fill certain positions with men who had not come up within the agency. It was the practice to appoint a retired military officer to head the Office of Defense Affairs and a former aerospace executive to direct Industry Affairs; also, Webb had a self-imposed rule that appointments to "sensitive" positions, such as Associate Administrator for Manned Space Flight, were to be cleared with DOD.[80] But by 1965 NASA employment had stabilized and was not likely to increase. It was no longer necessary to go outside for the scarce talent the NASA mission required. For Webb the problem, rather, was to find and train the managers who would run the agency in the post-Apollo period. The problem had to be approached from a number of angles: by assigning project managers to headquarters for a tour of duty; by establishing in 1965 an executive recruiting service or talent bank for selecting NASA personnel to fill key positions; and by moving top officials from headquarters to the centers, as when Edgar Cortright, then Deputy Associate Administrator (OMSF), became the Director of Langley in May 1968.

The program offices and centers had the same interest in personnel management but a different focus. At OSSA, for instance, program officials singled out three problems as critical: How could OSSA eliminate people who were not performing as they should? How could program officials recruit an adequate number of scientists who could stay in touch with their fields while working for NASA, particularly in headquarters? What should be the relation of the headquarters program manager to the field project manager, and by what standards should the performance of the former be measured?[81] The same issues applied to the other program offices and the centers that reported to them. They had their own problems, their own management and reporting systems, and their own ideas as to what successful personnel management involved. Webb and Seamans looked to uniform agencywide standards; the program associate administrators and center directors were sceptical of them. In effect, this is what the history of NASA personnel policy reveals: The agency was too decentralized for tight headquarters control of personnel management; such consensus as there was—for example, regarding personnel data banks or shifting manpower between centers—was arrived at through standing committees like the Personnel Management Review Committee or the task force that wrote the Hjornevik report; and major shifts of work or manpower from one center to another could only occur gradually, if indeed they could occur at all. Finally, personnel management was not, nor could it be, a discrete, isolated area apart from the broad policy issues that NASA management faced. How to recruit and train engineers, how to determine the mix of skills at each center, how to turn engineers and scientists into administrators—these were the essence of NASA program planning.

Chapter 6

Program Planning and Authorization

PREREQUISITES FOR SUCCESSFUL PLANNING

Be it Government agency or private firm, every large organization must be able to plan in order to act. Planning implies that there is an authority to decide what is to be done, how, by whom, and over what period of time. Confusion easily results from a failure to specify the sort of planning that is being discussed and whether it is for the short-term, intermediate, or long-term future. The annual budget submission of a Federal agency is a short-term planning exercise of sorts, since it involves projecting the agency's needs against what the Office of Management and Budget and Congress are likely to authorize. At the other extreme are those grandiose ten-to-twenty-year projections of what an agency or corporation might undertake if and when resources become available.

This chapter is about how NASA planned and authorized its intermediate-range programs (the logical, not necessarily the chronological sequence): the missions that were flown, the systems that were developed, and the aeronautical research concepts that were proved by test models. These were the programs with lead times of five to seven years, most of which were conceived between 1958 and 1961 and which were accomplished during the following decade. The emphasis then is less on review than on program approval, although it must be added that any distinction between planning, approval, and management review is inherently artificial, since all are part of a single process. The same procurement plan that was the basis of a request for proposal also represented a step in project definition. Moreover, planning was seldom complete at any stage in the life of a project up to actual hardware development, if then. Major research and development projects were always liable to change; examples include weight reductions in Surveyor, elimination of the Gemini paraglider, postfire modifications of the Apollo spacecraft, and extensions in the firing time of the J-2 engine. The separation of predevelopment from development planning in this chapter is mostly one of convenience.

The thesis of this chapter is that NASA had many of the prerequisites for successful intermediate-range planning. Planning for the medium term is coterminous with the earlier stages of the NASA "programming" function: the process of formulating proposed missions; reviewing and approving such proposals and committing the resources to implement them; monitoring progress; and readjusting goals, missions, and resource allocations. Why and how was NASA able to develop a medium-range programming structure? First, NASA planning was emphatically not a series of forecasts; it was a course of action, an attempt to make things happen, almost after the fashion of business planning. NASA plans served as bases for *current* decisions. Second, at least one program office during the 1960s—the Office of Advanced Research and Technology—engaged in defensive research, which aimed not at a breakthrough but at staying abreast of the latest technology. NASA management felt it disadvantageous to link research too closely to current operations. As James Webb explained to one Congressman, ". . . it is definitely not our policy to demand a mission requirement as justification for the expenditure of development funds. . . . If we are to feel sufficiently free to initiate this kind of program in the first place, we must not expect each development to find a mission use, nor restrict ourselves by a policy that would require every program to be carried to a full demonstration."[1] In this view, defensive research was amply justified if it highlighted possibilities for future projects, if it identified a new spectrum of technologies, if it fed into existing programs as supporting research and technology, or if it assisted agencies like the Federal Aviation Agency in meeting requirements—for example, in understanding the physical phenomena associated with sonic boom and turbine noise. The Office of Advanced Research and Technology was effectively charged with preparing a shelf of research programs, only some of which would lead to improved flight hardware. The others would define the state of the art against which future missions would press.

Third, the NASA organization had one division during the mid-1960s, the Office of Programming, that could provide management with independent technical advice. The importance of this small office was out of proportion to its size, owing to the combination of fiscal *and* technical review in the same office until the 1967 reorganization and to the expertise of the staff, many of whom (like DeMarquis Wyatt, William Fleming, and Bernard Maggin) had worked in Abe Silverstein's Office of Space Flight Programs before transferring to Deputy Administrator Seamans' staff. Until 1967 the Office of Programming was probably the closest thing NASA had to a central planning staff. By its functions of review, project authorization, and development of cost models for flight programs, it did much to ensure that NASA had a single, coherent program.

Fourth, planning was made easier because the main bottlenecks were *only* technical and fiscal. The problems that dogged Apollo and Gemini were principally of this kind: Has it been properly tested? Will it fly? How can the spacecraft be integrated with the launch vehicle? Indeed, most NASA programs in the 1960s were undertaken when circumstances had made them technically ripe and when the principal constraints were either the higher priority of other programs (say, Apollo in relation to the Orbiting Observatories) or lack of funding. Thus, NASA's planning problems were minimized considerably by the lack of *institutional* constraints. But it is in applications and, above all, in aeronautics that such constraints made themselves felt. NASA's aeronautical programs have usually been planned to support R&D in the civil aviation industry and in the Department of Transportation (DOT). And the problems in aeronautical R&D are not primarily technological at all. As a joint DOT-NASA study noted, "Technological advances are subject to a variety of institutional constraints which can be categorized as regulatory and legal, market and financial, attitudinal and social and organizational."[2] Problems such as aircraft noise, congestion in and around airports, and the feasibility of low-density, short-haul service cannot be treated solely as technological limitations, as NASA managers treated their space programs.

Finally, the organization of the program offices (and to a smaller extent, the centers) explicitly recognized the interdependence of NASA programming. The 1961 and 1963 reorganizations attempted to group the centers in related fashion. An obvious example of the connectedness of NASA programming has been the authorization and construction of facilities in advance of the programs they were intended to support. Consider, for example, the role of the Office of Tracking and Data Acquisition, whose mission was almost entirely one of supporting the other program offices. Tracking stations had to be built; radio antennas had to be designed to cope with the extremely weak signals transmitted by deep-space probes; continuous coverage had to be available for spacecraft in highly elliptical and synchronous orbits; and some means had to be devised to handle the ever-increasing rates of data transmitted by such advanced spacecraft as Mariner 9, Viking, and eventually, the space shuttle. These capabilities had to be available when needed, and it is a tribute to NASA programming that they were.

Equally important to the success of NASA planning, the agency had to create mechanisms for "cross-servicing," by which a center reporting to one program office could work for another.* This presupposed that some centers already had a high proportion of "institutional" facilities, like the wind tunnels at Langley and Ames and the data processing equipment at Goddard, that could be used by more than one center (or agency) for more than one program. Cross-servicing cut across but did not negate the equally important concept that each project, except for Apollo, should be lodged in a lead center with responsibility for overall coordination. The official position was that each center had its mission within the total NASA mission and that the agency's objectives were "not amenable to clear and easy separation one from the other. . . . the view that the agency program and . . . resources are each to be managed in total provides significantly greater flexibility to . . . agency management than would otherwise be the case."[3]

* Each NASA installation reported to a designated program office from 1963 to 1974, when they were all placed, for administrative purposes, under an Associate Administrator for Center Operations.

These elements of the NASA organization—especially the establishment of a central office for technical review, the interdependence of agency programs, the long lead times characteristic of R&D missions, the relative lack of nontechnical constraints—encouraged the agency to plan. But they neither forced nor dictated the actual structure of NASA programming.* The remainder of this chapter examines the NASA program planning structure, first by considering the agencywide guidelines for review and authorization, and then by taking a closer look at the planning philosophies of the four program offices: Tracking and Data Acquisition (OTDA), Advanced Research and Technology (OART), Space Science and Applications (OSSA), and Manned Space Flight (OMSF).

Program Review

Chapter 3 includes an account of the Office of Programming that examines the need for an independent staff arm in the Associate Administrator's office; the studies of February–April 1961 conducted by Young, Siepert, and Hodgson; the establishment of an Office of Programs under Wyatt before the November reorganization; and the subsequent creation of a Planning Review Panel to coordinate the agency's advanced studies programs. This chapter offers a fuller account of Wyatt's office in operation, what it did, and how it did it. The number of functions within the office kept shifting; some, like responsibility for publishing the material presented at program reviews or for coordinating facilities planning, were transferred elsewhere.† But three divisions in particular were the core of the NASA programming function: Resources Analysis, Budget Operations, and Program Review. The first was responsible for "the overall review and assessment of the planned and actual utilization of all resources available to the Agency and for the development . . . of improved . . . evaluation-validation techniques for all NASA appropriation categories." The Budget Operations Division implemented all programming decisions approved by the Associate Administrator and was charged with submitting all budgetary data to the Bureau of the Budget and the Congress.[4]

But it is the Program Review Division from 1961–1967 that is of chief concern. Director William Fleming was one of the key officials in the authorization process. As head of the Planning Review Panel, he coordinated advanced studies with the program offices; as a representative to the Aeronautics and Astronautics Coordinating Board, he coordinated NASA facilities planning with that of DOD; and as head of Program Review, he reviewed and approved project proposals under all three appropriation accounts (research and development, administrative operations, construction of facilities) before sending them to

* Note the difference between budget formulation and programming. The former represents NASA facing outward to the executive branch and the Congress; the latter involves internal debate and review of agency goals.

† Responsibility for preparing Seamans' program reviews and for publishing their results was assigned to the executive secretariat in December 1965. The Office of Programming's Facilities Standards Division was transferred to the Facilities Management Office (Office of Industry Affairs), also established in December 1965.

Seamans. Once signed, each proposal became a project approval document (PAD), which authorized the program office and its field installations to proceed and to let contracts; the PAD approved, in principle, the scope of the project and the means for getting the work done.

Only in the last analysis was the authority vested in Wyatt's office the authority to say no. Typically, a proposal would be revised, modified, and discussed until something acceptable to both sides emerged. Fleming's division had to be an independent source of technical advice to Seamans, while maintaining the confidence of the program offices in its objectivity and technical competence. Furthermore, the kind of review conducted in Fleming's office was not entirely, or even mainly, concerned with the technical soundness of proposals. It could be assumed, for one thing, that the program offices knew their business. Instead, the Program Review staff asked such questions as the following: How does this fit in with the agency program? Does it duplicate facilities? Are schedules realistic? Can the cost estimates for the project be validated? Was a "Huntsville proposal" a proposal of the Marshall center or "a Huntsville contractor proposal that had flowed through" Marshall?[5]

Let us examine two cases of the review process in action: the first involved a proposal to build a fluid mechanics laboratory at Marshall; the second, a proposal to continue funding a space science data center at Goddard. In the summer of 1964 Marshall requested that its proposal for a fluid mechanics laboratory, already refused by Seamans, be included in the FY 1966 budget.[6] After a thorough review, Fleming approved the proposal.* He began by assuming three possible approaches to the request. Marshall could continue its arrangement of testing hardware in Lewis facilities; it could use the nearby Air Force facilities of the Arnold Engineering Development Center, with the Lewis facilities to be used only for final configuration testing; or it could develop test facilities at a new laboratory, with Lewis' supersonic wind tunnels again to be used only in the final testing phase. In a sense the decision to be made was technical; a decision to proceed would represent Seamans' judgment that a new facility would not duplicate any other facility in NASA or DOD. But it was precisely for this reason that Marshall's first request had been denied: The Air Force had claimed an existing capability at the Arnold Engineering Development Center. If NASA proceeded to authorize the Marshall laboratory, Seamans and Fleming would be faced with reversing their original decision and justifying the warranted duplication of an existing facility. Just as important, the laboratory, if approved, could not possibly be built in time to support the early Saturn IB and Saturn V flights, which would have to be supported by facilities already in existence. Thus Marshall's proposal was twice vulnerable: Not only would it duplicate an existing facility, it would not be ready when needed.

* It is somewhat anticlimactic to note that the request for a fluid mechanics laboratory was eliminated in the December 1964 NASA-DOD Facilities Review. Here, the reasoning is more significant than the result.

Despite such persuasive reasons for refusing Marshall's request, Fleming argued that the justification for proceeding was even stronger. By authorizing a fluid mechanics laboratory, headquarters would give Marshall the same in-house competence in fluid mechanics as it already had in guidance and control systems or in static testing engines and stages. Moreover, the desired competence in fluid mechanics could be used to round out the center's launch vehicle development capability. Fleming conceded that such a laboratory would not be ready before 1969 at the earliest. But this, he argued, was precisely when the center would be ready for a new launch vehicle development assignment. And unless construction began well in advance of the assignment, it would be unavailable "for the preliminary fluid mechanics test which plays an important role in the early design and development phase of a launch vehicle stage." Once the proposed facility had been completed, it might also reduce the amount of testing that Marshall required in the Lewis supersonic wind tunnels. The decision to approve the Marshall proposal was not made on narrowly technical grounds but rather on a consideration of NASA-DOD relations, the need to strengthen in-house competence of a major development center, and a review of future programs for which the facility might be needed.

Similar considerations were involved in the decision to continue work on the National Space Science Data Center, established at Goddard in April 1964 to collect and maintain an inventory of data from sounding rockets and spacecraft. Unlike the Marshall proposal, the problem was not whether to approve the concept in principle—that was already settled—but how to bring it in line with other NASA policies. In November 1965 Fleming, after reviewing the project approval document submitted by OSSA for continued funding of the data center, recommended that Seamans sign it.[7] Again, there were considerations other than the technical feasibility of the data center concept itself. In his covering letter of approval, Seamans observed that "the ultimate development of a NASA Space Science Data Center has far reaching implications which become deeply involved with agency policy."[8] From this letter and Fleming's staff paper on the subject, it becomes apparent that these implications were broadly political. NASA had to coordinate its policies for data exchange with those agencies that would prove to be heavy users: DOD, the Commerce Department, the National Science Foundation, and the National Academy of Sciences. Within NASA, the program offices would have to consult with each other. OSSA, the manager of the center, would have to consult with OMSF on the data obtained from manned flight and justify to OART the absence of facilities for storing and disseminating OART data. OSSA would also have to prepare a plan for development and funding of the center itself: the estimated workload from all NASA installations and other agencies, the options for running the center efficiently, and the types of data to be stored and disseminated. In essence, the decision to go ahead with a space science data center represented a fairly major policy statement. The considerations that Fleming had in mind in recommending continued approval impinged on NASA's interagency relations, relations with the scientific community, and his perception of the kinds of research the center was designed to support.

The two programming decisions were neither particularly large in relation to total agency resources nor particularly well known outside NASA. Yet a number of these decisions tended to shape the agency over the long term. The Office of Programming made the assumptions underlying such decisions explicit and presented the options available to top management. Needless to say, the policy considerations in relatively minor decisions were also present in more important ones, such as the decision to assign the management of a major project to this or that center. Consider the policy elements involved in assigning the management of the launch vehicle for the unmanned Voyager spacecraft designed to land on Mars. In December 1964 NASA issued a PAD for Voyager, assigning project management to the Jet Propulsion Laboratory (JPL) and stipulating that the launch vehicle would be the Saturn IB/Centaur. This still left open the choice of program office and center charged with launch vehicle management. A decision to assign responsibility to OSSA and the Lewis Research Center would give one result; a decision to assign it to OMSF and the Marshall Space Flight Center would give another. The advantage of going to Lewis was that the project would have a minimal impact on Apollo; of going to Marshall, that the responsibility for overall design and testing would be placed at a single center. In October 1965 NASA officials reversed themselves and decided to use the Saturn V for Voyager. There were several reasons for this reversal, but the main one seems to have been the conviction of Marshall officials that "the Saturn V would relieve payload constraints . . . and the launches were scheduled for the late 60s and 70s, just when Marshall's work for Apollo would be slackening off."[9] The Voyager decision suggests the complexity of NASA's program planning and indicates why a division like the Office of Programming was needed.

Advanced Studies

One category of decision, authorizing advanced studies, was peculiarly sensitive to nontechnical considerations. The Planning Review Panel was created in October 1963 to pass on study proposals, particularly but not exclusively those generated internally. It is important to explain just what these studies were and why they were such a headache for top management.

By definition, an advanced study pertained to "flight missions beyond those currently approved or studies of as yet unapproved spacecraft, launch vehicle, or aircraft systems that may lead toward such future flight missions or studies leading to significant changes on an already approved configuration of spacecraft and launch vehicles."[10] So broad a definition could encompass almost any kind of study, and the results of an advanced study or even the decision to authorize one could involve NASA management in various difficulties.[11] Such studies were not particularly expensive; although OMSF received $20.3 million in FY 1965 for studies of advanced manned missions, the annual cost to the program offices for advanced studies was normally in the hundreds of thousands rather than in the millions of dollars.[12] The difficulties alluded to were of a different sort. For example, if a program office let a study contract, there was danger that the contractor would be in a particularly favorable position to win the contract that might result for flight hardware. Short of banning study contractors from bidding on hardware, NASA could resolve the issue either by making the results of a study contract available to all prospective bidders or by letting multiple study contracts, either for parallel efforts or to consider separate aspects within one study program.[13] As with in-house studies, every proposal for a contractor study first had to be reviewed in Fleming's office before it was sent to Seamans, with a recommendation to sign, reject, or keep on the back burner.

A much more serious problem was that the award of or even the announcement of a study contract seemed to commit NASA prematurely to certain programs. The decision to authorize a manned space station study was construed by Congress as an attempt by NASA to present it with an accomplished fact. Indeed, it was to fend off such suspicions that the Planning Review Panel was established in the first place. Webb specifically asked Seamans to prevent studies from going ahead without his knowledge and causing trouble for him on Capitol Hill.[14] Judging by subsequent events, even this was not enough. In July 1967 the Manned Spacecraft Center (MSC) issued invitations to twenty-eight firms to bid on a study of a manned Mars and Venus flyby in 1975 and 1977. MSC could not have picked a worse moment to announce such a contract, and the request had to be withdrawn. At an August meeting to discuss the NASA budget, Webb complained of rumors that

> people at Huntsville and other places . . . say they'd like to keep the image before the country that somehow man is going to go to Mars and Venus. But I do think that the image of NASA, when we're fighting for our lives here in the major programs ought to be one of controlling those things, or at least not make them a major matter of publicity on the theory that maybe they will elicit support. . . . it just seems to me that this is not the right atmosphere to be emphasizing that or having people say that if we just cut out that kind of money we could get along better, therefore . . . cut 10 percent off our budget, which is what the tendency in Congress is.[15]

Five weeks later Voyager was canceled; it was eliminated in conference by the congressional appropriations subcommittees that approved NASA funds, partly, it seems, because the committee members believed that the unmanned project was a first step toward a manned voyage to Mars.[16] What applied to approved projects could be said to apply with undiminished force to advanced studies. They were essential building blocks for agency planning, but without some kind of coordination—with Seamans, Fleming, Wyatt, and the heads of the program offices—no other element was more likely to be misunderstood.

Another difficulty in preparing advanced studies was the potential conflict of bureaucracies. That conflict might be internal, for example, OSSA and OMSF competing for the right to carry out studies on manned space stations.[17] Or it might be NASA in jurisdictional conflicts with DOD, whose interest in space stations overlapped that of NASA. The issue surfaced in 1963 and involved three distinct questions: Were advanced studies included in the Webb-Gilpatric and Gemini agreements, by which NASA and DOD agreed not to undertake major spacecraft or launch vehicle development without first seeking the approval of the other agency? How far did existing study programs duplicate each other? If the President approved a manned space station for the military, what role would NASA have in supporting the program? At a meeting of the Aeronautics and Astronautics Coordinating Board Manned Space Flight Panel in March 1963, the cochairmen requested the panel to make recommendations for NASA-DOD coordination in this area.[18] NASA's rationale for a space station was straightforward. First, "men and equipment had to be tested for long duration in the weightlessness of space, looking toward the time when trips would be taken into outer space and the planets. Second, a space station would be an ideal scientific laboratory in which to conduct . . . research into the basic physical and chemical characteristics of matter in space. Third, it would be easier and cheaper to assemble components for launching planetary and celestial voyages in space rather than on earth."[19] In short, the space station concept was basic to NASA's post-Apollo planning. For DOD the military value of a manned space station was very much open to question—and a November 1963 study by the President's Science Advisory Committee did question it.

NASA's positions in exchanges with DOD were that advanced studies were not covered by previous agreements, that a joint-concurrence approach would lead to delays that NASA was not prepared to accept, and that NASA could not accept an effective veto power by McNamara over its study programs. For his part, McNamara tried to pressure Webb into signing draft agreements that he sent to NASA before the agency had the chance to study them. (According to the former Director of NASA's Office of Defense Affairs, this "was a gambit used more than once by Mr. McNamara.")[20] Twice he sent Webb signed agreements, and twice Webb refused to cosign. NASA was already proposing a $3.5 million study of a Manned Orbital Research Laboratory; and while Webb was willing to "go more than half way" in meeting McNamara's requirements, he did not rule out unilateral action in case of disagreement.[21] The NASA-DOD agreement of 14 September 1963 was at most a compromise. The draft agreement, prepared by the Office of Defense Affairs and signed by McNamara with reservations, provided that advanced studies on a manned station would be coordinated through the Aeronautics and Astronautics Coordinating Board; after joint evaluation studies Webb and McNamara would make a recommendation to the President, including a recommendation as to which agency would direct the project; and if the President gave his approval, a NASA-DOD board would map out objectives and approve experiments.

But this agreement raised more questions than it answered. On 10 December 1963 McNamara canceled the Dyna-Soar (X-20) orbital glider progam and announced that he was assigning to the Air Force the development of a near-Earth Manned Orbiting Laboratory (MOL). DOD officials chose to regard MOL as something other than a space station, hence not covered by the September agreement. The upshot was that in 1964, as a congressional report acidly noted, "the separate NASA and DOD efforts . . . appeared to be subject to only a minimum of coordination."[22] NASA continued its advanced studies of space stations and began to let contracts for studies of follow-on uses for Apollo hardware. That there was an element of duplication between the NASA space station and the MOL seems obvious. That NASA did not wish to be fettered by prior DOD approval seems equally clear.

The moral seems to be that, short of the Space Council, whose coordinating authority was shadowy at best, and the President, there was no mechanism for meshing NASA policy on advanced studies with its only direct competitor. Within NASA, top management used several strategies to keep advanced studies under control. There was agreement in the agency that exploratory and feasibility studies were best done in-house, that they could be accomplished at minimal cost, and that the more detailed the studies were, the more important it became to call in industrial know-how. But there had to be some authority to coordinate studies and to prepare guidelines to resolve the problems they raised. Was it necessary, for instance, that a given study run continuously in order to keep abreast of the state of the art? Which studies were to be in-house and which contracted out? Should follow-on studies be authorized before the studies of which they were a continuation had been evaluated? Should NASA award development contracts only to those firms already awarded study contracts or to any qualified bidder? The last question is investigated in the account of phased project planning.

A task force study conducted just before the 1963 reorganization showed that NASA needed a policy on study contracts. Of 114 studies considered, which totaled $30 million, the task force concluded that 3 were appropriate but not as advanced studies; 27 appeared to be duplicative or "premature"; 3 were more appropriately done in-house; and another 17 required guidelines from management. The task force also noted that, while each program office had its own reviews of study results, "a uniform procedure for assessment and utilization [did] not exist."[23] There was no uniform review, no definition of the kinds of studies the agency ought to be doing, no indication of study priorities. Many advanced studies were not submitted for review because they were funded separately as supporting research and technology.

It was to meet these needs that the Planning Review Panel was created. Its mission encompassed not only a review of each study but also the preparation of an agencywide study plan. Studies to be contracted out would be approved by Seamans on PADs; the panel would then review specific studies to see that they conformed to requirements. Furthermore, each review would serve as a point of departure for the next round of studies. Thus, in the fall of 1964 Seamans wrote to the program offices, asking them to state the guidelines for studies contracted for FY 1965. The time was past, he noted, when the program offices could paint with a broad brush. Based on the panel's Advanced Study Mission Review, he announced that the 1965 contract studies would focus "on a few flight mission areas. . . . rather than being as widely diversified as in the past."[24] OMSF would concentrate almost entirely on "the definition of a program for manned earth orbital operations that will best utilize the Apollo, Saturn IB and Saturn V capability currently being developed." The emphasis would be more on using existing hardware than on using post-Saturn launch vehicles. OSSA would define Voyager and develop programs for unmanned planetary exploration. In applications, OSSA was expected to define the next generation of advanced technology satellites and to continue work on an operational meteorological satellite.* OART would work to define the next generation of research and technology programs.

The annual review uncovered many weaknesses in the program offices' advanced studies. In June 1967, for example, Fleming wrote to OMSF about its proposal for a manned space station study. He noted that the study plan duplicated about 50 percent of a study being conducted by an agencywide working group, that it was based on a single assumption, and that it made no comparison of the advantages of manned versus unmanned stations. Even if viewed as an OMSF exercise, the study proposal left something to be desired. Some studies would be carried out by Marshall, some by Houston, and one by OMSF itself; it was not clear whether OMSF or some lead center would coordinate and relate the studies to an overall plan. Also, the procedure whereby headquarters would direct the studies while a contractor carried them out would not work. Such work "NASA can and must do in-house. If we cannot find the time or people to carry out such work then there is a real need for a reassessment of how well our human resources are being utilized."[25] How could a development center like MSC be expected to accept the results of these studies without doing a complete evaluation of its own? Why should OMSF turn to a contractor for space station configurations when MSC had the most highly qualified group of engineers in the world for such work? "A group such as this would finish with a product that is usable by NASA since, being the creation of a development center under the direction of Headquarters, it would be acceptable to both." Fleming ended by strongly urging that OMSF cancel the proposed studies. If NASA management found it difficult to control its advanced studies programs, it was not for lack of expert technical advice.

In summary, advanced studies were of basic importance to NASA planning because they marked the beginning of the R&D cycle. Whether they pertained to launch vehicles, missions, or spacecraft, advanced studies tended to set the direction of long-run agency planning, although they seem to have had little direct impact on hardware development. For this reason, management had every reason to keep a tight rein on what the agency would authorize and fund. The Planning Review Panel drafted an annual study plan; PADs were issued that encompassed each program office's studies in the six mission categories;† while study contracts had also to be approved by the Associate Administrator, whose authority to

* For OSSA the review was an important matter. OSSA annually published a three-volume "prospectus" that could be used in short-term and intermediate planning but, under the terms of an openly expressed agreement between the office and Webb, was not designated a "plan."

† In 1964 the categories were Earth orbital missions, lunar missions, planetary and interplanetary missions, launch vehicles, aeronautics, and general.

withhold such approval was formal. On the basis of a recommendation by the Planning Review Panel, Seamans in August 1967 rescinded approval of twenty-two study PADs not yet placed under contract because they were untimely and inappropriate in relation to the current operating plan and to the budget position NASA had staked out for the ensuing fiscal year.[26] The agency could not do without the kind of planning that preceded detailed project definition. But management's efforts to keep advanced studies under central control were a mixed success, owing to the lack of center-program office coordination, the absence of guidelines for study contracts, the seeming inability of some program offices to do their studies in-house, and the necessity as late as 1967 to withdraw study PADs.

R&D Project Planning and Approval

Few aspects of NASA planning were new. DOD had faced most of the problems of advanced systems development several years before NASA was created. How to determine the element of risk in developing a new system, how to choose between alternative systems, how to select system characteristics in advance of competitive exploration, how to present program goals independently of a proposed solution—all these problems were inherent in R&D planning, whether military or civilian. The Air Force approach to systems management—conceptual phase, definition phase, acquisition phase, operational phase—showed more than a passing resemblance to phased project planning. However, the similarity of appearance matters less than the difference in results. The differences in NASA and DOD planning for R&D have been discussed elsewhere: the NASA emphasis on one-of-a-kind rather than serial production, the relative absence of costing models for NASA programs, and the use of agency installations rather than contractors for technical direction and systems integration.[27]

Given such conditions, NASA management faced two principal problems: how to make programs visible and how to direct on an annual basis programs that spanned several years. R&D programs normally received "no-year" funds; that is, the money remained available to NASA until it was spent. Agency proposals normally had to be matched against agency funds and missions; this was the problem of deciding which programs to authorize. Once authorized, R&D programs had to be funded, and officials needed projections of how much the centers were spending and proposed to spend; this was the problem of financial management and review. And any plan had to allow for changes in current programs. Put differently, the chief planning and approval documents—the PAD, the program operating plan, the project development plan, and the forms authorizing and allotting resources—were NASA's attempt to resolve problems inherent in doing R&D. The problems included the following: Given the current state of the art, is such-and-such a realistic proposal? To what level of detail should the center be required to explain how it intends to carry out the project? How can NASA absorb the major changes that can be expected to occur during the life of the project?

Chapter 3 discusses the origins of the NASA planning system. The following is a summary of the major developments in chronological sequence from the system approved by Glennan in January 1961 to the revised system of 1968. Glennan had established a system that, although far too complicated and soon to be superseded, had at least the germs of a uniform planning system. Changes in 1962–1963 simplified the process: the creation of the PAD, which described the scope of the plan approved by Seamans; and the revision of the project development plan, which, instead of preceding approval, became the single authoritative postapproval summary of how the program office proposed to accomplish its objective. These documents in turn served as bases for NASA forms (506, 504) that made funds available for a project. In fiscal terms, "the PAD establishe[d] the purposes for which funds might be spent; the 506 authorize[d] the writing of checks for these purposes; and the 504 [made] the deposit in the bank account which [made] these checks good."[28]

This was the official planning and approval system that obtained until the 1968 reforms. Not that the format remained unchanged during this period—far from it. The PAD format was revised several times. In 1963, for example, it was changed from being reissued annually to issuance on a "cradle-to-grave" basis by the Associate Administrator.[29] The phased project planning directive of October 1965 added a project definition phase to the cycle and slowed the process by which management moved almost directly from feasibility studies to approval of full-scale hardware development. However, no detailed guidelines were published until the summer of 1968. By then, Webb and Finger had moved closer to the point where planning, authorization, R&D funding, and budget formulation would dovetail into one system. Each PAD would correspond to one line item in the NASA operating budget, would be updated annually, would be signed by the Administrator or another official (e.g., the Associate Administrator for Organization and Management) who was delegated signoff authority, and would constitute a contract between headquarters and the center designated as project manager.

Even in a chapter on predevelopment planning, something must be added about NASA's financial management reporting systems. First, program authorization was a continuing process; thus, headquarters needed reports of actual as well as projected outlays. Second, NASA needed yardsticks of cost-effectiveness to assess the costs of future programs. In other words, the agency needed current data in order to evaluate future programs. The data normally appeared in two different formats. The program operating plan (POP), a quarterly submission by the centers to Seamans, showed actual obligations through the previous quarter and estimated future obligations through completion of the project. The POP served as a benchmark for measuring performance and R&D budget estimates, and as a basis for resource authorizations. In a sense, "pieces of the POP [were] approved by individual executive actions" taken by Seamans.[30]

The other reporting format was the contractor financial management system.[31] It was intended to provide NASA with a financial tool for planning and controlling project funds and with a basis for reports used by headquarters for overall planning. The effectiveness of such a system depends on the accuracy with which financial data can be reported, the avoidance of unnecessary detail, and the use of a common baseline for elements such as cost reports and change updates. Originally, NASA used a single format, form 533, which was approved by the Bureau of the Budget in April 1962 and was revised in 1964. But it would be another three years before NASA had an integrated financial management system. A 1965 survey by the Financial Management Division (Office of Administration) revealed a sad lack of uniformity: "personal choice of 'home-made' devices; little comprehension of the real purposes . . . of the system; nonuse by contractors or outright gamesmanship . . . very major downstream restructuring of entire project reporting levels and data specifications to accom[m]odate false starts . . . inadequate cross-communications between Centers and Contractors, Centers and Centers, and within Headquarters."[32] The survey's findings led to revised procedures, which were published as two manuals in March and May 1967. The new system differed from its predecessor in three important respects. It replaced the single-format 533 system with four monthly and quarterly 533 reports; it permitted the contractor to use its own accounting system and time periods in preparing reports, so that NASA and the contractor would possess the same information; and the "blank stub" of the 533 forms (i.e., the absence of prescribed line item entries) enabled project managers to use whatever work breakdown structure they wished, provided that it was compatible with the NASA agencywide coding structure used to classify all agency activities for reporting and budgetary purposes. Thus the revised system became an effective tool for preparing estimates of NASA's current and long-range needs.

Cost-Estimating Procedures

Intermediate-range planning, program authorization, and financial management all flowed into one another, but the ability to plan and to budget depended, in the last analysis, on NASA's ability to prepare accurate cost models of its R&D programs. The larger the program, the more difficult this was; and what NASA learned from its costing studies was, only too often, that their main value was retrospective. In the Orbiting Astronomical Observatory, Orbiting Geophysical Observatory, Surveyor, and Nimbus programs, which were begun in 1959–1960, costs grew by a factor of four to five subsequent to project initiation;[33] the principal reason was the lack of a well-defined spacecraft design or a clear definition of experiments to be developed (see table 6–1).

As a 1969 report noted, "one might have predicted the cost increases that were experienced as the spacecraft designs became better defined, the technological problems identified, and the experiment development and allied supporting effort established."[34] There were substantial cost benefits where technology could be transferred from one system to another with little design change.

Project	Date	Initial Estimate Total Cost	Initial Estimate Number of Spacecraft	Unit Cost	Final (or Current) Estimate Total Cost	Final (or Current) Estimate Number of Spacecraft	Unit Cost	Unit Cost Ratio (Final/Initial)
Tiros	10/58	16.9	3	5.6	72.6	12	6.1	1.1
OGO	(1/61)	25.3	3	8.4	218.5	6	36.4	4.3
Surveyor	(1/61)	115.9	7	16.6	468.5	7	67.0	4.0
OSO	(1/61)	14.7	3	4.9	95.7	8	12.0	2.4
OAO	(1/61)	53.4	3	17.8	280.7	4	70.2	3.9
Ranger	(1/61)	49.2	5	9.8	170.0	9	18.9	1.9
Nimbus	(1/61)	33.5	4	9.6	308.4	7	44.1	4.6
Relay	(1/61)	17.8	2	8.9	33.6	3	11.2	1.3
Syncom	8/61	12.7	2	6.4	27.6	4	6.9	1.1
Pioneer	11/62	27.0	7	3.9	133.9	7	19.1	4.9
Mariner Mars 1964	8/63	48.2	2	24.1	82.8	2	41.4	1.7
Orbiter	8/63	77.3	5	15.5	163.1	5	32.6	2.1
Biosatellite	9/63	49.9	6	8.3	160.0	4	40.0	4.8
ATS	4/64	109.3	5	22.1	143.7	5	28.7	1.3
Mariner Venus 1967	3/66	30.2	1	30.2	26.5	1	26.5	0.9
Mariner Mars 1969	3/66	98.0	2	49.0	130.3	2	63.2	1.3
Subtotal OSSA		784.3			2 515.9			
Mercury	2/59	200.0	-	-	384.0	-	-	1.9[1]
Gemini	12/61	529.0	-	-	1 283.0	-	-	2.4[1]
Apollo	5/63	12 009.0	-	-	19 741.0	-	-	1.6[1]
Subtotal OMSF		12 738.0			21 408.0			
Total		13 522.3			23 923.9			

[1] Cost ratio based on total cost.

Source: Memorandum, DeMarquis Wyatt to Thomas O. Paine, "NASA Cost Projections," 10 Apr. 1969.

When such changes were required to adapt a technology, as for Lunar Orbiter, they could be enough to nullify any gains. With Orbiter, there were two sets of technology transfer: the spacecraft design itself and the camera system based on Air Force camera technology. To adapt the camera system required major changes in storage, film developing, and remote readout, changes that contributed greatly to Orbiter cost increases.

Ignoring the small projects that used proven technology, there were three cases in which it was possible to make accurate estimates of planned or current programs: when spacecraft and experiment design were established before the start of the project; when NASA bought production-line items, especially sounding rockets and certain launch vehicles; and when NASA compared current programs with the funding levels originally authorized. In the first case it was possible to reduce design changes during the development phase. In projects such as Relay, Syncom, and the Applications Technology Satellite (ATS), the cost increases were only about 1.1 to 1.3 times the original estimate. Each was designed before NASA began the project, and in the case of ATS "a substantial amount of design and demonstration of critical subsystems was conducted . . . prior to its definition.[35] In the case of serial production most of the early estimates for launch vehicles and propulsion systems seem to have been quite unrealistic; one official called them "totally ridiculous." Here, the agency stood to gain much by accurate estimates. The tendency of the program managers was to make estimates based on what vehicles *should* cost and to ignore many of the hidden costs of development, especially the cost of assembling and maintaining the team that would produce the launch vehicle. The key was to separate more precisely the nonrecurring cost of producing the first unit—whether the motor, the airframe, the guidance system, or combined components—from the recurring costs of serial production. Despite the original cost overruns and schedule slippages, a launch vehicle stage like the Centaur could be produced serially once the hardware met design specifications. Today, Centaur and Delta are funded under R&D only because no other category seems to fit.

Because of the size of the programs, it is the third category that is of most concern. The concept of a cost overrun has meaning only in relation to some baseline of funding. The management information systems used by NASA were specifically intended to make these overruns visible. Such were the 533 reports, the manpower utilization report, and the NASA PERT/COST system that most prime contractors were required to use in reporting summary time and cost data. These systems were not invariably effective or welcome within NASA. A recent study of Polaris, where PERT—program evaluation and review technique—was first used, concludes that

> PERT did not build the Polaris, but it was extremely useful for those who did build the weapon system to have many people believe that it did.
> . . . the program's innovativeness in management methods was . . . as effective technically as rain dancing. . . . It mattered not that management innovations contributed little directly to

> the technical effort; it was enough that those outside the program were willing to believe that management innovation had a vital role in the technical achievements of the Polaris.[36]

The effectiveness of PERT on NASA programs is also open to question; in many programs PERT was introduced too late to make much of a dent in funding and schedules.[37] The point is that by 1964 the Office of Programming had in hand sufficient data and experience to analyze some of NASA's major programs. A study of Gemini conducted in June 1964 uncovered a deficit of $83 million for completing the spacecraft alone, an estimate based entirely on information available to management—particularly the monthly Project Gemini "OMSF Program Status" reports (also known as SARP charts). The program was broken into five major categories, and program schedules were examined from inception.[38] From these, the programming task force discovered that the program was overrunning both cost and schedule, that OMSF set about solving problems at the expense of time, and that total costs were likely to grow by a multiple of at least four. The evidence was sufficiently persuasive to lead to a drastic overhaul of Gemini design, management, and scheduling. In particular, the intervals between launches had been lengthening; MSC wanted launches two to three months apart, later four, before Mueller reduced the interval to two months.

The 1963–1965 period marked the maturity of NASA cost analysis. Besides the Gemini survey, the Office of Programming carried out several major joint studies: the Hilburn task force reports of September–December 1964, mentioned in chapter 4, which established the relation between schedule slippages and cost overruns; a study by the Aeronautics and Astronautics Coordinating Board of launch vehicle costs, which was based on the distinction between recurring and nonrecurring costs, and the unit cost for developing the first article in a production series; and a "cost validation" study at Marshall in the summer of 1963, a study that influenced the decision to implement phased project planning. The cost validation study was carried out by staff drawn from the Office of Programming, the Office of Administration, and OMSF. The study was ordered because Seamans was uncertain that centers like Marshall had a master plan for "pacing items"* in the Gemini and Apollo programs. The task force wanted to know the depth and status of mission plans and the basis for schedule and cost estimates; as one team member wrote in his daily log, Wyatt wanted to be able to tell Seamans that "there is a master plan—Behind the master plan are schedules—Behind the schedules there are work plans—That the work plans have been priced out."[39]

The studies were useful to the extent that top management wanted them, the Office of Programming had the staff to do them, and all concerned could agree on what they were trying to do. For officials to be able to plan at all, they had to understand the relations between schedules and costs or between the direct and indirect costs of launch vehicle production. No study could be effective unless officials at the highest operating level to which the study was addressed were

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* Pacing items were those events or components that, if delayed, would cause an equal delay in the entire program or in a planned launch.

interested in seeing its recommendations carried out. Some of the most successful reports, like the Booz, Allen and Hamilton study of incentive contracts (pp. 103–105), did not claim to make policy as much as point the way toward carrying out a course of action that had already been decided. Similarly, the costing studies of Gemini or the cost-validation analysis of the Saturn V and J-2 programs took those programs as givens.[40] The studies sought to reduce, if not eliminate the uncertainties inherent in the R&D process—uncertainties attacked in different ways by the PAD system and phased project planning.

PHASED PROJECT PLANNING, 1965–1969

To summarize the discussion to this point: the structure of NASA programming was intended to make planning more realistic, to test the validity of the planning, to "harden" concepts into development projects, and to serve as a mode of continuous review. Therefore, a document like the PAD could serve many purposes. It authorized projects at every stage of the R&D cycle from advanced study to advanced development; it served as the basis for the detailed project development plan, which was the prerequisite for hardware development; it preceded the issuance of every resource allotment; and it was the foundation for periodic financial management reports, such as the quarterly program obligating plans submitted by the centers through the program offices to Seamans. Since each phase of the R&D process (which in 1964 included advanced studies, project definition, and hardware development) called for a separate PAD, Seamans had three opportunities to intervene in the cycle.

Viewed in this light, phased project planning (PPP) appears to be what it was, the normal sequence in management theory for R&D. NASA had actually been phasing planning all along (see p. 84); PPP was introduced at a time when NASA had very few new starts, and the main reasons for enunciating the concept were to make actual practice more uniform and to give management at least one additional point at which to intervene. The issues that require explanation are the internal debate that preceded even the first tentative statement of policy, the delay between the policy directive of October 1965 and the detailed guidelines of August 1968, and the failure of line officials subsequently to understand or use PPP. A brief account may reveal something of each program office's approach to organizing complex programs. The difference between the 1965 and 1968 directives owed something to the three-year interval in which the agency tried to make PPP work. But it owed even more to the context in which the 1968 guidelines were drafted: They were only part of a system intended by Webb to channel resource authorization, planning, and program review through his office.

The 1965 directive established four phases in the life of a project: advanced studies (phase A), project definition (phase B), design (phase C), and development/operations (phase D).* In general, the program offices took exception not to the concept itself but to the terms in which it was couched. The draft guidelines did not recognize the need for establishing a project organization at an early date; they said little about the relative responsibilities of the program offices; they did not show how the concept related to the budgetary, POP, and procurement cycles; they did not distinguish very clearly between each of the phases; nor did they justify four decision points rather than the three that had previously been used. Most of the specific criticism was reserved for phases A and C. It was (and remained) unclear how advanced studies should be carried out—whether directly by the centers, under contract, or by a mixture of the two. One program manager criticized the phase A concept because it would involve several centers studying the same objective.

> If these studies are to be of any value, they will essentially be in competition with each other. If they are not competing, it becomes doubtful that the centers' more competent personnel have been assigned to the task. . . . Additionally, each NASA center appears to be saturated with work and no relief in sight. . . . it is doubtful that *large quantities of good studies* will be generated from which to be selective. This is the foundation upon which the entire procedure was established.[41]

Although the avowed purpose of PPP was to foster "maximum competition," neither the preliminary drafts nor the published directive worked out such a procedure. One of the problems in planning a major R&D program is to find firms with the capability to serve as prime contractors; in some very large projects NASA has had to rely on a single source or face the alternative of creating, at enormous expense, competition where none existed. Followed strictly, the 1965 directive would have mandated full competition at every stage—an unrealistic state of affairs when one firm was the obvious choice for follow-on development work. It left open the question of whether competition in phase D should be open to any firm or only to phase C contractors, and it ignored the real difficulty in having the program offices work with bidders who had not been involved in the earlier phases of PPP. It was common knowledge that a firm not involved in the first two phases had no real prospect of competing successfully in phase C. In fact, the program offices continued to do things the old way, even after 1965. In June 1967 when NASA had to select contractors for phase C of the Voyager spacecraft, competition was limited to phase B contractors. As one center director put it, "nothing significant would be gained by attempting at this time to enlarge competition."[42]

Thus the 1965 directive went too far, yet not far enough. It was very specific in listing the benefits of PPP and quite vague in explaining how the process would

* The programming cycle for facilities construction was slightly different. Its four stages were conceptual study, preliminary design, final design, and project execution. Unlike R&D projects, facilities projects were fully funded; that is, all the funds for one year were budgeted at once. See NHB 7330.1, "Approval of Facility Projects" (July 1966), p. 8.

work. For the program directors, agreement "in principle" obscured disagreements over detail. The directive omitted or glossed over many significant areas of planning: It set no cutoff point between large projects and supporting research and technology; it left open the possibility of limiting competition in the final phase to contractors already involved in detailed project definition; it said nothing about science, experiments, or payloads; and it did not specify how much time might elapse between phases. It is no wonder that the job of preparing detailed guidelines, originally assigned to Wyatt, went nowhere. The sheer difficulty of getting nine or ten headquarters offices to agree on anything was enough to stop Wyatt's people in their tracks, and agreement, when reached, was at a lowest common denominator level.

That PPP was implemented at all was due to Webb's determination to regain the control over NASA that he believed he had lost sometime before the Apollo fire. Chapter 3 summarizes the changes of 1967–1968: the creation of an Office of Organization and Management to bring the program and functional offices under Webb's control; the separation of technical review from budget preparation; the reorganization of the Office of Facilities to bring about master planning for the agency; finally, the overhaul of the system by which programs were planned, authorized, and reviewed. Webb wanted to know—because he did not think that he knew—what he was approving whenever he signed a PAD. By the summer of 1967 Harold Finger's Office of Organization and Management, especially the Planning Division, had prepared detailed guidelines, most of which were issued piecemeal the following year.[43] The new system would emphasize supervision, whether directly by Webb or by delegation to Finger, and make it possible to track every approved project down to its smallest work package.[44]

The basic features of the system were outlined in a memorandum dated 27 January 1968 from Webb to the agency's key officials. First, there would be a NASA operating plan to serve as "the official consolidated statement of NASA resource use plans for the current year." Each item in the plan would have its PAD, which would set the objectives, and would specify funding and work authorizations. "Together, the operating plan and the PAD system [would] provide a double entry type of approval, control and audit system within which both program and administrative objectives [could] be achieved." The program directors had to assume several responsibilities in submitting a PAD: "first, to approve and endorse its substantive and technical merit; second, to take into account all related administrative and functional requirements; and third, to reflect these considerations in the documentation he sends forward *through* the Associate Administrator for Organization and Management." Before the PAD reached Webb's desk it would first go to Finger for his signature. Webb wanted to "cut out the concurrence mill, which sometimes took a year, with 25 or 30 concurrences required to prove something."[45] By delegation from Webb, one signature would be enough. He also hoped for visibility; he wanted to know the right things so that "no one could bury a problem and keep it buried."[46] It was of the greatest importance that the Office of Organization and Management was built around—

almost created for—an R&D person, someone who could meet the program offices on their own terms. The Apollo fire had shown just how much had been hidden in the organization; and Apollo Applications, with its budget stretchouts and reprogrammings, had made the need for tighter fiscal controls even more obvious. Finger had to be able, if necessary, to say no; to refuse to sign a PAD if in his opinion it did not mesh with the NASA budget.[47] There was always a temptation for such an official to let the program offices do as they pleased. But as Finger noted, "if you do that very often you completely confuse your system. You no longer have a system."[48]

The PPP guidelines, when finally issued, were not superimposed on the system just described. If anything, they were a sort of commentary, in which the PAD, the project plan that supplemented it, and the request for proposal all fell into place as parts of an encompassing system. Phase A was now preliminary analysis; phase B, definition. Each phase would be covered by a PAD, and every current year portion would be revised as necessary. The PPP guidelines clarified those matters that had led to so much disagreement. For example, competition in phase C (design) would be restricted to firms capable of going on to phase D (development/operations). Other details included the in-house nature of the preliminary analysis phase, the type of contract to be used (fixed-price or cost-plus-fixed-fee in phases B and C, incentive contracts in phase D), and the role of the centers and program offices in monitoring contractors during the final development stage. The system did not lessen responsibility below the Administrator's level; it was not intended to make R&D work self-regulating or mechanical, which would have been self-defeating. In simplest terms, its purpose was to inform Webb or Paine or Newell of what it was he was signing, hence what he had to defend before the Bureau of the Budget and Congress.

Four Approaches to R&D Programming

The foregoing account of NASA's formal approval systems necessarily leaves many questions open. For all the overlap that existed, the program offices were created and maintained for different but complementary purposes. This section provides brief surveys of planning strategies in each of the four program offices, whether its function was support (OTDA), defensive research (OART), discipline oriented (OSSA), or mission oriented (OMSF).

The Office of Tracking and Data Acquisition (OTDA)[49]

Elevated to program office status in December 1965, OTDA had neither programs nor centers. In most respects, its role set it apart from the other program offices: the requirement that it support all NASA programs, its extensive international activities, its almost exclusive use of support service contractors to operate and maintain its tracking stations, and its unbroken success in meeting its schedules. OTDA's reliance on improvements in the state of the art was no greater than that of any other program office; yet the connection between technology and mission requirements is perhaps most obvious in OTDA. What has been most apparent in OTDA planning since the early 1960s has been the office's ability to keep funding requirements level and predictable. The office has largely accomplished this by closing many of its overseas tracking stations, consolidating its manned and unmanned networks, using fixed-price and award-fee contracts for facilities construction and operation, and developing a Tracking and Data Relay Satellite System to supplement its ground networks. By such means it has been possible to reduce the Deep Space Network (DSN) to three stations spaced at intervals of 120 degrees along a longitudinal axis and equipped with 64-meter radio antennas. More than any other program office, OTDA has managed to reduce the element of uncertainty inherent in R&D.

OTDA's success has depended largely on developing a sophisticated approach to planning. It must anticipate the needs of the centers, other program offices, and principal investigators. It must work out its requirements for supporting research and technology. It must have people stationed at the centers to assist in preparing the requirements documents that are the basis of OTDA planning: the system instrumentation requirements document, the network support plan, the work authorization document, and the like. Such planning demands a continuing dialogue between OTDA, program managers, and JPL and Goddard, the two installations responsible for almost all network support. Or rather, what one sees are two planning groups working side by side. On the one hand, OTDA has always planned its long-range network requirements. On the other hand, the centers must document the kinds of support they need for particular missions. On the OTDA side, the cycle begins with advanced studies to review and update network planning: new facilities, automatic data processing equipment, funding, and the like. This is followed by systems definition, which brings together OTDA and center personnel who negotiate requirements and draft a project plan. At every point, a complex flow of documentation is generated. The program offices provide a formal requirements document; this is validated by OTDA, which prepares its support plan; and JPL or Goddard then prepares additional material to justify the network support it is best able to provide.

The conspicuous feature of OTDA planning is that each case is determined by the characteristics of the mission to be supported. In general, unmanned deep-space probes have proved the most difficult to support, but the data rates of most spacecraft have increased by several orders of magnitude since the days of Explorer 1 and Mariner 4.* Particularly in the past decade, OTDA planning has involved tradeoff considerations, for example, the advantages of placing additional tape recorders on orbiting spacecraft versus augmenting the supporting ground

* Mariner 4 transmitted 8 ⅓ bits per second (BPS). When it becomes operational in 1983, the shuttle/spacelab will return somewhere between 250 000 and 50 *million* BPS. The cost per bit of data was reduced by 90 percent between 1965 and 1973. See *Review of Tracking and Data Acquisition*, pp. 103–104.

network. The relevant point is that OTDA must, to an extent, plan independently of specific future requirements. Once the *general* characteristics of future programs become known, the office begins feasibility studies. Formerly, OTDA let study contracts, but it now does most of the preliminary work itself. Consider, for instance, what was involved in designing the DSN 64-meter radio antenna at Goldstone, California, which was put into service in April 1966. Once the features of lunar and planetary programs were understood—extremely weak signals, long cruising periods, an anticipated increase in date rates—it became possible to plan network support. To build the earlier 26-meter antennas at Goldstone and elsewhere had been difficult enough; to build the larger one meant resolving severe technical constraints, once it was shown that one big antenna would be more cost-effective than several smaller ones.[50] Enormous steel castings had to be built to take the weight of the dish-shaped antenna; allowance had to be made for wind velocities and distortion caused by gravitational pull (both sides pulled in different directions when the antenna was not pointed at zenith); and the dish itself was made to rest on a thin film of oil, which served to cushion the mass of the antenna and to shut it down if the film's thickness decreased.[51] JPL let parametric studies (see note 11) and followed them with a preliminary engineering report and a design validation study. This was phased project planning before that term was made official, and Seamans singled out the construction of this great antenna as "almost a textbook case" of the system he recommended for the agency as a whole.[52]

In sum, OTDA planning was guided by three principal considerations. First, the characteristics of the mission dictated, within rather broad limits, the kind of support that OTDA provided. Was the mission manned or unmanned, Earth orbit or deep space? If in orbit, was it synchronous or elliptical, and how many contacts per orbit were needed? Were the data needed on a real-time basis, or could they be stored for later retrieval? Second, OTDA was not simply a passive witness to decisions made elsewhere. Planning involved a three-way exchange between OTDA, the program office requesting support (and in the 1960s, DOD, which provided tracking support for Apollo), and JPL and Goddard. Third, OTDA has coped successfully with the vastly increased data transmission rates of the newer spacecraft systems because it has been able to use and build on existing capability. The first 64-meter dish was a major breakthrough; the two that followed, at Madrid and Canberra, were almost routine by comparison. It has been OTDA policy to increase "existing capability . . . only after thorough analysis of support requirements." By insisting on coordination with program offices "from project inception until achievement of mission objectives," the office was able to anticipate the facilities and technology needed a decade later.[53]

The Office of Advanced Research and Technology (OART)

It has been said that OART, more than any other program office, carried on the NACA tradition of doing advanced research in-house. But this is only partly true, since what had once been the mission of an entire agency was now a subordinate part of the much larger entity that succeeded it. Like NACA, OART was charged with conducting research into the underlying principles of aeronautical and space technology, reducing "complex theory to design procedures," and testing systematically "to obtain design data for . . . vehicles of the future."[54] But OART had to go beyond NACA practice by "proving" a concept, that is, by building hardware to test it, whether or not the actual hardware found its way into future systems. The special features of OART work included a relatively large number of open-ended or continuing programs with no specified completion date, the role of the Associate Administrator for Advanced Research and Technology in reviewing supporting research and technology proposals by his own and other program offices, and the creation of a Mission Analysis Division—located at Ames, although attached to headquarters—in February 1965 to do advanced planning in order to identify future technology requirements.

All these features tended to change the role of the older centers. Some officials, notably Dryden, objected strenuously to the research centers' involvement in project management, which he preferred to leave to the newer development centers. Other NACA veterans, like Silverstein, believed that the older centers needed some development projects in order to open new research possibilities; if the centers had a few projects, they would inevitably spill into the center's research programs. In this, Silverstein's view prevailed, but there was a price to pay. At Ames, for instance, the changes of 1961–1965 had a profound effect: the transfer of many research division heads to headquarters, the organization of research divisions around disciplines rather than specific facilities, the increased use of wind tunnels for development work rather than research, the establishment of a Life Sciences Directorate in a center hitherto devoted exclusively to research in the physical sciences, and an increase in manpower to cope with the management of those projects (and the inevitable contracting for hardware and services) assigned to Ames.[55] In all this, much was undoubtedly gained; what was lost is harder to describe. The dilemma for OART planners was to justify the kinds of research done at the centers. Formerly, research in cryogenics or structural dynamics could be justified on the ground that it was worth doing for its own sake. But OART was created to foster research that could be justified on its merits and that would feed into NASA programs. The question posed was this: How could OART coordinate a number of small-scale efforts and organize them in related fashion, yet not tie each research task to a specific mission or completion date? As Finger, himself a product of Lewis, warned,

> 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.[56]

This background serves to explain the difficulty, for OART, of sponsoring research that was at once independent of mission objectives and tied to NASA planning. How, then, did OART plan, and how successful was it? Before its reorganization in October 1970 OART consisted of a Program and Resources Division (established from preexisting units in July 1964), seven program divisions,* and Mission Analysis.[57] Mission Analysis functioned as OART's long-range planning group, and it was deliberately located at Ames to provide the group with more of a research atmosphere than would have been possible in Washington, D.C. As with OTDA, the flow of information was two-way: a give and take between the division, other parts of NASA, research advisory committees like the Advanced Research and Technology Board of OART, and other agencies, especially FAA. The purpose of Mission Analysis was to identify options for future planning and to estimate the time in which a certain technology would be needed, what was called the technology readiness date. Not that such work had to await the creation of the Mission Analysis Division. Earlier, Langley had been studying the feasibility of an orbiting Large Space Telescope; Lewis was working on advanced propulsion systems; while several centers carried on work in short-haul transport aircraft. What set Mission Analysis apart was that it functioned as a planning staff for the entire program office; it concentrated on missions rather than on state-of-the-art improvements; and much effort was spent on mode analysis, that is, the choice between alternate means of conducting a mission.[58]

A second planning area was OART's review of the agency's supporting research and technology (SRT). Related to this was the creation of the Program and Resources Division, which was to bring in-house research under some kind of management control.[59] Besides the director, there were three subdivisions, each under a deputy director: Program Coordination, responsible for analyzing OART programs "for proper balance and for program overlaps or omissions"; Resources Management, which dealt with budgeting, funding, and reprogramming; and Administrative Management, which oversaw personnel, technical reports, congressional liaison, and the like.[60] The division gave OART program balance, even at the cost of going over the heads of the program division directors.

The major problem in coordinating SRT was the sheer quantity of the work. The Office of Space Science and Applications alone was spending over $80 million on SRT in 1968, most of it tightly linked to near-term programs. OSSA projects ran into the hundreds: large unfurlable spacecraft antennas; improved pointing accuracies for orbiting observatories; guidance, control, and navigation systems for launch vehicles; lunar and planetary roving vehicles; sensors for applications satellites—to mention only a few. Besides the work carried on in his own office, the Associate Administrator for Advanced Research and Technology had to be aware of such programs and the potential for wasteful duplication. He was supposed to review agencywide plans for SRT; review the technical content of each SRT task, as these programs were called; and recommend a total agency program and the assignment of tasks to each program office.[61] Internally, he had

* Biotechnology and Human Research, Electronics and Control, Chemical Propulsion, Space Power and Electrical Propulsion, Space Vehicles, Aeronautical Vehicles, and Research.

to have the staff work that would enable him, if necessary, to say no to his division directors, or that would give him independent support where divisions refused to cooperate. This twofold problem—reviewing agencywide SRT and meshing his office's programs with those of other program offices—was in some ways the opposite of that of OMSF: Where OMSF had a few very large programs, OART had a plethora of smaller ones, some of which, undoubtedly, had been authorized because they were "nice" to do.

If OART had a specific problem, it was lack of coordination between its own programs and those of other offices. There were too many PADs required for OART tasks; too little flexibility in allowing the centers to reprogram; and no mechanism for linking technology disciplines in one area, like avionics, with aircraft technology, which was in a separate category.[62] This problem was aggravated by two others: the absence of a fixed percentage of the NASA budget for research programs, so that dollar levels remained constant or actually fell; and the absence of management continuity. OART had five successive directors between 1962 and 1969. This state of affairs, a chronic one in the upper levels of Government, was especially damaging to R&D management. Writing in 1969, one observer noted the "continuing short-term shifts of objectives . . . inadequate horizontal communications between centers . . . a thin middle management" and the tendency to label people as "NACA types," "aerodynamics types," or "vehicle types."[63] This was the time when NASA began to adopt the program authorization system described earlier in this chapter. Partly to accommodate the new system and partly to handle its internal problems, OART made several changes between 1968 and 1970. It reduced the number of PADs from 30 to 8, the number of congressional line items from 8 to 3 (aircraft technology, space technology, and advanced research and technology), and the number of work units—the basis for OART reporting by the centers—from 5000 to 500 "Center Technical Objectives Resumes."[64] The 1970 changes were intended to give OART programs a focus and a consistency they had sometimes lacked. Aside from changes in nomenclature, these reforms included establishment of a research council to ensure a balanced research program and authorization of the program division directors to issue instructions to the centers over their own, rather than the Associate Administrator's, signature.

Interagency studies, OART's third planning area, are best represented by the joint NASA-DOT *Civil Aviation Research and Development (CARD) Policy Study,* begun in 1969 and completed in 1971.* The specific recommendations of that study are of less concern here than the manner in which it was carried out and the reasons for its success. The study group had a specific objective and precise terms of reference: The House and Senate committees that authorized the NASA budget wanted to know the benefits accruing from a given level of R&D. Here,

* By an unfortunate coincidence the CARD report was submitted to Congress in March 1971, just before both Houses voted to discontinue funding the supersonic transport, the section on which was deleted to avoid the semblance of influencing the vote.

NASA's role was almost a throwback to NACA's support for the military. Furthermore, the study group had a literature of policy studies on which to draw, from the 1948 "Finletter report" to the 1969 report of DOT's Air Traffic Control Advisory Committee. Thus the interagency working groups and the consultants who participated had some notion of how their work would tie in with and comment on previous policy studies. What made the coordination of NASA and DOT even tighter was the role of those NASA employees, including many top OART officials, who had gone to work for DOT. Moreover, the two agencies set up a joint office in January 1972 to handle followup work in three areas—aircraft noise abatement, airport congestion, and the need for improved short-haul transport—singled out in the report as high-priority items. In other words, the interagency team viewed its study as only a first step toward implementation of its major recommendations in civil aviation. And the final report was noteworthy in recognizing the importance of nontechnological constraints, such as regulatory systems, the social impact of airport congestion, and the cost-benefit effects of various levels of R&D funding.

The Office of Space Science and Applications (OSSA)[65]

In turning from OART to OSSA, certain differences of program size and advisory structure are immediately obvious. OSSA sponsored programs much larger than those of OART, while the content of the programs—much more than in OART—was determined in part by outside advisors to NASA. But the term "advisory" scarcely does justice to the role of the Space Science Board of the National Academy of Sciences or the Space Science and Applications Steering Committee (SSASC), which, established in May 1960, assisted OSSA in selecting scientific payloads for flight missions. SSASC and its subcommittees served many purposes: they strengthened contacts between NASA and the scientific community, gave representation to various interest groups, and acted as source evaluation boards in choosing principal investigators. Their functions were legal as well as advisory, since NASA could not negotiate exclusively with a university investigator without SSASC approval.

The relation of OSSA to its advisory committees was one of the most serious policy issues facing Newell and John E. Naugle, who succeeded Newell as Associate Administrator for Space Science and Applications in September 1967. To say that the problem involved differences between NASA and outside scientists over the scope and functions of advisory committees is to underestimate the complexity of the issues. First, agency officials sought to avoid setting up boards so structured that NASA would be bound by whatever advice they offered. This had been an issue between NASA and the Space Science Board as early as 1959, when NASA acted to make the board "less of an independent advisory group with a role in initiating policy and more of a service entity responding within carefully prescribed limits to tasks specified by NASA."[66] Thus, when NASA proposed developing an Orbiting Astronomical Observatory (OAO) in 1959–1960, the board recommended that NASA instead support rocket- and balloon-borne experiments in astronomy. Only in 1962 did the board bow to an accomplished fact and endorse the OAO.* Similarly, NASA rejected the recommendation of an ad hoc Science Advisory Committee in 1966 that the agency establish a general advisory committee of non-NASA scientists reporting to the Administrator. Webb had a history of rejecting this proposal because he thought a committee of outsiders might interfere with his authority to make policy for NASA. If established, such a committee would blur the lines between advising and policy making, assume some of the functions of the Space Science Board, serve as a crutch for a weak Administrator, and take over functions already delegated to the Deputy Administrator and the heads of the program offices.[67] To Webb and Newell, the pros and cons of a general advisory committee reduced themselves to purely administrative terms. To the members of the Science Advisory Committee, its proposal was justified by frustration in serving on committees chaired and dominated by NASA employees.

Another problem was the relation between the various advisory groups on which OSSA drew. The complexity of the advisory process more than matched the complexity of the programs for which advice was sought. By 1967 the system of the early 1960s was no longer adequate. There were no guidelines explaining why or whether NASA needed such groups, how they were to be used, or the jurisdictions of the Space Science Board, the Missions Boards composed of non-NASA scientists and established in 1967 to map out overall strategies for NASA science programs, and the SSASC subcommittees. In administrative terms the structure of NASA advisory boards looked backward "to the days of discrete programs rather than forward to flight and research environments characterized by high degrees of interdependence between disciplines, between science and engineering, and between techniques of flight investigation."[68] To NASA, the way to make the system work was to bring in the most capable scientists to shape the content of space science, while keeping control of programs in NASA hands. But to many scientists, the advisory process could not be a dialogue between equals because as outsiders they could have no authority for final decisions and could not know as much about NASA programs as NASA employees did.[69]

Outside scientists assisted NASA as advisors, as principal investigators, and as members of boards to evaluate proposed experiments. How did OSSA, building on their work, organize and plan its programs? Organizing space science was no simple matter, since each program was a combination of scientific payloads, the spacecraft that flew them, and the vehicle (developed at non-OSSA centers, principally Lewis) that launched them. When considering a potential mission, it was necessary but not sufficient to ask, "Are the scientific objectives worthwhile?" OSSA officials had to go three steps further: "Is it technically feasible?" "Are there sufficient people to do it?" "Can we get the funds to support it?"[70] The

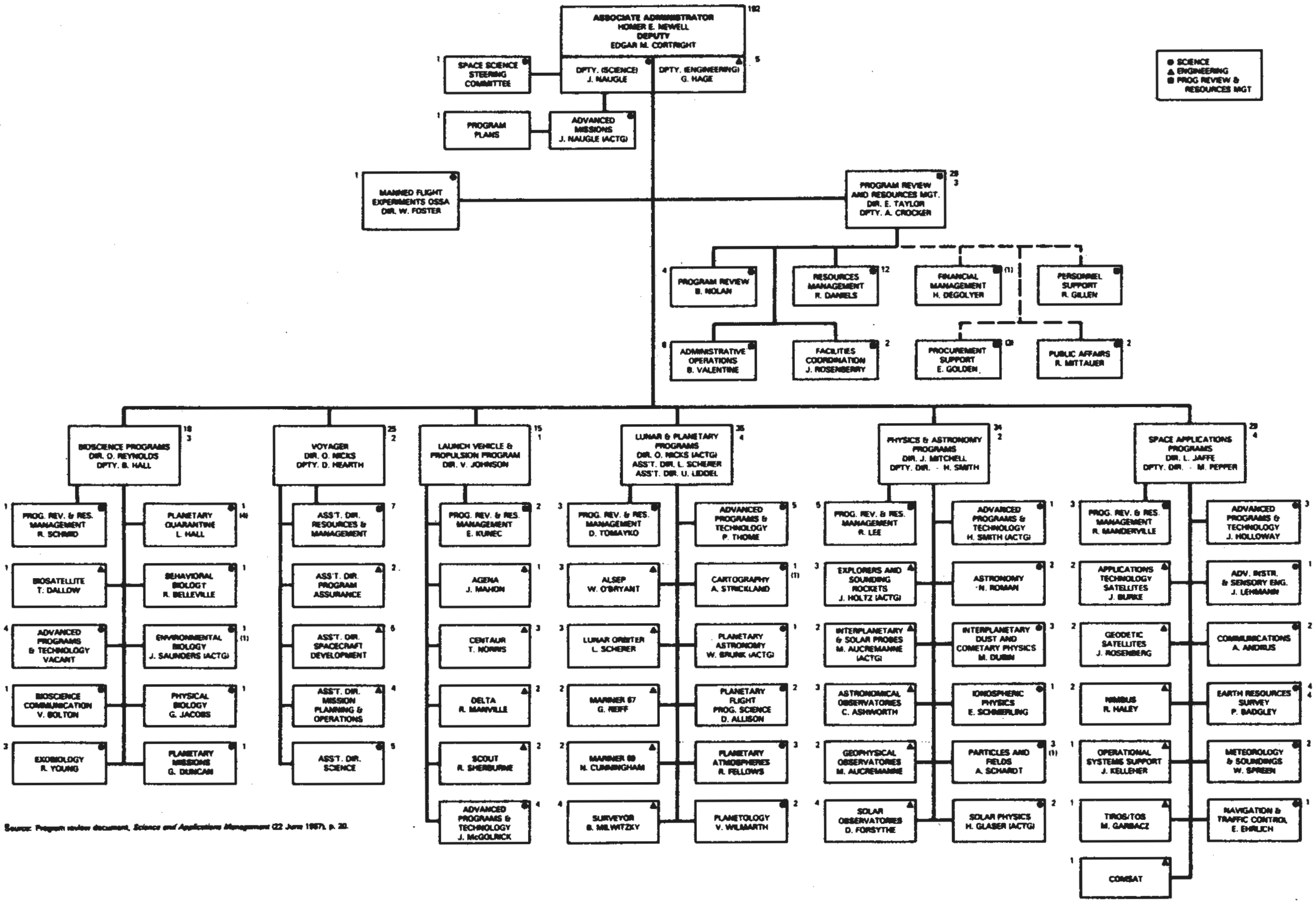
* Two other constraints further diminished the board's effectiveness. It met infrequently (three to four times a year), and after 1964 it was supported exclusively by NASA funds.

OSSA program structure was designed to resolve these questions; its purpose was to combine the evaluation of proposals for basic research with the management of programs calling for engineering skills of a high order. Figure 6–1 illustrates some of the most important features of the OSSA organization.

The fundamental organizational principle was "the establishment of a manageable number of technical offices to handle separate program areas."[71] Each division was intended to be as self-contained as was practical; each contained flight programs related to common objectives; and, without exception, scientific discipline groups were located in the divisions they were primarily intended to serve. Three other features, not clearly brought out by the chart, are also noteworthy. Each division contained a small Program Review and Resources Management group to provide administrative support; and except for Voyager, each had its own Advanced Programs and Technology group to assist in future planning. Furthermore, it was OSSA policy to pair scientists and engineers at each operating level; where the head of one division was a scientist, the deputy was an engineer, and vice versa. This practice, which Newell transferred from his experience at the Naval Research Laboratory, was designed to avoid the pitfalls of a strictly discipline-oriented approach, in which neither side had the ability to see the total picture. For this reason, OSSA management insisted that scientists named as principal investigators had to be prepared to get their hands dirty. The payload had to meet several criteria, as indicated earlier: cost, compatibility, and competence. The outside scientist had to become an insider, had to learn the engineer's language, had to grapple with the unavoidable tradeoffs in turning a research concept into flight hardware.

Another important OSSA concept was the distinction between the headquarters program manager, who was "the senior . . . staff official exclusively responsible for developing the Headquarters guidelines and controls," and the project manager, who was "the senior . . . line official exclusively concerned with the execution of his project."[72] This distinction was not unknown elsewhere, but OART tasks rarely rose to the level of projects, while OMSF project managers tended to be systems managers within very large programs. The program manager reviewed the effectiveness of center management, identified alternate courses of action, and developed a close working relation with the project manager responsible for the effective day-to-day management of the project at the field installation. Moreover, the installations' roles and missions were quite distinct. Wallops Station managed NASA's sounding-rocket program; Goddard handled Earth-orbital and applications satellites; while JPL, a contractor-operated facility working for NASA, managed the Deep Space Network as well as a significant part of the agency's lunar and planetary programs.

The existence of these installations once more raises the issue of the purposes for which NASA research centers were being maintained. At Goddard, with some twenty flight projects in 1967, the maintenance of so much scientific and engineering talent in a Government laboratory could be defended on several counts. The Government could not contract out its responsibility for determining that it



Source: Program review document, *Science and Applications Management* (22 June 1967), p. 20.

Figure 6–1.—The OSSA Organization as of 1967.

was getting good science for its money. It needed people who could build at least one subsystem of the spacecraft they had designed to fly. Goddard management chose to run flight projects in one of three ways: designing and building a spacecraft in-house (e.g., the Small Scientific Satellite); monitoring a contractor who designed and integrated the subsystems (e.g., the Orbiting Observatories); and following the procedure used in certain advanced systems, like the Nimbus weather satellite, in which the center "actually bought the subsystems and acted as spacecraft contractor and hired an integrator. . . . The Nimbus approach was twofold, to not only monitor, but you get up there in their plant and you are right over their shoulder."[73] Once the center had developed several strong discipline areas, it was even better equipped to do its work, as scientists in one discipline began to work with and consult with people in related disciplines. For example, people in planetology worked with people in Earth resources, or scientists in optical astronomy worked with colleagues in meteorology, since the different divisions used the same general type of instrumentation. Moreover, the scientists who worked in these discipline groups performed important services for the whole of NASA. They evaluated research proposals for headquarters, advised other Government agencies on the value of the space program in fulfilling their purposes, and were detailed as experts to the program offices for limited periods. Finally, by attaching project scientists to each flight project, Goddard management tried to ensure that the spacecraft managers and the principal investigators would understand what the other was doing. The function of the project scientists was to bring about a "cross coupling and understanding of the needs of the experimenter . . . and what the project's problems are."[74]

So far the presentation has been limited to a still picture of the OSSA system of program planning. The results of OSSA planning presupposed the following elements within the organization: the existence of a strong in-house capacity to design programs, combined with the ability to integrate experiments with flight hardware; the establishment of a manageable number of technical divisions to handle separate program areas within OSSA; the cross-fertilization of scientific and engineering skills at each operating level; the creation of a Program Review and Resources Management Office to handle budgets, reports, and procurement policy; the establishment of separate program review and advanced mission groups in each division; and the corollary policy that planning, rather than being something imposed from the top, flowed upward from the centers, contractors, and advisory groups with which OSSA worked. In addition, with the adoption of a management information and control system in October 1965, OSSA had both an information system and a set of instructions that extended downward from the program division to the project offices.

This is a somewhat idealized version of how OSSA officials did their medium-range planning, or thought they did. Some ground rules, like that of pairing scientists and engineers, dated from the early 1960s. Other features, such as the establishment of advanced mission groups in 1966, owed something to planning for the post-Apollo period, when OSSA and OMSF would both be staking claims to a piece—a rather large piece—of the action. And many of these principles had to be imposed over the stiff resistance offered by Goddard and JPL. At Goddard the differences between Director Harry Goett and headquarters officials became so serious that he was dismissed in July 1965. Here the issue seems to have been Goett's reluctance to accept supervision by headquarters program managers or to allow OSSA representatives to attend meetings between Goddard officials and center contractors.[75]

At JPL the situation was made more complex by the laboratory's status as a contractor-operated facility that behaved, for most purposes, like a NASA center. The disagreements between JPL and NASA, which were intensified by the string of Ranger failures, were touched on in chapter 2. The "mutuality clause" was an irritant, but the underlying differences had more to do with program management than with anything else: OSSA, in particular, insisted on a tighter, more projectized organization than the one to which JPL had been accustomed.

To state the purpose of OSSA program planning is to emphasize both the difficulty of the task and the office's success in reducing it to almost manageable proportions: "the coupling of the undisciplined scientific activity into a highly disciplined engineering and administrative activity—the design, preparation, and conduct of a space mission."[76]

The Office of Manned Space Flight (OMSF)

The foregoing analysis of how OART and OSSA conducted their planning accentuates the distinctive features of OMSF planning.[77] The obvious differences between OMSF and the other program offices pertain to size and the kinds of programs that OMSF managed. Indeed, OMSF did not plan in the sense that Newell's or Bisplinghoff's office did. There was no similar structure of large and small projects, some under way, others phasing down, and others moving from design to development. At OMSF planning was as much within as between programs. At the end of 1961 all three of OMSF's major programs—Mercury, Apollo, and Gemini—had been approved or were ongoing. No new program was approved or introduced as a budget line item until FY 1967. In this sense, there was very little to bridge the gap between current and future programs.

The size and share of NASA funds and manpower enjoyed by OMSF put the organization in a special category, one not reflected in the organization charts. Although superficially similar to other program offices—it too was headed by an Associate Administrator and had to submit PADs for each program—the sheer size of manned spaceflight programs made control by Webb, Seamans, or Dryden difficult, or at least incomplete, compared with the other program offices. OMSF was semiautonomous within the agency structure, while the OMSF centers were semiautonomous, almost baronies, within the OMSF framework. Mueller, as well as the center directors, had independent ties with Congress, the aerospace community, the press, and, through the Science and Technology Advisory Committee, the scientific estate. The real key to understanding the OMSF program structure is the high priority of Apollo and its special claim to NASA resources. If the responsibility for the development of the Centaur launch vehicle and its RL-10 engines was transferred from Marshall to Lewis, it was because, as a former NASA official explained, Marshall officials had much more interest in the Saturn vehicles that they had designed than in the Centaur vehicle, and for that reason they were prepared to see Centaur canceled. If in October 1965 Webb decided that the Saturn V would be used to launch Voyager, it was in part because he wanted to retain the Marshall capability once Apollo phased down. Because of the overriding claims of the lunar landing, NASA management and Congress were prepared to accept, tolerate, or encourage practices they might have disapproved of elsewhere, like the creation of Bellcomm, the extensive use of support service contracts, and the construction of facilities—Marshall's static test stands, the crawler-transporter at Kennedy Space Center—that were peculiar to one program rather than to the continuing needs of the agency. At the same time, once the large programs began to phase down, NASA would face grave problems. What would happen to the contract and in-house work force assembled to carry the lunar landing program to completion? What would become of centers like Marshall that were organized around a few very large development projects? What would become of OMSF after the first lunar landing? Did the Apollo hardware have uses beyond the program for which it was developed, or was a launch vehicle like the Saturn V a technological dead end? Insofar as the other program offices rode on the coattails of the Apollo program, they too were involved in its fate. The size and sunk costs of Apollo were such that a serious miscalculation in OMSF might drag the agency down with it.

For a clear understanding of the nature and purpose of OMSF planning, it is necessary to concentrate on two areas: the management approach of George Mueller, who succeeded Brainerd Holmes as Associate Administrator for Manned Space Flight in September 1963, and OMSF's Advanced Mission Studies program from its inception shortly after Mueller's arrival to the fall of 1965, when NASA submitted Apollo Applications as a budget line item.

Under Mueller, who came to NASA from Space Technology Laboratories, the manned program reached its "classical" phase. One might even argue that the most important administrative changes at OMSF occurred in a little more than one year, from September 1963 to the end of 1964. Mueller knew about Holmes' troubles and from the beginning expressed a desire to work closely with top management.[78] But, although he was more diplomatic than Holmes had been, he was no less bent on having his way. During his first year at NASA, he devised technical and management approaches that were to dominate OMSF planning until well into the 1970s: the organization of OMSF along program lines instead of having one office working on launch vehicles and another on spacecraft; the division of each program into discrete "work packages"; the concurrent development of the vehicle and ground support equipment; the greater use of redundant (duplicating) systems in the launch vehicle and spacecraft; the introduction of the concept of the "open-ended" flight mission;[79] and the all-up mode of flight testing and, with it, the delivery of complete systems to the Cape. Mueller knew of the Air Force's experience in the all-up testing of Minuteman.[80] Despite the initial resistance of his center directors, Mueller was able to sell the concept to them because the logic of the situation—the "end of the decade" deadline for the lunar landing, the knowledge that programs were slipping dangerously, the inefficiency of the current mode of flight testing—made some sort of change inescapable. NASA could not afford to repeat the Saturn I testing experience, in which four launches of the first stage were followed by launches of coupled second and first stages.[81] The centers, Marshall in particular, had to take a bolder approach. Mueller believed that NASA no longer needed and certainly could not afford a step-by-step advance. For this reason he also decided to cancel all manned Saturn I flights and to man-rate only the Saturn IB and Saturn V launch vehicles.

Mueller was equally radical in handling headquarters and center operations. He restructured the Apollo program so that every functional element at the headquarters program office had a corresponding element in the center project office. The several systems comprising the Apollo spacecraft were defined through the subsystem level, and for each of the major systems he required that one person be responsible full-time for performance, costs, and schedules. In short, Mueller acted to stratify his organization to the lowest level. As Associate Administrator for Manned Space Flight, he defended his programs before top management and Congress, set and interpreted policy with his program managers and center directors, and set the terms on which long-range planning would proceed. To Apollo Program Manager Brig. Gen. Samuel Phillips, USAF, who had been the Minuteman manager and, more important, Vice Commander of the Air Force Ballistic Missile Division before being detailed to NASA in 1963, Mueller delegated responsibility for planning schedules, budgets, systems engineering, and other functions needed to carry out the program. Below Phillips' level were the center program offices, the prime contractors, and the intercenter coordination panels that knit the program together. What Mueller succeeded in creating was a "manned space family" with a stronger voice in policy making than any other program office. By meeting frequently with Apollo prime contractors (organized as the Apollo Executives Group), by intensive briefings of the House Science and Astronautics Committee (especially its Manned Space Flight Subcommittee) at Manned Space Flight centers, and by creating his own long-range planning group in conjunction with Bellcomm, Mueller developed lines of communication with external groups that could make or break the Manned Space Flight program. He also went far toward making the OMSF Management Council a more effective policy-making body. He reduced it to include himself and the three center directors, combined the monthly council meeting with the monthly program schedule review, and carried a resolution by which decisions could be deferred if they required extended discussion.[82]

Organizational changes at the centers both preceded and paralleled these reforms. Each case was a response to the logic of programs with long lead times, geographic dispersal of prime contractors, and the need to integrate the flight hardware and the ground support equipment in one place. As shown in chapter 3, there was not even a consolidated Launch Operations Center until May 1963. The subsequent history of what became the Kennedy Space Center (KSC) bears witness to the importance attached by OMSF and top management to concentrating launch operations in one center. In December 1964 KSC absorbed the Florida Operations of the Manned Spacecraft Center (MSC), thereby assuming control of "all manned spacecraft upon arrival at the Center and total responsibility for manned space vehicles."[83] In October 1965 KSC assumed responsibility for NASA unmanned launches as well, over the bitter protests of Goddard, which had previously managed them. At Marshall the August 1963 reorganization reflected the transition from a center whose roots were deep in the arsenal tradition to one whose principal function would be to manage large contracts for developing and producing complex launch vehicles. This reorganization established an Industrial Operations Division "as the . . . element responsible for multi-program management with Research and Development Operations providing technical support and management of in-house . . . projects."[84] Concurrently, center management extended its use of support contracts on a one-contract-per-laboratory basis. At MSC in Houston there were two reorganizations in 1963. The first, in May, divided operations from developmental activities, with separate offices for preflight program management and for mission operations. The second, in November, gave Director Robert Gilruth and his deputy, James Elms, joint responsibility for four assistant directors and for the Apollo Spacecraft and Gemini program offices.[85] All these changes—the consolidation of responsibility for launch operations, the separation of development from operations at the development centers, and the transition from organization by systems to organization by program—provided a foundation for the Manned Space Flight program that was sturdy enough to last the decade.

Yet Mueller's success in the medium term may serve to explain the comparative failure of OMSF in the long term. Although Mueller established an Advanced Missions Office under Edward Z. Gray as early as October 1963, it would be almost three years before NASA was sufficiently confident in its post-Apollo planning to present Apollo Applications (AAP) as a budget line item. Given the nature of ongoing OMSF programs, the reasons for the delay become understandable. First, there is an inherent tension between managing current programs and planning programs for the long term. If one office has responsibility for both, current programs will generally take precedence over future programs because of the difficulty of planning as if there were no monetary constraints while carrying on in the real world.

Second, there were genuine differences between Mueller and his center directors over mission possibilities after the lunar landing. There were three options: missions to the near planets, such as Mars; expanded lunar exploration; and manned Earth-orbital laboratories.[86] Despite its fantastic expense, Mueller was attracted by the idea of a manned expedition to Mars, while Gilruth at MSC and von Braun at Marshall were convinced "that the major effort of NASA in the post-Apollo period must be directed toward full exploitation of near Earth space capability and, thus, the follow-on lunar activities, *if they are required,* can be carried out at a more scientifically efficient pace."[87] The difficulties with the space station concept are discussed earlier in this chapter. NASA could not commit itself prematurely to an Earth-orbital station (or anything else) for fear of bringing down on itself the wrath of Congress and—what was equally to be dreaded—the antagonism of DOD. Hence the hesitation in defining the sequel to Apollo. What began as a program of lunar exploration had shifted by 1967 to Earth-orbital operations.

Third, OMSF's planning exercises left the role of space science equivocal. At least up to 1966 science was something added on, rather than integral to, manned spaceflight. It sometimes seemed as if OMSF management based its planning for science on the existence of surplus hardware rather than on a felt need for science-based exploration. In any case, the development centers were not equipped to the same degree to do research. Marshall had magnificent engineering capabilities but few facilities for doing research, whether basic or applied. MSC, on the other hand, had a number of laboratories, like the Lunar Receiving Laboratory, that could accommodate research in the life sciences and lunar geology. The real problem facing OMSF was how to work with OSSA in any follow-on to Apollo, a problem that Seamans' "roles and missions" memorandum of 26 July 1966 failed to resolve.[88] OMSF was given full responsibility for Apollo and AAP missions, while OSSA was to be responsible for the scientific content of NASA spaceflight programs. However, the approaches of the two offices were so different that cooperation would have to be the result, not the precondition, of any joint action. OSSA officials were privately sceptical of OMSF's ability to do long-term planning, they regretted the selection of Saturn V rather than the Saturn IB/Centaur as the Voyager launch vehicle, and they differed sharply with Mueller over the design of experiments and the ways in which flight hardware would be used. For these reasons, OMSF found it exceedingly difficult to submit a program that could be made to follow logically from programs actually in progress. All too often, OMSF planning seemed prompted by inquiries from Congress and the President, rather than by any conviction that "this is the way we ought to go."*

Conclusions

To show that NASA had the means for successful medium-term planning, as was asserted at the beginning of this chapter, is not the same as showing how NASA did it. The strategies of project approval and review so far discussed were

* Thus the 1966 Apollo Program Development Plan stated that no advanced mission would be included "until such time as the advanced programs are defined and approved" (p. 17-1).

useful in channeling ideas and proposals upward and the decisions of the program directors downward to the centers and project managers. But the project approval documents, the phased project planning directives, or the controls on advanced studies were not planning documents in any real sense. Rather, they set the terms on which planning took place. They were approaches by top management toward controlling manpower and resources throughout NASA. Webb and Seamans could not defend the agency budget until they knew what it was they were defending. Nor could they administer programs if each PAD required concurrences by two dozen officials before it reached their desks. To put it differently, the PAD, the project development plan, and similar documents were tools of management control; they recorded, at several removes, program decisions made elsewhere by other officials.

To understand how program planning really took place, one must examine each program office, its areas of responsibility, and how it related to the others. Each of the three substantive program offices had its own planning staff, as well as control divisions to review the planning of the several divisions comprising each office. But no program office developed a *system* to handle its R&D projects: not OMSF, because there was nothing in the Apollo program to dictate what the follow-on to the lunar landing would be; not OSSA, because programs like Viking and the High Energy Astronomical Observatory were not routine extensions of capabilities developed for earlier programs; and not OART, because of the difficulty of doing research that was at once detached from specific missions, yet somehow expected by top management to help define the technical parameters of NASA flight programs. What the offices could do was to refine management tools within the approval system represented by the PAD. Top management could do a great deal to eliminate paperwork, to make decisions explicit, and to get program directors to justify their decisions, year by year and project by project. On the evidence, it seems that they could do little to determine the technical content of specific programs; program planning was not just a reflection of choices made on the seventh floor of FOB-6.

The ways in which Voyager or Lunar Orbiter or the test facilities and laboratories at Houston and Marshall took shape owed much more to engineering than to administrative considerations. One need only recall such examples as the conviction of center directors that projects or facilities were technically ripe;[89] the ambition of the directors to retain certain capabilities even when their reason for being was gone; the knowledge that many of the uncertainties dogging earlier programs (e.g., in the development of launch vehicles) no longer existed; and the existence, by the mid-1960s, of subsystems like the Surveyor soft lander or the pointing devices of the Orbiting Geophysical Observatories, that could be recombined for entirely different spacecraft systems. In short, the planning techniques described in this chapter represent the interplay of sophisticated technologies with the convictions of NASA management and line officials about the kinds of programs the agency ought to have. The decision to go to the Moon gave NASA one kind of program, to which unmanned planetary probes and supporting research and technology must contribute. The decision dating from 1967 that space must be treated as a resource to be exploited as well as a region to be explored gave NASA another program with other ends in view. Program planning was the point at which technical constraints, political pressures, and administrative solutions converged.

Chapter 7

The NASA Budgetary Process

THE FUNCTIONS OF THE BUREAU OF THE BUDGET

The budgetary process accounted for the difference between what NASA wanted and what it ultimately received. In the strictest sense, the Federal budget is "the proposed annual financial plan . . . which the Congress considers and approves or modifies. . . . This is the medium through which an agency determines, requests, and obtains the financial authority needed to carry out contemplated programs, and the mechanism . . . for . . . control of operations within the limits of funds made available by the Congress."[1] This definition explicitly recognizes that the Federal budget is rather more than a financial document. It enunciates goals, serves as a benchmark for comparing actual with expected accomplishments, is the basis for authorizing and appropriating legislation, and (as the mechanism by which programs already approved are funded) is a record of past negotiations and a preview of programs not yet approved. The budget, in short, translates substantive programs into dollars and cents.

The absence of coordination, of legislative review and approval by a single body accounts for some of the distinctive features of the Federal budget. As Wildavsky notes, budgeting is *fragmented* because congressional subcommittees are semiautonomous units that concentrate on limited areas of the budget; *specialized* because the full congressional committees assign budget review to their subcommittees; *nonprogrammatic* because most committee members view their task as making marginal adjustments to existing programs; and *incremental* insofar as Congress and the Office of Management and Budget (OMB) take the previous year's budget, rather than the worth (in both senses) of the total program, as their point of departure.[2] Particularly in the 1960s, critics of Federal budgetary procedures seized on these features because they made the establishment of priorities within the total budget impossible. Or—what came to the same thing—the division of budgets into smaller and smaller parts made overall evaluation exceedingly difficult. According to this view, "the overall budget tends to emerge as the accidental outcome of a number of specialized decisions."[3] Hence the number of proposals, dating from the first Hoover Commission (1947–1949), for reform. These included proposals for performance budgeting, that is, incorporating statements of output in agency budgets; for program budgeting, by which agencies would make their operating assumptions explicit to the Bureau of the Budget; for projecting multiyear costs; for examining alternatives to a given approach and for considering needs and costs together; and for introducing improved financial management systems according to guidelines prepared by the U.S. Comptroller General.[4]

The principal agent in preparing a unified national budget was the U.S. Bureau of the Budget (BOB). Long before it was reorganized as the Office of Management and Budget in July 1970, the Bureau's role transcended that of adding each agency's figures to get the correct sums.[5] Substantive programs cost money; and the Bureau's power to review and adjust agency estimates amounted to policy making, whether intended or not. The Bureau and its successor had powers, some of them statutory, others assigned by executive order, to deal with a variety of Government-wide issues. It had (and still has) the authority to set personnel ceilings for most agencies, including NASA. It prescribed standards for agencies to use in contracting for services. It was responsible for supervising methods of financial reporting by Federal agencies and for promoting Government-wide procurement policies. Since 1939, when it became part of the Executive Office of the President, it has had the function of clearing all recommended legislation, whether or not it involved appropriations. In brief, BOB and OMB had policy-making functions, some assigned or delegated explicitly, others gained almost by default. The Bureau coordinated programs that involved more than one agency; appraised pending legislation in terms of its compatibility with the programs of the President; required departments to include cost projections of programs they wished to fund; and informed the President of executive agencies' performance. The questions examined here are, how did NASA work through the budgetary process, and how did the process itself affect the planning and conduct of NASA programs? As a corollary, to what extent did BOB coordinate Federal planning for science and technology in a period when NASA was spending one-third of the Federal R&D dollars?

Difficulties in Reviewing the NASA Budget

Three features that NASA shared with other R&D agencies made external review difficult. First, there were no guidelines for a unified national science policy; second, BOB was at a disadvantage in reviewing NASA programs; third, the nature of the programs made them difficult to justify in quantitative terms. These were not necessarily disadvantages in the abstract; one might argue, for example, that there was no compelling reason for a unified Federal science policy.

Indeed, the diffuseness of publicly sponsored research, the sector-by-sector approach, could be justified on the ground that it rescued publicly supported R&D agencies from a system of rigid centralization. Alternatively, the multiplicity of bodies for reviewing and coordinating Federal science policy tended to become self-defeating, especially in the absence of staff support. Congress in the 1960s lacked both the staff and the central review of the budget that would appear to be essential to legislate for science. The same weaknesses were evident within the Office of Science and Technology, the President's Science Advisory Committee, and the Federal Council for Science and Technology, all of which were chaired or directed by the President's Science Advisor. The effectiveness of a science advisory system depended on a conjunction of events and personalities that rarely occurred. The President had to want independent advice; Eisenhower gave his advisors an effective voice in shaping policy, Kennedy less so, and Johnson and Nixon least of all. There were, besides, structural defects built into the system. Thus Dr. Donald Hornig, President Johnson's Science Advisor, was limited by the small size of his permanent staff; by the direct access to the President enjoyed by the heads of DOD and NASA, the two agencies that accounted for the bulk of Federal R&D spending; by Johnson's preoccupation after 1965 with the Vietnam War; by the absence of yardsticks for determining priorities within the science budget; and by the ability of NASA or DOD to set their own policies—for example, establishing the Electronics Research Center or choosing lunar orbit rendezvous as the Apollo mission mode—while ignoring or circumventing the formal coordinating mechanisms of the Executive Office and its science policy staff.[6] The Science Advisor and the committees he chaired could advise, persuade, issue reports, and appear individually before Congress. But neither Hornig nor the Science Advisory Committee could do very much to set policy within NASA.

The absence of advisors in the Executive Office who were at once effective and disinterested reinforced NASA's tendency to limit the scope and range of its planning. NASA planned in terms of substantive programs and did little to relate manpower to programs. BOB was the only agency that could, at least potentially, mesh NASA programs with each other and with the Federal community. But the difficulties of appraising the NASA budget went beyond the competence of Bureau examiners. Bureau officials knew that the size, not just the technical nature of NASA programs, made detailed oversight difficult. NASA R&D programs were funded incrementally; in other words, allotments were made by the program offices to the field installations more than once a year. This, along with NASA's contracting structure, made "the relationship of specific end items and annual funding requirements almost impossible to establish."[7] Bureau examiners also had to contend with the uncertain nature of estimates for current or future programs, since unforeseen problems might render the estimates almost worthless. Finally, the number of examiners was very limited; as late as 1965 the Military Division, whose forty-three staff members oversaw the NASA, DOD, and Atomic Energy Commission budgets, had only three examiners working on the NASA budget.[8]

Moreover, NASA programs by their very nature were peculiarly impervious to cost-benefit analysis. It was one thing to choose between two methods of attaining the same goal; it was another, considerably more difficult task to choose among competing goals. Few NASA programs produced benefits that could be measured in dollars. To study cost-effectiveness, NASA had to proceed on assumptions that were themselves open to question. Even when NASA tried to quantify the benefits of a specific program, other, noneconomic considerations eluded analysis. When NASA used cost-benefit studies to justify the decision to develop a reusable space shuttle, the General Accounting Office (GAO) pointed to issues that were not reducible to quantitative terms. Whether a space shuttle was or was not economically justified, NASA had to take other matters into account: whether the value of technological spinoffs was sufficient to justify the program; whether the shuttle offered the U.S. space program unique capabilities; whether the United States was prepared to use the shuttle indefinitely and not just to some predetermined date; finally, whether the nation should make so heavy a commitment to manned spaceflight, when unmanned vehicles might reap most of the benefits and avoid most of the risks of a manned system.[9] The specific conclusions of the GAO report need not detain the discussion. What matters is that NASA officials were quite ready to concede the difficulty of making cost-benefit studies of space systems.[10] For that matter, such studies, especially when contracted out, might have little influence on decision making at the highest level, or they might be commissioned simply to justify decisions already taken for other reasons.*[11] One official frankly conceded that NASA found it "extremely difficult to quantify such elusive economic considerations as they affect research and development efforts in the space environment."[12]

Given these problems, what resulted from the annual budget reviews? The following sections involve a closer look at the review procedures of BOB, an account of the planning-programming-budgeting system from its introduction in 1965 to its demise in 1970–1971, and an analysis of the ways in which NASA's internal long-range planning tied to the external reviews of BOB and Congress. First, however, it is necessary to explain the categories under which NASA programs were funded.

How the NASA Budget Was Formulated

NASA Appropriation Accounts

From fiscal years 1963 through 1969, NASA was funded under three accounts: research and development (R&D), administrative operations (AO),† and

* The decision to build a Tracking and Data Relay Satellite System may have owed more to NASA's desire to reduce its dependence on tracking stations located on foreign soil than to any presumed cost benefits.

† From 1959 to 1962 this account was "salaries and expenses"; for FY 1963 it was merged with R&D as "research, development, and operations"; and since 1969 (FY 1970) it has been "research and program management."

construction of facilities (COF). These titles should not be taken too literally. Many items in R&D had little to do with research, while the COF account omitted some of the most important construction work when it involved the installation of "severable" equipment. With these caveats in mind, two features of the NASA budget are evident. NASA budgeted on a "program" or performance basis; and the requirement for an item, rather than the nature of the item itself, primarily determined the funding category to which it belonged.

R&D and COF had more in common with each other than they had with AO. Both were funded on a no-year basis, with funds available until spent; AO was an annual appropriation, with unspent monies lapsing to the U.S. Treasury at the end of the fiscal year. Moreover, NASA was permitted under its annual authorizations to reprogram internally within COF and to transfer funds from R&D to COF with authority to construct. The principal limitations on transfers and reprogrammings were the extension of the powers of the congressional authorization committees from about 1963, the imposition of the requirement that NASA give the committees prior notice for certain kinds of reprogramming in the R&D and AO accounts, the reduction in 1965 of NASA's transfer authority from 3 percent to 0.5 percent of the total authorized for R&D,[13] and restrictions on dollar amounts reprogrammed within COF.[14] Some of these changes ensued from the shift in power from the appropriations to the authorization subcommittees, where the most intensive reviews of NASA took place. Others stemmed from the belief of committee members that NASA was not doing an adequate job of planning for its facilities; that much of NASA's capital spending duplicated equipment available at DOD installations; that NASA was using R&D money directly to fund its facilities projects; and from the resentment directed by Congress at NASA's practice of changing the quantitative scale of projects without actually changing their intended purpose, and of presenting requests for capital plant improvements as a lump sum amount.

Thus the NASA appropriation categories meant more and less than their titles signified. R&D funds could be used for facilities, provided the money was spent on "collateral" (or "severable") equipment; that is, equipment "placed in use in a facility but is not permanently attached thereto except for operating purposes and is removable without significant damage to the real property."[15] In other words, the shell of a building that cost $500 000 (and that was funded out of COF) might house equipment worth millions of dollars that was paid for by R&D funds. Administrative operations was more than an administrative overhead account. It included the direct expenses for operating the NASA centers, the salaries of all NASA civil service personnel, payments to support service contractors, and the funds for the operation and maintenance of the agency's capital plant.[16]

Two other features of R&D not revealed by appropriation titles should be noted. R&D included certain items that were produced in quantity and as such hardly qualified as research or development. This was especially true of launch vehicle procurement: Once the uncertainties in the production of Centaurs and

Deltas were eliminated, those vehicles continued to be funded under R&D as a convenience. Also, a substantial portion of R&D (and AO) funds was used to pay non-NASA personnel, whether they worked directly on projects or in general support; NASA employees, on the other hand, were paid out of AO regardless of the activity in which they were engaged. With this exception, there was no hard-and-fast demarcation of categories. R&D included equipment funding, unit production costs of launch vehicles and overhead costs, as well as the costs inherent in research and development.

Accordingly, NASA appropriation titles and their line item entries can be seriously misleading if taken at face value. There is nothing to show that construction projects and other capital expenses were fully funded, that is, that the total funds were requested and appropriated within a single fiscal year; or that operating expenses were budgeted one year at a time; or that major R&D projects were funded incrementally. Furthermore, annual appropriations only represented new obligational authority, which was quite distinct from actual disbursements. As table 7–1 shows, during fiscal years 1965 and 1966 NASA's obligations were greater than its appropriations, and its expenditures were greater than either. This was possible because of the lag between obligation of funds on a contract (authority for the contractor to work) and expenditures (payments for work actually performed).

To compound the confusion further, the NASA budget included only those programs for which funds were both authorized and appropriated. What did this omit? It chiefly omitted those programs in the definition phase for which NASA had not yet sought authorization. For years the NASA authorization acts included the following provision:

> No amount appropriated pursuant to this Act may be used for any *program* which has not been presented to or requested of either [authorization] committee.[17]

Yet when NASA presented its 1966 budget request to the Senate Aeronautical and Space Sciences Committee, members were surprised to learn that nearly $8 million in 1965 funds had been spent on one unauthorized program—Voyager. Seamans explained that Voyager was a "project," not a "program"; that the funds for Voyager had been reprogrammed from Mariner following the decision to start conceptual studies of Voyager; and that NASA would request authorization once management determined to go ahead with the program.[18] Thus to the question, "When is a program not a program?," NASA could reply, "When it is a project."

In short, a line item entry for a major R&D program could not include all direct and indirect costs. The total expenditures for a single program would have to include funds reprogrammed, funds for facilities in support of the program, and, in particular, it would have to account for the differences between the amount *appropriated*, the amount *obligated*, and the amount *spent*. The following sections examine how these sums were determined.

Table 7-1. — NASA requests, authorizations, appropriations, obligations, and disbursements—all appropriations, 1959–1968, in millions of dollars.

Fiscal Year	Budget Request	Authorization	Appropriation	Obligations[1]	Expenditures[1]
Total	*34 156.1*	*33 100.4*	*32 399.8*	*32 082.2*	*30 446.4*
1959	146.6	146.6	146.6		
1959	280.0[2]	259.2	184.3[3]	298.7	145.5
1960	508.3	490.3	523.6[4]	487.0	401.0
1961	964.6	970.0	964.0	908.3	744.3
1962	1 940.3	1 855.3[5]	1 825.3	1 691.6	1 257.0
1963	3 787.3	3 744.1	3 674.1	3 448.4	2 552.4
1964	5 712.0	5 350.8	5 100.0	4 864.8	4 171.0
1965	5 445.0[6]	5 227.5	5 250.0[7]	5 500.7	5 092.9
1966	5 260.0	5 190.4	5 175.0	5 350.5	5 932.9
1967	5 012.0	5 000.4	4 968.0	5 011.8	5 425.7
1968	5 100.0	4 865.8	4 588.9	4 520.4	4 723.7

[1] Actual obligations and disbursements during the fiscal year.
[2] Requests for NACA/NASA amounted to $280 054 000. Requests for transfers from DOD resulted in the transfer of $146 619 532 in obligational authority to NASA.
[3] Includes $101 100 000 appropriated to NACA, $83 186 300 to NASA, and $146 619 532 transferred from DOD.
[4] $38 500 000 based on FY 1959 authorization Public Law 86-12.
[5] Includes $71 000 000 supplemental for COF for which existing authorization was available.
[6] Includes $141 000 000 supplemental request for FY 1964 R&D program.
[7] Includes $72 494 000 R&D supplemental against FY 1964 authorization.
Source: *NASA Data Book,* table 4-4.

The Preparation of the NASA Budget, 1958–1966

Between 1958 and 1970 NASA drafted and submitted its budget requests to BOB within two different sets of Bureau guidelines. The first procedure was employed from 1958 to the end of FY 1966; beginning in FY 1967, NASA was required to submit program memorandums and special studies conforming to the planning-programming-budgeting system mandated for executive agencies by President Johnson in August 1965. What, specifically, did BOB demand of the agency in justifying its request? How did NASA submit requests for R&D programs, few of which could be fully funded and thus had to be spread over several years for budgetary purposes? From 1958 to 1966 the cycle began with the semiannual spring and fall previews. Although the spring preview was not a formal requirement, and actually preceded the letter from the Budget Director that began the cycle, it held certain advantages for top management. As "a tentative and generalized first approximation," it eliminated marginal program elements, brought policy questions to the surface, and produced "a feedback into program implementation then underway."[19] Wyatt's Office of Programming assembled the materials sent by the program offices, prepared a first draft of the preliminary budget, and reviewed it at some length with top management.

The spring preview took place in March, fifteen months before the start of the fiscal year for which the budget was being prepared. Thus the review of March 1964 concerned fiscal year 1966, which began on 1 July 1965. The preliminary budget went to BOB in May, and it led to negotiations between management and the examiners of the Bureau's Military Division that continued until late summer, when the Bureau provided budget targets at two levels of effort. This concluded the first phase of the NASA budget review.[20]

By then NASA had begun to flesh out the details of its upcoming submission. In August and September top management sent instructions to the program offices for detailed estimates. On 30 September NASA formally submitted its request to BOB; during October and November Webb, Dryden, and Seamans met with the Director of the Budget and the President; and by January the President's final decisions had been converted into material for justifying the budget request before the authorization and appropriations committees. On the basis of various BOB staff papers, it does not seem that top management was deeply involved in the details of the budget submission until the final stages of the cycle. In 1967 one examiner thought it noteworthy that "unlike past years Mr. Webb has personally reviewed in great detail a variety of program alternatives . . . and has made all major program and planning decisions himself."[21] Taken in context, this means no more than that he wrote and signed certain program memorandums enunciating his views on items in the 1968 budget. As a former Director of the Budget, Webb was aware that he could do more for NASA by establishing his agency's general posture toward the President's budget than by captious criticism of every detail. Webb contributed to firming up the budget by meeting with his program directors during the semiannual reviews, by meeting with the Director of the Budget to resolve any differences before the budget went to the Hill, and by using his right of appeal to the President to settle those matters that could not be settled between the Director and himself—a right that was itself controlled by guidelines issued by BOB.[22]

Three points about the budget review cycle deserve emphasis: the source of NASA's budget estimates, the multiyear character of NASA programs, and the Bureau's role in paring down the NASA budget. First, how did NASA officials match current expenditures against their requirements for the ensuing fiscal year? Estimates were made from the program operating plans (POPs) submitted quarterly by the field installations to the program offices and, through them, to the general manager. The POP was a financial plan that served as a basis for budget formulation, particularly when the greater part of the budget consisted of outlays for programs approved earlier; as a check on overobligating and overspending, both forbidden by the so-called Anti-Deficiency Act; as a basis for the current year operating plan; and as the baseline of "planned financial activity" against which actual financial performance could be measured.[23] The POP system was an effective tool for measuring actual expenditures, although it had to be adjusted to the everchanging demands of complex programs. Thus in 1966 the Management Committee chaired by Deputy Administrator Seamans made changes designed to leave the POP system more flexible than it had been. The committee confirmed the practice of fully funding fixed-price contracts, recommended an integrated financial management plan for comparing approved with actual funding levels, and authorized the centers to deviate from planned funding levels, provided they could justify their actions.[24]

Second, NASA had to consider three budgets simultaneously: the current operating budget, the budget for the ensuing fiscal year, and the preliminary budget for the fiscal year after that. The interrelations of the budgets were important because a deficiency in one year might be made good by reprogramming or diverting funds the following year. The NASA budget submissions explicitly recognized these relations. Even before the agency was required to adopt the planning-programming-budgeting system, NASA was sending up budget estimates with five-year cost projections. To that extent, drafting preliminary estimates constrained NASA officials to do some kind of long-range planning: to decide, for example, which year would provide a suitable launch window for an interplanetary probe; to determine whether a new tracking station that would support several spacecraft should be started this year or next; and generally, to establish some order of priorities.

Third, the detailed negotiations between NASA and BOB went far to shape the content of the operating budget. For all the rhetoric and talk of "economy," Congress did little to alter the agency's requests before the 1967 session, and even then it followed the Bureau's lead. Between 1961 and 1967 Congress cut the Administration's request by more than 10 percent only once: In 1964 it reduced the NASA request from $5.712 billion to $5.100 billion (table 7–2). Unlike the Bureau's action, this was an across-the-board reduction rather than the elimination of entire programs.

Actions of the Bureau, not Congress, led to canceling the last two Apollo flights; closing the Electronics Research Center; reducing Surveyor flights from 17 to 10; freezing NASA excepted positions at 425; and eliminating certain programs before they reached the development stage, such as the Advanced Orbiting Solar Observatory canceled by NASA in December 1965.* The Bureau's strategy consisted of forcing NASA to make hard choices, to choose between programs that were merely desirable and those essential to the agency's mission. With only three or four individuals assigned to evaluate a $4 to $6 billion submission, and with several dozen budget officers in NASA prepared to justify every penny, the Bureau

* It is also possible that the Bureau reduced NASA's requests to forestall action by a Congress that was in an economizing frame of mind.

Table 7-2. — NASA budget requests and appropriations, FY 1959-1971, in millions of dollars.

Fiscal Year	Administration Request	Amount Appropriated	Percent Cut
1959	$ 280.0	$ 222.8	20.4%
1960	508.3	485.1	4.6
1961	964.6	964.0	–
1962	1 940.3	1 825.3	5.9
1963	3 787.3	3 674.1	3.0
1964	5 712.0	5 100.0	10.7
1965	5 445.0	5 250.0	3.6
1966	5 260.0	5 175.0	1.6
1967	5 012.0	4 968.0	0.9
1968	5 100.0	4 588.9	10.0
1969	4 370.4	3 995.3	8.6
1970	3 715.5	3 696.6	0.5
1971	3 333.0	3 268.7	1.9

Source: Thomas P. Murphy, *Science, Geopolitics, and Federal Spending* (Lexington, Mass.: Heath Lexington, 1971), p. 364.

could force reductions only by concentrating on a few large programs. Secure in the knowledge (after 1967) that the White House would not intervene to restore major cuts in the NASA budget, Bureau officials wasted no time in cutting back. The history of the NERVA* nuclear rocket program is a good example of how BOB/OMB tactics worked. When Congress eliminated the very ambitious NERVA II program in 1967, NASA kept the program alive at a more modest level. Sensing that the program was vulnerable, BOB/OMB pared down NASA budget requests over the next three years. By FY 1972 the program was barely alive; OMB reduced the NASA request for that year by nearly two-thirds, as the NERVA funding level dropped from $32 million to $9.9 million. Since no prospect of an operational nuclear rocket remained, in January 1972 NASA elected to terminate NERVA in favor of a smaller nuclear rocket system.

However, in some cases programs were kept alive when Congress restored funds eliminated by the Bureau. In January 1965, for example, NASA, under pressure from the Bureau, announced that it would not request funds for the M-1 liquid-hydrogen engine, the SNAP-8 nuclear power system, or the large (6.6-meter-diameter) solid-fuel rocket motor. Webb and Seamans were very careful to avoid the words "cancelation" and "termination" in referring to these

* Nuclear Engine for Rocket Vehicle Application.

development programs. As it happened, Congress restored funds sufficient to keep the large-solid-motor program alive for two more years, through the successful test firing of June 1967.[25]

The de facto cancelation of the three programs was important because it was the first major cut by the Bureau and the President since early 1961. By 1965 the advantage of managing programs that did not have to compete with equally compelling alternatives was almost gone. By then, the most important Great Society programs had been enacted, and the war in Southeast Asia was claiming a growing percentage of the budget. NASA submissions were beginning to come under the cold, hard scrutiny of Budget examiners, who were demanding that NASA offer alternatives to existing programs, quantify the noneconomic benefits of space exploration, show that a program like Apollo Applications did not duplicate DOD's Manned Orbiting Laboratory, and, generally, adopt a level of analysis that would have been unnecessary a few years earlier. Until then NASA had seldom been "nickeled and dimed" by the Bureau; now there would be little else. There seems little doubt that Webb was no longer able to influence the President to restore budget cuts to the NASA program. That had not always been the case. Webb's meeting with President Kennedy on 22 March 1961, when Webb appealed for restoration of cuts made by BOB in a supplemental appropriation request, initiated Kennedy's "involvement in space policy which was to culminate . . . with his announcing his decision that the United States should attempt to send men to the moon."[26] In 1966 Johnson was no longer "the guy 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." Instead, Johnson was telling Webb, "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."[27]

The Planning-Programming-Budgeting-System and the NASA Budget

The budgetary cycle just described was superseded in 1967 by a system that was controversial out of all proportion to its effect on Federal budgeting. The planning-programming-budgeting system (PPBS), already used by DOD for its budgeting cycle, was extended to many civilian agencies in 1965.[28] The reasons for its success in shaping the DOD budget may account for its failure to "take" outside the Pentagon; in 1971 OMB quietly dropped the reporting requirements that were an essential part of PPBS.[29] The following section considers to what extent NASA's budget was "programmatic" before 1965 and why NASA failed to use the system in its internal planning.

Taken in isolation, the basic concepts of PPBS were neither new nor revolutionary. The purpose of the system was to combine analysis with budgeting in order to determine the output for specific programs. The system was intended to make goals explicit, to estimate total program costs (direct and indirect) over several years, and to present alternative paths to the same objectives. Some of the analytical tools incorporated in PPBS had been available for years before its introduction: the 1921 Budget and Accounting Act had given GAO broad powers to review Federal programs, and an act of 1956 had called on agencies to provide long-range cost estimates and to maintain their accounts on an annual accrued expenditure basis.[30] What was novel was combining these and other budgetary concepts in the Defense Department, when Robert McNamara became Defense Secretary in 1961. PPBS tools were refined by a team of analysts, many of whom were recruited from the RAND Corporation; and it was such former RAND staff members as Charles J. Hitch, who became Assistant Secretary of Defense (Comptroller), and Alain Enthoven, who headed the Pentagon Office of Systems Analysis, who introduced DOD to the rigors of program budgeting. Few agencies needed it more. The contrast between McNamara and his predecessors may have been overdrawn; for all his cost-reduction programs and cancelation of weapons systems like Skybolt and the B-70, there is little doubt that PPBS in the 1960s would have been impossible without the administrative reforms of the preceding decade, especially those embodied in the 1958 Reorganization Act (discussed in chapter 8). Nevertheless, prior to 1961 there had been an almost complete divorce between budgeting and military strategy within DOD. Budgeting had tended to be by service rather than by mission. Financial planning had been done on an annual basis, which led to premature commitments (and overcommitments) to weapons systems, as well as to considerable unnecessary duplication in the ballistic missile programs. Finally, there had been a "lack of reliable information on the costs of weapons systems. . . . new weapons systems generally ended up costing two to three times as much as they were estimated to cost when the program was originally approved."[31] When McNamara became Defense Secretary about 40 percent of DOD development funds went for overruns on existing contracts.[32]

None of these problems could be considered apart from the others. For cost-estimation of military programs to be successful, several elements that were lacking would have been required: clear identifications of task, valid data, estimate updates, standardized work breakdown structures for estimates, independent reviews of estimates, and the like. The newly instituted DOD program budgeting procedures were designed to assemble everything necessary to track the real costs of programs. The Secretary of Defense was to be served by a central analytical staff, the Office of Systems Analysis, which reported directly to him and was independent of service interests. Financial planning was to be done on a multiyear basis. In addition to the annual budget, DOD officials would present Congress with a Five-Year Defense Plan, which included eight-year force projections and five-year projections of costs and manpower for the ten major military programs into which the Defense budget was divided.[33] The plan combined costs and benefits, linked force with financial planning and, in Enthoven's words, "provided a vehicle by which the Secretary of Defense could make program decisions and tie them into the preparation of the annual budget."[34] PPBS, in sum, led to a more integrated budget structure than DOD had yet known; with its emphasis on comparison of alternatives, the quantifying of outputs, and the use of cost-effectiveness techniques, it seemed to offer a revolutionary planning system for Governmentwide use.

This was not to be. PPBS disappeared; it "became an unthing" before it had really been tested outside DOD.[35] The history of PPBS in NASA may explain why the system failed to make much of a dent in the bureaucracy, especially since NASA seemed more disposed to use it than did other agencies. The NASA budget anticipated some features of PPBS: five-year cost projections, organization by broad program categories, and a budget structure that identified and considered costs for a specific project together. NASA had a multiyear budget. In addition, aside from military interest in space, there was no division of responsibility for the conduct of the U.S. space program. Because the space program made use of systems like spacecraft and the vehicles that launched them, it seemed to lend itself especially well to program budgeting. In other words, "the space program consis-t[ed] mainly of a number of efforts to develop, test, manufacture and operate aggregations of physical equipment that perform clearly defined functions."[36] So confident were BOB officials of NASA's willingness to accept the system that one examiner confided that "it will not be a matter of selling them on a new approach, but more a matter of developing suggestions for worthwhile actions."[37]

Yet PPBS seems to have had very little effect on NASA budgeting. There were just enough similarities to make the reporting requirements of PPBS seem redundant, just enough differences to make it appear to be a threat to the stability of NASA program planning. The emphasis of the Pentagon Office of Systems Analysis on concentrating similar programs in one place suggested that PPBS might lead to amalgamation of NASA and DOD programs under single agency management. But the reasons for the failure of PPBS to take root in the Federal community in general and in NASA in particular go deeper. For one thing, it was oversold. President Johnson's endorsement of the system was enough to create suspicion that PPBS was too true to be good, that the system was nothing more than a gimmick. At the press conference in which PPBS was instituted, Johnson said that

> under the new system each Cabinet and agency head will set up a very special staff of experts who, using the most modern methods of program analysis, will define the goals of the departments for the coming year.[38]

PPBS would "make our decisionmaking process as up to date . . . as our space-exploring programs." The thrust of Johnson's message was that program budgeting would be imposed from the outside and, by implication, that most executive agencies were not equipped to understand the objective, scientific basis for decision making. The result is no surprise: Many of the agencies affected were quietly hostile to PPBS, although some were more than others. Agencies like the Department of Agriculture and the Department of Health, Education, and Welfare (DHEW) needed the integrated planning that PPBS purported to supply far more than NASA did. In the former, the principal constraint on program management was the difficulty of discovering what the various bureaus and semi-autonomous divisions actually did. DHEW and Agriculture had incentives to use PPBS that simply did not exist for NASA. Unlike NASA, neither agency had any kind of planning apparatus, especially for long-term planning. PPBS seemed to open the way for the Department Secretaries to gain some control over the bureaus—which were ostensibly subordinate but in reality semi-independent—that comprised their departments.[39] Additionally, a rigorous system of policy analysis might establish the costs and benefits of the programs supported by, for example, the U.S. Office of Education, or it might establish the continued need for the Rural Electrification Administration, at a time when 99 percent of all U.S. farms were connected to regional power grids.

In general, PPBS could not be implemented where the agency head gave it no support. In cases of agency indifference or hostility, the system became merely one more reporting requirement imposed by BOB's Circular A-11. Webb's attitude was colored by his experience as President Truman's Budget Director. Moreover, he consistently opposed the delegation of responsibility for making decisions to any group of experts; this was the basis for his rejection, in 1966, of a proposal that NASA establish a general advisory committee of outside scientists to map a policy for the agency's space science programs. Whatever he might have said publicly, Webb was fundamentally sceptical of any system or technique that promised a "quick fix" to the uncertainties of research and development. As he explained to Budget Director Charles L. Schultze, one of the prime movers in the development of PPBS, the system promised a delusive certainty for programs with long lead times; NASA programs were not usually amenable to cost-effectiveness analysis; and the requirements of multiyear planning, "if literally insisted upon, could serve to deprive the agency head, the Bureau of the Budget, and the President of much of the flexibility they need."

> The problem, as I see it, is to devise a procedure which will provide for essential and useful long-range planning of alternatives, and with the necessary information . . . communicated to the Bureau of the Budget for review, without requiring either the agency or the Bureau to give official status prematurely to a particular plan or action. To set such priorities too firmly in advance also invites constant and ingenious pressures to enlarge areas of special interest.[40]

Webb's lack of enthusiasm, the prior existence of a programmatic budget, the reluctance of officials to commit themselves in advance to programs of uncertain duration and funding, and the nonquantifiable nature of NASA's output sufficiently account for the insignificant role that PPBS played in post-Apollo planning. The essential difference between DHEW and NASA was that the former was, so to speak, the sum total of numerous quasi-autonomous divisions, while NASA was organized around projects whose successes or failures were obvious and unambiguous. In short, "much of what [Agriculture] or HEW generated in the form of information for use by management under PPBS was something NASA already had."[41]

Consider the failure of PPBS from another perspective. Why did PPBS appear to succeed at the Pentagon, only to fail elsewhere? Principally because the Defense Secretary *wanted* independent analytical support and because he used the results of the analysis in preparing the budget requests that went to the President. Only superficially were the draft Presidential memorandums (DPMs), prepared by the DOD Office of Systems Analysis, the same as the program memorandums (PMs) required of civilian agencies. "The critical difference was that the DPM was sent to the President, while the Program Memorandums went to the Budget Bureau. . . . The DPM was a decisional document; the PM only an intermediate step in the long process of budgeting. . . . The DPM was prepared by systems analysts to reflect McNamara's views; the PM was composed by analysts removed from the centers of power."[42] The concept of PPBS assumed a central "steersman" who directed and shaped agency policy. But as the analysis of headquarters organization in chapter 3 shows, and as other studies of public administration confirm, "the chief problem of the central administrator is to pick and choose a limited number of places and situations for strategic intervention, rather than seriously trying to 'steer the ship' in any detailed way.[43] Had PPBS been rigorously applied within NASA, it would have seriously limited the discretion of the centers and program offices in carrying out the agency's mission.

The NASA Budgetary Cycle, 1967–1970

The introduction of PPBS did not immediately lead to any formal changes in shaping the NASA budget. The first, rather tentative guidelines, issued in October 1965 by BOB, explained the purpose of the system and described the three documents that agencies would henceforth submit: the program memorandum, which would cover each of the agency's programs, compare it with various alternatives, outline its assumptions, and list projected costs; special analytical studies in selected areas; and the program and financial plan (PFP), which would set forth projected funding in tabular form.[44] The program categories to be used would be determined by the Budget Director in consultation with agency heads who, in turn, would assemble a staff to handle PPBS requirements.

How did these guidelines impinge on NASA? In organizational terms they had almost no effect. Webb established no new division to deal with PPBS. Instead, the work of drafting program memorandums, special studies, and PFPs was parceled out to offices burdened with other responsibilities. Indeed, the 1967 reorganization went completely against the grain of PPBS by splitting budget preparation from technical review. Webb virtually assured that there would be no division below the level of the Office of the Administrator to coordinate budget preparation. More precisely, the 1967 changes concentrated the responsibility for preparing the budget in Lilly's Office of Administration, not in Wyatt's new Office of Program Plans and Analysis. Lilly became the NASA Comptroller de facto five years before that position was created to take account of budgetary realities. The fate of the Office of Program Plans and Analysis illustrates a familiar pattern in NASA administration: No planning office has had much influence in shaping policy once it was divorced from daily operations. So far as one can tell, the creation of Program Plans and Analysis had nothing to do with BOB requirements and almost everything to do with power shifts at headquarters in the aftermath of the Apollo fire.

The first cycle in which NASA was required to use the PPBS approach was in 1966–1967, for the FY 1968 budget. To complicate matters further, this was when NASA at last set into motion its apparatus for post-Apollo planning. By the spring of 1967, several groups were working concurrently on different segments of the budget. Wyatt's office drafted program memorandums; the Resources Analysis Division of the Office of Administration prepared the PFPs; and the program offices made the special analytical studies requested by BOB. By then PPBS and the agency's own internal planning were so intertwined that it was hard to know where one left off and the other began. The program offices, after all, were commissioning their own advanced studies; one on large space stations even was accepted by the Bureau to meet the analytical studies requirement. In addition, a Planning Coordination Steering Group had been created by the program directors at the end of 1965 to do long-range planning in selected areas; much of its work, and that of its supporting working groups, paralleled the reports demanded by the Bureau. One finds the same elements in either case, particularly the emphasis on analyzing options for specific programs. Yet there was little, save for the staff support of the Office of Program Plans and Analysis, to link the planning teams with each other.

By the fall of 1967 NASA had had some experience of the system mandated by BOB, yet that system was not widely understood within the Bureau itself. The staff papers of the Bureau examiners reveal that PPBS was not working as intended: NASA officials were not meeting budgetary schedules and the Bureau was not working with NASA planning groups to validate their cost estimates. In any case, the events of that year, including the Apollo fire, made coherent planning very difficult. During 1967 NASA *and* the Bureau were reorganized, making this the first budgetary cycle for many in both agencies.* The internal reviews of the Apollo fire preoccupied every key official for months, affecting costs and schedules in areas that used two-thirds of NASA's funds. Congress had reported, and the President had agreed to, a $500 million appropriation cut in August, thus forcing major program changes on NASA. For the first time since 1961 (except for the 1964 reductions noted above) Congress rather than the Bureau cut the NASA budget request: Voyager and Advanced Manned Missions were deleted in conference, and NASA did not define its current year operating plan until November. Finally, the simultaneous hearings on the Apollo fire and the 1968 authorization tied up the agency for months; something had to give, and that something was the

* One of the changes within the Bureau was the establishment of an Economics, Science, and Technology Division, headed by Jack Young, to monitor the NASA budget.

agency's planning structure. Both sides, NASA and BOB, were accountable for the shortcomings of the 1967 budget cycle: BOB because it did not develop methods refined enough to evaluate the benefits of alternative space missions; NASA because it allowed itself to be overtaken by events and because of divided counsels and the loss of morale throughout the agency. A BOB examiner summed up the situation just after NASA received its appropriations for 1968:

> Morale is bad throughout NASA because of its first beating at the hands of Congress in the agency's history, the lack of Presidential support . . . the Apollo fire and other severe technical problems and schedule delays, and the strict guidelines for the 1968 budget. Mr. Webb is under siege by his staff for not fighting as hard as they think he should for their programs, by Congressional critics for a variety of assumed slights and irritations, and by the trade press which tends to blame him for all NASA's current problems, both internal and external.[45]

The instinct of the Bureau examiners was to cut, pare, and slash requests they deemed wasteful. All too often, what was meant as program analysis ended up indistinguishable from plain old economizing.

In truth, there were events external to the space program that made it impossible to evaluate proposals on their merits. NASA requests were cut back steadily by the Bureau after 1966, not because they lacked virtues that earlier requests possessed, but because of the Vietnam War, a balance-of-payments deficit, an overheated economy, and the higher priorities of Great Society programs. Johnson wanted to reduce spending without sacrificing the substance of his social commitments. When the NASA authorization bill was sent to the White House in August 1967 for Johnson's signature, Schultze and Presidential Assistant Joseph Califano listed the pros and cons of the President's issuing a statement before signing the bill. In signing, Johnson would in effect accept a $517 million reduction already voted by the House Appropriations Committee. Schultze argued that by issuing a statement, "it will help avoid later charges by supporters of the space program of a double cross. Eventually we are going to have to cut at least this much from the space program. If supporters of the program . . . fight for and get some restoration of this cut only to be faced with an administration-initiated reduction, they may charge bad faith."[46] Hence Schultze's warning to Webb: "Avoid making commitments . . . for increases above the levels at which you are operating. . . . Exercise special prudence in filling vacancies. . . . Except when major Presidential items are concerned, avoid appealing for restoration of congressional cuts in recommended appropriations."[47]

The changes in PPBS after 1967 should be considered in terms of NASA's long-range planning rather than its budgeting. In any case, the future of program budgeting became less certain once Johnson announced his decision not to run for reelection in 1968. Thus the program decisions generated by the Administration could have, at most, a provisional validity. More important, neither President Nixon nor his Budget Directors had much faith in the assumptions on which PPBS was based. By reorganizing BOB as the Office of Management and Budget

(OMB) and by establishing a Domestic Council within the Executive Office, Nixon separated budgeting from program analysis as thoroughly as Webb had done for NASA in 1967. The formulation of policy would take place outside the budgetary process. In Schick's words, "budgeting would operate alongside program coordination. . . . and other administrative functions. It would not be the central process for shaping the President's program and analyzing policy alternatives."[48] The separation of the Domestic Council from OMB and the subsequent elimination of the reporting requirements developed by Schultze and his staff effectively killed PPBS.

So much for the formal and procedural aspects of NASA's budget preparation. Chapter 9 offers a consideration of the substantive content of NASA's program memorandums and special studies and of their effect on the agency's long-range planning. Now the discussion turns to Congress and to the fate of the NASA budget request once it was approved by BOB and sent to the Hill.

The Authorization and Appropriation Cycle

For NASA the critical program choices were made and reviewed in the initial phases of the budgetary cycle. As discussed above, most of the substantial cuts were made by the President or the Budget Director before the NASA budget went to Congress. Until 1967 the sheer complexity of legislative review tended to work in NASA's favor. The process of review might, with luck, timing, and political skill, lead to appropriations that were at best higher and at worst no more than 10 percent lower than the original submission.

The following were the principal stages in the cycle of congressional review:

1. Initial hearings before the House and the Senate authorization committees, followed by passage of House and Senate authorization bills after debate on the floor of each House.
2. Similar review by the House and Senate appropriations subcommittees responsible for the NASA budget.
3. Convening conference committees to resolve differences in the versions of the authorization and appropriations bills passed by each House.
4. Passage of the final authorization and appropriation acts.

The important features of the cycle were, first, that NASA had to seek annual authorizing legislation before it could secure appropriations; second, that the locus of power tended to shift from the appropriations subcommittees to the legislative committees once the annual authorization requirement became permanent; third, the lengths to which NASA went to avoid friction with its committees; finally, the temporary erosion of some good will in Congress, owing to the disclosure of the events leading to the Apollo fire, NASA's reluctance to submit a complete copy of the Phillips report, and the agency's failure to present Congress with a coherent post-Apollo program.

The annual authorization requirement stemmed from the "Johnson rider" to NASA's first appropriation act in 1959, a requirement extended indefinitely a year later. Before 1959 most agencies were permanently authorized, and their only recurring hearings were before their appropriations committees. In that year, the authorization requirement was extended not only to NASA but to all expenditures for "aircraft, missiles, and naval vessels"; in 1962, to all new military research and development programs; in 1963, to the Coast Guard's construction and procurement programs; and by 1966, to the Peace Corps, the Atomic Energy Commission, and the Agency for International Development.[49] The authorization requirement doubled the number of annual reviews of NASA programs. But it signified more; the leaders of both Houses wanted "control" and "oversight" authority before administrative action was taken, as well as review after the fact. The authorization committees, especially the House Science and Astronautics Committee, developed staffing and review procedures to keep informed of every phase of the civilian space program. The House committee was divided into subcommittees corresponding to each of the NASA program offices; and these, especially the Manned Space Flight Subcommittee chaired by Representative Olin Teague (D-Tex.), expected to be fully briefed at the centers by key program officials.[50] They, rather than the full committee, reviewed and passed on NASA requests.

The authorization committees acted to shape NASA programs in three closely related ways. First, the bills reported out of committee set the ceiling, the maximum, for NASA appropriations. Second, the committee reports accompanying the authorizing legislation imposed limitations and preconditions on how the funds made available could be spent. Third, the committees prescribed the conditions under which NASA could reprogram or transfer between accounts, as well as the percentages and dollar sums involved. (Of some 130 reprogramming motions made by NASA between 1958 and 1969, virtually all were approved.) And the committees were extremely sensitive to any sign that NASA was trying to outflank them. In 1969, for example, the members of the Senate Aeronautical and Space Sciences Committee learned that the MSC Lunar Receiving Laboratory, originally authorized at $8.1 million, would be completed for approximately $16 million, most of which was accounted for by equipment provided out of R&D funds. They also discovered that NASA had built a neutral buoyancy facility at Marshall—a gigantic water tank to simulate weightlessness—using over $1 million of R&D money after the committees had denied funding under COF. To prevent this from recurring, the committee reaffirmed and wrote into the 1970 Authorization Act a provision that required NASA to notify the authorizing committees of intent to use R&D funds for any facility whose cost (including collateral equipment) would exceed $250 000. They further requested that every facilities project include "the total estimated costs necessary to provide for a completely operable facility." The same act also canceled unfunded authorizations for fiscal years 1967–1969, that is, funds for which no appropriations were voted; committee members suspected that NASA was requesting more money than was necessary.[51]

By virtue of their authority to review the substantive content of NASA programs, the authorization committees were best able to consider the agency as a whole. The appropriations committees had to review numerous independent agencies, while the authorization committees reviewed at most two or three, including NASA and agencies like the National Science Foundation and the National Bureau of Standards. There were certain differences between the committees, differences subtly reflected in the language of their reports. Where the House Science and Astronautics Committee "recommended," the Senate Aeronautical and Space Sciences Committee "concurred." Because the House committee generally initiated the NASA authorization hearings, the Senate committee could act as a court of appeal to restore cuts made by the former. Since the Senate committee had no subcommittees, its review was less exhaustive than that of the House, which was doubtless a welcome relief for NASA officials who had to make the trip up the Hill.

Aside from limitations written into authorizing legislation, the many recommendations included in the reports, although not binding, tested NASA's responsiveness to congressional advice. Thus the 1964 act and subsequent authorization acts urged NASA to distribute R&D funds on a geographical basis.[52] A 1966 staff paper listed occasions when NASA took action "consonant with" advice contained in reports of the Science and Astronautics Committee.[53] The committee doubted the need for a lunar roving vehicle experiment for Surveyor; NASA discontinued the development. The committee instructed that the thirteenth, fourteenth, and fifteenth Ranger spacecraft be dropped; NASA deleted the last six, which suggests that NASA would have discontinued the program even without prodding from the House. The committee further requested that NASA not proceed with the Electronics Research Center until the agency had submitted a detailed report justifying the center and the site selection procedure; NASA submitted the report on 1 February 1964 and did not proceed with the center until after the report was submitted. As a final example, the committee recommended reducing the Mariner program by $15 million to eliminate a 1965 Venus flyby; NASA canceled the mission.

However, NASA did not invariably conform to congressional recommendations. In its 1964 report, the Science and Astronautics Committee suggested that NASA seriously consider closing its Flight Research Center, since there seemed to be no reason for its continued existence beyond the X-15 program. NASA replied that the X-15 was an ongoing program and that research on high-speed aeronautical flight called for the center's continued operation. Moreover, NASA would not comply with committee recommendations where it believed itself better qualified to pass on the technical merits of programs; for this reason, the agency did not follow the suggestion of the Science and Astronautics Committee to favor solid-fuel over liquid-fuel propulsion research.[54] NASA took note of but did not strictly comply with the committee's expressed wish that R&D funds be distributed on a geographical basis. Although NASA officials pointed to the use of subcontracts for distributing R&D money, there is little to show that contracts were let in order to maintain the regional parity that both Houses encouraged.*

Thus NASA complied with Congress where it could safely do so, and it reserved the right to determine its needs in other matters. Until 1967 NASA could count on strong support in the House and the Senate. All four of the committees that reviewed the agency's budget were chaired by members from districts (or regions) where NASA had placed large contracts. Representative George Miller (D-Calif.) was chairman of the Science and Astronautics Committee from 1961 to 1972. Senator Clinton Anderson (D-New Mex.), of the Aeronautical and Space Sciences Committee from 1963 to 1973, was also a member and sometime chairman of the Joint Committee on Atomic Energy. Albert Thomas (D-Tex.), the powerful chairman of the House Independent Offices Appropriations Subcommittee, was succeeded in 1966 by Tennessee Democrat Joe Evins; his Senate counterpart was Warren Magnuson (D-Wash.). Yet it would be as foolish to overestimate the importance of regional influences as it would be to ignore them entirely. For one thing, there were supporters of the space program, like Senator Margaret Chase Smith (R-Maine), who represented regions with which NASA did very little business, even indirectly. For another, many field centers and a goodly portion of the aerospace industry were already in place when NASA was established; for reasons predating NASA, it would have been exceedingly difficult for the agency to place prime contracts, say, for Apollo, outside those regions where the capability already existed, which were mainly, although by no means exclusively, southern California, Texas, the Southeastern States, and the New York and Boston areas. But most important, the so-called "political" decisions, like the selection of Houston as the site of the Manned Spacecraft Center, were no more (or less) political than the programs that first led to the decision to transfer the Space Task Group to a new installation. Granted that the Vice President (who was also the Space Council chairman), the Speaker of the House, the chairman of the House Independent Offices Appropriations Subcommittee, and the chairman of the House Manned Space Flight Subcommittee were Texans. There were other good reasons for selecting Houston: it was well located in relation to Marshall and the Cape, and it had some of the best port facilities in the country.[55] As Murphy notes, "there were some powerful political figures in virtually every major metropolitan area where NASA might have put a facility. The series of location decisions led to an integrated system of facilities and in none of the cases involved did NASA select an unlikely or unsuitable site."[56] Moreover, the kind of political support gained by these decisions was emphatically a perishable good. As President, Johnson had other constituencies to satisfy than when he had been chairman of the Space Council. Nor did NASA's accumulated good will

* NASA had more funding flexibility in its university programs, since supportable work could usually be found in any large geographical region.

survive the Apollo fire, BOB cuts, and the establishment of other priorities in the mid-1960s.

To understand, then, how NASA worked with and through Congress, one must recognize other strategies that were more important than the major site and source selection decisions; the latter were essentially nonrecurring. One tactic was the exceptional thoroughness with which NASA prepared for its annual hearings. No more than other agencies could NASA afford to come before Congress ill prepared. But sometimes the very thoroughness of the presentations tended to obscure the points being made. During the 1968 authorization hearings, members of one Science and Astronautics Subcommittee "received a lengthy lecture on the effect of control lag on the dynamic stability of aircraft, saw slides depicting the failure data for alkaline batteries under simulated space use, and learned the effect of heat stabilization on battery separator materials."[57] Without technical staff support, it is unlikely that Congressmen could make much of such briefings; too often, it seemed as if NASA wanted to win committee votes by the sheer bulk of the information it supplied. NASA's congressional hearings could cut both ways. The committees were impressed by the thoroughness and tidiness of NASA's budget requests, a thoroughness intended to leave no doubt of the rightness of the agency's position. But that same thoroughness also irritated those Congressmen who had to pass on the NASA budget. As one frustrated subcommittee chairman—who was by no means unfriendly to NASA—told NASA Director of Space Sciences Newell:

> Another real problem . . . which makes it difficult for the committee to function properly is that we never get two sides of the argument. It is fairly easy for me to make up my mind as to who is right or wrong . . . on the question of medicare, or tax reduction . . . because I have someone else doing my research for me . . . there are those who are opposed and who will mention all of the reasons why this act should not be allowed, and there are those on the other side who give all the reasons why it should be allowed. . . . We don't have people appearing before this committee in opposition to the manned lunar landing program . . . or the Surveyor program, or whatever it is. . . . once I think the committee should lose confidence in the judgment or in the veracity of the statement that is being given . . . I think probably it would be extremely disastrous.[58]

It was crucial that NASA's top officials be selected for their ability to get along with Congress. Glennan and Webb were careful to observe several rules of the game: keep the committees fully informed, even beyond statutory requirements; never present Congress with accomplished facts, such as "foot-in-the-door" programs that might commit the legislature to huge and continuing appropriations; respond to the mood of Congress by taking timely administrative action; and live within the funds voted, that is, not request supplemental appropriations unless such requests were unavoidable.* All these rules might be summarized as follows: The head of the agency had to be able to sense what Congress would and

* Congress was more than normally unpredictable in passing on supplementals. NASA's request for a $141 million supplemental for FY 1964 was cut by half.

would not accept. As discussed, NASA tried to bring its advanced studies under some kind of control, lest Congress interpret them as studies of programs already approved by top management. This is why Seamans withdrew his approval of twenty-two studies in August 1967 and why NASA canceled an ill-timed study proposed by MSC for a manned Mars and Venus reconnaissance spacecraft. In other cases, NASA tried to anticipate the inclination of Congress. After being criticized for spending too little on aeronautical R&D, NASA established the position of Deputy Associate Administrator for Aeronautics (OART) in May 1967. To forestall a congressional investigation of the Centaur program, NASA transferred the program from Marshall to Lewis in October 1962. When the House subcommittees pressured NASA to spend more on unmanned space science, NASA created the Lunar and Planetary Missions Board, ostensibly to involve outside scientists in tactical as well as strategic decision making. And in one case, the 1964 investigation of the Ranger 6 failure, NASA seems to have tried it both ways: It used the hearings both as a forum for justifying its relations with JPL and as an implied threat to JPL to improve its managerial and technical performance.

All these examples were, so to speak, actions at a distance. Although it was a response to an internal need, the decision to transfer Centaur was reinforced by the mood of the Congress. Needless to say, top NASA officials had to know their way around the Hill and how to deal directly with Congress. The Administrator not only had to speak on behalf of the agency but also had to anticipate budget cuts and to use personal influence either to avoid them or to restore whatever had been eliminated. One example that may stand for many occurred when the NASA appropriations bill reached the floor of the Senate in August 1966. Senator William Proxmire (D-Wis.) introduced two bills to cut the 1967 authorization by $500 million and $156 million. Webb and his allies acted promptly. Senator Anderson "bolted his back and said, '$5 billion is the psychological level and I am going to do everything in my power to keep you from dropping below $5 billion.'" Webb

> had to round up Senators out of the boondocks . . . and get a live pair not to lose the Proxmire amendment. . . . I have to tell [Stuart] Symington, who is the senior Democrat on the [Aeronautical and Space Sciences] Committee that I was going to interpret his vote as a personal vote of confidence or a vote of no confidence in me personally because he was prepared to support (?) us on the $500 million cut and to vote with Dick Russell . . . to cut us $160 million on the second Proxmire amendment.
>
> . . . You have got to estimate this situation as accurately as we estimate the other elements of success in our business and I don't think that I am giving you anything except cold reality.[59]

Both motions were defeated.*

* On another occasion, when the chairman of the House Appropriations Committee tried to reduce the NASA budget by close to $1 billion, NASA officials managed to kill the move by going to all the subcommittee chairmen and impressing them with the fact that if this could happen to NASA, then it could happen in their own areas. In this way, the various members of the main Appropriations Committee were able, in a sense, to "take it away from the chairman."

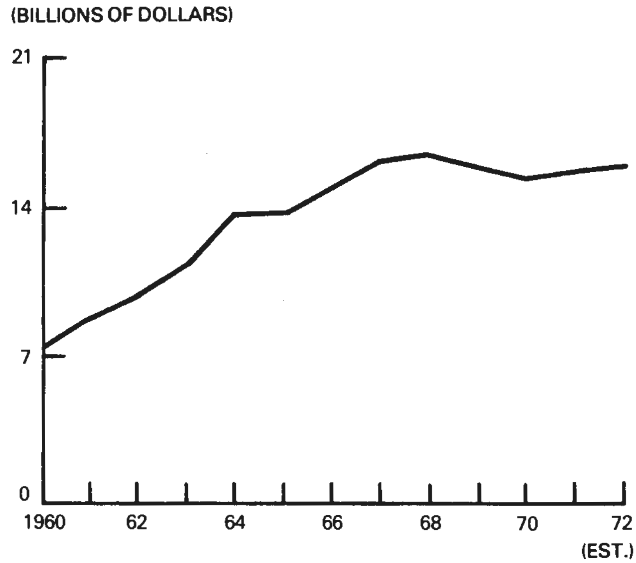
NASA could woo Congress with briefings at the centers and special presentations for the benefits of the committees. But the ability of NASA's top officials to twist arms or successfully threaten the collapse of the space program in the absence of funding was no small asset either.

What has been said so far applies mainly to events preceding the Apollo fire. Had there been no fire, the NASA budget would probably have tapered off as the Apollo mission was completed, construction was ended, and the costs of standardized launch vehicles became more predictable. To exaggerate, the fire was the great divide; for the first time since 1961 Congress began to question NASA budget requests, to eliminate (and not merely reduce) line items, and, in general, to make the NASA budget very austere indeed. To this point, the discussion has concerned the procedural aspect—the "how" of the budgetary process. It is now time to consider the substantive changes within the NASA budget: how total outlays grew and then declined rapidly, how NASA fitted into certain more general patterns of Federal R&D spending, and how other Federal programs impinged on NASA's programs.

FEDERAL R&D SPENDING IN THE 1960S

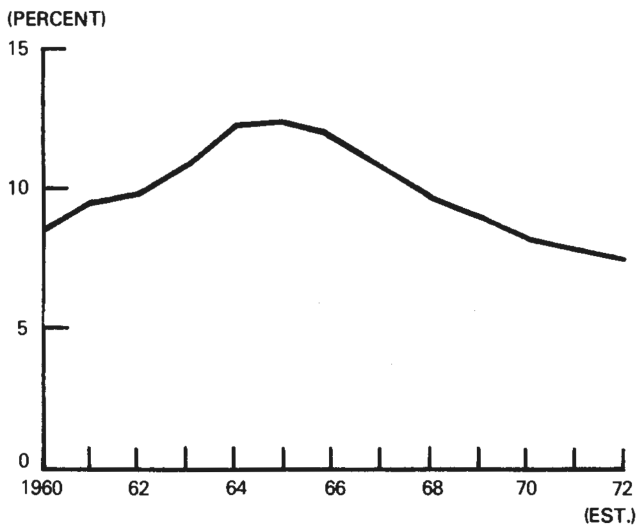
Broadly speaking, there are three ways to look at the NASA budget. One can regard it as a percentage of the Federal budget, especially of the portion for R&D; one can chart the growth rate of specific program categories; or one can take the entire NASA budget and consider the most important changes from the Kennedy administration until 1970. A useful analysis may begin by considering total R&D spending during the period under consideration. As a proportion of the gross national product (GNP), total R&D funding rose to 3.0 percent in 1964 and declined to 2.6 percent in 1970.[60] The ratio of R&D expenditures to total Federal budget outlays declined from 12.4 percent in 1965 to an estimated 7.4 percent in 1972.[61] Although these figures are useful indicators of gross trends in Federal spending, one must look at specific programs to see what the trends really amounted to (figures 7–1 and 7–2).

First, from 1960 to 1966 the steepest growth rates were influenced by the expansion of the space program; the decline of the program led to a corresponding drop in Federal R&D spending. The history of NASA funding, its dramatic rise and fall, was unique among R&D categories, most of which either remained stable or showed steady growth. What one sees in the late 1960s is a rise in absolute dollars for R&D, a drop in R&D spending as a percentage of total Federal outlays, and significant increases in R&D for programs or agencies that had previously spent little in this area. Some of the largest percentage increases in R&D spending after 1966 occurred in community development and housing programs; education and manpower programs, mostly sponsored by the U.S. Office of Education and the National Science Foundation; transportation, including joint NASA-DOT programs such as the supersonic transport and the quiet-



Source: National Science Foundation, *An Analysis of Federal R&D Spending by Budget Function* (NSF 71-25), p. 1.

Figure 7–1. — Federal R&D expenditures, FY 1960–1972.



Source: National Science Foundation, *An Analysis of Federal R&D Spending by Budget Function* (NSF 71-25), p. 1.

Figure 7–2. — Ratio of R & D expenditures to total outlays, FY 1960–1972.

engine program; and environmental and national resources programs that, while constituting only a modest percentage of Federal R&D spending, showed the largest relative growth from about 1971. In a sense, the increases for these programs can be considered independently of the fate of the NASA budget. Agencies such as the Department of Housing and Urban Development or the Office of Education are not R&D agencies in the sense that NASA and the National Institutes of Health are. Rather, there was a shift in spending from R&D to social welfare programs, whether or not they had R&D components. In this context, it is worth noting that although health outlays between 1966 and 1970 rose at a much higher average annual rate than any other function, almost all of the increase was attributable to funding the Medicare and Medicaid programs, beginning in 1966.[62]

The issue is not that funding for space declined in order to provide for social services. Features that were built into the space program, like the completion of facilities projects or the standardization of launch vehicles, would have reduced NASA spending even without competing programs. This is not to deny that Johnson and Nixon intended to cut the space budget in order to save their social welfare programs. But did the former decline because the latter increased? To prove that it did, one would need to know the extent to which funding for social programs simply marked a redistribution of existing dollars. If a causal relation existed, the space budget could be expected to resume its growth as the growth rate of domestic spending began to level off. However, independently of any shifts in domestic spending, the NASA budget declined for nine consecutive fiscal years, beginning in 1967.

The decline of NASA spending as a percentage of Federal spending was the result of many concurrent trends. On one hand, NASA continued to claim a large percentage of R&D funds; in 1972 defense, space, and atomic energy accounted for 86 percent of federal R&D spending.[63] But R&D itself declined steadily as a percentage of the budget. To a degree this was because BOB/OMB and Congress began to question not only the kinds of research being funded but the rationale for doing such research at all. Hence the rider to the 1970 military authorization bill (the so-called "Mansfield Amendment"), which forbade the use of appropriations for research projects or studies "unless such project or study has a direct or apparent relationship to a specific military function or operations."[64] Although Congress viewed NASA and DOD requests much more sceptically than it had five years before, there is little evidence that either Congress or BOB/OMB had any comprehensive scheme to redistribute R&D funds to domestic programs. The budgetary process did not work that way, nor were social investment and services all of one sort. Rather, the social programs—instituted by Johnson, continued by Nixon—have claimed a larger percentage of the budget since 1965. The principal increases were in retirement, disability and unemployment compensation, the creation of new low-income assistance programs for the poor, and the expansion (1965–1970) of social service programs in education, health, and manpower training. Together, the last three categories accounted for nearly 11 percent of

GNP (nonrecession) in 1970.[65] Income security alone rose from 21 percent of the budget in 1960 to an estimated 29 percent in 1972.[66] By comparison, NASA's share of the budget, which peaked at 4.7 percent in 1966, declined to 1.5 percent in 1972.[67]

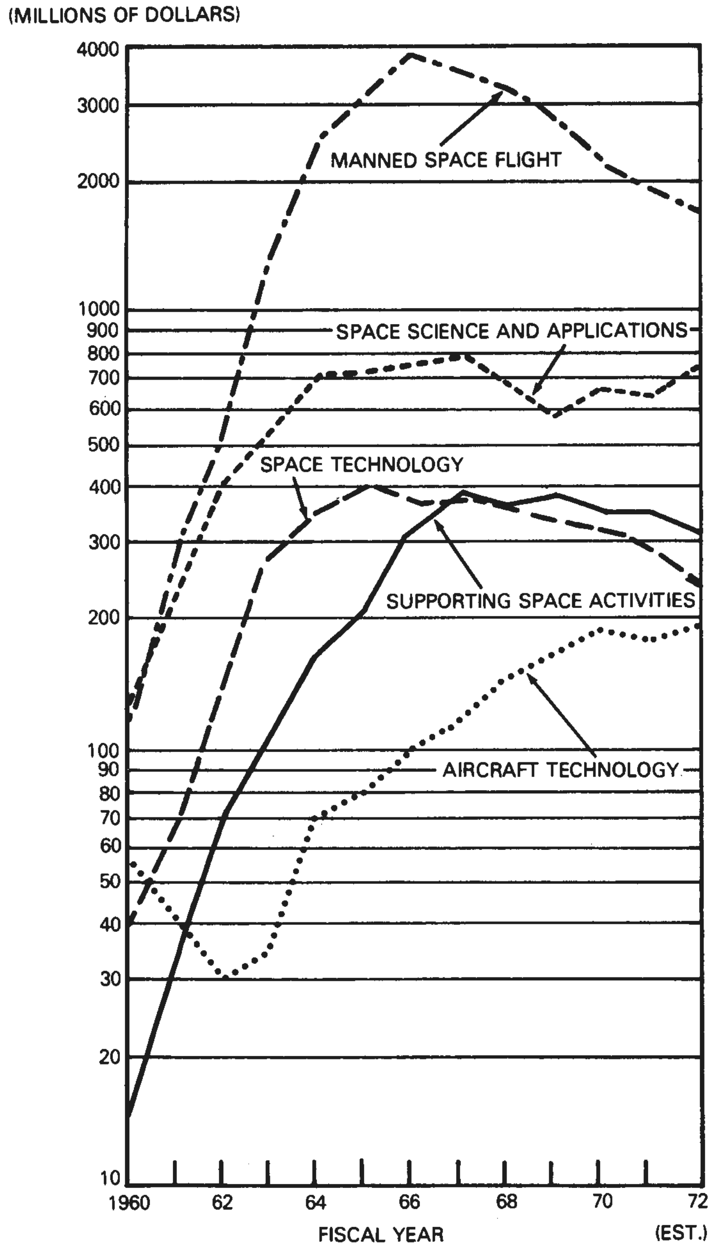
Trends in NASA Program Categories

The agency's program categories reflected the rise and fall that characterized the budget as a whole. The term "programs" is used here rather than appropriation accounts because of disadvantages in using the latter as yardsticks, including the use of R&D money for facilities projects, which distorts the real expenditures for R&D programs; the continual reprogrammings within accounts; the difficulty of discriminating between new obligational authority and actual outlays during the fiscal year; and the use of funds for both NASA and contractor employees. A categorical breakdown gives some idea of where the money went. The National Science Foundation (NSF) has classified all NASA activities as "space research and technology."* According to the NSF categories, NASA was the only Federal agency to conduct activities that involved either R&D or construction of R&D facilities. Moreover, the latter category declined steadily as major construction projects were completed; by the late 1960s the bulk of NASA facilities spending was for capital equipment rather than R&D plant construction. By 1970 such outlays represented less than 2 percent of total expenditures, and they were at no time more than 14 percent.[68] Trends in R&D expenditures are shown in figure 7-3.

The principal trends in NASA outlays are readily apparent: the high proportion of funds spent on manned spaceflight and the sharp and steady decline in such funding after 1966; the parallel funding patterns for space science and applications, with a renewed spurt in 1968-1969 as Viking, Pioneers F and G, and Mariner 1971 got under way; the leveling-off for supporting space technology, principally in tracking ships and aircraft for Apollo; and the steady growth in aircraft technology since 1963, especially in the form of nonreimbursable support for programs sponsored by FAA and DOD. Except for the last category, 1966 was the turning point, as measured by almost any standard. The decline of manned spaceflight (after completion of Gemini and with approaching completion of the heaviest investment in Saturn and Apollo), which in 1966 accounted for 71 percent of NASA outlays, was mainly responsible for the cutback in the average annual growth rate for R&D spending after 1966.

A related question concerns the effect of the funding levels on different agency functions. By definition, supporting space technology would tend to rise and fall with the programs it supported. But the relation between the funding

* DOD space programs were placed in a separate "military astronautics" category. The sharp drop in spending for military space R&D in 1969 was due mainly to the cancelation of the Air Force Manned Orbiting Laboratory.



Source: National Science Foundation, *An Analysis of Federal R&D Funding by Budget Function* (NSF 71-25), p. 71.

Figure 7–3. — Space research and technology expenditures by function.

levels of the three substantive program offices—OART, OSSA, and OMSF—is surprisingly difficult to ascertain. One almost has to fall back on impressions, hints, and occasional remarks in memorandums, since there are no detailed studies of, for example, the effect that Apollo had on the other offices' programs. Programs like Ranger and Surveyor were approved prior to Apollo, but their original purpose was subsumed in the greater glory of the lunar landing. Beyond such program changes, only a few tentative conclusions are possible, pending further research in this field.[69] First, the introduction of Apollo appears to have had "only a very secondary beneficial impact" on OSSA funding growth from 1961 on; while the continued level of Apollo funding in fiscal years 1967 and 1968 seems to have contributed to a major slowdown in OSSA activities, beginning in FY 1967. Second, Apollo stimulated to some degree the growth in OART spending after 1961, principally in supporting research and technology; but even this influence is uncertain, because OART at the time was moving beyond NACA practice by not only doing applied research but by building hardware to "prove" the research concept. Also, the funding of all four program offices grew steadily until 1966. It seems likely that many research programs, particularly at the older centers, were approved because they were considered as direct or indirect support for Gemini and Apollo, but to demonstrate a causal relation, without a case-by-case evaluation of programs, is impossible. There seems to have been a more direct relation dating from 1967, when basic research and unmanned programs were cut to support Apollo.

Phasing Down the Space Program, 1965–1970

The discussion in this chapter has tended toward one question: By what criteria did BOB and Congress decide whether and how much the NASA budget rose or fell? Obviously, NASA was not a closed system; one cannot entirely discount the budgetary impact of the Vietnam War and Johnson's policy of combining a tax cut with continued social service spending. Clearly, there was no grand scheme to shape the agency from outside. As far as it is possible to isolate internal from external causes, one of the major reasons for the decline in the NASA budget was the agency's failure to plan effectively for the long term. There were three kinds of programs for BOB and Congress to consider in the period of concern: approved programs that were nearing completion (such as Apollo); approved programs for which continued major funding was sought (Voyager); and new programs like Apollo Applications that NASA wished to initiate, with the implication that Congress would continue to fund them after the first year. But these categories were never watertight; much of NASA's work, especially in advanced research, would strongly influence future programs. Thus the future of NERVA hung on the decision to continue production of the Saturn V, of which NERVA was to be the upper stage. And the production of Saturn V depended in turn on the uses to which the vehicle might be put after the first lunar landing.

The same considerations applied to the large-solid-motor program that NASA took over from the Air Force in 1963, almost had to terminate in 1965, but continued until 1967 with funds restored by Congress. The program led to remarkable advances in propulsion technology; on its final test firing, the SL-3 motor generated 25 million newtons of thrust, far more than any other rocket motor developed to that time.[70] But no program in 1967 required technology of this order.* Or consider the M-1 liquid-hydrogen engine, initiated when NASA planners were thinking in terms of a direct ascent mode for the lunar landing. Once Saturn V replaced Nova as the Apollo launch vehicle, no such engine was needed. Yet it was kept alive for more than another two years.

Three features of agency policy contributed to, perhaps caused, cutbacks in NASA programs. The first was the inability of the agency's top officials to submit or prepare an official long-range plan for post-Apollo missions. There was no lack of planning within NASA, considering the prospectuses by the program offices, center proposals, and advanced studies. But Webb was extremely reluctant to commit NASA to anything specific beyond Apollo, partly because there were serious disagreements even in OMSF over the future of manned spaceflight, partly because any formal plan would, in Webb's view, commit the agency to programs that it would not be able to renounce. Significantly, the one attempt between 1963 and 1968 to specify programs after Apollo was not even called a plan. The Future Programs Task Group, established in January 1964 after President Johnson requested of NASA a statement of objectives beyond those already approved, submitted a report in April 1965.[71] But it merely enumerated, without choosing between, the kinds of options available once certain assumptions were granted. The Senate Committee on Aeronautical and Space Sciences criticized the report for just this reason: It did not explain how or when a selection between priorities would be made, indicate the funds needed for various alternatives, or mention military considerations and the role of DOD. In a sense, these criticisms were beside the point. As chapter 9 details, Webb was interested primarily in developing a capability to operate in space, while at least some Congressmen were more interested in the uses to which that capability would be put. Thus NASA and, to a degree, Congress, were at cross-purposes. Not Webb nor Mueller nor the Planning Coordination Steering Group could develop a convincing program, one that distinguished between the respective roles of manned and unmanned programs or the relative merits of orbiting space stations and applications satellites. To confuse the issue further, NASA officials tended to veer from one kind of justification to another. The Apollo mission was defended for reasons of prestige, for the benefit of beating the Russians in a race they were not always aware of being in, or for the long-term benefits it promised all mankind. But NASA did not hew to any line consistently or with conviction.[72]

* Once the development team was dispersed, it would have cost more to start up the program than to carry it to completion. One wonders how much NASA spent in the late 1960s on closeout costs for programs that were terminated.

Second, the Apollo fire destroyed some of the trust that had developed between NASA and Congress since 1961. What angered some Congressmen almost as much as the fire itself were the circumstances in which NASA had awarded North American Aviation the command service module contract, as well as NASA's refusal to make public the Phillips report. Support in Congress declined, to be regained gradually over the succeeding eighteen months. Those who had opposed the space program before the fire became more open in their opposition, while others tended to back away from earlier positions of support.

Finally, NASA tended to conduct long-range planning in almost purely substantive terms. As discussed in chapter 5, one of NASA's primary problems was what to do with its skilled manpower once the programs for which they were recruited phased down. If scientists and engineers were to remain at one center, it was imperative to establish the center's role beyond its original mission. As mentioned, as early as 1963 the House Science and Astronautics Committee had suggested closing the Flight Research Center. During the next seven years NASA was forced to close the Electronics Research Center, place the Mississippi Test Facility on a standby basis, and order sharp reductions in force that threatened the ability of other centers to keep their most talented people.

In conclusion, the budgetary process worked in NASA's favor when it had an overriding mission to accomplish, few direct competitors, and no opposing vested interest. In one sense, NASA's problem after 1965 was to develop an integrated plan that would involve all its capabilities; in another sense, it was to attract new clients with an interest in furthering the space program. For lack of both, Voyager was canceled and Saturn V was discontinued after the fifteenth vehicle.[73] Several missions, including the Skylab space station (Apollo Applications renamed) and the unmanned Viking mission to Mars, were delayed, the former by four years, the latter by almost three. Furthermore, the agency's Sustaining University Program was canceled; and the nuclear rocket program, though kept alive as NERVA I, lacked a specific mission. The fragmented, incremental nature of budgeting worked in NASA's favor during the early 1960s because what was lost at one stage could be regained further down the line. However, this feature of the budgetary process did not prevent continually declining budget requests and continually declining appropriations after 1966;[74] it merely guaranteed that the NASA budget would not be reviewed as a whole. Perhaps the civilian budget was never amenable to such examination. Few of its larger programs were susceptible to the kind of cost-benefit analysis that was at the heart of PPBS. As shown, the very special conditions that made PPBS work at the Pentagon did not hold for most civilian agencies and particularly not for NASA.

Chapter 8

The Structure of NASA-DOD Relations

The Scope of Interagency Relations

Most of the preceding chapters touched on ways in which the Defense Department assisted NASA. Units such as the Defense Supply Agency, which administered many NASA contracts, the Army Corps of Engineers, which managed NASA's largest construction projects, and the Air Force, which detailed officers to serve as program managers and directors of center operating divisions, provided essential services in support of the agency. This was in addition to the early, once-only transfers of the Saturn project and other launch vehicles, spacecraft like Tiros, contractor-operated facilities like the Jet Propulsion Laboratory, and the technical skills of the von Braun team. Simply to list examples, however, gives only the barest hint of the significance for NASA of the totality of the support; the Department of Defense (DOD) was the one Federal agency with which NASA had to come to terms in order to carry out its mission at all. The essence of their relationship had far more to do with mutual need than with philosophical arguments concerning the existence or the desirability of one space program or two. The Space Act only outlined the scope of interagency relations in the most general way. The act declared that, while aeronautical and space programs would be managed by a civilian agency, "activities peculiar to or primarily associated with the development of weapons systems . . . or the defense of the United States" would remain DOD's responsibility; and it enjoined NASA to make available "to agencies directly concerned with national defense . . . discoveries that have military value or significance."[1] It is as well, then, to set aside preconceptions. "Civilian" and "military" are not the same as "peaceful" and "nonpeaceful"; duplication of programs could be "warranted" or "unwarranted"; and much of the struggle over the military uses of space was as much between elements within DOD as between DOD and NASA. In short, the principles underlying the U.S. space program resulted from the many subordinate agreements subsisting between the two agencies. One has to begin from the particular to arrive at the general because, in this sphere, "no clear-cut divisions of responsibility exist or are possible, and it is difficult to describe the situation in general terms."[2]

What were the elements comprising the NASA-DOD relationship? In at least four ways their interests impinged on each other: common technologies; NASA's continuation of NACA's support of military aeronautics; NASA's overwhelming dependence in its early years on the launch vehicles and ground support provided by the Air Force and on the Saturn rocket and von Braun team transferred from the Army; and the persistent attempts by the Air Force to investigate the military applications of space, especially of manned Earth-orbital operations. As to common technology, there is no discontinuity between civilian and military R&D, no line that one can arbitrarily draw with rocket guidance and data processing on one side, avionics and solid-state physics on the other. A launch vehicle is only a modified ballistic missile; and it cannot be overstated that for everything between sounding rockets and the Saturn I,* NASA relied on vehicles successfully developed by the Air Force between 1954 and 1959—notably the Atlas, Thor, and Titan ballistic missiles in their original or modified versions. This shared technology also signified that NASA and DOD would have to coordinate programs to avoid "unwarranted" duplication of launch vehicles and facilities. Officials of both agencies would want to exchange information in areas of mutual interest, such as space medicine or bioastronautics, in which NASA and DOD were simultaneously performing thousands of research tasks. Indeed, few areas of NASA's R&D were without potential military application. The Surveyor program—than which nothing could seem more unmilitary—is a case in point. Its retromotor, designed to reduce the spacecraft's approach velocity, was used as the second stage of the Air Force's Burner II launch vehicle; the automatic landing system could be applied to vertical or short take-off and landing (V/STOL) aircraft; while the lightweight, remotely controlled TV camera could be used in military communications.[3] Hence the crossovers between military and civilian programs: flying DOD experiments aboard Gemini; transferring NASA's Syncom communications satellite to DOD in 1965; and the use, by Defense agencies, of geodetic and meteorological information supplied by NASA.

The transformation of NACA into NASA did not affect its role in supporting research for the military, except to blur the distinction between support and coordination. It is useful to recall the importance of NACA applied research and the ways by which research concepts were translated into military hardware. The concept of the sweptback wing described in a 1945 report was applied to the B-47 and B-52 bombers and the century series of fighter aircraft. The concept of low-aspect-ratio wings to reduce atmospheric drag at supersonic speeds made possible the F-104 and the X-15 rocket plane. Perhaps the best-known example of the military uses of NACA research was the 1953 paper of Allen and Eggers

*The first stage of the Saturn rocket was developed by the von Braun team at the Army Redstone Arsenal at Huntsville, Alabama.

that demonstrated the superiority of a blunt nose cone in coping with the extremely high temperatures generated by the atmospheric reentry of a ballistic missile. Similar research continued after NASA's establishment and extended to every area of advanced research and technology, but with this difference: NASA collaborated with the services in refining the concept into the development phase. The X-15, for example, was a joint NACA (NASA)-Air Force-Navy project. Moreover, the same agencies collaborated on solid-fuel propulsion programs, despite the absence of near-term missions in NASA's case. All this was in addition to testing Air Force flight models in the unique facilities available at the Ames and Langley centers; for example, the Langley 18.3-meter vacuum sphere was one of the very few available for "dirty" tests, involving the discharge of contaminating substances such as exhaust gases.

Between 1958 and 1966 almost all NASA launches, other than for sounding rockets, took place at the Air Force Eastern Test Range at Cape Canaveral, Florida, and at the Western Test Range at Vandenburg Air Force Base, near Point Arguello, California.* Even after NASA acquired land just north of the Eastern Test Range in 1961–1962, all NASA launches (except the sounding-rocket and Scout satellite launches at Wallops Island) continued on ranges operated by and under conditions stipulated by the Air Force. The nature of NASA programs, however, soon led to disagreements over how NASA would pay DOD for range and tracking support. Moreover, the "single manager" concept of range support ran afoul of the determination of NASA officials to decide their own requirements. It might, for instance, seem like gross and unwarranted duplication when NASA built tracking stations "colocated" near DOD-operated facilities on Antigua and Ascension Island. NASA officials disagreed. The colocation issue could only be decided on the merits of each case, not by assertions of abstract principle. For all the draft and signed agreements prepared by both agencies, the problems of funding and range support were not amenable to any simple or permanent solution, whether a solution involved defining an agency's "unique requirements" or identifying the free services that each agency provided (or should provide) the other.

For brevity's sake, NASA-DOD relations may be categorized under the headings of support, coordination, and rivalry. The body of this chapter involves a closer look at these categories: how they evolved, the formal mechanisms of interagency relations, and certain problems stemming from the dual management of the U.S. space program. Analyzing specific problem areas should bring us closer to answering the following questions:

1. How did the two agencies understand such terms as "coordination" and "single management"? How well did each adjust abstract principles to institutional realities?

* Originally called the Atlantic and Pacific Missile Ranges, they were redesignated the Eastern and Western Test Ranges in May 1964.

2. By what rationale did NASA and DOD pursue similar, overlapping programs, and how did they control wasteful duplication?
3. In what sense, if any, was there a national launch vehicle or range support program in the 1960s?
4. In sum, how well did organizational relations serve both agencies' purposes?

The Beginnings of a Division of Labor: Advent and Syncom

The Space Act left the scope of the relations between NASA and the military unchartered. The general principles that evolved were a precipitate of many agreements, programs, and working-level relations. Certain preconditions for working together had to be met. There had to be agreement on which programs properly belonged in either agency, on how NASA would acquire the launch vehicles it needed, and on which officials were authorized to speak on behalf of their agency in relation to the other. Within DOD, there had to be an administrative reshuffling to decide the role of the services in the conduct of military space programs; were they to be concentrated in one, parceled out among all, or located in the Office of the Secretary of Defense?

But although the services might agree on little else, they were as one in opposing the pretensions of the Advanced Research Projects Agency (ARPA) to become the military space agency, since its authority would have been at their expense.[4] Less than two years after its establishment, ARPA had become a job shop for research tasks that none of the services happened to be doing. The 1958 reorganization led to the creation of the Directorate of Defense Research and Engineering, whose charter gave its head the authority to "approve, modify, or disapprove programs and projects of the military departments and other DOD agencies."[5] Not until the end of 1959 was the Director's authority over ARPA made explicit, and it was the effect, more than the cause, of the process by which ARPA was divested of its most important programs: the Tiros weather satellite went to NASA; the Transit navigation satellite, to the Navy; the early-warning Midas satellite and the Samos reconnaissance satellite, to the Air Force; and Notus, the interim communications satellite system that became Advent, to the Army. ARPA would be a job shop, responsible only for developing advanced systems and turning them over to one of the services at the point at which each system became operational.

The Army's ill-fated Advent program is worth a closer look because of its relation to NASA's Syncom communications satellite.[6] The independent origin of both programs and their ultimate convergence may serve as a case study of features common to civilian and military programs: shared technologies; the risks inherent in advanced R&D, particularly where the launch vehicle, spacecraft, and ground support were proceeding concurrently; the distinction drawn by NASA between developmental and operational phases of R&D; and the problems in setting jurisdictions proper to each agency. Defense Secretary McElroy had created ARPA in February 1958 with the partial objective of initiating and developing space programs for which there was no clear service jurisdiction. One of these, the communications satellite program, was transferred from ARPA to the Army in September 1959, renamed Advent in February 1960, and effectively terminated in May 1962. From its inception Advent was designed as a synchronous communications satellite—a satellite that orbited at the Earth's speed of rotation at an altitude of 35 900 kilometers and appeared as a fixed point in the sky. Three such satellites can provide worldwide coverage, need fewer ground stations than a medium-altitude satellite, and do not present complicated tracking problems. However, the theoretical advantages of synchronous coverage can be nullified by technical difficulties. A synchronous satellite needs a more powerful launch vehicle than one in medium orbit; it needs more electronic parts and, as a matter of course, a backup satellite in orbit in case of failure; and a spacecraft in synchronous orbit can be jammed more easily than a number of medium-altitude satellites, since, being stationary, it can be pinpointed more readily.

The origins and purpose of Advent were such that they seemed to involve no duplication between DOD and NASA. Defense had a pressing requirement for an operational communications satellite; NASA, as an R&D agency, did not. Under a November 1958 agreement, ARPA was placed in charge of active communications satellites, i.e., spacecraft that receive, amplify, and send radio signals, while NASA would work on passive satellites—balloons, for example—which merely reflect signals sent from ground stations. But this arrangement was not binding. "NASA was not foreclosed from research and development in the active satellite field; in fact the agreement recognized that at an appropriate time, and making full use of the knowledge derived from the military experience, NASA would do some development work on components and prototypes for a nonmilitary communications satellite system."[7] This is precisely what happened. As the Army proceeded with Advent, NASA contracted with Hughes Aircraft in 1961 for a lightweight synchronous satellite. Writing to Webb in June 1961, Deputy Secretary of Defense Roswell Gilpatric indicated that he considered NASA's Syncom as "complementary to, not duplicative of, the military Advent."[8] By agreement that August, NASA undertook to develop the satellite, with DOD furnishing the ground support. Advent was running into serious difficulties. Not only had the program overrun its original cost estimates, but the Centaur upper stage of the launch vehicle that would place Advent in orbit (which was being developed by NASA) had been delayed for more than three years, and no earlier launch would be possible until the Titan III then being developed became available. Additionally, the triode tube, on which Advent was based, was already obsolete. Under the circumstances the program had to be dropped in favor of a medium-altitude communications satellite. But although such a program was approved, it ran into delays while DOD officials negotiated fruitlessly with the Communications Satellite Corporation (ComSat) to provide services. Almost by default NASA, by 1963, had become the only Federal agency working on a program for a synchronous communications satellite.

The rest of the story may be summed up briefly. NASA launched and placed in orbit three Syncoms in 1963–1964, the first of which never responded to ground signals, while the second (launched 26 July 1963) and third (19 August 1964) operated successfully. At the end of 1964 the orbiting satellites were transferred from NASA to DOD as forerunners of an Initial Defense Communications Satellite System. In June 1966 a single Titan III inserted seven communications satellites into random, near-synchronous, equatorial orbit, creating the nucleus of a worldwide military communications system.

The history of Advent and Syncom illustrates a great deal of the direction in which NASA-DOD relations were tending in the early 1960s. Note particularly Syncom's status as a coordinated rather than a joint project. NASA designed the spacecraft but had no Syncom stations of its own; the ground support, funded and purchased by DOD, was salvaged from Advent. Syncom was a program whose success depended "on the functioning of separate, co-operating systems."[9] It was experimental, and it was not designed to handle bulk traffic. Once the research concept had been proved, NASA was willing to turn over the program to the potential user, the more so as NASA had begun to negotiate contracts for "advanced technological satellites" designed to carry several packages of experiments in communications technology. In both communications and meteorology, NASA had to face the question of where development left off and operations began. In meteorology, NASA ceded the Tiros satellite to the Weather Bureau to meet its and DOD's need for an operational weather satellite, while continuing work on the more advanced Nimbus. In communications, Congress created ComSat in 1962 as a profit-making entity for operating the U.S. portion of a future global communications satellite network. There was no need or justification for NASA to develop and operate a system that would duplicate ComSat's Early Bird program for an "experimental-operational" synchronous satellite.[10] The transfer of Syncom to DOD thus served two purposes: It gave DOD access to a technology that it needed, and it removed the suspicion that NASA was developing an operational communications satellite system.

But the most important lesson of the Advent and Syncom programs was that the cancelation of one and the transfer of the other would have been much less likely without the agency reorganizations discussed in the following section. The U.S. space program in 1958–1959 was a welter of projects parceled out among NASA, ARPA, and the services. During the next three years, the Director of Defense Research and Engineering became the official charged with the conduct of Defense R&D; ARPA was downgraded to the role of job shop for the Office of the Secretary of Defense; with minor exceptions, the Air Force was charged with conducting the military space program; while the Defense Communications Agency, previously created in 1960, became in May 1962 the "focal point for continuing integration of the space and ground elements of the communications satellite systems to meet Department of Defense requirements."[11] As Director of Defense Research and Engineering, Dr. Harold Brown could decide to cancel Advent because the 1958 act created the position that charged him to approve and review all major Defense R&D programs. The decision to cancel followed a series of reviews at the level of the Office of the Secretary rather than at the service level. The Project 39 review of March 1961 "to study and review major outstanding problems in the Defense Establishment," was followed by the Advent Program Survey that December, which was chaired by the head of the Office of Electronics in Brown's Directorate.[12] There had to be officials in both agencies who could, to paraphrase Matthew Arnold, see these programs steadily and see them whole. It is time to turn to the organizational changes that made such oversight possible.

NASA-DOD Relations, 1959–1963

The military space program moved through three overlapping phases from 1959 to 1961. First, the most promising ARPA projects were turned over to the services; the Air Force was made responsible for ballistic missile development in 1959, for military space development generally in 1961, and for military support of NASA in 1962; and the Office of the Secretary of Defense under Gates and McNamara began to demand that the services justify programs by matching costs and benefits. The directive of 6 March 1961 grew out of recommendations by two of President Kennedy's task forces that DOD activities in general and space programs in particular be centralized. It authorized each military department to conduct preliminary research, but it assigned to the Air Force responsibility for "research, development, test, and engineering of Department of Defense space development programs or projects which are approved hereafter."[13] Since the Air Force was already responsible for more than 90 percent of DOD space development, the real force and substance of McNamara's order consisted in bringing the three services under tighter central control by the Secretary, the Deputy Secretary, and the Director of Defense Research and Engineering. The Air Force could not select the projects that were to be developed. DOD officials were explicit about this point; the aim was to prevent interservice conflicts "by further restricting the independent freedom of action of the three military services . . . by limiting the latitude of the military departments to increase emphasis and funding for various projects."[14]

The McNamara directive tightened and clarified the ground rules for conducting military R&D in space, without explaining the requirements that would justify military space programs or their relation to NASA's programs. Meanwhile, the Air Force conducted a major reorganization of its own. Since 1954 Gen. Bernard A. Schriever had been in charge of the Air Force ballistic missile program as head, first of the Western Development Division of the Air Research and Development Command (ARDC), then of the Air Force Ballistic Missile Division that replaced it in 1957, and finally of the Air Force Systems Command (AFSC), established on 1 April 1961 by a merger of ARDC and the Air Materiel Command. The 1961 reorganization consolidated the Air Force space and ballistic missile programs, with AFSC assuming "direct responsibility for everything except the logistical support functions."[15] It created two new divisions—Ballistic Systems and Space Systems—which became completely autonomous in October 1962, reporting directly to AFSC Headquarters.* By a series of related changes, the nonprofit Aerospace Corporation was established in 1960 as a spinoff of TRW/Space Technology Laboratories, which wanted to bid on Air Force hardware contracts; the Aerospace Corporation, on the other hand, was responsible for advanced systems analysis and general technical supervision of Air Force missile and space systems. And last, though not least important, a 1962 directive assigned responsibility to the Air Force for support of NASA.[16]

Four concurrent developments within NASA strengthened the agency's hand in negotiating with DOD. First, NASA and DOD concluded a series of agreements between 1959 and 1963.[17] The agreement of November 1959 laid down the principles by which each agency would reimburse the other for services rendered; and to date it has remained the only general agreement, although it has often been modified.[18] The agreement of September 1960 formally established the Aeronautics and Astronautics Coordinating Board (AACB), although it had met for the first time three months earlier. The Board's importance, however, was less in what it accomplished for the time being than in its terms of reference. Where the moribund Civilian-Military Liaison Committee created by the Space Act had no authority to implement its decisions, the members of the AACB and its six panels† were authorized to take actions "utilizing the authority vested in them by their respective agencies."[19] The cochairmen were the NASA Deputy Administrator and the Director of Defense Research and Engineering.

These agreements were a sort of organic law for the space program. The Webb-Gilpatric agreement of 23 February 1961 stipulated that neither agency would initiate the development of a new launch vehicle without first seeking the consent of the other.[20] The agreement of 14 January 1963 provided that the Merritt Island Launch Area would be operated as a NASA installation, separate and distinct from the Eastern Test Range, although the Air Force would continue to provide common services for NASA and DOD users.[21] This superseded an earlier agreement under which Merritt Island would have been operated jointly, and it suggests how far NASA was prepared to go in asserting the right to determine its own needs. One week later, the Gemini agreement confirmed NASA's hard-won independence.[22] Here, too, Webb turned down McNamara's proposal of a joint program. The agreement of 21 January affirmed NASA's role as program manager, while stipulating that DOD would participate under arrangements to be made by an advisory Gemini Program Planning Board. Of these five agreements, the first two established the organizational ground rules, the third served as the basic document in coordinating military and civilian programs, while

*In July 1967 the two divisions were superseded by the Headquarters Space and Missile Systems Organization (SAMSO).

† Manned Space Flight, Unmanned Spacecraft, Launch Vehicles, Space Flight Ground Environment, Supporting Space Research and Technology, and Aeronautics. The Civilian-Military Liaison Committee was formally abolished by the President's Reorganization Plan No. 4, 27 July 1965.

the fourth and fifth confirmed that NASA was the dominant partner in the manned exploration of space.

These agreements were by no means the only examples of NASA's assertiveness. In March 1962, for example, NASA established independent field installations at the launch facilities of the Eastern and Western Test Ranges. Similarly, NASA sought to participate more closely in the development of vehicles like the Agena upper stage, which it needed for its own launches. By a September 1963 agreement between NASA and the Air Force Systems Command, NASA was assigned a role in launch vehicle planning and became a member of the Air Force Configuration Control Board for the Atlas, Thor, and Agena vehicles.

The second development to affect the conduct of the national space program was President Kennedy's decision to assign the lunar landing mission to NASA. After May 1961 the Air Force had no clearly defined manned mission in space. Its Man in Space Soonest project, when transferred to NASA, evolved into Project Mercury—a nonmilitary project that could not have succeeded without military support. The Air Force Systems Command's 1962 proposal for a "Blue Gemini" went nowhere for lack of support by Air Force Headquarters and by the Office of the Secretary of Defense. When Webb and McNamara signed the Gemini agreement, the only approved manned military program was Dyna-Soar, a winged orbital glider first conceived in 1957–1958 and formally initiated as a program in 1960, when Boeing was chosen to design the glider and the Martin Company to supply the Titan I booster.[23] Even before the Gemini agreement, Dyna-Soar had run into trouble; and it is not too much to say that the agreement hastened Dyna-Soar's demise, the more so because the former could do most of what the latter was intended to do, and more. Thus by early 1963 proponents of a manned military program were caught in a merry-go-round of requirements. To justify such a program, they had to explain what a manned mission could accomplish that an unmanned satellite could not; they had to show how a military project could be designed to avoid duplicating what Gemini was accomplishing in Earth-orbital operations; and they found it useful to assert that the Soviet Union had gone further than the U.S. in the military use of space. But Gemini, by including more than a dozen military experiments, inevitably raised the spectre of unwarranted duplication should the Air Force proceed with a manned program.

A third development in NASA-DOD relations was signaled by the establishment of a NASA Office of Defense Affairs in December 1962.* As with AACB, its establishment was more notable as an expression of policy than for any immediate accomplishment. The new office, headed by retired Adm. W. Fred Boone, was to promote interagency cooperation, serve as "the focal point for all major defense-related matters within NASA, [and] speak for NASA within the framework of established policy."[24] NASA and DOD were already linked in many ways: through AACB and its panels; through the Air Force Systems Command liaison office, located in the same downtown Washington office building as the

* When Seamans replaced Dryden as cochairman of AACB.

Office of Manned Space Flight; and through the military detailees stationed at the centers. Treading carefully, for there were many bureaucratic feet to step on, Boone showed discretion in adopting the operating principle that "we would not attempt to have all communications and interactions with the Defense Department channelled through our Office. . . . we would avoid permitting the Office . . . to become a bottleneck impeding the flow of information and the conduct of NASA-DOD business."[25]

Fourth, NASA moved to centralize its ground support network. By 1965 NASA had three networks: STADAN (Satellite Tracking and Data Acquisition Network), successor to the Minitrack Network developed for Vanguard and used for tracking unmanned, Earth-orbital spacecraft; the Deep Space Network managed by JPL, which tracked lunar and planetary probes; and the Manned Space Flight Network (MSFN), which consisted in 1965 of nineteen land-based sites plus instrumented ships and aircraft managed by DOD. These networks were complementary in certain respects. MSFN, for example, had to work with spacecraft up to lunar distances and, like the Deep Space Network, it had a number of 26-meter radio antennas for tracking. MSFN and STADAN were sufficiently similar that NASA consolidated them into a single Space Tracking and Data Network in mid-1971, although NASA management never took the final step of completely centralizing the range structure, which would have been undesirable for two reasons. The program offices and their center representatives would have been most unwilling to surrender control of mission operations and tracking, and a persuasive case could be made that "to divorce support completely from direct program control or access is to endanger the responsiveness of that support base to the programs it should serve . . . separately managed support resources by a centralized office may sometimes be more costly than program control since some equipment should be used only during the lifetime of a particular program."[26]

What headquarters could do, it did. The creation of a unified Launch Operations Center at the Cape in May 1963 removed Marshall management from the scene. The new center, renamed the Kennedy Space Center (KSC) that December, took over Houston's Florida Operations in 1964, and in October 1965 assumed control of all unmanned launches, except for sounding rockets, on either coast. In like manner, the Office of Tracking and Data Acquisition (OTDA) assumed management of JPL's Space Flight Operations Facility, once its prospective use by Pioneer and Lunar Orbiter made central control necessary. As recognition of its coequal status, OTDA was designated a program office in December 1965.

Although these moves provided tighter control over launch support and tracking and data acquisition, headquarters continued to manage the two separately. The furthest that NASA was prepared to go in coordinating them was to create the position of Mission Operations Director with overall responsibility for manned spaceflight programs and to establish an Operations Support Requirements Office (OSRO) staffed by representatives of the program offices, OTDA, and the centers participating in manned spaceflight. Reporting to the Mission

Operations Director, OSRO was charged with considering operations support as a whole, particularly in cases where more than one program and more than one center were involved.[27] Equally important, the office was intended to be a single point of contact with the Air Force National Range Division for all manned flight support requirements.[28] Whether complete centralization might have accomplished more is debatable. What is evident is the rationalization of NASA's ground support activities and the creation of well-defined patterns of cooperation and support between NASA and DOD. The following section considers these patterns.

Reimbursement Arrangements

While reserving to NASA control of Merritt Island, the Webb-McNamara agreement of January 1963 left open the question of how NASA would pay for those services that the Air Force continued to provide. In 1963 much of what would become the Kennedy Space Center was still a swamp, more a wildlife sanctuary than a launch facility. When the first Saturn IB flew, in February 1966, it was from the Eastern Test Range, as were all subsequent Saturn IB launches for the main Apollo program.* Only those launches requiring the Saturn V were from KSC's launch complex 39, which was developed by NASA specifically to accommodate them. So heavily did NASA rely on Air Force facilities that the Air Force transferred several launch complexes—launch complexes 34 and 37 for Saturn, launch complex 12 for the Atlas-Agena, launch complex 16 for the Titan II, launch complex 36 for the Centaur—to NASA, since they were already used almost exclusively for NASA launches. Indeed, DOD supported NASA to such an extent that launches of the Navy's Polaris missile at the Eastern Test Range had to wait for those of NASA.[29]

The relationship between NASA and the Air Force gave rise to certain issues, in themselves highly technical, yet important judged by the time spent by officials of both agencies in trying to resolve them. With the 1963 agreement, NASA became responsible for master planning and developing facilities at Merritt Island, as well as for the preparation, checkout, and launch of its own flight missions. This agreement left open the funding of services that DOD continued to supply, such as the use of launch pads, downrange tracking and data acquisition, and relay, instrumentation, search and recovery ships and aircraft in the Atlantic and Pacific Oceans. The differences over funding were more than merely technical; they involved each agency's conception of its role in the national space program. Precisely because differences went so deep, none of the interagency working groups set up to resolve the problem arrived at a settlement acceptable to both sides: not the panel established to work out the details of the Webb-McNamara agreement, nor the interagency task forces that studied the problem

* However, Skylabs II, III, and IV, and Apollo-Soyuz, all of which used the Saturn IB, were from KSC.

from 1965 to 1967, nor the Director of the Budget, into whose lap both agencies finally tossed the problem.[30] Basically, the task forces identified four alternative methods of funding. NASA could pay the actual cost of services provided; it could enjoy a host-tenant relationship, paying only for "abnormal" services; it could pay on a pro rata basis, according to some arbitrary estimate of the proportion of the total workload for which NASA was responsible; or it could continue the existing arrangement, under which NASA reimbursed the Air Force only for those requirements that were unique to a given flight project.

In practice, the four options narrowed to two: cost sharing, as DOD preferred, or reimbursement for an agreed proportion of total costs. Why, then, was the problem so intractable? The reasons are complex, intertwined with political considerations that were not always made explicit. First, there was the difficulty of separating the costs peculiar to NASA programs from the total cost of running the Eastern Test Range as a national range used by several agencies. NASA was prepared to pay for certain readily identifiable additional services incurred by the Air Force as part of the NASA workload. The agency accepted the concept that a national range—that is, a facility used by more than one agency—should be run by a single manager. But NASA officials took the argument a step further. Where the range was being operated on behalf of several users, it was impractical to charge each agency on a job order basis.[31] What counted was the creation and maintenance of a national resource. In the eyes of agency spokesmen, NASA was consistent, since the same principle had been applied by NASA laboratories to work done for other agencies, including DOD.

> NASA desired reimbursement only for work and materials over and above the normal capabilities . . . of the NASA elements involved; i.e., unique out-of-pocket costs. Only under such an arrangement could NASA keep its teams of scientists, engineers, and technicians intact and efficiently employed; maintain effective control over the operation of its facilities and the flow of work; and achieve the degree of administrative . . . flexibility essential to the most effective . . . management of its research. . . . The Administrator held that the type of R&D work performed by NASA under its charter could not be done on a job order basis.[32]

NASA officials hinted that no other arrangement could be accepted. Or rather, they intimated that if McNamara insisted on cost-sharing at the Cape, then "NASA would feel obligated to exercise an authoritative voice in planning and management commensurate with its share of funding.[33]

The history of the funding controversy does have—if not a lighter side—then a kind of awful predictability familiar to students of bureaucratic strategies. Above all, both sides seemed to shrink from any sort of final decision, even to canceling the outdated 1959 agreement. The task force report of December 1963, which recommended that existing funding arrangements be continued, only served as a temporary remedy for confusion. In October 1965 Defense officials reopened the matter by suggesting that NASA cooperate in arriving at an equitable division of costs. This touched off another round of studies and reports that lasted over two years and left both sides as far apart as ever. There were joint working groups, exchanges of letters, and a budget request by McNamara that struck out $45 million from the Defense budget in support of Apollo—an amount promptly restored by the Bureau of the Budget. By February 1967 NASA and DOD were still so far apart that Boone, who handled negotiations for NASA, and his DOD counterpart "could not even agree as to how we should report that we disagreed."[34]

These protracted and exhausting negotiations did lead to an interim settlement, however inconclusive. In April 1967 both agencies wrote to Budget Director Charles Schultze, requesting a judgment on issues pending. Schultze agreed to arbitrate, provided that his decision was accepted by both agencies as binding. When the Bureau's judgment was conveyed to NASA in February 1968, its conclusions left the status quo virtually intact. The Bureau's decision applied to FY 1969 only; and no more final judgment would be possible, pending a financial management system at the Eastern Test Range that would "provide a basis for full identification of costs based upon valid accounting procedures."[35] In essence, the Bureau accepted NASA's position on funding; for 1969 NASA and DOD were to pay for range operations on a 60 : 40 basis, except that NASA would pay 85 percent of the cost of Apollo aircraft. Out of a total Eastern Test Range budget of $260.9 million, NASA would provide $51.4 million, DOD the rest. Such was the inconclusive conclusion to a controversy begun six years earlier.

While the issue of Eastern Test Range funding laid bare fundamental differences over the management of the space program, other funding agreements presented few problems. Where NASA procured launch vehicles from the Air Force, it paid only for the production item, not for development costs. Similarly, when NASA, in April 1964, delegated responsibility to the Defense Supply Agency to administer its contracts, it was agreed that NASA would pay for direct and indirect costs on a per-hour basis. Whatever technical problems might arise, there were no serious philosophical differences comparable to those at the Eastern Test Range. These differences arose in three cases: when NASA believed that DOD support might involve technical direction of NASA programs, when DOD pressed for the consolidation of colocated NASA facilities to avoid unwarranted duplication, and when DOD officials substituted their judgment for NASA's in determining NASA's requirements. The issue of the operation of tracking stations illustrates all three cases. The agencies' positions were lucidly stated by Boone:

> DOD, as operator of the national missile ranges and their associated down-range tracking stations, tended to view each station as an entity, operating under the cognizance of the range operations director . . . and called up by him to provide tracking and telemetry support to any missile or spacecraft requiring such support.

NASA, on the other hand,

> regarded each station as an integral part of a world-wide network which was, in turn, a part of a closed-loop operational system encompassing the mission control center, the network, and the spacecraft . . . the individual network stations must be standardized as much as possible and integrated into a single network under central operational management and control. . . . It was around this basic issue . . . that most of the subsequent controversy centered.[36]

NASA officials asserted that the totality of Apollo mission operations had to be under direct agency control; and they drew a line between routine housekeeping services, which they were prepared to delegate, and the technical operation of facilities, which they were not. Moreover, they insisted that colocation and duplication were not the same thing. The NASA tracking stations on Antigua and Ascension Island did not duplicate nearby DOD facilities. The NASA facilities, which operated on the unified S-band system, were part of the Deep Space Network and had nothing in common with the DOD system; they could not be operated by part-time labor pulled from a general-purpose technical pool; and it would serve no purpose and save no money to take the stations out of an integrated mission support system to meet the theoretical requirement of single management.[37] It is conceivable that, up to 1962, both agencies might have arrived at a system with similar bandwidth capacity. By 1965 NASA and DOD had gone their separate ways; thus single management remained a very live issue.[38]

In practice, NASA management was more flexible than a flat assertion of the agency's position would imply. By an agreement of 22 May 1965, NASA and DOD agreed to three principles in the management of colocated tracking stations:[39] (1) where facilities were colocated, one agency would be responsible for all base support functions, such as public works, utilities, and logistics; (2) the single manager for base support would normally operate the instrumentation; and (3) where an exception to the above promised cost savings, the agencies would carry out a joint study to devise other arrangements. Thus NASA continued to operate the unified S-band instruments at Antigua and Ascension, although DOD managed both stations.

Another instance in which NASA and DOD had to bend principles pertained to outfitting and managing tracking ships for Apollo. Here the issues were even more complex, since they involved the Navy's Bureau of Ships as well as NASA and the Air Force. In its 1964 budget request, NASA asked Congress for $90 million to convert and equip three ships from the Maritime Reserve for tracking and data acquisition in support of Apollo. When it was learned that both NASA and DOD were planning additional ships without much regard to what the other was doing, the authorization committees withheld funds pending a joint study to resolve several issues. Who would design and operate the ships? Would NASA or the Air Force determine Apollo support requirements? Would the ships be manned by civil service crews or by union crews supplied by Pan American World Airways, the support contractor for the entire Eastern Test Range? And who would operate and maintain the shipboard Apollo instrumentation—NASA or DOD?

After the usual lengthy negotiations—this time including an ad hoc AACB Committee on Instrumentation—on 15 January 1964 the two agencies signed and sent their agreement to Congress.[40] NASA and DOD would work out requirements, with the Air Force placed in charge of centralized planning and management; the Navy would acquire and modify the ships through a specially created project office; and the Navy Military Sea Transportation Service would operate and maintain the ships at sea. Except in two respects, the agreement gave NASA most of what it wanted. NASA had insisted on ships manned by civil service crews to avoid the possibility of a strike delaying an Apollo mission. The Air Force, however, continued to use union crews as long as its Pan American contract remained in effect; ultimately, they were phased out and replaced by civil service crews. In addition, NASA had demanded a free hand in operating the ships' Apollo instrumentation; as part of the 1964 agreement, NASA relinquished operations to DOD, despite its oft-stated goal of "a fully integrated network operation."[41] Yet in virtually every other respect, NASA got what it wanted. The ships were to be operated by the Navy, not the Air Force; NASA, as well as the Air Force, would develop the plans for operating ships "as Range facilities in the Apollo network"; the funds for the ships would be kept by NASA, rather than turned over completely to the Air Force; most significant, "DOD would accept as top priority the Apollo support requirements *as stated by NASA.*"[42] In practice, NASA settled for something less than the "totally integrated network" it had considered indispensable.

Launch Vehicle Planning

One of the most critical areas for coordination pertained to the national launch vehicle program. Coordination studies by NASA and DOD went beyond the issue of avoiding wasteful duplication. The development of new booster stages and the phase out of older ones were involved in the long-range planning of both agencies, since the diameter of the vehicle, total thrust, and propulsion system determined the payloads to be launched and the orbits in which they were placed.

Three things should be kept in mind in order to understand the NASA position on launch vehicle development. First, NASA began to develop its largest launch vehicles well in advance of a specific mission requirement. This was true of the giant F-1 and J-2 engines that powered all three stages of the Saturn V, and Webb used those as examples of the value of research independent of specific missions.[43]

Second, certain concepts relating to the national launch vehicle program had come to be widely accepted by 1963: that neither agency should start a new launch vehicle development without joint review; that the number of engine systems should be limited and standardized; that both agencies should cooperate in developing "building block" components that they could both use; and that, in the interest of economy, NASA and DOD should study the possibility of reusable as well as expendable boosters. Several of these concepts had been recommended, or at least discussed, in two influential reports of 1961–1962. The first, prepared by an Ad Hoc Booster Panel of the President's Science Advisory Committee (PSAC), was released early in June 1961, just after President Kennedy went before Congress to propose an expanded national space program.[44] The other was the report of the Large Launch Vehicle Planning Group (LLVPG) created by AACB in July 1961, which submitted its final conclusions in February 1962. LLVPG was to consider the combination of launch vehicles that was best fitted to serve the ends of the manned lunar landing, manned scientific missions, and advanced military operations.[45] Neither task force arrived at specific conclusions on the course that the national space program should take. The members of LLVPG disagreed on the mission mode for the lunar landing, hence, on the launch vehicle for Apollo.[46] Yet both reports were straws in the wind. There was strong sentiment in the scientific and engineering communities for a thorough investigation of the civilian and military uses of solid- and liquid-fuel propulsion. There was also, by 1963, a livelier awareness of the difficulties in marking out the boundaries of each agency's jurisdiction. As shown, the early understanding that DOD would work on active, and NASA on passive, communications satellites quickly evaporated. The same held for the development of big space boosters, originally NASA's responsibility. By 1961 the Air Force was at work on a large launch vehicle, which would meet its requirements for sending large payloads into Earth orbit and would also be available to NASA. This was the Titan III.[47]

Third, the national stable of launch vehicles in the early 1970s was very different from what it had been a dozen years earlier. Then NASA had had available seven vehicles, six of them derived from missile programs.[48] By 1972 the process of winnowing and sifting and standardizing had gone very far. The only remaining Thor-based vehicle was the Delta, which, along with the Atlas-Centaur, was used for medium and large payloads. The Titan III-C (or the Titan III with the Centaur upper stage) was used for very large packages. The Saturn booster was no longer available, although the remaining vehicles were used to launch Skylab in 1973 and Apollo-Soyuz in 1975. Rejected by the Air Force in favor of the Titan III, the Saturn could have been retained only if Congress had approved an ambitious manned program beyond Apollo. Congress gave no such unqualified approval; NASA suspended production of the Saturn V in 1967 and discontinued it in 1970. Thus the most significant addition to the national launch vehicle program was the use of the Titan III for the largest payloads. The Titan III had several advantages over other large boosters. It could launch multiple payloads up to synchronous orbit; accept a variety of upper stages, including the Centaur, as well as solid-fuel strap-on boosters; and it was capable of using "standardized major components which can be put together in various combinations to perform . . . effectively for different orbits and payload weights."[49] Even before the first launch of the Titan III–C, on 18 June 1965, DOD was urging on NASA its feasibility as the booster for Surveyor and Voyager.[50] NASA engineers conceded its effectiveness, but they could not use it in place of Saturn. With the completion of the Apollo and Skylab programs, however, there was no further role for Saturn. Of necessity, NASA then turned to the Titan III for the largest payloads.

At no one point did NASA and DOD freeze the number and configuration of their launch vehicles. Instead, they coordinated research and development at several levels. One such way was to narrow the options. The Nova vehicle was dropped when it became apparent that the Saturn would be large enough for the

Apollo mission. Another way was to coordinate advanced research for vehicles for which there was no immediate need. Take, for instance, the history of the large solid-fuel propulsion program.[51] In his 25 May 1961 message to Congress, Kennedy designated DOD as the agency to develop solid propellant motors. Although NASA, for technical reasons, chose to concentrate on liquid fuels, it was recognized that NASA's requirement for a solid-fuel motor might be greater than that of the Air Force.* In December 1963 NASA agreed to fund the program and on 1 March 1965 assumed full management responsibility for developing the 6.6-meter motor, even though no money was provided for it in the 1966 budget request. Webb was called on by several congressional committees to explain why NASA was discontinuing a program developed over such a long period and at such great expense. The provoking aspect of his testimony was his steadfast refusal to say that the program was being "canceled" or "terminated"—only that no more funds would be requested.[52] He also contrived to convey that NASA had to do this kind of advanced research in order to anticipate whatever the space program would require. In fact, NASA kept the program alive for another two years through reprogrammings and the partial restoration of funds by Congress. The success of the large-solid-motor program was measured less by the production of a new vehicle than by the demonstration of its feasibility. Nevertheless, such a program could hardly be continued at a time when NASA flight programs were being cut or eliminated from the budget.

Also important in developing a national stable of launch vehicles was the joint study begun in July and completed in December 1964 by the AACB Launch Vehicle Panel.[53] The study confirmed that the existing vehicles were adequate to the needs of NASA and DOD. The panel was invited to consider three options, exclusive of the Saturn V and the Scout: continued use of existing vehicles, including the Titan III; the first option less the Titan booster; and the first option less the Saturn IB. The panel concluded that there would be a cost difference of less than 1 percent among these options and that no major savings would result from shifting from present launch vehicles to a system based largely on the Titan III. Coming near the midpoint of the Apollo program, the study confirmed that coordination between NASA and DOD was successful; that the Titan III would be a favored launch vehicle for major programs to come in the late 1960s; and, most significant, that the process of choosing a launch vehicle depended on the mission that the user agency had in mind. The panel examined all the costs, direct and indirect, first of developing, then of producing a launch vehicle; and one of its conclusions was that the production cost was often the least important element in determining whether or not a vehicle should be used. In certain cases, booster costs were as little as 8 percent of total mission costs; the rest was accounted for by the cost of the spacecraft, the integration of the spacecraft and the booster, and the preparation of the mission.[54] In sum, the 1964 launch vehicle

* True for the 6.6-meter motor but not for smaller boosters. Minuteman was a solid-fuel missile, while the Titan III–C used 3.05-meter solid-fuel strap-on boosters.

study derived more precise estimates for the cost of producing launch vehicles, for substituting one vehicle for another, and for confirming the NASA decision to use the Saturn IB for Apollo.

Interagency Support and Coordination

One can only skim the complex of relations between NASA and DOD. For convenience, "support" and "coordination" can be distinguished as follows: support is where one agency assists in carrying out the other's programs; coordination is where the agencies exchange information on programs being managed by either or both, in order to avoid unnecessary duplication. These definitions are scarcely watertight. In particular cases where the Air Force supported NASA, there was also an element of coordination, since NASA and the Air Force used different contractors for common use items, even in cases where they used the same items.* Also certain programs, like Gemini, took on some aspects of a joint program as they proceeded. Thus support and coordination are relative terms, and there is a spectrum of possibilities from single management at one end to joint projects at the other.

One of AACB's principal functions was to detect and eliminate wasteful duplication. As one may have come to expect, there is nothing self-evident about the term. The mere fact that both NASA and DOD were sponsoring research in space medicine or microbiology hardly meant that half of it was unnecessary. A 1963 joint review of space medicine in NASA and DOD recognized that duplication was warranted, "if the research problems demanded more than one approach, if there was a scarcity of support in the particular problem area, or if it was necessary for maintaining 'in-house' capability."[55] Or consider facilities coordination between NASA and DOD. At the annual AACB review NASA was represented by William Fleming of the Office of Programming, who was succeeded in 1968 by Robert Curtin, the Director of the Office of Facilities. As with basic research tasks or colocated tracking stations, there were no hard-and-fast criteria regarding warranted duplication, but there were certain rules of thumb. A facility that went beyond existing capabilities was not considered as duplication. But even where one facility was similar to another, there were often extenuating circumstances. Duplication could be tolerated where one agency could not handle the other's workload,† or where one laboratory was intended to support a program peculiar to one agency,‡ or where one agency considered the other's research to be

* Under pressure from GAO, NASA and DOD carried out certain "economy studies" in 1968–1969, which aimed at consolidating such things as photographic work at the Eastern Test Range and the Kennedy Space Center.

† This was the justification for the Ames Space Science Research Laboratory, although some similar work was performed at the Air Force Cambridge Research Laboratory.

‡ E.g., the Spacecraft Instrumentation Evaluation Facility at MSC, whose capabilities could not be duplicated by existing DOD facilities.

in the national interest.* In general, the annual facilities review worked by a process of "distillation"; thus in July 1968 NASA initially considered some eighty projects and ended by reviewing only fourteen.[56] The final joint review was the end of a long series of prior decisions. Indeed, some projects were dropped, less because of duplication than for other reasons, for example, because the facility was too far ahead of current needs. In sum, the existence or necessity of duplicating projects or facilities created problems for NASA and DOD that had to be resolved on a case-by-case basis.

These instances of NASA-DOD coordination should suffice to demonstrate the general principles. Most of the studies involving AACB panels were technical and noncontroversial. Some, like the 1968–1969 economy studies, were intended to consolidate base support at the Eastern Test Range and the Kennedy Space Center. Others, like the 1963 review of space medicine research, were information exchanges designed to provide a common data bank. In yet another category were joint studies of research that both NASA and DOD thought potentially useful: a 1966 study of reusable launch vehicles; a 1968 study of the Data Relay Satellite, which could assume many of the tracking and command functions performed by ground stations; or a 1969 study of the feasibility of a single space transportation system for NASA's and DOD's use.[57] These examples may stand for a host of others. In very few cases did these studies raise issues that could not be resolved at the working level. Where the two agencies could not agree was in the sphere where program philosophy and program management overlapped, particularly in the cases of Gemini and the Manned Orbiting Laboratory.

Finally, something should be said about NASA support for DOD. The support took three forms: testing DOD prototypes at NASA facilities, sharing knowledge gained in NASA programs with other agencies, and conducting research on behalf of DOD. To exemplify the first category, NASA tested 130 flight models between 1961 and 1969 in Langley wind tunnels.[58] This support proved so valuable that officials indicated in 1969 that "DOD expects to ask for help on each new system, in the future placing even heavier demands on NASA."[59] In the second category were the various experiments performed aboard Mercury, Gemini, and Apollo; one might add communications satellites like Syncom, which began as NASA projects and ended up transferred to DOD. In the third category was NASA support for the B-70 supersonic plane and for the "limited warfare" research project on behalf of the services in Vietnam. The Air Force had intended the B-70 to be a manned strategic bomber, despite grave doubts about its feasibility or necessity. By late 1962 it was known in Air Force circles that McNamara would never allow the B-70 to enter production with a new generation of manned bombers; and the plane, renamed the XB-70, became an experimental model that flew instrumentation installed by NASA. In March 1967 the Air Force transferred management to NASA, after which the XB-70 continued as a joint project for another two years.[60] The agreement was advantageous to both sides,

* As DOD considered the V/STOL Research Laboratory at Langley to be.

since the Air Force could cut the losses it incurred in sponsoring the prototype of a strategic bomber that would never be built. NASA, on the other hand, wanted the vehicle for its own research, particularly in connection with the civilian supersonic transport program. This case was the reverse of Syncom: What began as a program to develop an Air Force weapon system ended as a joint research project mostly funded by NASA.

A more unusual kind of technical support was provided by the NASA Limited Warfare Committee, established in December 1965 after the Air Force Systems Command asked NASA to develop certain kinds of hardware for use in Vietnam.[61] Given the nature of the terrain and the strategy of guerrilla warfare, the services needed unconventional technical support for a war that was not being fought by conventional rules. Most of the research was carried out at Ames and JPL, involved about 100 scientists and engineers, and cost NASA between $4 and $5 million a year. The limited warfare program led to some ingeniously designed equipment: a quick method of patching holes in inflated life rafts, a better parachute steering mechanism, a helicopter that did not make a chopper noise, an acoustic detector that located mortars by ground vibrations, and an aircraft target marker. Although the specific tasks that NASA performed were classified, the fact that NASA was doing this kind of work for the military was generally known. Nevertheless, this support—although it was fundamentally no different from any other NASA research applied by DOD—placed NASA on somewhat shaky ground. Except for the clause in the Space Act that enjoined NASA to make available to DOD "discoveries that have military value or significance," the program lacked clear authorization and made NASA vulnerable to congressional inquiry. For these reasons and because it had achieved its purpose, the limited warfare program was phased out in 1969.

Gemini and the MOL Decision, January 1963–August 1965

An account of NASA's Gemini program and of DOD's Manned Orbiting Laboratory (MOL) brings into sharper focus all the elements of support, coordination, and rivalry discussed so far. Gemini was a NASA program coordinated with DOD. Under the terms of the Gemini agreement, DOD took part in planning experiments, launch operations, and flight operations. Yet the fortnight preceding the agreement was marked by McNamara's attempt to take over the program, first, by informally proposing a merger of NASA-DOD manned space programs under DOD management, then by formally proposing a joint program.*[62] NASA could not accept either arrangement without compromising its independence. Gemini had been planned to meet the needs of NASA's manned program; it had been under way since December 1961; it had been designed with military needs in mind; and it could not be transferred from NASA without

*According to one source, McNamara proposed that DOD take over all manned flight in Earth orbit; NASA, all flights beyond Earth orbit.

causing substantial delay. There were also compelling political reasons for Gemini to remain within NASA, since the arrangement by which NASA operated tracking stations in Mexico, Nigeria, Zanzibar, and Spain prohibited their use to support military programs. Under McNamara's terms these stations would be unavailable, and the existence of a joint civilian-military program would jeopardize negotiations for tracking stations elsewhere.[63] The effect of transferring Gemini to DOD would be to place in doubt NASA's image as a civilian agency dedicated to the peaceful exploration of space. But beyond these objections, cogent as they were, NASA officials sensed that they could not accede to such a proposal and still retain control over their programs. Just before the meeting that preceded the final agreement, Webb wrote to Seamans that

> I have no doubt whatever that McNamara is underrating the problems that will be created with Congress if he insists on the participation in our management or that we participate in the management of the development of military equipment such as weapons systems. We can contribute a great deal, but when it comes to the actual development, that is not our function under the law.*
> . . . Under the proposed arrangement, we would lose control of the research which we will do. The basic policy from NACA days is that we would fund it, and would do it. This made us independent of those who wanted us to undertake contract research, but, of course, we were always sensitive to their needs.[64]

The Gemini agreement deferred for almost a year the issue of how a military space program might impinge on NASA. Under the terms of the pact, "Gemini was not to be thought of as a joint program, but rather as a program serving common needs, with the Department of Defense paying for the military features, NASA in full charge of the program, and the role of the [Gemini Program Planning] board strictly advisory."[65] The disagreement over Gemini had nothing to do with whether NASA would support the military or not. That support was never in question, only NASA's right to determine how it would provide it. Webb insisted—even more in private than in public—that NASA served the purposes of national security; that NASA and DOD should act in the future, as they had in the past, on the basis of coordination, not joint management; and that the objective of military control in space required the kind of research that was "being done at this stage more efficiently in NASA than it could be done elsewhere." When, in July 1963, Vice President Johnson phoned Webb to ask how much of "our present peaceful space program can be militarily useful," he replied,

> All of it can be directly or indirectly militarily useful. . . . All these ground installations can, in time of need, be converted to, or can be utilized to handle, military requirements.[66]

The Gemini agreement raised troubling questions about the purpose and future of manned military space programs. Although Dyna-Soar was not dropped until December 1963, its cancelation had been expected for almost a year prior to the formal announcement. As early as March 1963, in discussions between top

*This, however, was what NASA did for DOD in establishing a limited warfare program.

officials of NASA and DOD, McNamara, according to Webb, had asked what benefits Dyna-Soar would have for NASA "and whether or not those benefits could not be obtained from some other program . . . rather than having to spend the 600 million dollars involved in funding the Dyna-Soar project."[67] NcNamara was already thinking ahead to a military space station, and the summer of 1963 was marked by interagency negotiations on the coordination of studies for manned orbital space stations that led to a joint agreement in September. The announcement of Dyna-Soar's cancelation was yoked with one to authorize the MOL, a program that would use a Gemini capsule to house a two-man crew for a stay of up to thirty days. This led to the impression that MOL was a substitute for Dyna-Soar, when the truth was a little more complex. Dyna-Soar had attempted too many things at once, among which, to develop precise reentry and landing capabilities and to test the capability of man in space. It had outgrown the Titan I and Titan II boosters and, in any case, could carry only one man, rather than the two-man crew of MOL. But the latter was not simply a tradeoff for the former; Dyna-Soar was aimed at maneuverability and reentry problems, while MOL was to investigate the uses of men working in space in a "shirt-sleeves" environment.

The final authorization of MOL was piecemeal. The initial decision of 10 December 1963 was followed by the joint NASA-DOD agreement of 25 January 1965 and the final approval given by President Johnson on 25 August 1965. While many details remain classified, enough is known about MOL to clarify the reasons that led to approval. The elements leading to the 1963 MOL decision included pressure from the Air Force to demonstrate the need for a manned military space program and from Congress (especially the House Government Operations Committee) to explore the military uses of space, and the sentiment, not stated publicly by Defense officials, that the Air Force should receive something in return for the cancelation or phasedown of the Skybolt missile, the B-70, and Dyna-Soar.[68] The significance of Dyna-Soar in this context is that there was not room in the Air Force budget for both Dyna-Soar and MOL, and that cancelation of the former was one more illustration of McNamara's concern for economy and cost-effectiveness. Because MOL would be based on proven technology, rather than on Apollo hardware not yet flown, the Air Force's case was much improved. By basing the program on Gemini rather than Apollo, the Air Force could also use its Titan III, rather than NASA's Saturn IB.

The 1963 decision to authorize MOL inaugurated a definition phase that lasted twenty months, to August 1965. The original plan called for the "Gemini B" capsule, attached to an orbiting pressurized cylinder (the "laboratory") that McNamara described as "approximately the size of a house trailer."[69] Although the program would be supported by Gemini's tracking network, it would be totally funded and managed by DOD. Yet on certain critical matters, McNamara either said nothing or spoke in the vaguest terms. As DOD officials saw it, MOL was not a space station and did not come within the terms of the September agreement with NASA. Yet the reasons given for the program only raised doubts as to its necessity. How accurate was McNamara's assertion that MOL involved no duplication of Gemini? What, precisely, could MOL do that could not be done equally well by unmanned spacecraft or by Gemini itself? And if MOL was not a space station (though to all appearances it seemed to be one), how would it affect NASA's plans for a post-Apollo space station? These doubts were not so much removed as ignored by McNamara and top Air Force officials as they began the tedious process of specifying the details of MOL.

In fact, this preliminary phase lasted as long as it did because the MOL concept raised questions of cost, timing, and, most of all, requirements. An ad hoc subcommittee of the Space Vehicle and Space Sciences Panels of PSAC reported in November 1963 that a general purpose space station could not be justified for military or nonmilitary purposes; that a nonrecoverable space station should not be considered by the military until it had been decided that the Gemini and Apollo capsules were inadequate for military purposes; finally, that DOD should begin a test program using a one-man Gemini capsule launched by a Titan II.[70] Moreover, the Bureau of the Budget, which had to authorize the program, took more than a year to study MOL before approving it. As late as November 1964 the Bureau's Military Division could find little to justify a separate MOL. A Bureau staff paper of that date assembled most of the objections to MOL and summarized them forcefully:

> The contributions that an operational manned system would make . . . appear to have been sufficiently established . . . and, therefore, specific space flight experiments, like those proposed for the MOL, are not required for this purpose. . . .
> An operational system for these [military] uses would require a vehicle larger than the MOL. . . .
> The cost of such a manned system would clearly be far greater than that of an unmanned system for the same purposes.[71]

And the study concluded that the MOL "did not now appear justified on the basis of the originally stated need for an experimental testing of the potential capabilities of manned space flight for high priority military purposes."[72] If the Defense Department thought MOL necessary, then the program should, at the least, be "nationalized," that is, made the basis for experiments of both military and general interest. In short, elements within the Bureau of the Budget were still very sceptical about MOL twelve months after it had been initially approved.

What was the NASA position toward MOL? Webb, Dryden, and Seamans were told in advance of the MOL decision and agreed to it. Other NASA officials, however, were not briefed, not even George Mueller who, as Associate Administrator for Manned Space Flight, would be the official most concerned with the project.[73] It was Webb's stated policy not to "second-guess" the military and not to oppose DOD programs that did not directly oppose NASA interests, if MOL could be said to fall into that category. It would also be politic, at the least, not to clash head-on with the Air Force over something that the Air Force was bent on having. Publicly, NASA officials defended MOL up to the day of its cancelation in June 1969. They insisted that MOL was a military project within the overall national space program; that it complemented, rather than duplicated, Apollo; and that the two agencies were working on the Air Force project in the same spirit in which they had defined Gemini.[74] And indeed, during 1964 and 1965 NASA and DOD concluded a number of working-level agreements defining the MOL mission, several of which involved the good offices of the Director of the Bureau of the Budget.[75] Privately, however, several NASA engineers and managers took a position scarcely distinguishable from the 1963 report of the PSAC Space Vehicle and Space Sciences subcommittee. As they saw it, the Air Force was maneuvering DOD "into a position of defining the MOL program as the *National* Space Station," thereby putting pressure on NASA to fly its experiments aboard Gemini B. Furthermore, the Air Force wanted to remove the program from AACB coordination and start a direct relationship with NASA.[76] On technical grounds, they were equally sceptical; considerably less than 1 percent of the data obtained by MOL would be superior to what would be obtainable from available systems.[77] On the basis of studies conducted by NASA for DOD between January and May 1965, the use of Apollo-Saturn was found preferable to Gemini B/ Titan III. The former could place very large payloads in orbit, which could be manned continuously through rendezvous resupply operations; while the Apollo command module could also accommodate a three-man crew, rather than the two-man crew of Gemini B.[78] In effect, some NASA technical managers suspected that MOL really did duplicate NASA programs, at a time when influential Congressmen were demanding less duplication and more standardization.

President Johnson approved MOL, one may assume, because the Air Force made a convincing case on its behalf, while those within the Government who opposed it fell into line. Sometime early in December 1964, the Director of the Bureau of the Budget (Kermit Gordon) and the President's Science Advisor (Dr. Donald Hornig) decided to support it. On 10 December Gordon recorded the understanding reached between himself, Hornig, Webb, and McNamara. It was agreed that the program would emphasize military experimentation, assembling structures in space, and reconnaissance; other objectives, mainly scientific, would be sought in cooperation with NASA; and NASA and DOD would define experiments to support these goals.[79] The studies carried out by NASA as part of the agreement were intended to refute the contention that MOL would simply duplicate Gemini and Apollo. The pressure to cancel or drastically alter MOL had been growing since the fall of 1964; thus Senator Clinton Anderson (D-New Mex.), chairman of the Senate Committee on Aeronautical and Space Sciences, wrote to the President urging that military and civilian space stations be combined to avoid waste.[80] The joint statements of Webb and McNamara on 25 January 1965 dismissed that possibility out of hand. Both confirmed the understanding arrived at in December: MOL would be a military program with NASA support; it would be directed to military purposes but also to certain broader scientific purposes; and NASA would compare Apollo and Gemini systems to see which would best serve the ends of the program.[81] By April DOD had decided to proceed with Gemini B and to let a design definition contract with McDonnell Aircraft. On 4 June the Military Operations Subcommittee of the House Government Operations Committee released a report that pushed the MOL in the most forceful way.[82] The committee recommended that DOD "should, without further delay, commence full-scale development of a manned orbital laboratory . . . project." On 9 July NASA and DOD officals briefed the Space Council on MOL and NASA plans for manned space stations. Finally, on 25 August President Johnson approved MOL. After almost two years of discussion and analysis, the Air Force had its program.[83]

MOL was approved because the Air Force, backed by several congressional committees, wanted it, because NASA chose to support it, and because the Budget Bureau and the President's Science Advisor ultimately accepted the merits of the experimental program.[84] The views of the decision makers on the merits of the classified experiments and on whether MOL could effectively implement them actually controlled the decision. If McNamara, Hornig, and the others had not been convinced, the decision would have gone the other way.[85] NASA took the position that MOL did not duplicate any current NASA program, was not a space station, and could be justified on its own terms. Whatever reservations NASA officials had, they kept to themselves. Given the limited experimental nature of the final approved program, it could be argued that MOL did not compete with NASA's plans for manned orbital space stations. NASA's plans were far more grandiose. In any case, neither the Manned Orbiting Research Laboratory nor the National Multipurpose Space Station nor "Apollo X" was ever approved in anything resembling the original form. The threat to NASA was that the duplication argument could be turned around so easily. Prior to MOL approval, the program was criticized for duplicating NASA hardware and systems. Once approved, the argument turned back on NASA. Even before final approval, one NASA official wondered if pressure

> would be applied to NASA . . . to fly our experiments on MOL if, in fact, it appears that it would be less expensive to accommodate these on MOL rather than the [Apollo Extension Systems] program.[86]

And in March 1966 the House Government Operations Committee issued a report recommending a merger of MOL and Apollo Applications.[87] Whatever the merits of the duplication controversy, the existence of a manned military program in space was bound to impinge on NASA's post-Apollo planning.

CONCLUSIONS

The connections between military and civilian space programs were so ramifying and complex that it is advisable to state the most important ones as summary conclusions.

First, although it began as an agency that depended heavily on DOD support, NASA succeeded in freeing itself from overt DOD control by 1963. Whether one considers Gemini, the management of the Merritt Island Launch Area, or the existence of colocated tracking stations, the pattern is the same. NASA would cooperate with DOD but never to the point of relinquishing its authority to meet its needs. The shift from dependence began within the first two years following NASA's creation. NASA began to work on active, as well as passive, communications satellites, despite an informal agreement with DOD to work only on the former. NASA had moved well beyond such understandings in asserting its right to manage its programs, to modify military launch vehicles to serve as boosters, and to let contracts to firms already heavily involved in defense work.

During NASA's first three years, the Air Force went to considerable lengths to become the dominant partner in the national space program. Even some years later, Boone observed that "the Air Force is inclined to look upon NASA as a competitor rather than a partner in the field of space."[88] By 1963, however, the Air Force needed NASA almost as much as NASA needed the Air Force. NASA was doing basic research in the life sciences, in the composition of the upper atmosphere, and in propulsion that was as valuable for military as for civilian purposes. The NASA centers had research and test facilities that the services needed badly, among which were sixteen different wind tunnels, a ground-based flight-motion simulator, and an 18.3-meter vacuum environmental sphere. The framework within which the two agencies coexisted could accommodate almost any kind of program management, whether it was a program managed by one agency with the other sharing in planning experiments (Gemini, MOL); a joint program (X-15); a program started by one agency and transferred to the other (Syncom, the large solid motor); a joint program primarily funded by one agency (XB-70); or programs "whose success is dependent on the functioning of separate, co-operating systems" (Syncom, Anna IB geodetic satellite). The relationship was strong enough to endure almost any strain, provided it was grounded in mutual respect.

Second, the inevitable overlap of two agencies working in the same research areas was made tolerable by the concept of warranted duplication. There could be duplication in programs, facilities, and research tasks as long as they were addressed to agency needs or represented different approaches to the same research problem. Two facilities or programs were seldom identical, in any case. But duplication could even be defended as a positive good, insofar as it widened the number of options available. The ballistic missile programs of the 1950s were, in that sense, test cases for the virtues of duplication. As Sapolsky observes,

> Looking back it is quite possible to select the 'best missile proposals' (or, conversely, to point to obvious mistakes), but this can be done only because the range of alternatives and their limitations are known. At the time when initial allocations had to be made, nothing was certain. Centralizing decision making and eliminating competition (retrospectively, duplication) then would only have decreased the probability of obtaining the best system within any given time period.[89]

Third, most of the coordination between NASA and DOD was handled quite efficiently by working-level groups at the centers or by AACB panels. There were, however, cases where agreement could only be reached by the agency heads or, failing that, by referral to the Bureau of the Budget or the President. In one instance, NASA and DOD could not agree on funding arrangements for NASA launches at the Eastern Test Range. The history of that controversy suggests the old saw that the case was "hopeless, but not serious." When one considers that the matter was exhaustively studied and that the Director of the Budget could provide only an interim solution, it suggests that NASA and DOD could survive the strain. Even the most explosive disagreements, such as those over Gemini and the space station programs, were defused, if not by general managers like Seamans or R&D directors like Brown, then by the heads of the agencies involved. The important point is that the preconditions for coordination existed. What were they? One, that DOD should accept NASA's definition of a "coordinated" program as one where concurrence was "not required as a pre-condition to further action"[90]; two, that both agencies should have a mutual interest in cooperating; three, that NASA's programs, particularly in manned spaceflight, should have a priority sufficiently high to require support by the services; and four, that both agencies should centralize the organization of their space and launch vehicle programs to make cooperation possible. The last point refers to the NASA reorganizations of 1961 and 1963, the creation of the Air Force Systems Command, the merger of the Eastern and Western Test Ranges under a single National Range Division, and the use by both agencies of AACB panels as standing committees to regulate the working-level coordination of military and civilian programs. Perhaps the most remarkable thing about the NASA-DOD relationship is not that it worked so well, but that so often practice was better than theory, and mutual interest overrode the funding and duplication controversies recounted in this chapter.

Chapter 9

NASA's Long-Range Planning, 1964–1969

The purpose of this chapter is to trace NASA planning from 1964, when NASA drafted its first tentative proposals for a sequel to Apollo, to 1969, when it sent a comprehensive plan to the President's Space Task Group. Rather than enumerating the details of each plan and task report, the discussion describes the assumptions behind NASA planning, maps the transition from one kind of planning to another, and above all, explains why NASA, having promised so much, delivered so little. To assess NASA planning one must break it into components. One must know where in NASA and by whom the planning was done, how the existence of certain kinds of technology (e.g., in launch vehicles) affected planning, and what kinds of organizational changes were preconditions for carrying out substantive programs. This chapter argues, first, that many disagreements over future programs, especially between NASA officials and non-NASA scientists, were really disagreements over governance; second, that the principal flaw of almost every agency plan—whether commissioned by general management or by the program offices—was the failure to describe organizational changes that would have to accompany the programs that officials were trying to sell; and third, that some of the most successful planning was embodied in the small-scale, incremental changes or adaptations made by the centers, which did not constitute part of any agencywide plan. In the following discussion, NASA planning is scrutinized in the light of these assertions.

Origins of NASA Planning, 1959–1963

Certain features of the civilian space program set the terms on which NASA planning occurred. In the 1960s NASA was an agency with a single mission but with numerous subordinate goals, not all of which were consistent with each other.* The Space Act was permissive rather than mandatory as far as ends were concerned. It was a shopping list as much as an enabling act, which freed NASA to pursue those programs that were technically possible, politically feasible, and challenging enough to enlist the support of key technical personnel. For these reasons, manned spaceflight was never so dominant as to crowd out all other program philosophies. For one thing, aeronautics remained an important part of the supporting research that NASA did for other agencies. For another, there were always a certain number of research programs within NASA that were independent of the major programs. So that the agency might keep abreast of technical developments, NASA thought it necessary to develop capabilities independent of any specific mission or use. This policy lessened the danger noted in a 1966 Senate report that "there may be a penalty attached to the 'approved mission' policy for advanced development. Premature obsolescence is one hazard. Commitment of resources before the full cost-benefit can be known is another. The narrowing of component and subsystem engineering is a third."[1]

The substance of NASA planning was done by two groups, by center researchers and program managers, and by task forces and panels summoned from time to time to provide the agency with advice. Within NASA, the most important planning consisted of advanced studies conducted by or commissioned for the centers. The preceding account of the study programs stressed the measures taken by management to avoid jurisdictional conflicts with DOD and to prevent Congress from construing an approved study as an approved program. But this is not quite the whole story; management did not regard studies as a necessary evil. Studies did not normally lead to specific kinds of flight hardware. They were used instead to demonstrate how NASA could improve the efficiency of launch vehicles like the Saturn IB; develop future missions as extensions of current programs; or design models of in-flight experiments, especially those requiring the presence of man. In addition, many studies kept alive concepts that might serve as bases for programs not yet authorized by general management.

The studies began almost as soon as NASA came into being. The earliest studies on the design and purposes of Earth-orbital space stations dated from 1959. By 1962 enough work had been done to justify a space station symposium at Langley; and by 1968 one center, MSC, had conducted forty studies, which had cost $6.3 million.[2] Although most of the centers had formal planning groups, three centers—Langley, Marshall, and MSC, which established a Space Station Study Office in February 1962—were especially active in advanced studies. The concept of the orbiting space station fascinated NASA engineers because it could be used to further almost every goal that, at one time or another, was annexed to the U.S. space program. An orbiting station might serve for space exploration, for basic research, for national security purposes, and for scanning the Earth's surface. The

* Note that what was a mission for a center or program office might be a subordinate goal for the agency at large. There is no inconsistency in distinguishing a center's mission—e.g., to develop manned spacecraft—from the NASA mission of putting a man on the Moon and returning him safely.

centers and various ad hoc NASA-wide task forces had to explain what a space station would entail before they could convince management that the ideal was, in fact, worth pursuing. They had to show that a long-duration station, one that would operate for a year or more, was technically feasible. They had to study the vehicles that would be needed to resupply and equip the station. They had to know the environmental requirements of supporting a crew of a given size. Above all, they had to establish the justification for a *manned* station. The presence of man in space was at once the main justification for the space station and its greatest stumbling block, for it had to be demonstrated that man could do what a completely automated system could not.

The immediately apparent feature of NASA study programs is the continuity of the research on space stations. What preceded and what was an alternative to the lunar landing program became, first, an "extension" of it and then a sequel to it. Between 1959 and 1969 center planning groups confirmed that the basic technology for orbiting stations was available, that such stations could serve a variety of purposes, and that their cost could be reduced considerably by having them supplied by means of reusable space transportation systems.[3] The impact of the studies was cumulative. Particularly as the first Apollo launches drew near, NASA increased the funding and manpower of the study groups. There was one agencywide study in 1966, another the following year, and two in 1968. The roots of post-Apollo planning lay in the agency's beginnings; by 1969, planning involved the combination of elements and concepts that already existed.

By comparison, the planning offices reporting to the Administrator achieved very little. From 1959 to 1962 NASA prepared and updated a formal long-range plan, with projections of current and tentatively approved programs. In 1963 the plan was dropped, along with the Offices of Plans and Program Evaluation that drafted it. Other experiments, like the Policy Planning Board, were no more successful. The Board, a mixed panel of headquarters and center officials, met a few times in 1964–1965 before its dissolution; and its members were advised that Webb did not want to receive any formal reports or recommendations.[4] Except for the Future Programs Task Group, which was created under pressure from the White House, NASA management issued no formal statement of post-Apollo plans between 1963 and 1968. To be sure, the formal planning sequence worked badly: the long-range plan was not integrated with the budgetary process, offered little guidance to the program offices and centers, and tended to be distributed outside NASA before detailed project planning had taken place.[5] But none of these defects was beyond all remedy; presumably, if NASA management did nothing to improve long-range planning, it was because officials had no time and little use for it. By 1963 most of the funds that Congress was likely to vote were for currently authorized programs, leaving only modest sums for programs beyond advanced studies. Because Apollo and Gemini almost totally preoccupied key officials, it was difficult for most of them to spare much thought for a future that might be very different from the present. The tendency was mostly in the other direction, to a reduction of commitments. In the case of the supersonic transport program, Dryden, according to one source, successfully argued that the agency should limit itself to R&D support since, with Apollo under way, "NASA could not politically sponsor two high-technology, enormously expensive programs in the same budget years without one of them being sacrificed to the other or killing each other off in competition for funds."[6] In any case, there seemed little point in presenting Congress with ten-year cost projections for programs that would have to be authorized one year at a time.

But the principal reason for the absence of a long-range plan, encompassing all the others, was Webb's refusal to authorize one.[7] He would not commit himself publicly to new programs where costs were unpredictable, congressional approval uncertain, the likelihood of changes ever present, and the program offices themselves deeply divided over long-range plans. A formal plan would simply tie his and other agency officials' hands. Despite a certain flamboyance of language, Webb behaved as cautiously as the head of an agency that employed over 400 000 persons and disposed of a $5.5 billion operating budget could be expected to behave. He was convinced that the agency could not plan unilaterally, that decisions about the sequel to Apollo were political decisions and, as such, the prerogative of the President and Congress. When he, or Seamans on his behalf, approved the annual study program, he did nothing more than encourage the program offices to focus on the near-term prospects for technology already being developed. Neither Webb nor Seamans saw his role as one of blocking out the outlines of future missions. That was the job of the program offices. In turn, they insisted on their right to be informed, the right to be consulted, and the right to warn. Later it is shown what Webb demanded of the program offices before their plans could become line items in the NASA budget.

THE FUTURE PROGRAMS TASK GROUP, 1964–1965

The real point of departure for a survey of post-Apollo planning is the report of the Future Programs Task Group. By the end of 1963, NASA had assumed the organizational shape it was to retain into the 1970s, insofar as the field centers reported to the directors of substantive program offices, NASA and DOD had staked out their respective jurisdictions, and the large construction projects were under way.

But there were also signs that the honeymoon of NASA, Congress, and the President was coming to an end. Congress had cut the Administration's budget request for 1964 by more than 10 percent and a NASA request for a supplemental appropriation by half. Potentially a more serious problem for NASA was the agency's shifting position on the purpose of the lunar landing. Was the investment in Apollo predicated on beating the Russians to the Moon?, to demonstrate American technological superiority?, to inaugurate the exploration, not only of the Moon, but of the near planets as well? Or was the Apollo mission a means to create a capability to operate in space for whatever purposes the United States chose? In practical terms, three-quarters of NASA's work force was working on some aspect of the manned spaceflight program. Unless NASA could sell a program to extend Apollo beyond the lunar landing, it would have to start disbanding most of the work force by 1966, when the major facilities would be completed and the Saturn V launch vehicle and the Apollo spacecraft would be in production.

The Future Programs Task Group was created to prepare a reply to a letter dated 30 January 1964 from President Johnson to Webb.[8] With the 1965 budget due to go to the Hill, the President wanted to know what NASA was doing to lay the basis for future programs. The proximate reason for his letter pertained to the NERVA nuclear rocket program and the absence of near-term missions that would require it. But for Johnson, NERVA was only an excuse for what principally concerned him. Could NASA list possible space objectives beyond those already approved? What planned supporting research and technology would these aims require? How much of NASA's current R&D work, especially in launch vehicles, could be used in support of future programs? To prepare a reply Webb named Francis Smith, a Langley engineer and future Assistant Administrator for University Affairs, to head a special task force. Its summary report, dated January 1965, was released the following April. While the task force was drafting its report, Webb sent interim replies to the President, of which the first (20 May 1964) outlined several possible future missions without choosing among them. But in a letter of 16 February 1965 he endorsed two specific objectives: the exploration of Mars by unmanned vehicles, already recommended by the Space Science Board in October 1964, and the use of the Saturn booster and the lunar module for a variety of missions in Earth and lunar orbit and for exploring the lunar surface. In a sense, Webb's letters and the final report were more significant for what they left unsaid than for their explicit proposals, of which there were few. Indeed, the Senate Committee on Aeronautical and Space Sciences seized on the lack of specific recommendations as a basis for criticizing the report: "Alternatives are presented, but no criteria are given as to how a selection would be made."[9] This, however, was beside the point, since Johnson had asked only for "a statement of *possible* space objectives beyond those already approved." More serious criticisms were that the report contained little that was new, and that it said almost nothing about military applications and coordination with DOD.

In fact, the Senate committee had hinted at real weaknesses in NASA's planning structure. Although Smith and the task group adhered to the letter of Johnson's instructions, one would suppose that if NASA had a specific post-Apollo plan, it would have been presented. If NASA presented options without choosing among them, it was because there was almost no agreement within NASA as to what should follow the lunar landing. But even if there had been something approaching unanimity, the climate in 1965 was unfavorable to ambitious space programs. Webb or Mueller might have been able to carry the agency with them. They were much less likely to carry the Bureau of the Budget, Congress, or the public. Moreover, NASA planning was complicated by its relation to military space programs. As shown, NASA had come to accept the Air Force Manned Orbiting Laboratory (MOL) as a legitimate military program that in no way conflicted with Apollo. Webb ratified the December 1964 memorandum of understanding on the scope and purpose of MOL. But the Future Programs Task Group report was silent about the potential conflict between a military MOL and a NASA space station in areas such as the experiments to be flown, the availability of Apollo hardware for MOL, and the possibility of needless duplication. Also, the 1961 Webb-Gilpatric agreement required NASA to seek the approval of DOD before proceeding to develop a new launch vehicle. The 1964 AACB launch vehicle study demonstrated that NASA would save almost nothing should it decide to switch from the Saturn to the Titan family of launch vehicles. Nevertheless, NASA engineers were seriously considering the Titan III as the launch vehicle for major programs listed as options for the 1970s: space stations in synchronous orbit or unmanned payloads to the near planets. But NASA in 1965 had not arrived at any firm conclusions as to how or whether it would modify the Titan III for its own purposes.

To the extent that there was agreement, it was that Apollo had created a capability to operate in space. But that was about the extent of agreement. Webb, for example, stressed "capability" almost to the exclusion of the programs that capability made possible. In his view, the lunar landing mattered because it was the most dramatic proof that the United States had achieved the freedom to operate as it chose in space. At a 1965 briefing for Webb on "Apollo Extension Systems," he dismissed the idea that the lunar landing was any kind of end in itself. What NASA was developing, his argument ran, was the "capability to fire, to launch, to get into orbit."

> We have got a hypothesis . . . that the lunar landing is the most useful way to do the development and to prove we have done it. But this could actually be displaced in terms of national objectives.
> . . . Now I don't want the argument to center on whether we know that we are going in '68 or sometime later. I want it to center on the development of a capability which we have several possibilities to use.
> . . . I want to begin to talk about the true situation [rather] than to continue so sharply to focus on that just because President Kennedy used language that none of the three of us [Webb, Dryden, Seamans] recommended to him when he said "we will put a man on the moon." [10]

What kind of follow-on to Apollo would Webb approve? At the Apollo Extension Systems and other briefings, he said more, far more, about what the Apollo mission might lead to than what, in his opinion, it ought to accomplish. He was willing enough that proposals should percolate upward from the program directors. But no proposal would become a budget line item until it met specified conditions. First, it must involve minimal interference with the current Apollo mission; second, it should make the fullest use of existing hardware; third, it had to define with precision the goals and experiments of the proposed mission; fourth, it had to avoid the appearance of duplicating military programs, especially MOL; finally, it must not commit the agency to funding levels appreciably higher than the current approved budget.[11]

Unlike the Administrator and general manager, the program directors were free to defend interests that were something less than agencywide. As Associate Administrator for Manned Space Flight, George Mueller had to tackle three problems, each of which could be resolved on condition that the other two were handled at the same time. He had to retain the funds and hold together the manpower assembled for Gemini and Apollo, arrive at programs that he could sell to top management and Congress, and ensure that Apollo itself should somehow generate its sequel. Mueller's design was nothing if not ambitious. For the "main-line" Apollo program, he envisaged an annual flight schedule of six Saturn IBs, six Saturn Vs, and six launches of the Apollo spacecraft—the "6–6–6" formula, later changed to 6–6–8.[12] As for post-Apollo plans, Mueller enumerated five options: Earth-orbital programs for long-duration space stations; lunar operations; planetary landings; an all-out program in Earth-orbital, lunar, and planetary activities; and a "balanced" program that combined other options in a cost-effective way.[13] Each program would be directed to a precise objective. Thus, if the nation should desire direct economic benefits, the logical sequel to Apollo would be a program of Earth-orbital operations. In Mueller's view, Apollo Extensions—which became Apollo Applications in August 1965 and Skylab in February 1970—was not so much one of the five program options as it was an intermediate step from Apollo to future programs. It was his conviction that the agency had to organize around one big mission rather than risk seeing its resources frittered away on a number of smaller ones. To disperse what had been assembled, only to reassemble it, would be immensely wasteful. Any new goal must have the same national priority as Apollo. Without some precise goal, such as the lunar landing, "I do not believe that our progress would have been as rapid, as widely supported, or as sound as it has been."[14] By late 1965 Mueller had seized upon a national goal that would more than equal Apollo: a manned landing on Mars and return by 1980.

But this is getting ahead of the story. NASA was not a unitary, centralized agency; planning was done from the bottom up rather than the top down. Marshall and Houston had been doing space station studies since the early 1960s. In 1964–1965 these centers and OMSF divisions at headquarters had begun to block out the elements of a post-Apollo planning organization. At Marshall von Braun created a Future Programs Group in the fall of 1964. At headquarters Mueller appointed William Taylor in May 1964 to head a special studies office to design a post-Apollo program; in October it was strengthened by the addition of a thirty-man task force established to consider uses for Apollo hardware through 1971; and in August 1965 Mueller moved from advanced studies to project definition by establishing a Saturn/Apollo Applications Office at headquarters.[15] At that time and for several years beyond, OMSF planners considered two kinds of program: one using surplus Apollo hardware, the other pointing to the development of an Earth-orbital space station. Before the space station concept could become an approved program, Mueller, his center directors, and E. Z. Gray, the head of the OMSF Advanced Manned Missions Division, had to specify what such a project would accomplish. In general terms, Mueller and Gray knew what they wanted a space station to do. It would have to support a variety of experiments, which would be developed in modules attached to the main station; it would have to be deployable in a number of orbits, ranging from a 30° inclination to synchronous orbits; it would require a minimum lifetime of three years; it would be designed for deployment in lunar orbit; and it should have "modular growth potential to fully utilize the launch capability of the Saturn V when the mission requirements develop to this level of size."[16] But working out the general principles was not easy; in late 1965 only three Apollo Applications experiments were under development.[17] In addition, OMSF plans had to satisfy two requirements: to furnish the Bureau of the Budget with precise cost estimates and to establish working relations with OSSA, which would make space science an integral part of a follow-on to Apollo.

Yet the differences between the program offices went deep. It was Newell's contention that "OSSA was established to be responsible for space science, not *unmanned* space science," a conviction not shared by Mueller.[18] OMSF was mission oriented, while OSSA was organized around research disciplines; hence Newell's office was not locked into fruitless, interminable arguments over the merits of manned versus unmanned flights. Indeed, to most outside scientists, the burden of proof that man was necessary to operate in space fell squarely on OMSF. Specifically, some scientists, especially those working for NASA as principal investigators, thought that there was too little science and too much engineering in NASA; that flight experiments assumed the presence of man, whereas it was precisely his presence that had to be justified; and that the results obtained from Mercury and Gemini could have been obtained with much less expense from automated systems. It was not that manned programs were unnecessary. A case could be and was made that man was needed as a scientific observer, as a subject for medical experimentation, as a technician to maintain and repair equipment, and as an astronaut-pilot, once low-cost space transportation systems became available.[19] The point was to consider each case on its merits and to decide, for instance, whether lunar exploration called for the trained astronaut-scientist, a package of scientific instruments left on the surface, or both.

While OSSA claimed the authority to plan space science for the whole of NASA, OMSF had the money to pay for and to fly approved experiments. In practice, the issues between the two offices had to be resolved by compromises that were not always acceptable to OSSA. In November 1963 Newell established a Manned Space Sciences Division whose director, Willis Foster, reported to him and to Mueller; and in January 1964 Mueller created a Manned Space Flight Experiments Board to evaluate recommendations for experiments to be flown on Gemini and Apollo. Under this arrangement, each program office was responsible for designing experiments within its own sphere: OSSA for space science, OART for technological experiments, and the OMSF Directorate of Space Medicine for medical experiments. Meanwhile, a DOD review board would submit military experiments to be flown by NASA.[20] While the program offices had full authority to design experiments, OMSF had the ultimate authority to accept and integrate them with the flight hardware.

The Situation in Mid-1966

By July 1966 the only definite result of NASA planning was the existence of several program alternatives, none of them authorized. At headquarters planning was being done, not only by specialized divisions within the program offices, but also by a Planning Coordination Steering Group (PCSG) established by the three program associate administrators late in 1965. In a joint memo to Seamans, they had proposed creating ad hoc planning groups to draw together the plans already drafted by the offices they directed.[21] As finally approved by Seamans the PCSG would be supported by five working groups, each of which would review the planning already under way, use that planning as their point of departure, and then develop programs within guidelines set by PCSG. As a new entity with no independent base, PCSG did not play an important role until 1968–1969 when, under Newell's leadership, it tried to develop an agencywide plan for the 1970s.

Meanwhile, OMSF and OSSA continued to do the most important planning. In OMSF, planning centered on the Earth-orbital space station and on the concept of an "orbital workshop" using the spent upper stage (S–IVB) of a Saturn IB (later changed to the Saturn V). The orbital workshop, which was at the heart of Apollo Applications, was supposed to perform a number of missions, including lunar exploration, solar astronomy, and experiments whose general purpose was to establish the usefulness of man in space. The basic Apollo Applications hardware would consist of the orbital workshop; a multiple docking adaptor for the command and service modules that would house the astronaut crew; an airlock connecting the workshop with the modules; and an Apollo Telescope Mount (ATM) that, attached to either the service module or the docked lunar module, would be an observatory to study the Sun's fine structure in 1969 during the solar maximum.[22] The ATM was intended to carry out part of the mission of the Advanced Orbiting Solar Observatory (AOSO) canceled in December 1965, but it would go beyond AOSO in making use of man. The astronaut-scientist could orient and point the ATM in the general vicinity of the Sun, determine and set camera exposures and the sequences of the various experiments, recover exposed film and magnetic tapes, and select solar events of interest.[23] This, in simplest terms, was what Apollo Applications was about. But other considerations tended to complicate this scheme, which itself was the product of two years of designs, advanced studies, and negotiations between OMSF and OSSA. How would the orbital workshop feed into the concept of the long-duration space station? Where, precisely, would the ATM be located? Was the ATM really the most effective way of doing solar astronomy or was it make-work for Marshall now that work on Saturn was phasing down? Furthermore, the design and outfitting of the workshop itself was not beyond criticism. The original plan—the one approved by Seamans in August 1966—called for launching a fueled S-IVB stage. After the fuel had been burned getting into orbit, the astronauts, who would be launched separately, would outfit the stage as a workshop. This "wet" workshop would enable NASA to use the Saturn IB instead of the Saturn V as the launch vehicle. But it also meant that the astronauts would have to assemble the workshop while working in space, something that Gemini had shown to be difficult and cumbersome.

Had the difficulties involving Apollo Applications been purely technical, Mueller would still have had his hands full. But organizational questions arose at the same time. Mueller wanted the entire program under OMSF control; in this and in the actual design of the ATM, he and Newell came to a parting of the ways. Newell argued that the ATM belonged on the service module—a proposal that even MSC Director Robert Gilruth had trouble accepting.[24] The upshot was that Mueller managed to persuade Seamans to assign the ATM to Marshall and to accept his proposal for placing the ATM on the lunar module. Seamans signed the project approval document authorizing the ATM on 29 August 1966, two weeks after Mueller and the Management Council had worked out the "roles and missions" of Apollo Applications in a series of meetings at Lake Logan, North Carolina.[25] Apollo Applications would follow the same pattern as the program from which it grew. Marshall was charged with developing the ATM and the workshop; Houston, with astronaut training, crew systems, and flight operations. The Lake Logan agreement confirmed that the management of Apollo Applications would be concentrated in OMSF and that experiments and proposals would be incorporated at the discretion of Mueller and his program directors.

But the most serious problems dogging the program pertained to its underlying assumptions: the role of man in Earth-orbital operations, the use of Apollo hardware, the wet workshop. All were subjected to very sharp criticism from NASA officials, from Congress, from the Bureau of the Budget, and from various scientific advisory groups; most of them stressed the lack of well-defined flight experiments and the possibility that the program would only duplicate MOL. In June 1966 Newell and his deputy, Edgar M. Cortright, drafted a memo pointing to "the lack of a substantial, visible end product to serve as a focus for the effort. After four or five years of activity, NASA will have spent many billions of dollars and have relatively little to show for it in comparison with where we could be in space for about the same amount of money. . . . [Apollo Applications] as now configured just doesn't seem to justify such high costs for an extended period."[26] In Congress, critics of the program tended to seize on the possibility that Apollo Applications would wastefully duplicate MOL and that it was high time for NASA and DOD to come together in a joint program.[27] For different reasons, the Bureau of the Budget shared this concern. Budget Director Charles Schultze and Budget examiners were sceptical that NASA needed more money. In negotiations with Webb, Dryden, and Seamans, he insisted that, while the Bureau had no wish to reduce U.S. manned capability in space, neither did he believe that the space budget should be based on what could be done within the limits of U.S. technical capability, on what the Russians were doing, or on the peak level of industrial manpower for developing Apollo. The space program was not a WPA.[28] With important decisions pending, the Bureau needed answers to certain pressing questions. Should the nation continue manned flight after the lunar landing? Should NASA buy more launch vehicles and spacecraft to keep production lines running? And what specific manned space flight capability did the United States need? In the summer of 1966 NASA officials had not yet arrived at precise, definitive answers.

THE ROLE OF THE OUTSIDE ADVISOR

The job of long-range planning was immensely complicated by NASA's need for outside scientific and technical advice. NASA's various committees reflected the diverse purposes of the committee members.[29] Some, like the Space Science and Applications Steering Committee (SSASC) and its subcommittees, were primarily source selection boards for evaluating flight experiments. Others, like the missions boards established in 1967, were intended to map out long-range research and to serve all of NASA in a particular discipline. Last, there were bodies like the Manned Space Flight Science and Technology Advisory Committee (STAC), whose purpose was not so much to design future programs as to work out the details of programs already approved. The same diversity applied to membership as to purpose. The members of the Lunar and Planetary Missions Board, for example, were appointed by the Administrator but reported to the Associate Administrator for Space Science and Applications, the same official who appointed all the members of the SSASC subcommittees.

What was the rationale for the mixed advisory boards? Why did NASA seek outside advice at all? What use did it make of such advice, and to what extent did advisors merely respond to the initiatives of NASA management? The principal reason for seeking outside advice was the impossibility of NASA providing it for itself. Unlike engineering, where NASA had talent comparable to the best in industry, NASA could not attract scientists of Nobel laureate caliber. Indeed, scientists of the highest rank were more valuable to NASA as consultants than as staff; a scientist not actively involved in ongoing research might find himself out of touch in little more than a year. Moreover, it was much more difficult to combine science and administration than it was to combine engineering with administration. As Newell complained in 1965,

> We have not yet solved the problem of how to maintain the continuing scientific competence of a professional scientist while at the same time asking him to devote his working hours to administration. . . . We can achieve the best in our scientific programs only if those in the very topnotch group have a major influence on the planning of science as well as in carrying it out.[30]

The best scientists—Luis Alvarez, Harold Urey, Charles Townes—were prepared to serve as consultants, as members of advisory panels, and as principal investigators, but they were not willing to abandon lucrative consulting work or to submerge their careers in the larger goals of NASA programs.

Indeed, NASA's use of outside advisors was of a piece with its policy of contracting for goods and services. The relation between NASA and its principal investigators was strictly contractual; the advisory bodies that passed on experiment proposals were, legally, source selection boards. For the rest, the NASA advisory panels served the same purposes as similar groups elsewhere in the Federal community. They provided independent appraisal by distinguished outsiders; they were sources of new ideas; and, to a degree, they served to legitimize programs that NASA officials independently decided the agency must have.

But whatever its virtues, the structure of the NASA advisory process had serious drawbacks, especially its extreme complexity. Writing in 1967, one official observed that "so many different types of institutions, organizations and relationships are evolving currently that it is difficult even to enumerate, much less describe the elements of the overall situation."[31] There was no substantive body of policy that set forth how or even why NASA had to draw on these groups for advice; there were important jurisdictional overlaps between the Space Science Board and internal advisory panels; and the center planning groups and the agency advisory committees were virtually insulated from each other. To Webb and Newell the problem with the advisory process was that it was unpatterned and unsystematic and that it failed to involve scientists in policy making. Many scientists, including (or especially) those serving NASA as consultants or principal investigators, saw the problem as systemic rather than incidental to the NASA advisory process. Their most prominent spokesmen, such as Norman Ramsey, Philip Abelson, and Bruce Murray, wanted autonomy in the making of science policy that NASA was not prepared to give. Their argument boiled down to three propositions: that the separation of power and responsibility was deadly for science; that NASA space science was hit-or-miss, with little evidence of coherent planning; and that even a successful program like Surveyor ended as "a shallow imitation of what it was intended to be, or what could have been done with the enormous funds and extended time."[32]

A brief account of the Lunar and Planetary Missions Board illustrates these generalities. Earlier, mention was made of the Ad Hoc Science Advisory Committee established by Webb in January 1966 and chaired by Norman Ramsey, a Harvard chemistry professor. The committee was created not to advise on specific projects but rather to examine how to conduct the program and to suggest ways of involving outside scientists to a greater degree in science policy making. So thoroughly did the Ramsey committee do what it was asked to do, that all but two of its proposals had to be turned down. Its recommendation for a general advisory committee of outside scientists was rejected because it would have required a fundamental reorganization of the agency and because it might force the Administrator to choose between accepting the committee's advice and supporting the

President's program.[33] Webb and Newell flatly rejected a proposal for strengthening the scientific competence of the laboratories at Marshall and for reorganizing the centers generally to give experimenters greater power. They did accept the suggestion for a consortium of universities to manage the construction of space observatories. Even the proposal that NASA did accept, for the creation of a Planetary Missions Board, had been tentatively approved by NASA before the Ramsey committee completed its work. Officially established as of 1 May 1967, the Lunar and Planetary Missions Board (and the Astronomy Missions Board established in November) was to be an advisory committee of outside scientists appointed by Webb, although the executive director, as required by law, was a NASA employee detailed from OSSA.[34] In three respects the Board's terms of reference were broader than those of any previous advisory body, even if they fell short of the general advisory committee recommended in the Ramsey report. It was chartered to perform its functions for all of NASA, not just OSSA; unlike the Space Science Board, its members had access to NASA internal documents; and "unlike previous advisory bodies, the LPMB was to consider both general and specific NASA objectives."[35]

The Board might have had a greater effect on NASA policy had it been created a few years earlier. The Board members wanted an integrated program as they conceived it, one with a balance between a few large missions and small-scale programs using automated spacecraft. The Board ultimately failed in its purpose largely because its members could not bring themselves to accept the cancelation of programs that they considered to be essential. Each program cutback or termination from 1967 through 1970 marked a stage in the deterioration of relations between the Board and NASA: the cancelation of Voyager in September 1967, Mueller's indifference to the Board's recommendations, the September 1969 report of the President's Space Task Group, the cancelation of two Apollo flights in 1970. Committed as they were to a vision of what was scientifically desirable, Board members had little patience for the budgetary pressures that shaped NASA from without and the internal forces that made it imperative to keep manned space programs alive at the expense of smaller unmanned ones. To them, as well as other scientists who served as principal investigators, the agency was simply the only available means for achieving certain important ends. It should be stressed that there was no basic difference between those scientists who supported and those who publicly criticized NASA; indeed, some of NASA's severest critics, like University of Iowa physicist James van Allen, often served as principal investigators. What disturbed Board members was the sacrifice of programs like Surveyor and Lunar Orbiter to what they regarded as engineering extravaganzas. When they learned the details of the report of the President's Space Task Group, which had recommended a manned mission to Mars before the end of the century, their first reaction was to offer to resign; and further decisions to replace several Apollo missions with Skylab and move the Viking project to 1975 only added to their frustration. The changes and cancelations strengthened their conviction "that science was accorded second-citizen status" and that "the scheduling of the lunar exploration is matched more to engineering . . . than to scientific requirements."[36] The gulf between the Board and NASA was unbridgeable, and in August 1970 the Lunar and Planetary Missions Board held its final meeting.

Rather than specific recommendations concerning future programs, the overriding issue between NASA and the scientific community was governance—the decisions on what programs should be approved and at what level of funding and who should be charged with conducting space science supported with public funds. In turning to the actual recommendations of the advisory bodies on which NASA drew, the surprising thing is how cautious they were in drafting post-Apollo programs. Most of them endorsed the validity of manned spaceflight and all argued in favor of a "balanced" program as they conceived it. The governance issue was seldom raised explicitly; for that, one must turn to the report of the Ramsey committee or the papers of the Lunar and Planetary Missions Board.

In the papers of the Space Science Board, one finds some cautiously worded criticism regarding the content, rather than the organization, of the space program. In 1965–1966 the Board released several reports bearing on long-range plans, three of which were based on a summer study held at Woods Hole, Massachusetts, in 1965.[37] The study was sponsored by the National Academy of Sciences and funded by NASA. Two conclusions are noteworthy: that the national space program should embrace a number of goals rather than a single overriding mission and that there should be a gradual shift from manned to unmanned programs and from lunar to planetary exploration. In July 1966, Harry Hess, a Princeton geologist and chairman of the Space Science Board, enlarged on the proposals in a letter to Webb.[38] The Board, he explained, was not prepared to question the value of a continuing national space program or of Apollo, but its members were convinced that there would have to be changes in emphasis during 1968–1975. Aside from repeating the proposals of the Woods Hole study, the Board recommended "continued manned lunar exploration with Apollo hardware but with decreasing allocation of resources toward the end of the period." The Board was even more sceptical of the need for a manned space station in Earth orbit. To be sure, not all scientists shared these views; Dr. Charles Townes, the chairman of STAC and recipient of the 1964 Nobel prize in physics, emphatically disagreed, but his was increasingly a minority view outside NASA.

The President's Science Advisory Committee (PSAC), many of whose members served on NASA advisory bodies, showed the same mixture of praise for NASA achievements, ambivalence over its program planning, and reluctance to touch on the governance issue as the reports mentioned. In two 1967 reports PSAC carried the proposals outlined by the Space Science Board several steps further. The first, "The Space Program in the Post-Apollo Period," was released in February and represented the most ambitious survey of the space program in several years. The Joint Space Panels of PSAC proposed an elaborate but balanced program, "based on the expectation of eventual manned planetary exploration."[39] In common with the earlier reports, the PSAC report stressed "a balanced program . . . integrating manned and unmanned efforts . . . ," and that "the most challenging ultimate objective for space exploration is the exploration by man of the nearby planets."[40] While the report endorsed several NASA objectives, it did so with reservations; it recommended one or two manned lunar explorations per year for several years as well as unmanned spacecraft "capable of landing significant scientific payloads anywhere on the moon."[41] But the report was far from enthusiastic about the conduct or results of NASA planning. In particular, PSAC sharply criticized the ATM—not the concept itself but the way that NASA proposed to realize it. The Space Science Board had said as much: Several Advanced Orbiting Solar Observatories "would have been an order of magnitude cheaper than a single Apollo Telescope Mount solar mission, and would have been available sooner, provided continuous long term observing, and supported a substantially larger number of experiments."[42] The Committee also recommended a greater integration of manned and unmanned mission planning.

The report of the PSAC Space Science and Technology Panel was completed in December but not made public. Whereas the earlier report had surveyed prospects for the ensuing decade, this report focused on the ensuing fiscal year.[43] In general, its criticisms were those of earlier PSAC and Space Science Board reports, although, if anything, its conclusions were even more pointed and sceptical. Beyond the governance issue, the PSAC panels and the Space Science Board wanted a different kind of program balance than NASA seemed able to provide. What did their reports have in common? First, an emphasis on the importance of stronger unmanned planetary programs, despite assurances by NASA that the agency was doing all that could be done; second, a tendency to question the value of Apollo Applications because it was competing with scientifically more valuable programs, because the role of man seemed to be inadequately justified, and because MOL hardware, suitably modified, could be used instead.[44] Finally, the PSAC reports, especially, pointed to certain economies that might be achieved in planning space programs, such as using DOD launch vehicles and MOL hardware, using a separately launched lunar-roving vehicle as an adjunct to manned missions, and combining unmanned spacecraft with ground-based studies. The PSAC report of December 1967 was especially critical of one argument advanced in favor of Apollo Applications: "Operational space systems for economic benefit are unlikely to be manned systems."[45] The overall effect of the reports was to cast doubt on the adequacy of NASA planning.

Toward a Post-Apollo NASA, September 1966–October 1968

Since preceding chapters have described the administrative changes of 1967–1968, very little need be added by way of summary. Most of the important changes had their source either in the Apollo fire or in the budget cuts voted by Congress, which led to the elimination of Voyager and the reduction of Apollo Applications by one-third. The fire led to the headquarters reorganization of March 1967, to further delays in Apollo and Apollo Applications, and to the creation of an Office of Organization and Management under Harold Finger as a check on the presumed freedom of the program and functional offices to do as they pleased. In particular, Finger worked to revise the project authorization system, so that the project approval document (PAD) would become "a single control document for each of our program activities" and would remove "from the program offices, particularly the large project program offices, some of their earlier flexibility to adjust funds among different projects and programs."[46] In Apollo Applications, for example, there would be PADs for every financial management code, one each for the orbital workshop, the Saturn IB, spacecraft development, and the like; and each PAD would include the definition of major subsystems, estimates of total funds for completing the job, the principal headquarters-center program responsibilities, and identification of related PADs.

The reductions in NASA's budget requests also affected the nature and scope of agency planning. Webb became more determined than ever to salvage Apollo, even if it meant postponing decisions about its sequel. Thus Webb hesitated to sign a definitive contract with McDonnell-Douglas for the Apollo Applications airlock, even though both sides had fully agreed to its terms and NASA had the option to cancel it "if the clearing up of uncertainties makes it unwise to proceed with the work under this contract."[47] Moreover, the reductions in force at various centers, particularly Marshall, also added to delays in those programs that had been approved. Some of the effects of these losses in manpower are described in an earlier chapter, in particular, the rise in the average age of center personnel, the loss of morale caused by massive reductions, and the conversions of support contractor personnel to civil service categories. The effects on research and long-range planning at the centers took several years to work out. The process of adjustment is often difficult to trace, since it was the long-term result of many small, incremental changes made by the centers and headquarters. The nature of these adjustments is touched on at the end of this chapter.

There were, however, important developments in NASA planning that have not yet been examined. Take, for instance, the field of launch vehicle development, particularly as it pertained to the Titan III. As shown in chapter 8, this Air Force vehicle had become an important element in post-Apollo planning. As early as 1964, NASA and DOD had carried out a joint study to establish the feasibility of switching from the Saturn to the Titan family. In addition, the Air Force had urged on NASA the use of Titan III for Surveyor and Voyager. In 1964–1965 NASA was too deeply committed to the Saturn IB to consider switching for unmanned payloads. But the Titan remained an increasingly attractive alternative for unmanned programs still in the planning stage. Since 1962 NASA had studied the Titan as a booster for unmanned payloads; in 1966 a Lewis center study showed the value of Titan III-Centaur for future high-velocity missions, and later that year NASA contracted with the Martin Company for a study of Titan III-Centaur integration.[48] About the same time, NASA took note of the March 1966 report of the House Government Operations Committee recommending a merger of MOL and Apollo Applications; at the Budget Bureau's request, NASA prepared a study to see if Apollo Applications could be designed around Titan III or Titan III-MOL. Predictably, NASA concluded that it could not, since its current programs were adequately supported by existing vehicles.

Future programs were a different matter, however. Three gaps were evident. No vehicle except the Saturn V was capable of putting a payload of 15 000 to 56 000 kilograms into low Earth orbit; several missions, such as a Mars-Venus flyby, were beyond the capacity of the Atlas-Centaur; and no current vehicle could resupply a large manned space station, in the event that one was built.[49] In addition, decisions had to be made on reducing the costs and the number of launch vehicle types and whether to modify existing vehicles, make new combinations of existing stages, "or develop new vehicles for missions beyond the capability of existing vehicles."[50] The Saturn V was too big and expensive, while the Saturn IB/Centaur and the large solid-fuel motor programs had already been scratched. In 1967–1968 NASA conducted a number of studies, including two joint studies with DOD, to establish its mission requirements for the next decade. In particular, a 1968 joint "economy study" recommended the Titan IIID-Centaur, a new combination of existing stages, as the most promising vehicle for future missions. In February 1969 NASA and DOD reached informal agreement on cooperating in the future development of the Titan III. NASA would be in charge of integrating the Titan IIID with the Centaur, would procure standard Titan equipment through the Air Force, and would handle the technical direction of Titan IIID-Centaur launch operations.*[51]

Another area of concern to NASA was aeronautical research. Although funding for aeronautical R&D steadily rose from 1963, it remained an insignificant fraction of the NASA budget—in 1968 a little over 2 percent. Yet the importance of planning aeronautical research was quite out of proportion to the amount spent on aeronautics programs. NASA had come under considerable pressure from Congress to spend more on aeronautics dating from a 1966 report of the Senate Committee on Aeronautical and Space Sciences, which had recommended a consolidated Federal aeronautics budget.[52] The problem for NASA was to integrate aeronautical R&D with its other programs and to find the right organizational location for aeronautics. For many reasons, NASA continued to need an aeronautics program, one not separable from its other activities. Aeronautics remained essential to NASA programming. Most of the center directors and many headquarters officials had spent part of their careers in aeronautical research for NACA/NASA. At centers like Langley and Ames it was not possible to separate physically the different facilities for aeronautical and space R&D. NASA support and NASA facilities were highly valued by DOD and FAA. And hybrid programs like the X-15, the wingless lifting body, and the space shuttle marked the convergence of aeronautical and space technology. As NASA moved in the early 1970s

*Production of the Saturn IB and Saturn V had already been suspended in the fall of 1967.

from Apollo Applications to the space shuttle, the experience gained in aeronautical research and testing became an exceedingly valuable asset in the conduct of the space program. In the early 1970s NASA management also decided that the best way to upgrade aeronautics was to strengthen it within an existing program office, such as the Office of Advanced Research and Technology (OART), rather than establish a separate "Office of Aeronautics." Had NASA established an aeronautics office separate from its own field centers, the office would have been "an external competitor for work in 'OART centers,'" and would have ended up weaker rather than stronger.[53] And it was not practical to separate one OART center to report to a new aeronautics office since none of the OART installations, except for the very small Flight Research Center, was devoted exclusively to aeronautics.

Early in 1968 NASA made a fresh start in long-range planning. In January Webb appointed Floyd Thompson, the Director of Langley, to chair a task force to recommend a program for the post-Apollo period.[54] At the end of January Webb named Thomas O. Paine, the director of General Electric's think tank TEMPO, to succeed Seamans as Deputy Administrator. In March Newell, who had moved up to become Associate Administrator the previous September, reorganized the planning groups set up some two years before. The Planning Coordination Steering Group became the Planning Steering Group (PSG) chaired by Newell and consisting of Wyatt, the deputy directors of the program offices, and the center directors. The working groups, increased from five to twelve, were assigned the job of drafting "Planning Source Documents," which were to serve as the basis of the program memorandums required by the Bureau of the Budget, as a source of material for project approval documents, and as the raw materials of long-range planning. In addition, a separate Planning Coordination Group (PCG) of headquarters planning officials was created under Arnold Frutkin, the Assistant Administrator for International Affairs, to guide the working groups and to submit their planning source documents to PSG for review.[55] To complement the reports of the working groups, the PCG would draw on institutional working groups for analyses of the organizational elements in planning: the balance of in-house and contractor work, the effect of new programs on center operations, and the like.[56] This was clearly a more ambitious planning process than the one-shot Future Programs Task Group of 1964–1965. The objective of the new planning system was to break down the parochialism that divided headquarters from the centers and, by bringing key NASA officials together, "to develop significant alternative program possibilities so that management decisions . . . can be . . . effectively determined."[57] Given the decentralized nature of NASA policy making, this was asking a great deal of agency officials. Moreover, the new planning system aimed at replacing the general manager concept, under which Seamans had been responsible for all project approvals and for monthly reviews of the status of these projects, with group management. This was the rationale for the establishment of a Management Council in January 1968, to which the PSG would report, and for replacing the program reviews for each program office held for the Deputy Administrator with a general management review before the Management Council.

The planning reforms were intended to reverse some of the byproducts of a decade of decentralized management. But to put the matter thus hardly accounts for the comparative failure of PSG/PCG to plan successfully. One has to know what the system was *not* before one can evaluate it. PSG/PCG did not present the Administrator, Congress, or the Bureau of the Budget with a single authoritative NASA program. Rather, it offered three authorized NASA planning groups. In 1968 there were more than a dozen ad hoc and standing advisory and planning groups, most of which had no formal connection at all with the PCG.[58] Two that did, Bellcomm and the Mission Analysis Division at Ames, remained distinct and apart. Bellcomm, in particular, became a sort of in-house planning staff attached to Mueller's office.[59] By 1968 Bellcomm officials were sitting in as observers at meetings; indeed, Bellcomm was commissioned by STAC to prepare a study on the uses of man in space.[60] Within the NASA organization there was as much competition as cooperation in drafting a long-range plan.

Three additional problems impeded center-headquarters cooperation. Except for PCG, which consisted of headquarters planning officials, all the members of PSG and the working groups participated part-time. Second, the process itself was, or became, exceedingly complex; aside from the standing committees reporting to Frutkin and Newell, there was a special studies group within the PCG and a "synthesis" group of top headquarters officials within the PSG. The nomenclature and the process it tried to describe were both cumbersome, and early in 1969 the system was revamped and streamlined. Finally, Newell, Frutkin, and the chairmen of the working groups hesitated before two quite different courses. They could outline the programs they considered intrinsically desirable at whatever cost, or they could anticipate the sort of budget that the Executive Office and Congress would accept and design programs that could be managed within the lower budgets of the 1970s. Given the political atmosphere during the last two years of the Johnson administration, the problem, it turned out, was for NASA to keep what it already had rather than to make a completely fresh start.

The End of a Decade—Report of the President's Space Task Group, October 1968–October 1969

At a White House press conference on 16 September 1968, James Webb announced his resignation as NASA Administrator, effective 7 October, his 62d birthday. After nearly eight years directing the space program, he was leaving to pursue interests in education and urban affairs and also to smooth the transition to the next administration.* As President, Nixon would certainly want his own

*Another version of the circumstances behind Webb's resignation is heard inside NASA. In a meeting with the President, he sought to restore various budget cuts and threatened to resign unless he had his way. At this, Johnson called in the White House press corps to announce that Mr. Webb had something to say, whereupon Webb announced that he was leaving NASA.

man; Humphrey would necessarily want someone else as well. Webb left the agency at a time when NASA was making measurable progress toward the lunar landing but with few approved programs beyond it and with the design of Apollo Applications still in doubt. Webb's prognosis for the space program was almost grim:

> I am not satisfied with the program. I am not satisfied that we as a nation have not been able to go forward to achieve a first position in space. What this really means is that we are going to be in second position for some time to come.[61]

In the summer of 1968 Apollo Applications was more than a year behind schedule, owing to cuts made by Congress—the authorized $253 million was eventually reduced to $150 million—and to the reprogramming of funds from Apollo Applications to Apollo. Reporting in July, the Thompson committee endorsed the concept of Apollo Applications but expressed serious reservations about its design that ranged from the planning of experiments to the absence of backup hardware to the "questionable nature" of the ATM experiment.[62] Webb's departure made a complex situation even more complicated. First as Acting Administrator and then, from March 1969, as Administrator, Paine's view of long-range planning was very different from Webb's. Paine wanted an ambitious post-Apollo program, specifically one that included a program of manned lunar exploration after the first landing; and he believed that a large, long-duration space station—something talked about but not acted on in NASA for almost a decade—must be on the agenda.

Between October 1968 and June 1969 the NASA planning apparatus creaked into gear. To describe even briefly the plans and task force studies of the next year would take the discussion too far afield. Suffice it to say that Paine went far beyond Webb in planning for the future, undeterred by the practical difficulties in getting the White House to make funding available. He emphatically endorsed Mueller and Townes' proposal for extended manned exploration and even went beyond them. In December 1968 President-elect Nixon appointed Townes to chair a special task force to consider the space program over the next two decades. The Townes report, which was not released by the White House, did in fact call for a vigorous, multifaceted program, although it disapproved of any commitment to a large orbiting space station.[63] Paine impatiently dismissed what he saw as the report's aversion to the word "commitment"; those who had drafted it, including Seamans, did not wish to "commit" the nation to anything. To this, Paine replied that while he could understand the reluctance to make commitments, he could not sympathize with it. The great value of Apollo was that it "gave more meaning to the space program because people identify more readily with men than with machines." And he continued:

> We have been frustrated too long by a negativism that says hold back, be cautious, take no risks, do less than you are capable of doing. I submit that no perceptive student of the history of social progress doubts that we will establish a large laboratory in earth orbit, that we will

> provide a practical system for the frequent transfer of men and supplies to and from such a laboratory, that we will continue to send men to the Moon, and that eventually we will send men to the planets. If this is true, now is the time to say so. . . . We in NASA are fully conscious of practical limitations. . . . In the light of these considerations, we can be sensible and moderate about our requests for resources—*but we must know where we are going.*[64]

By early 1969 two groups in addition to PSG were weaving the fabric of NASA planning. Paine was meeting with his program and center directors to draft a specific plan for a follow-on to the first lunar landing, which was scheduled for July. Mueller and his staff, assisted by Bellcomm, were preparing their version of the shape of things to come. They had one great advantage over the members of PSG and its working groups: they knew (or thought they knew) where they were going. Mueller wanted both the space station and a low-cost transportation system. He saw the station as a logical and necessary step in a national space program, as a way station to the moon, as practice for planetary missions, and a step in reduction in the costs of space operations."[65] The transportation system would have all the virtues of economy, plus the added virtue of changing the role of ground support from one of "being . . . the senior partner in the operation into a truly supporting role where it handles those things that require external coordination rather than internal operations."[66]

Almost as soon as Paine became Acting Administrator, he endorsed Mueller's plan for an orbital space station. In May 1969 Paine set up two task forces: one, headed by Charles Mathews, Mueller's deputy, to examine the concept of a manned space station in permanent Earth orbit; the other, headed by Mueller, to study the space shuttle, a low-cost transportation system for supplying the space station. Then on 22 July, two days after the Apollo 11 landing, Mueller announced that NASA was switching from a "wet" to a "dry" workshop, that is, an unfueled S–IVB outfitted on the ground and launched by a Saturn V. There were several reasons for this change: the cancelation for budgetary reasons of MOL on 10 June, which ended the debate over wasteful duplication; the knowledge of OMSF officials that Saturn Vs would be available for Apollo Applications after the lunar landing; finally, the conclusion of Mueller that, with the cuts in the 1970 budget, NASA would no longer be able to support the wet workshop schedule with the funds available.[67] As one official put it,

> We decided that we had no choice. . . . Obviously the Saturn-5 costs will be in excess of the Saturn IB costs. But you will see the program that we have here is one that predicates a space station and space tug coming up together. . . . one of the forcing functions, in addition to the dollars, was the fact that the weight of the workshop had been growing with time. . . . It is a good illustration of what happens when you put a program in a holding pattern. . . . And we have just recently gone out of that holding pattern and are now hopeful that we will get approval to go forward with this dry workshop and to move out and finish the job.[68]

All this time Newell had been trying to persuade headquarters and center officials to produce a long-range plan. What had been the "Synthesis Group" of the previous planning cycle became the Planning Steering Group; what went by that name in 1968 was now the Planning Review Committee and included the program and center directors; while the working groups, renamed planning panels, were "to guide the planning activity" but "not attempt to do all the planning within an assigned category."[69] The flaws in the earlier planning structure only repeated themselves in 1969. There was the same inability of PSG to represent itself as spokesman for the entire agency, the same lack of adequate staff support, and apparently the conviction of some members of the planning panels that drafting an integrated plan was a futile exercise.

These difficulties were compounded by the unchecked decline in the NASA budget and by President Nixon's establishment in February 1969 of a Space Task Group (STG) to draft an overall plan for the next decade of the U.S. space program. The STG, chaired by Vice President Spiro Agnew, included Robert Seamans, who became Secretary of the Air Force that February; Thomas Paine; and Lee DuBridge, the President's Science Advisor. The existence of a high-level task force outside NASA meant that internal NASA planning would be done mostly in terms of what that task force found acceptable. In effect, planning within the agency proceeded along paths that alternately converged and moved apart. The various planning groups were drafting programs that were intrinsically desirable for NASA; they were thinking in terms of programs that were likely to be approved given current and projected funding levels; and they assembled the kind of program that could be sold to the STG. In the end, the STG represented a partial victory of the views of Paine and Mueller.[70] In its September 1969 report to the President, the STG recommended a balanced program of manned and unmanned space exploration and singled out as a primary goal a manned Mars mission before the end of the century. This, it will be recalled, had been Mueller's proposal for a long-term objective to succeed Apollo; but the idea had remained dormant virtually until the launch of Apollo 11, when Vice President Agnew had advanced what he called "a simple, ambitious, optimistic goal."[71] This was all that Mueller, von Braun, and Paine had needed and this goal, expanded into a plan of impressive scope, became the cornerstone of the STG report.

In addition, the STG sketched three possible NASA programs at three different funding levels:

1. A manned Mars mission by the mid-1980s; an orbiting lunar station; a fifty-man Earth-orbiting space base. Funding would rise from $4 billion in FY 1970 to $8–$10 billion in 1980.[72]
2. Mars mission in 1986; $8 billion maximum in early 1980s.
3. Initial development of space station and reusable shuttles, as in the first two options, but deferral of decision on Mars landing date, while maintaining goal of a landing at some point after 1980 but before the end of the century. The concurrent development of the shuttle and the space station would call for a rise to $5.7 billion in spending by 1976; if they were developed serially, funding would rise to $4–$5 billion.

For all the boldness of its planning, the STG had no power to commit the nation to anything. It was merely a statement of alternatives, like the NASA reports to the STG or the various PSAC and Space Science Board reports of 1965–1967; and it pointedly avoided setting a specific date for a manned mission to Mars. In the event, it was as much as Paine could do to hold on to what the agency already had. Throughout 1969 NASA continued to lay off employees at the centers, and at the end of the year Paine announced the closing of the Electronics Research Center, even as work on the unfinished $60 million complex proceeded. By that time it was becoming apparent that, as one journalist wrote, there would be "no set goal for landing men on Mars, no plan to colonize the moon and no sudden push to orbit a permanent manned space station above the earth in the next five years."[73] The most ambitious goals of the STG report were tacitly dropped; Nixon's message of 7 March 1970, which was an endorsement of the third and least expensive of the STG options, made no mention of a Mars landing. The result of four years of studies and long-range planning was one "dry" orbital workshop launched in May 1973, four years behind schedule; three "visits" to the workshop by astronaut crews; and the commitment by President Nixon in January 1972 that a reusable space shuttle would be built. Strictly speaking, there was no post-Apollo space program. Instead, there were discrete programs, some of which, like the shuttle and Skylab, were what NASA managed to salvage from the manned programs of the 1960s.

THE ADEQUACY OF NASA PLANNING—INSTITUTIONAL CONSIDERATIONS

A summary account of NASA planning brings out its extreme complexity, the mixture of technical and administrative considerations that guided it, and the inability of NASA planners to design a plan around which the entire agency could rally. This concluding section concentrates on three aspects of NASA planning: how and by whom it was done, how well it succeeded, and the rather puzzling lack of attention paid by NASA officials to the administrative consequences of substantive programs.

Recall that in the 1960s there were at least four planning cycles, the last two of which overlapped. In the early 1960s NASA prepared and then dropped a formal long-range plan. This was followed by the Future Programs Task Group of 1964–1965, the various special studies and task forces directed by OMSF and OSSA, and the PSG/PCG planning exercises of 1968–1969. Having said this, were there any features common to all of NASA planning? The evidence suggests there were. NASA planning was additive rather than synthetic; that is, every agency plan tended to be the sum of its parts, not an integrated whole. Most planning, and almost all that mattered, was carried out by the centers and program offices, not by headquarters staff offices reporting to the Administrator. There was a persistent tension in the plans drafted by the program offices and agency task forces between the technically feasible and the politically acceptable.

No plan had any chance of success until it was acceptable to the NASA Administrator, the Congress, and the White House. Lacking a rigorous analysis of the costs and benefits of each plan, NASA officials below the level of the Office of the Administrator relied on the technically feasible. And "feasibility" means only that something is possible, not that the method or program is the most effective means of accomplishing a given end. As shown, even the OMSF center directors were sceptical of the design of the ATM and its location on the lunar module.

What complicated the job of planning was the confusion between an "integrated" and a "balanced" program in the various reports and studies dealing with post-Apollo planning. The latter term was almost always used by those who attacked, as well as those who defended, NASA policy. The Space Science Board, PSAC, the Space Task Group, and the Townes committee all believed that what they proposed struck the proper balance between manned and unmanned programs, or lunar-planetary exploration and Earth-orbital applications satellites. Yet Webb, at least, was prepared to argue that NASA already had a balanced program within the funding authorized. The concept of a balanced program had meaning only in terms of some uniform standard to which all could refer and, lacking which, could be used to advocate whatever some official or advisory body considered desirable.

In theory, an integrated plan could be defined as the "framework that would meld many separate program elements into a coherent whole."[74] Interpreted this way, the term was ambiguous. All too often, NASA officials tended to confuse means with ends; the space station was treated as a "mission" when it was only a "capability." In an agency that was no longer organized around one overriding mission, the proposal to design an unmanned interplanetary probe could be regarded from two quite different viewpoints: either as preliminary to a manned mission, or as an end in itself. The difficulties in drafting an integrated plan were part of the failure to consider what such a plan would imply for the organization and management of NASA. For the moment, one might distinguish between the short- and long-term difficulties of drafting such a plan. At the end of the 1969 planning cycle, Newell wrote a report to serve as a kind of balance sheet of the strengths and weaknesses of NASA planning. He was remarkably frank about the difficulties of getting all the agency divisions to participate. He noted that there was not enough center participation; that the scope of the planning task, added to other responsibilities, had overworked many line officials; that some (unnamed) persons could not separate their roles as heads of centers and operating divisions from their agencywide responsibilities within PSG; finally, that fundamental conflicts over program priorities between OSSA and OMSF had been aggravated by impending budgetary cutbacks.[75] None of this should have been surprising. The decentralized structure of NASA was designed to carry out the Apollo mission, but it was not calculated to lead to integrated planning. Precisely because manned spaceflight took so large a portion of the agency's budget and manpower, planning tended to be mostly in terms of devising a sequel to Apollo or moving as far from it as possible. It is also worth noting that the very same problems that

Newell cited in getting the centers and headquarters to work together had been anticipated in the problems that OMSF had working with *its* operating divisions. What Seamans singled out as the chief faults in OMSF planning in the summer of 1967 were virtually identical to those discussed by Newell over two years later:

> The apparent absence of an agreed upon base underlying estimates and assumptions; the overly centralized direction to planning that forbids candid review and analysis of meaningful alternatives by providing only one program view for consideration; and an apparent lack of Center participation in the key elements of the planning process that deal with program objectives and realistic possibilities of contributing to their achievement. Above all, there appears to be a lack of candid communication within OMSF and between OMSF and other organizational elements of NASA that frustrates the possibility of developing and implementing the best total Agency program under the varying conditions that we must face.[76]

It was this lack of communication between agency divisions that made the long-term success of any planning exercise doubtful. In addition, there was no authoritative voice to speak for the agency. PSG and its panels might have evolved into a kind of standing committee for agency planning, but, before this happened, their role was preempted by OMSF assisted by Bellcomm. There is also evidence that some officials would not or perhaps could not put all their cards on the table. Adequate planning requires that the planners be kept fully informed about the organization's resources. But, as Newell observed,

> We found that some of the centers would not discuss the question of their staffing because they were afraid that if they indicated that they could take on a new project that they wanted to get, the availability of people would be signalled for headquarters to take those people away and put them somewhere else.[77]

The attitude of "we have nothing to gain by speaking up" meant, almost inevitably, that a proposal presented by a working group "had more certainties than challenges; each element could be shown to be feasible in terms of projected time and effort, but the total effect in terms of forward motion was pedestrian, even timid."[78]

Perhaps one can account for the failure of NASA planning by asking what an integrated plan would have involved. A successful plan would have related three pairs of variables: aeronautics to space technology, the rationale for unmanned systems to that for manned systems, and substantive programs to institutional changes. Nothing is more striking than the failure of the working groups or the Institutional Working Group of 1968 to recommend changes at the centers or changes in the relations between centers and headquarters that would have accompanied the programs they advocated. In essence, the NASA organization of 1969–1970 was almost unchanged from that of November 1963. The reader may object that this is putting the cart before the horse and that there could be no agreement on organization in the absence of agreement on programs. It is true that the 1961 reorganization succeeded the lunar landing decision. But the situation in 1968–1969 was fundamentally different in two respects: the agency no longer had an overriding mission comparable to Apollo, and in a period of declining budgets, the agency needed flexibility to adjust to changes. In fact, the phasedown of Apollo had raised questions that were basically administrative. What should be the division between advanced research and development at the centers? Should each center "belong" to a designated program office, or should emphasis on cross-servicing become more common? Should responsibility for applications remain with OSSA, be assigned to a separate program office, or be diffused throughout the agency? Should NASA maintain a separate Office of University Affairs despite the virtual demise of NASA support for university research? How should NASA avoid excessive dependence of DOD support?[79] In the area of manpower planning alone, some questions could not wait for new programs before they were resolved, questions such as the following: Should work be moved from centers that had too much to centers that had too little? Was there any way of defining "wasteful duplication" in a way that would eliminate unnecessary, overlapping facilities at the centers? And how could NASA best maintain its in-house competence and promote employees with management skills to more responsible positions?

In 1968–1969 no key official dared to discuss publicly the organizational shifts that a post-Apollo program would entail, although task forces like the one that wrote the 1966 Hjornevik report had already done some of the necessary thinking. Organizational structure does matter, even if it only ratifies power relations that already exist. The restructuring of center-headquarters relations was potentially the most explosive issue facing NASA management. A major reorganization could easily have torn NASA apart, since almost certainly it would have meant that some centers would have gained at the expense of others.

Although no official discussed the scope of organizational change publicly, a few had ideas on what NASA ought to become. Mueller, for instance, proposed a restructuring of NASA that would have left the agency, in organizational terms, where it had been before 1961.[80] He proposed a stricter demarcation between research centers like Langley, development centers like Marshall, and operational centers like KSC. In view of the availability of manpower at JPL and Marshall, he suggested the transfer of development projects to these installations. He went further in advocating clearer statements of roles and missions for the centers, the withdrawal of research centers from project management, the separation of research functions from development and contract administration at the research laboratories, the creation of a separate headquarters office to manage projects once they became "operational," and the delegation of responsibility for planning to the program offices, with a separate policy staff for general guidance. Finally, he urged that officials recognize that NASA's competence was in applied, not basic, research and that NASA should rely on universities for the latter. In effect, Mueller proposed a radical simplification of the NASA organization at a time when there was no consensus on a post-Apollo organization. Some of his proposals, like the one for an "Office of Operations," were workable. As one official observed at the end of 1969,

> At some point . . . we will be faced with the need for 24-hour-a-day, 365-day-a-year operations with several manned and unmanned space vehicles in operation at the same time. This will mean greatly expanding and integrating launch and mission control capability on one hand, and simplifying and cost cutting of systems on the other.
> . . . At some point we will need to give serious consideration to a total operations organization here in Headquarters to manage an agency-wide operations program.[81]

On the other hand, an attempt to work out a strict division of labor between the centers would have been fraught with risk, especially if a center's original reason for being should end. Also, as shown, some of the older NACA centers like Langley welcomed the assignment of flight projects because development work generated new research problems for the center's laboratories. The truth seems to be that no center could survive simply as a job shop. As Marshall officials explained to the Hjornevik task force,

> A Center must have a central role and mission around which it builds its competence and achieves its place in the world.
> With a central role and mission firmly established and operating, a Center can take on related activities to fill in peaks and valleys in its workload, even working for other Centers, if necessary.[82]

In 1969 the issue of the reorganization of NASA was simply too divisive to be raised. Yet changes in organization had to accompany—and in some cases were a precondition for—a functioning agency.

In sum, NASA failed to produce an integrated plan, either as a future course of action or as a means of adjusting to the actual funding levels authorized by Congress. Yet there is evidence that a few centers were able to plan successfully, even in the absence of guidance from headquarters or knowledge by top management that anything out of the ordinary was happening.[83] The evidence is fragmentary; successful planning at Goddard or Langley was not part of any agencywide plan, was as much a response to the logic of current programs as it was to funding cutbacks, and has to be inferred from scattered documents. At a center like Goddard, which had eighteen ongoing projects in 1971, the emphasis was on plotting manpower requirements in order to maintain balance between the projects. All NASA center directors had broad discretionary powers; a director had the authority to control personnel assignments, to ask for more people if necessary, and to reprogram funds from one research task area to another within the same research subprogram. This flexibility is the key to understanding how a center like Goddard could cope with its responsibilities for developing unmanned Earth-orbital satellites, for managing NASA's data-reduction network, and for dealing with the growth and complexity of a new generation of spacecraft. As an example, consider the growth in complexity of the Orbiting Solar Observatories (OSO), the first of which was launched in 1962. By 1971 the OSO had evolved into a very large, very complicated orbiting laboratory: It had more than tripled in total weight, had greatly increased its relative pointing accuracy, and returned a much larger volume of data. As one center official remarked,

> Scientists no longer are satisfied with a static experiment and wish to perform as dynamic an experiment as possible. For example, the first OSO's were capable of only photographing the entire solar disk. Now the scientists want to examine specific portions of the solar disk of interest to them.[84]

Center management developed the ability to move employees from one project to another, to prevent an imbalance in the mix of skills at the centers, and to reduce or eliminate manpower in areas that no longer demanded top priority. This was not so much planning in the PSG sense, as it was adaptation to a tight budget, stricter personnel ceilings, and the perceived need (as of 1971) for a new in-house flight project that would have to be managed within the resources available. Not that Goddard's experience could be repeated elsewhere; the center was unique for its mixture of large and small flight projects, the coordination of science and engineering disciplines with those responsible for managing NASA tracking networks, and the ability of its project managers to perform in-house work that other centers usually contracted out. But it was precisely this kind of restructuring at the field level that represented the most successful planning within NASA at the end of the 1960s.

Chapter 10

Summary Conclusions

The leading premise of this book is that NASA was (and is) an organization, not a specific mission. The space agency was created two-and-a-half years before President Kennedy made the decision to commit the United States to a lunar landing, and it was still in business the day after Neil Armstrong and Buzz Aldrin touched down in the Sea of Tranquillity. Once one concedes that Apollo marked a rare convergence of technology and political support, one is still as far as ever from knowing the institutional elements that were characteristic of the space program and that would persist beyond Apollo. NASA's remarkable success in managing its programs depended on the ability of the agency's top officials to enunciate goals, to maintain good relations with the White House and Congress, to shape the agency from within, and to delegate to the program offices and centers the authority they needed to get the job done.

In 1961 NASA was a new organization in a state of flux. When Webb and Seamans appeared on the scene, NASA was a loosely structured agency whose field centers worked in relative isolation from each other and from headquarters. The lunar landing mission demanded much greater coordination—and for the time being, greater centralization—than had been the case. One of the most important aspects of the Apollo program was the speed with which the crucial administrative and program decisions were made and the major prime contracts awarded. Except for the decision to go to all-up testing, the major Apollo program decisions were made between August 1961 and July 1962. Had they been stretched over a longer period, it seems unlikely that they would have received the support that they did. A comparison between the establishment of the Manned Spacecraft Center (MSC) and the Electronics Research Center (ERC) brings this out. NASA announced the selection of Houston as the MSC site after a brief survey. Yet the creation of the center generated powerful political support; the site itself was well located in relation to Michoud, Marshall, and the Cape; and the reasons given for establishing a new center were justified in relation to the Apollo mission. In contrast, almost two years elapsed between the decision to establish the ERC and its formal establishment. There was no such consensus as existed in the case of MSC; NASA could not convince Congress or the public that a capability in electronics research was as vital to the agency as one to develop the Apollo spacecraft. The point is that the agency's top officials made the important decisions while there was time to do so. The 1961 reorganization had to be reversed two years later, but it gave NASA management the opportunity to bring the centers under tighter control than before.

Another element in the success of the NASA organization was flexibility: flexibility for the Administrator to appoint to excepted positions, to award major R&D contracts without competitive bidding, to reprogram within appropriation accounts and to transfer between them, to devise and administer a custom-tailored entrance examination, and the like. Examples such as these represent flexibility within the system, not a departure from it; variances from the norm were allowed by Congress, the Bureau of the Budget, and the Civil Service Commission. This flexibility allowed for that "free play of the joints" without which institutional rigor mortis sets in. The use of excepted positions, for example, served not only to retain employees within the organization but also to bring in new blood and to expose NASA to outside influences. Similarly, without the authority to negotiate major contracts noncompetitively, it is unlikely that the lunar landing would have occurred on schedule. Indeed, this authority was probably more important for NASA than the introduction of incentive provisions in 1962. As shown, incentives were difficult to administer: they required a great deal of manpower and paperwork, the criteria for incentive payments were hard to pin down, and a contradiction was inherent in fixing targets for changing programs. NASA management might well have awarded development contracts without adding incentive provisions. But it is hard to imagine Gemini, Apollo, or Nimbus becoming operational had the agency been bound by competitive bidding or other rules that would have constrained its ability to choose its sources. The Apollo engineering support contracts were good examples of the agency's freedom in this respect. The TIE contract began as a letter contract and so remained for over a year, until NASA and Boeing negotiated the definitive terms. In this and other cases, the flexibility available to NASA depended on congressional willingness to tolerate practices that the legislature might have disallowed elsewhere.

Similar flexibility extended to other sectors. In the period under investigation, NASA had no formal, agencywide, long-range plan; no general advisory committee, such as the one established for the Atomic Energy Commission; no inspector-general, chief scientist, or chief engineer; no directorate for managing launch support and tracking and data acquisition together; no central planning staff attached to the Office of the Administrator. Webb explicitly rejected a proposal to create a general advisory committee of outside scientists. He and other NASA officials also opposed a congressional bill to create an "Inspector of Programs and Operations" for NASA because the legislation would have involved assigning an already limited number of personnel to another overhead function and would have created a suspicion among NASA engineers that their independence was being restricted. Also, senior officials were understandably reluctant to have people looking over their shoulders and questioning their programs. These functions were handled in other ways. Moreover, the absence of a plan or general advisory committee rescued the agency from becoming captive to policies that might cease to be relevant.

To maintain flexibility and to adapt the agency to change, reorganizations were frequent: in 1961, 1963, 1965, and 1967. This policy of calculated change had two purposes. Top management was unwilling to be rigidly bound by its own past policies. More important, each reorganization went beyond simple corrections—to improve communications between decision making and supporting staff or to free the centers from unneeded supervision—but was designed to turn the agency around from one set of programs to those of a quite different sort. NASA was vulnerable: first, because it had to stake its claim to territory of its own, rather than becoming (as its predecessor agency, the National Advisory Committee for Aeronautics, had become) a supporting arm of the military services or a supervisory agency with a small in-house staff and contractor-operated facilities, like the Atomic Energy Commission; second, because, as Raymond Bauer and others have noted, the civilian space program is discretionary. "We do not *need* to do it, in the same imperative sense that we believe we need to be militarily armed."[1] NASA's vulnerability was accentuated by the special oversight exercised by Congress. NASA had to obtain authorizing legislation before appropriations could be voted, keep the congressional committees "fully and completely informed" of pending action, and "come into agreement" with the legislative committees for certain kinds of reprogramming.[2] During the 1960s top NASA officials had to be ready to change when change was imperative and to refuse to accept organizational forms as important beyond the goals they might serve.

NASA managers saw their responsibilities in political terms and took it upon themselves to justify NASA where it mattered most: to the President, to the Bureau of the Budget, whose fiscal authorities set the terms of the annual budget request, and to Congress, which had the power to modify that request. What Sapolsky has said about Polaris surely applies here:

> Competitors had to be eliminated; reviewing agencies had to be outmaneuvered; congressmen . . . newspapermen and academicians had to be co-opted. Politics is a systemic requirement. What distinguishes programs in government is not that some play politics and others do not, but, rather, that some are better at it than others.[3]

NASA would describe a goal within the broader mission: put a communications satellite in synchronous orbit, or develop a manned spacecraft to soft-land on the Moon and a vehicle with liquid-hydrogen upper stages to launch it. But actual development involved far more than the finding that the job could be done. The technical problems—say, of negotiating the prime contracts or fitting schedules to costs—had political dimensions, owing to the requirement that NASA submit its programs to Congress for annual authorization. Also, important development concepts would receive very little support either from Congress or the user community unless they could be shown to work. Thus NASA had to choose between pursuing its own programs or "seeking development funding without having the backing of other agencies who [might] well utilize the emerging capability in time."[4]

Previous chapters have enumerated case after case in which NASA asserted its organizational independence, in no case more so than its relations with the military. The history of NASA from its establishment to 1963 can be charted in terms of NASA's ability to design its programs, procure its hardware, and support its spacecraft without overt interference from the military. The transfer of JPL and the von Braun team to NASA, the Webb-Gilpatric memorandum of understanding, President Kennedy's decision to assign the lunar mission to a civilian agency, and the Gemini agreement represent stages by which NASA asserted its determination to run the agency as its officials considered necessary. Not that relations between NASA and DOD can be easily categorized. Although chapter 8 classifies them as support, coordination, and rivalry, some programs did not fit neatly into any category; others, like Gemini, tended to become joint programs over time; while a program like MOL was in some ways competitive with Apollo, although the former relied heavily on NASA technology and ground support. Nevertheless, without a strong assertion of independence, NASA would have become what the services anticipated on the eve of the Space Act—a research agency supporting military projects.

The political strategies of NASA management were fourfold: to maintain NASA's independent status as an R&D agency; to curb outside interference by advisory and coordinating groups; to seek the approval of Congress for measures that the agency was about to take; and to limit NASA's support for other agencies, the better to concentrate its resources on Gemini and Apollo. NASA's relations with DOD are an example of the first type of strategy; its conflicts with PSAC, the Ramsey committee, and the Lunar and Planetary Missions Board are examples of the second; chapter 7 lists cases where NASA responded to the mood of Congress; while NASA's position on the supersonic transport reflects Webb and Dryden's desire not to strain NASA's resources to the limit. In addition, Webb dismantled the headquarters office that prepared the NASA Long-Range Plan, precisely to avoid premature commitment to projects beyond Apollo.

The account of NASA's relation with its advisory committees illustrates Webb's reasons for denying outside scientists the role they demanded. In rejecting the Ramsey committee's proposal for a general advisory committee, he did so specifically because such a committee would have fettered his power to run the agency and to defend the President's budget. In NASA, the advisory process worked effectively in designing experimental payloads or selecting principal investigators. Within rather narrow limits, advisory groups could do even more; thus the Astronomy Missions Board, established in November 1967, proposed what became the High Energy Astronomy Observatory and may have saved the Apollo Telescope Mount when NASA officials were seriously considering its cancelation.[5] But the Lunar and Planetary Missions Board and the Astronomy Missions Board, the principal attempts to create parallel advisory bodies for "strategic" scientific planning, were short lived. There were other flaws in the advisory process: the overlapping of jurisdictions, the lack of standard operating procedure, and the infrequent meetings of such groups as the Space Science Board. Yet it seems clear that the comparatively ineffective role of the missions boards owed something to management's reluctance to give their members the responsibilities they had come to expect. In general, then, NASA management was exceedingly wary of delegating authority to outside advisory groups.

As has been noted, NASA was remarkably decentralized for so large an agency. Perhaps it would be more accurate to say that programs such as Apollo or the Orbiting Observatories could not have been managed without the delegation of authority to the centers and JPL: authority to negotiate contracts up to a specified amount, to transfer funds between programs, to start new research tasks without seeking specific authorization, to shift manpower from one division to another, and so on. The strategy of senior management was to give the centers what they needed to get the job done but not so much that their work would lose its relevance to the agency's mission. During the 1960s the "research" and the "development" centers tended to become more like each other; centers reporting to one program office began to work for others; while those centers with a mixture of projects weathered the budget cuts at the end of the decade better than those with one or two large development programs that were phasing down. One of the most important byproducts of Apollo was the pressure it placed on the older centers to enter into development work, as with Langley's management of Lunar Orbiter, Lewis' of Centaur, and Ames' of Pioneer and Biosatellite. It was not so much a matter of pressure from headquarters as pressure from within the centers themselves that brought about this change. It should be added that many NACA engineers adjusted rapidly to the style of the new agency and rose to high positions within it: younger men like Edgar Cortright, Harold Finger, and George Low, as well as veterans like Abe Silverstein. One wonders if centers like Langley and Lewis really had much choice in taking on these programs. Had they remained research centers and nothing else, they would very likely have dwindled to insignificance. The centers had, so to speak, to latch onto the coattails of Apollo.

Several lessons may be derived from the history of NASA's efforts to delegate authority to the field installations. The first is the extent to which successful decentralization hinged on the development of new management devices for monitoring and control. The second is that reorganization in the field had to be matched by changes at headquarters. The third lesson is the most important of all.

> Decentralization is relative. In a large agency . . . there can be no such thing as complete centralization or decentralization . . . top management that has pursued a policy of centralization over the years may feel that minor relaxations of such a policy constitute a conversion to decentralization. Conversely, an organization accustomed to liberal delegations of authority and responsibility might view one or two decisions to withhold some further delegations as a return to centralization. . . .

> As more and more authority for a wide range of responsibilities is decentralized to the regions, the need for strong, centralized planning increases. This is particularly true in the management of the Agency's resources.[6]

Did NASA have this kind of centralized planning? George Mueller once summarized the relations between headquarters and at least some of the centers.

> One reason that the Manned Space Flight Centers are enthusiastic about the MSF organization is that MSF has delegated authority to the centers to the greatest extent possible. The centers have few "documented type" constraints placed upon them, but the constraints have been carefully chosen so that MSF has good control.[7]

This may have been adequate for Apollo, whose scope was such that headquarters, while it could coordinate, inspect, and develop standards, could hardly manage it directly. By 1968–1969 the same centers—Marshall especially—were in the early phases of a withdrawal process brought on by cuts in manpower and funds. The problem of new roles and missions could be alleviated by the centers, but only in part. Most of them were adaptable, and nearly all had gone through at least one reorganization in the late 1950s or early 1960s, moving from aeronautics research to launch vehicle development, as at Lewis, or from development work on guided missiles to lunar and planetary probes, as at JPL. By 1969 another cycle of reorganization was under way, as facilities that were no longer needed were closed, others were modified to accommodate new programs, while new facilities like the Lunar Receiving Laboratory at MSC were accomplished facts. Yet the more subtle changes in a center's mission could only occur gradually. And here, it seems, the failure of headquarters to draft a coherent long-range plan left the centers at a serious disadvantage. The advanced studies and task-force reports of 1964–1969 were no substitute for a NASA-wide plan. The difficulties in planning were real enough, as PCSG and the members of its working groups found out. There were too many planning groups, with little coordination among them; a lack of common interests among the centers; and the artificial forcing of the planning process by the creation of the President's Space Task Group. Still, top management might have done more to bring the process to some visible result inside the agency. In particular, not enough was done to relate substantive programs to an institutional framework.

NASA throve during the prosperous early 1960s and survived the cutbacks of the late 1960s because of four elements within, or conferred upon, the organization: administrative flexibility; the ability of senior management to play the political game on the Hill, at the White House, and before the public at large; the decentralization of program management to the field; and the timeliness with which the important decisions were made. Whether the success of NASA in managing large-scale endeavors affords a precedent for future Manhattan Projects or Apollos is another matter. Apollo will always stand as a monument to the ability of hundreds of thousands of men and women in widely dispersed locations to accomplish a program of staggering magnitude. But to the extent that

Apollo serves as a model for future "wars on poverty" or "wars on cancer," the lessons of the program will have been learnt badly. Whatever can be said about the NASA organization, there were no miraculous shortcuts to success, neither PERT nor incentive contracts nor project management as such. The problems of education, of transportation, of revitalizing the inner cities are—as has been said more than once—problems of kind rather than degree.[8] They are also problems of value. In all three cases, technology may contribute to a solution, but it cannot of itself define the problem. The space program enjoyed a favorable political environment, few direct competitors, and no vested interests. In organizational terms, the success of NASA depended on turning all three to advantage.

Notes

INTRODUCTION

[1] Herbert Simon, *Administrative Behavior* 2d ed. (New York: Free Press, 1957).
[2] Ibid., p. 79.
[3] For problems of administrative feedback, see the book of that name by Herbert Kaufman, with the collaboration of Michael Couzens (Washington, D.C.: The Brookings Institution, 1973).
[4] Personnel figures are excerpted from tables 3-1 and 2-4 of the *NASA Historical Data Book, 1956–1968* (NASA SP-4012, 1976).
[5] James E. Webb, *Space Age Management: The Large-Scale Approach,* McKinsey Foundation Lecture Series, Graduate School of Business, Columbia University (New York: McGraw-Hill, 1969), especially pp. 60–65.
[6] On this concept, see Richard L. Chapman et al., *Project Management in NASA* (NASA SP-324, 1973), p. 109.

CHAPTER 1

[1] D. Brainerd Holmes to Philip Drotning, 12 June 1963. Holmes was Director for Manned Space Flight, 1961–1963.
[2] Richard R. Nelson, *The Moon and the Ghetto: An Essay on Public Policy Analysis* (New York: W.W. Norton & Co., 1977), p. 144. Citation that follows is in ibid., p. 145.
[3] The concept of "key decisions" was suggested by L. L. Durisch and Robert E. Lowry, "The Scope and Content of Administration—The TVA Illustration," *Public Administration Review* 13 (Autumn 1953): 219–226.
[4] Section 203(b)(5) of the Space Act.
[5] Wernher von Braun, Director, Marshall Space Flight Center, briefing of House Science and Astronautics Committee, Subcommittee on Manned Space Flight, 24 Jan. 1964, in hearings on *1965 NASA Authorization,* 88th Cong., 2d sess. (1964), p. 803.
[6] Bureau of the Budget Bulletin 60–2, 21 Sept. 1959, and Circular A–76, 3 Mar. 1966.
[7] Robert L. Rosholt, *An Administrative History of NASA, 1958–1963* (NASA SP-4101, 1966), p. 259.
[8] Apollo Program Office, *NASA-Apollo Program Management,* vol. 1 (Dec. 1967), p. 2-8.
[9] "Dr. Mueller stressed the importance of a philosophical approach to meeting schedules which minimizes 'dead-end' testing and maximizes 'all-up systems flight tests,'" at 22d meeting, Manned Space Flight Management Council, 29 Oct. 1963. This is apparently the first official reference to the all-up concept.
[10] Webb, to Heads of all Headquarters Offices and Directors of Field Centers, "Office of the Administrator," 29 Dec. 1965.
[11] "Organization and Management," in "Preliminary History of NASA, 1963–1969," final ed. (15 Jan. 1969), p. VI-39. This unpublished manuscript was reproduced for internal NASA use after preparation for the White House Administrative Histories Project, with a preface by Acting Administrator Thomas O. Paine and a foreword by James E. Webb.

CHAPTER 2

[1] On NACA, see Senate Committee on Aeronautical and Space Sciences, *Policy Planning for Aeronautical Research and Development,* 89th Cong., 2d sess. (19 May 1966), pp. 38–43, 166–168.
[2] Arthur L. Levine, *The Future of the U.S. Space Program* (New York: Praeger, 1975), p. 14.
[3] *Policy Planning for Aeronautical Research and Development,* p. 166.
[4] Ibid., p. 42.
[5] Enid C. B. Schoettle, "The Establishment of NASA," in Sanford Lakoff, ed., *Knowledge and Power* (New York: Free Press, 1966), pp. 185–186.
[6] Michael H. Armacost, *The Politics of Weapons Innovation: The Thor-Jupiter Controversy* (New York: Columbia University Press, 1969), pp. 226–233.
[7] Schoettle, "The Establishment of NASA," p. 212.
[8] Ibid., p. 234.
[9] House Committee on Government Operations, Military Affairs Subcommittee, *Government Operations in Space,* 89th Cong., 1st sess. (4 June 1965), p. 40.
[10] Ibid., p. 53.
[11] The authoritative account of the lunar landing decision is John Logsdon, *The Decision to Go to the Moon* (Cambridge: MIT Press, 1970).
[12] Ibid., pp. 34–35.
[13] House Science and Astronautics Committee, *Defense Space Interests,* 87th Cong., 1st sess. (1961), p. 19.
[14] Levine, *Future of the U.S. Space Program,* p. 71. Emphasis in original.
[15] Logsdon, *Decision to Go to the Moon,* p. 62.
[16] On the reasons for selecting Houston, see Thomas P. Murphy, *Science, Geopolitics, and Federal Spending* (Lexington, Mass.: Heath Lexington, 1971), pp. 207–210.
[17] Minutes of 1st meeting, MSF Management Council, 21 Dec. 1961.
[18] The first part of the quotation is from a memo of 11 July to Wiesner from Donald Horning, chairman of the Space Vehicle Panel; the second part, from PSAC, *Report of the Space Vehicle Panel* (*On the Matter of Lunar Mission Mode Selection*), 26 July 1962, p. 15.
[19] Webb to Holmes, 7 Aug. 1962.
[20] *Astronautics and Aeronautics, 1966* (NASA SP–4007, 1967), p. 349.
[21] Erasmus H. Kloman, *Case-Study of the Surveyor Program* (unpublished study for National Academy of Public Administration, 1971), p. 110.
[22] House Science and Astronautics Committee, Subcommittee on NASA Oversight, *Investigation of Project Ranger,* 88th Cong., 2d sess. (1964), pp. 162–163, 165–166, 168–169.
[23] Ibid., p. 233.
[24] Webb and Dryden, revised draft of "Consideration of Supplemental Appropriation During FY 1963 for the Manned Lunar Landing Program," Jan. 1963.
[25] A summary of the Phillips report was prepared by the General Accounting Office at the request of Senator Margaret Chase Smith (R-Maine) in May 1967.
[26] See *Astronautics and Aeronautics, 1964* (NASA SP–4005, 1965), pp. 99–100.

CHAPTER 3

[1] Thus the NASA Management Instruction (NMI) describing the functions and responsibilities of the Associate Administrator for Organization and Management was issued on 14 Mar. 1968, exactly one year after the office was created.
[2] Oral History Exit Interview with Dr. Robert C. Seamans, Jr. (8, 20 May; 3 June 1968), p. 55.
[3] For pros and cons of study committees, see Anthony Downs, *Inside Bureaucracy* (Boston: Little, Brown and Co., 1967), pp. 207–208.
[4] Robert Rosholt, *An Administrative History of NASA, 1958–1963* (NASA SP–4101, 1966), p. 148. Hereafter cited as *Administrative History.*
[5] Ibid., p. 153.
[6] Ibid., p. 154.
[7] For a very detailed account of the Kimpton report, see ibid., pp. 161–169.
[8] See appendix C, "Biographical Sketches of Principal NASA Officials" for careers of Webb, Dryden, Seamans, et al.

[9] Statement of Albert Siepert in House Science and Astronautics Committee, *1963 NASA Authorization*, 87th Cong., 2d sess. (1962), pp. 269-270.
[10] The key papers are "A Summary Look at 'The Headquarters Organization Problem,'" 27 Feb. Summary in Rosholt, *Administrative History*, pp. 200-201; "Clarifying and Strengthening the Role of NASA's General Management," 14 Apr. Ibid., pp. 203-206; "Reappraising NASA's Organizational Structure to Achieve the Objectives of an Accelerated Program," 12 June. Ibid., pp. 209-210; and "Organizing to Achieve the Objectives of an Accelerated Civilian Space Program," 7 Aug. Ibid., pp. 218-221.
[11] Ibid., p. 205.
[12] Paper prepared by DeMarquis Wyatt, "Budget Formulation and Execution," 3 Mar. 1967, p. 1.
[13] In the November 1961 reorganization the functions of program review were divided among the new divisions of Technical Programs and Reliability and Quality Assurance.
[14] Rosholt, *Administrative History*, p. 221
[15] Statement of Raymond Bisplinghoff, OART Director, in House Science and Astronautics Committee, *1964 NASA Authorization*, 88th Cong., 1st sess. (1963), p. 1882.
[16] House Science and Astronautics Committee, *1965 NASA Authorization*, 88th Cong., 2d sess. (1964), p. 103.
[17] This was GMI 4-1-1 in the pre-1965 NASA coding system.
[18] Memorandum to Seamans through Director of Administration from Walter Hahn (Director, Management Analysis Division), "Inadequate and Conflicting Management Systems," 28 Sept. 1962.
[19] Transcript of remarks by Harry Goett at Seventh Semi-Annual Management Conference, Langley Research Center (4-5 Oct. 1962), p. 7.
[20] In NASA a "program" is defined as "a related series of undertakings which continue over a period of time (normally years), and which are designed to accomplish a broad scientific or technical goal. . . . Program responsibility is assigned to the appropriate Program Office within NASA."

A "project" is "within a program, an undertaking with a scheduled beginning and ending, which normally involves one of the following. . . .

"(1) The design, development and demonstration of [a] major advanced hardware item

"(2) The design, construction and operation of a new launch vehicle (and associated ground support) during its research and development phase

"(3) The construction and operation of one or more aeronautical or space vehicles and necessary ground support in order to accomplish a scientific or technical objective." NASA Management Instruction (NMI) 4-1-1, 8 Mar. 1963, pp. 1-2.

[21] Rosholt, *Administrative History*, p. 227. The Office of Tracking and Data Acquisition is counted as a program office, although it had no centers and no "programs."
[22] On the problem of relieving Seamans of part of his workload, see memorandum from Webb's executive assistant R. P. Young to Webb, 30 July 1962.
[23] House Science and Astronautics Committee, *1965 NASA Authorization*, p. 69.
[24] For an excellent survey of the NASA Technology Utilization Program, see Edward E. Furash, "The Problem of Technology Transfer," in Raymond A. Bauer and Kenneth J. Gergen, eds., *The Study of Policy Formation* (New York: Free Press, 1968), pp. 281-328.
[25] From transcript of Webb's briefing of the Administrator's Management Advisory Panel, 19 Apr. 1968, p. 28.
[26] The directive setting forth NASA policy concerning functional management is NPD 1240.1, 13 June 1966.
[27] Ibid., p. 2.
[28] Transcript of Management Advisory Panel meeting, 19 Apr. 1968, p. 23?
[29] The centers reported to the program offices as follows: Goddard, JPL, and Wallops Station to OSSA; Ames, Flight Research Center, Langley, Lewis, and the Electronics Research Center that NASA proposed for the FY 1964 budget to OART; Kennedy Space Center, Manned Spacecraft Center, and Marshall Space Flight Center to OMSF. For establishment of the Launch Operations Center, see Seamans exit interview, pp. 51-52.
[30] Ibid., p. 100.
[31] "Dr. Seamans stated this group would meet weekly to focus its attention on management problems, processes and procedures in order to insure that the new organization works effectively. Program matters would be discussed in detail at the monthly status reviews." From minutes of first Management Committee meeting, 14 Oct. 1963.
[32] Based on a memorandum from Wyatt to Edgar Cortright, Deputy Associate Administrator (OSSA), "Presentation Formats, Associate Administrator's Monthly Program Meetings," 9 Dec. 1965.
[33] This is as good a place as any to sort out and explain the various titles of headquarters officials. The heads of the program offices were "Directors" from 1961 to 1963, when they became "Associate Administrators for _____." The Office of Tracking and Data Acquisition became a program office in December 1965. Following the 1963 reorganization, the heads of the offices reporting to Webb (e.g., Public Affairs, Legislative Affairs,

International Programs) became "Assistant Administrators for____." Following the 1963 reorganization, the heads of the offices reporting to Seamans (e.g., Industry Affairs, Defense Affairs, Programming, Administration) became "Deputy Associate Administrators," changed to "Assistant Administrators" in the 1965 reorganization. Although it appears in early organization charts, the office of "Associate Deputy Administrator" actually dates from 1965, when it was created for Willis Shapley. The Associate Deputy Administrator had general responsibility for external affairs, especially liaison with Congress, the Bureau of the Budget, and the Department of Defense. One of the most confusing titles was "Deputy Associate Administrator." In 1962–1963 there were two such officials, one for "Manned Space Flight Centers," the other for "Other than Manned Space Flight Centers." The 1963 reorganization replaced these with a single official who acted as Seamans' deputy. The Deputy Associate Administrator from 1964 to 1966, Earl Hilburn, had a number of responsibilities for procurement, liaison with the General Accounting Office, and as all-purpose troubleshooter. Hilburn was director of two task forces that investigated the 1964 Ranger 6 failure and the relation between costs and schedule slippages in major NASA programs. The position lapsed when Hilburn left NASA but was revived in the 1970s.

[34] See draft memorandum, 14 Nov. 1962, enlarging the scope of Office of Plans and Program Evaluation and giving its head special responsibility for evaluating current programs. "In this regard I [Webb?] believe we should reconsider foregoing revision of the long range plan for calendar year 1963 in order to apply maximum available effort to initiating the review and analysis outlined above."

On 13 March 1963 Webb wrote to Abe Hyatt, the office Director, that "there is no doubt that our short range planning needs increased emphasis, and at the same time should be given higher priority than updating the long range plan." In August Webb decided to disperse the functions of the Office of Plans and Program Evaluation among other headquarters divisions, and Hyatt left at the end of October.

[35] Webb to James Elliott, Director of Management Analysis (Office of Administration), 7 July 1965.

[36] This and the following paragraph are based on several internal memorandums, especially one from James Elliott to members of the NASA Management Committee, 20 May 1964, and a briefing memorandum for the Administrator, 5 May 1965.

[37] These included policy statements (NPDs), Management Instructions (NMIs), detailed handbooks (NHBs), statements of procurement procedures (NPCs), and temporary notices (NNs). Headquarters Management Instructions (HQMIs) and delegations of authority (HMDs) were added later.

[38] Published as NPC 107.

[39] According to Seamans, Webb "wanted to have a clear-cut outline of what every responsible person's job was and who they dealt with, and all this kind of thing—which is . . . a classical way of dealing with big organizations . . . but it's sometimes harder to visualize what you do in given circumstances if there are only word-type job descriptions." Seamans exit interview, p. 60.

[40] For origins of secretariat, see draft report of Adm. Rufus E. Rose (USN, Ret.), "Development and Establishment of the Executive Secretariat," 27 Jan. 1966.

[41] The plan for a secretariat was outlined by Jack Young in "Plan for Keeping the Members of General Management More Fully Informed," 2 Oct. 1963, which was revised by Seamans before being fowarded to Dryden and Webb.

[42] Interview with Lawrence Vogel, Director, Headquarters Administration, 13 Oct. 1976.

[43] There is a good description of the State Department secretariat in a "Report on Federal Secretariat Functions," prepared by NASA consultant J. S. Patterson and submitted 17 Aug. 1961.

[44] Source: Vogel interview. It must be stressed that Webb needed the secretariat to get on top of *internal* information and that he preferred part-time consultants like Gen. George Cabell (USAF, Ret.) or Ambassador Joseph C. Satterthwaite as contacts with other agencies such as the Central Intelligence Agency and the State Department.

[45] Memorandum from Webb to heads of all Headquarters Offices and Directors of Field Centers, "Office of the Administrator," 29 Dec. 1965. This memorandum incorporated many of the changes recommended in "The Office of the Administrator: Evolving Concepts and Practices," prepared by Jack Young and staff in Dec. 1965.

[46] Minutes of the "Special Meeting of the Deputy Administrator on Reorganization," 30 Dec. 1965. Seamans was appointed Deputy Administrator on an interim basis, since the Senate was not in session, and his appointment was routinely confirmed in Jan. 1966.

[47] See note 45 above. Vogel was both executive officer and executive secretary.

[48] This example is cited by Assistant to the Administrator, W. H. Close, "The Secretariat," 17 May 1967.

[49] Seamans exit interview, p. 79.

[50] See note 46 above.

[51] Briefing for Webb on Voyager program by Edgar Cortright, 8 Feb. 1967, pp. 82, 47.

[52] Ibid., pp. 82–83.

[53] Webb to Seamans, 5 Jan. 1967, and Webb to Finger, 6 Jan. 1967.

[54] *Astronautics and Aeronautics, 1967* (NASA SP-4008, 1968), p. 75.
[55] NMI 1130.1, "Role and Responsibilities—The Associate Administrator for Organization and Management," 14 Mar. 1968. See note 1 above.
[56] Transcript of Management Advisory Panel meeting, 19 Apr. 1968, pp. 41, 48–49.
[57] Webb memorandum, 27 Jan. 1968.
[58] Newell was *not* made Associate Administrator in anticipation of Seamans' departure; he was offered the position before Seamans announced his intention to leave. Newell to NASA Historian Eugene Emme, 20 Sept. 1968.
[59] T.E. Jenkins (Director, Program and Special Reports Division, Executive Secretariat) to Newell, "NASA Monthly Status Reviews in support of the NASA Management Council," 7 Jan. 1968.
[60] This office was originally created by Webb to enable Gen. William McKee (USAF, Ret.) to serve as a troubleshooter, and it consisted of little more than an office with a secretary. It was wound up shortly after McKee left NASA in 1965 to become the FAA Administrator.
[61] NMI 1156.15, 12 Feb. 1968.
[62] The first quotation is excerpted from Newell's memorandum to Directors of Headquarters Program and Staff Offices, 11 Mar. 1968; the second, from a memorandum of 4? Nov. 1968, "Regularly Scheduled Meetings Chaired or Attended by the Administrator." Newell's 11 Mar. memorandum incorporated the recommendations of an Ad Hoc Group on Project Status Reviews that reported on 1 Mar.
[63] Transcript of Management Advisory Panel Meeting, 19 Apr. 1968, pp. 28, 29.
[64] On the problem of communications within bureaus, see Downs, *Inside Bureaucracy*, chap. 10.
[65] Gen. Jacob E. Smart (USAF, Ret.) et al., "A Philosophy of Management for NASA," 23 June 1967, p. 1.
[66] Ibid., pp. 16–17.
[67] Leonard R. Sayles and Margaret K. Chandler, *Managing Large Systems: Organizations for the Future* (New York: Harper & Row, 1971), p. 173. Prof. Sayles, of the Columbia University Graduate School of Business, was appointed a special assistant to Webb in Sept. 1966 and was a "counsellor" to the Management Advisory Panel when it was created in 1968. Emphasis added.
[68] For the inspector-general concept, see memorandum from Charles G. Haynes, Director of Inspections (Office of Administration), 28 June 1966. He noted that the following headquarters offices and divisions had inspection functions: the Inspection Division, the Audit Division, and the Division of Management Analysis and Research, all in the Office of Administration; the Office of Programming; and the Office of Industry Affairs.

CHAPTER 4

[1] Report of Steering Group for Study of NASA Acquisition Process, *Management Study of NASA Acquisition Process*, June 1971, p. 6.
[2] *NASA Source Evaluation Board Manual* (NPC 402, Aug. 1964), p. 2-1.
[3] House Committee on Government Operations, Military Operations Subcommittee, *Government Procurement and Contracting, Part 2*, 91st Cong., 1st sess. (25–27 Mar. 1969), p. 505.
[4] Testimony of David E. Bell, Director, Bureau of the Budget, House Committee on Government Operations, Military Operations Subcommittee, *Systems Development and Management*, 87th Cong., 2d sess. (21 June 1962), p. 44.
[5] House Committee on Science and Astronautics, *Review of the Space Program*, 86th Cong., 2d sess. (1960), p. 400.
[6] On these institutions, see Dean Coddington and J. Gordon Milliken, "The Future of Federal Contract Research Centers," in Thomas P. Murphy, ed., *Science, Geopolitics, and Federal Spending* (Lexington, Mass.: Heath Lexington Books, 1971), pp. 87–110.
[7] Webb to Dryden and Seamans, 25 Oct. 1963. In congressional testimony, John Young, the NASA Director of Administration, stated that it was NASA policy not to create not-for-profit corporations. See House Committee on Government Operations, Military Operations Subcommittee, *Systems Development and Management—1963*, 88th Cong., 1st sess. (1963) pp. 214–215.
[8] In 1966, for example, 6 percent of RAND's $22 million budget was for work done under contract to NASA. *Armed Forces Management* (Feb. 1966), p. 71. Many RAND studies were commissioned by OMSF and the Apollo Program Office in support of long-range and contingency planning. The extent of NASA's use of "nonprofits" may be gauged by the fact that in 1964 RAND had contracts with NASA totaling $3.3 million, while MIT's Lincoln Laboratories had contracts totaling over $7 million. *Astronautics and Aeronautics, 1964*, p. 435.

[9] Interview with Kenneth Webster, Office of Assistant Associate Administrator for Center Operations (Systems Management), 31 Aug. 1976.

[10] Webster interview. See also NHB 2410.1, *Management Procedures for Automatic Data Processing Equipment,* July 1965. The annual reports to the Bureau of the Budget on utilization of ADP equipment were standardized in the Bureau's Circular A-55, 15 Nov. 1963.

[11] House Committee on Science and Astronautics, Subcommittee on Advanced Research and Technology, *1968 NASA Authorization,* 90th Cong., 1st sess. (1967), pp. 567-568.

[12] In 1969 the following centers were authorized to negotiate contracts up to $2.5 million: Ames, Langley, Lewis, Goddard, the Manned Spacecraft and Marshall centers, and the Space Nuclear Propulsion Office. Up to $1 million: Kennedy, the Headquarters Contracts Division, and the NASA Pasadena Office. Up to $500 000: the Flight Research Center and Wallops Station.

[13] *NASA Source Evaluation Board Manual,* p. 4-1.

[14] Clarence Danhof, *Government Contracting and Technological Change* (Washington, D.C.: The Brookings Institution, 1968), p. 95.

[15] This paragraph is based on an article by Robert B. Hall, "The Armed Services Procurement Act of 1947 Should Be Reformed," reprinted in House Committee on Government Operations, Military Operations Subcommittee, *Government Procurement and Contracting, Part 7* (22, 26-28 May 1969), pp. 2001-2015.

[16] Ibid., p. 2006.

[17] Robert L. Perry, "The Atlas, Thor, Titan, and Minuteman," in Eugene M. Emme, ed., *The History of Rocket Technology: Essays on Research, Development, and Utility* (Detroit: Wayne State University Press, 1964), p. 149.

[18] This turned out to be the case. It took the Thor only 3.5 years and the Atlas 5.2 years to go from program approval to first operational squadron, instead of the 6-8 years first projected. By comparison, it took the B-47 7.8 years and the B-52 9.4 years to attain operational capability. John Greenwood, "The Air Force Ballistic Missile and Space Program (1954-1974)," *Aerospace Historian* (Dec. 1974), 195. Quote is from Michael H. Armacost, *The Politics of Weapons Innovation: The Thor-Jupiter Controversy* (New York: Columbia University Press, 1969), p. 157.

[19] Armacost, *The Politics of Weapons Innovation,* p. 157.

[20] In 1958 Ramo-Wooldridge merged with Thompson Products to become TRW, Inc., while Space Technology Laboratories (STL), which had performed general systems engineering and technical direction for the Air Force, became a separate incorporated subsidiary. In 1960 the nonprofit Aerospace Corporation was established with a nucleus of STL personnel to free TRW/STL to compete for production contracts.

[21] Armacost, *The Politics of Weapons Innovation,* p. 159.

[22] Danhof, *Government Contracting and Technological Change,* pp. 50-51.

[23] Joseph Fernandez, *The Origin, Evolution, and Operation of the NASA Contractor Source Evaluation Board Process,* unpublished M.Sc. thesis (Massachusetts Institute of Technology, June 1966), p. 11. Emphasis in original.

[24] Ibid., pp. 12-13.

[25] For an account of the 1959 "production of documents" controversy, see Rosholt, *Administrative History,* pp. 99-102.

[26] Ibid., p. 257.

[27] See "Office of Procurement: Organization and Functions," July 1963.

[28] House Committee on Government Operations, *Government Procurement and Contracting, Part 2,* pp. 475-476. The justification for noncompetitive procurement was signed by Webb in Dec. 1967.

[29] House Committee on Science and Astronautics, *1964 NASA Authorization,* 88th Cong., 1st sess. (1963), p. 3020.

[30] According to the National Science Foundation, they supplied a 90-percent average share during fiscal years 1960-1966 and 85 percent during 1967-1969. *Astronautics and Aeronautics, 1968,* p. 333.

[31] Published as *Report to the President on Government Contracting for Research and Development,* S.Doc. 94, 87th Cong., 2nd sess., May 1962. This report, except for two brief omissions, is reprinted in its entirety in W. R. Nelson, ed., *The Politics of Science* (New York: Oxford University Press, 1968), pp. 193-220, from which the following excerpts are cited.

[32] Ibid., pp. 200, 201.

[33] Ibid., p. 216. For recommendations concerning R&D contracts, see pp. 209-210.

[34] For details of Salary Reform Act, see Danhof, *Government Contracting and Technological Change,* pp. 121-122; for Kennedy's memorandum of 2 May 1963, see House Committee on Government Operations, *Systems Development and Management—1963,* pp. 271-281.

[35] On these and other reforms in Defense management, see testimony of Director of Defense Research and

Engineering Harold Brown, in House Committee on Government Operations, *Systems Development and Management,* pp. 436–440, and Assistant Secretary of Defense (Installations and Logistics) Thomas D. Morris, in ibid., p. 551.

[36] House Committee on Science and Astronautics, *1964 NASA Authorization,* p. 463.

[37] Another catalyst for DOD and NASA reforms was the publication in 1962 of Peck and Scherer, *Weapons Acquisition Process: An Economic Analysis.* This was one of the first studies to demonstrate the inefficiencies of CPFF contracting. Peck and Scherer found an average cost production error of 220 percent in a sample of twelve CPFF programs. The study and its influence on NASA policy were discussed in a memorandum from Assistant Administrator for Industry Affairs Bernhardt Dorman to Harold Finger dated 18 Dec. 1967.

[38] NASA Circular 231, 29 May 1962. Subject: Special Procurement Study Reprinted in *1964 NASA Authorization,* pp. 1786–1787.

[39] Charles to Webb, 25 Feb. 1963. Subject: NASA Procurement. This memorandum summarizes Charles' 56-page report, "Recommendations Concerning NASA Procurement Policies," submitted at the same time. Two other reports by Charles were "Conversion from CPFF to CPIF," 7 Aug. 1963, and "Cost Reduction Incentives in Research and Development Contracts," 23 Aug. 1963.

[40] On Sept. 1962 circular, see Circular 242, 1 Sept. 1962. Subject: Use of Incentive Contracts. Reprinted in House Committee on Science and Astronautics, *1964 NASA Authorization,* pp. 3009–3011. For Nov. 1963 directive, see House Committee on Science and Astronautics, *1966 NASA Authorization,* 89th Cong., 1st sess. (1965), p. 387.

[41] Webb to James E. Underwood, 27 Sept. 1966. Webb was also a member of the Commission on Government Procurement from March 1972 to the completion of its report the following December.

[42] As justification for Electronics Research Center, see NASA report, "Role and Mission of the NASA Electronics Research Center," in Senate Committee on Aeronautical and Space Sciences, *1964 NASA Authorization,* 88th Cong., 1st sess. (1963), p. 1002. The entire report, at pp. 999–1009, is perhaps the most concise analysis of the rationale for maintaining a large in-house staff.

[43] *Report of the Survey Task Team for Study of Major Systems Contracts* (JPL: 10 Nov. 1965), p. 38.

[44] House Committee on Science and Astronautics, Subcommittee on Manned Space Flight, 88th Cong., 2d sess. (executive session, 4 Mar. 1964), pp. 627, 626.

[45] Testimony of Deputy Associate Administrator (OSSA) Edgar Cortright in House Committee on Science and Astronautics, *1965 NASA Authorization,* 88th Cong., 2d sess. (1964), pp. 1539–1540.

[46] Third draft of a memorandum from Executive Secretary Lawrence Vogel to Deputy Associate Administrator for Industry Affairs William Rieke, 2 Dec. 1965. Subject: Administrator's Selection of Contractors to Provide Support Services.

[47] This section is based on the following sources: "DOD Contract Administration Services Support Task Group Report," to George Mueller, 5 Feb. 1965; Paper, Clyde Bothmer, Office of Industry Affairs, to Rieke, 30 July 1965. Subject: The Future of Contract Administration in NASA; NASA, Office of the Executive Secretary (Program and Special Reports Division, 31 Oct. 1966), *Procurement Program,* pp. 32–33.

[48] Seamans to Mueller, 23 Sept. 1964.

[49] Memorandum, E. Z. Gray, Director, Advanced Manned Missions, 7 Apr. 1965. Subject: Component/System Interaction Problems.

[50] Statement of Webb in transcript of *Senate Hearing Dry Run* (8 June 1967), p. 6. This was a rehearsal involving Webb, Mueller, and Phillips for a hearing in executive session on the Apollo fire by the Senate Committee on Aeronautical and Space Sciences.

[51] See note 48 above.

[52] Webb to Seamans, 20 Oct. 1964. This is the source for indented quotations below.

[53] Sources: Rough notes and staff papers of joint cost and schedules validation team at Marshall Space Flight Center, June–July 1963; interview with James Elliott, Office of Management Planning, 5 Oct. 1976.

[54] Seamans to members of NASA Management Committee, 17 July 1964. Subject: Outline for Discussion—Probable Contributing Factors to Project Schedule Slippage.

[55] *First and Second Interim Reports to the Associate Administrator on Studies Relating to Management Effectiveness in Scheduling and Cost Estimating,* 15 Sept. 1964 and 15 Dec. 1964. The staff work underlying these reports was carried out by the Program Review, Resources Analysis, and Management Reports Divisions of the Office of Programming, with Thomas E. Jenkins as coordinator.

[56] *First Interim Report . . .* p. 26.

[57] See ibid., pp. 27–28, for specific recommendations.

[58] Phased project planning was also used in studies for the Advanced Orbiting Solar Observatory (canceled in December 1965), the Hypersonic Ramjet Experiment, and the 445-newton-thrust engine for Surveyor, Voyager, and the Manned Orbiting Research Laboratory. Cited by Bernard Maggin, "Phased Project

Planning," NASA Management Seminar, 12 Jan. 1966.
59 Senate Committee on Aeronautical and Space Sciences, *1966 NASA Authorization*, 89th Cong., 1st sess. (1965), p. 95.
60 NPD 7121.1, 28 Oct. 1965. Subject: Phased Project Planning.
61 Alain Enthoven and K. Wayne Smith, *How Much is Enough? Shaping the Defense Program, 1961–1969* (New York: Harper & Row, 1971), p. 240.
62 *Report of Commission on Government Procurement*, vol. 2 (Dec. 1972), p. 100, n. 11.
63 For DOD policy on program definition, see DOD Directive 3200.9, 1 July 1965. Subject: Initiation of Engineering and Operational Systems.
64 A personal service contract is one in which "an employer-employee relationship between the Government and contractor personnel is provided for in the contract, or actual practice in this respect leads to that conclusion." The U.S. Comptroller General and the Civil Service Commission, in decisions handed down in 1965 and 1967, ruled such contracts invalid. A contract for nonpersonal services "contemplates the furnishing of a service as an end product, rather than merely man-hours of effort. The contractor is actually independent, not merely a servant, employee or intermediate agent of the Government." For these definitions, see NASA Office of Programming, Program Reports Division, *Procurement Program* (27 Oct. 1964), p. 27.
65 House Committee on Government Operations, Special Studies Subcommittee, *A Cost Profile for Support Services*, 90th Cong., 2d sess. (23 Apr. 1968), p. 7. This was one of a series of hearings held by subcommittee chairman Porter Hardy, Jr. (D-Va.) in 1967 and 1968 on NASA contracting for support services.
66 These guidelines are in section 3, "Criteria for Contracting Out," in *NASA Policy and Procedures for Use of Contracts for Nonpersonal Services* (NPC 401, Apr. 1964), issued after reviews by the General Accounting Office and the Civil Service Commission disclosed that the method used at Goddard in hiring technical writers and typists violated the Civil Service Act and the 1949 Classification Act.
67 The relevant guidelines are in the Bureau's Bulletin 60–2 (21 Sept. 1959), which was superseded by Circular A–76 (3 Mar. 1966; revised, 30 Aug. 1967).
68 GAO Report B–133394, "Potential Savings Available Through Use of Civil Service Rather Than Contractor-Furnished Employees for Certain Support Services," June 1967.
69 Bernard Sisco, Deputy Assistant Director for Administration, Goddard Space Flight Center, to Carl Schrieber, NASA Office of Procurement, 12 Nov. 1964.
70 House Committee on Government Operations, *A Cost Profile for Support Services*, p. 6.
71 House Committee on Government Operations, Special Studies Subcommittee, *Support Service Contracts*, 90th Cong., 1st sess. (21 June 1967), p. 70.
72 However, the OMSF centers were permitted to use Boeing for "local support," for which the necessary funds would be transferred to Boeing's contract for the first stage of the Saturn V. Memorandum, Mueller to Paine, 9 July 1969. Subject: Phasedown of Boeing TIE Support . . . Following the First Successful Lunar Landing Mission.
73 Samuel Phillips to Mueller, 13 Dec. 1968. Subject: Future OMSF Engineering Requirements.
74 The discussion of the Bellcomm, General Electric, and Boeing TIE contracts is based on the following sources: inspection of pertinent files in Headquarters Contracting Office; interview with Alexander Lyman, NASA Office of Energy Affairs, 3 Dec. 1976; Apollo Program Office, "Apollo Program Office Experience with Engineering Support Contractors," 15 Sept. 1969; and Apollo Program Office, "Paper on the Boeing Technical Integration and Evaluation Contract . . . ," 1 Oct. 1968.
75 "Apollo . . . Experience with Engineering Support Contractors," p. 11.
76 This quotation and the Gemini-Apollo comparison are in ibid., p. A-2.
77 See, for example, House Committee on Science and Astronautics, *1964 NASA Authorization*, pp. 146, 376–377, 1126–1133 (Bellcomm) and 389–390, 1102–1107 (GE).
78 Ibid., p. 1130.
79 House Committee on Government Operations, Military Operations Subcommittee, *Avoiding Conflicts of Interest in Defense Contracting and Employment*, 88th Cong., 1st sess. (22 Nov. 1963), pp. 81–83. Restrictions on GE are in NASA Circular 280, 16 Apr. 1963. Subject: Restrictions on contracting with the General Electric Company where competitive advantage may exist. Reprinted in House Committee on Science and Astronautics, *1964 NASA Authorization*, pp. 3265–3266.
80 "Paper on Boeing TIE . . . ," p. 4.
81 Ibid., p. 8.
82 Ibid., pp. 6–7.
83 On a visit to the Manned Spacecraft Center in August 1968, Finger explained "that one of the reasons for selecting Boeing for the TIE contract was that North American Rockwell's interest in subcontracts with Boeing for the SST made Boeing less competitive with North American Rockwell than other large aerospace firms. [North American Aviation has merged with Rockwell Standard in September 1967.] Therefore, Boeing

was in a better position to step in to manage the Downey plant if such a drastic measure had been necessary to get the Apollo spacecraft program back on its feet after the Apollo 204 accident." Lawrence Vogel, memorandum for the record, "Mr. Finger's Visit to MSC to Review Boeing TIE Activities, 20 Aug. 1968." 8 Nov. 1968, p. 7.

[84] See "Paper on Boeing TIE . . . ," passim.

[85] Lawrence Vogel, memorandum for the record, 8 Nov. 1968. Emphasis added.

[86] *Astronautics and Aeronautics, 1971,* pp. 41–42.

[87] This is the charge made by H. L. Nieburg. "The so-called 'supporting role' of Bellcomm as a decision-making input may rather be a determining influence in the policy choices of NASA officials. . . . That this process is at work was revealed in the most important NASA technical decision: selection of the mode of flight for the manned lunar landing." H. L. Nieburg, *In the Name of Science,* revised ed. (Chicago: Quadrangle Books, 1970), p. 261.

[88] Courtney J. Brooks, James M. Grimwood, Loyd Swenson, Jr., *Chariots for Apollo* (Comment draft, Aug. 1976), p. 137.

[89] Lyman interview and memorandum, Webb to Mueller, 26 Sept. 1967. Subject: Procurement Plan for a Continuation of Systems Analysis, Study, Planning and Technical Support Performed by Bellcomm, Inc. under Contract NASW–417.

[90] "Apollo . . . Experience with Engineering Contractors," p. 1.

[91] Brooks et al., *Chariots for Apollo,* p. 152 and n.

[92] Gilruth to Mueller, 9 Jan. 1969. See also letters from von Braun, 21 Jan., and Kurt Debus, 14 Jan.

[93] House Committee on Government Operations, Special Studies Subcommittee, *Investigation of the Boeing-TIE Contract—Part 1,* 90th Cong., 2d sess. (15 July 1968), pp. 3, 6, 8.

[94] When the Panel on Government Laboratories of the President's Science Advisory Committee visited MSC in 1964, they could not "help contrasting the atmosphere in which NASA's Manned Spacecraft Center operates with that of the Air Force's Avionics Laboratory. While competent professionals populate both, the sense of mission in MSC is infinitely stronger. . . . Unlike some of the agencies previously treated, NASA has a strong line management organization for its technical effort. The NASA organization, furthermore, is relatively new and does not exhibit yet the 'aging' effects observed in older organizations." *Report of Panel on Government Laboratories of the President's Science Advisory Committee* (Jan. 1965), pp. 11, 21.

[95] Merton J. Peck and Frederick M. Scherer, *The Weapons Acquisition Process: An Economic Analysis* (Boston: Division of Research, Graduate School of Business Administration, Harvard University, 1962), pp. 56–57.

[96] Webb to Frank R. Hammill, Jr. (Counsel, House Committee on Science and Astronautics), 5 Apr. 1965.

[97] Thomas P. Murphy, *Science, Geopolitics, and Federal Spending,* table 6-14, pp. 183–185 and 182, 186.

[98] "Statement of the Administrator of NASA on Selection of a Contractor for the Saturn Stage S-II," 15 Sept. 1961, and covering letter from Webb to Seamans, 16 Oct. 1961.

[99] Peck and Scherer, *Weapons Acquisition Process,* p. 331, n. 13.

[100] Fernandez, *Origin . . . of the NASA . . . Source Evaluation Board Process,* pp. 15, 23. It would seem that the high cost barriers to entry into major systems development have given certain firms a lock on such programs. DOD figures on contract awards show that eighteen of twenty-five contractors in 1958 were still in the top bracket in 1969. *Report of Commission on Government Procurement* (Dec. 1972), 2:124, n. 20. NASA figures are more difficult to interpret because the ability of a contractor to remain in the top bracket year after year might owe less to its ability to compete for new contracts than for payments on major contracts already awarded, e.g., the Grumman contract for the lunar module. See *NASA Data Book,* tables 5-22 to 5-27.

[101] Wyatt to Hilburn, 15 June 1964. Subject: Source Evaluation Boards, Draft Manual of Procedures, Comments. The examples of overruns and slippages noted above are excerpted from this memorandum.

[102] This was one of the reasons for awarding RCA a contract for operating and maintaining two new tracking facilities. NASA wanted to write in a ceiling on overhead, the amount of the fixed fee, and the like; and RCA's response to these special provisions was the most satisfactory received. "Selection of Contractor for Operation, Maintenance, and Logistic Support of the New Data Acquisition Facilities near Fairbanks, Alaska and Rosman, North Carolina," 27 June 1963.

[103] Peck and Scherer, *Weapons Acquisition Process,* p. 377.

[104] Erasmus H. Kloman, "Case Study to the Lunar Orbiter Program," draft submitted to National Academy of Public Administration (June 1971), pp. 41–42, 70. One of the principal reasons for awarding North American Aviation rather than the Martin Company the Apollo command and service modules contract—although the SEB had given the latter a higher overall rating—was because of its outstanding performance in developing the X-15, F-86, and F-100. For excerpts from the SEB report, see Brooks et al., *Chariots for Apollo,* pp. 71–72.

[105] Eldon Taylor (Director, Program Review and Resources Management, OSSA) to Bernard Moritz (Acting Associate Administrator for Organization and Management), 20 May 1969.

[106] Finger to Phillip Whittaker (Assistant Administrator for Industry Affairs), 28 Jan. 1969.

[107] Herbert Kaufman, *The Limits of Organizational Change* (University of Alabama Press, 1971), pp. 33, 35.

[108] *Procurement Program* (31 Oct. 1966), p. 8.

[109] *Management of NASA Study of NASA Acquisition Process*, p. 25.

[110] Edward B. Roberts, "How the U.S. Buys Research," in David Allison, ed., *The R&D Game* (Cambridge, Mass.: MIT Press, 1969), pp. 292, 294. See same author's "Questioning the Cost/Effectiveness of the R&D Procurement Process," in M.C. Yovits et al., eds. *Research Program Effectiveness* (New York: Gordon and Breach, 1966), pp. 93–113, which was based on research supported by NASA Grant No. NaNSG 235–62.

[111] Roberts, "How the U.S. Buys Research," p. 289. In a study of forty-one Defense contracts, ranging from $100 000 to $8 million, and ten non-DOD (NASA?) awards, from $1 million to $40 million, Roberts found that "about 60 percent of the R&D awards were made on a sole-source basis—without *formal* competition." Ibid., p. 284.

[112] *Management Study of NASA Acquisition Process*, p. 6.

[113] Memorandum, Dorman to Finger, 18 Dec. 1967, and *Procurement Program* (31 Oct. 1966), p. 17. In FY 1966, ninety-two incentive contracts, totaling $4.3 billion, were cost-plus-incentive-fee; fifty-one ($447 million) were award fee; thirty-two ($222 million) were fixed-price incentives; and fifteen ($306 million) were mixed.

[114] Mueller said this at an executive session of an OMSF program review, 20 Apr. 1965. Transcript, p. 10.

[115] Dorman to Finger, 18 Dec. 1967.

[116] Mueller to Morton Henig (Assistant Director, Civil Division, GAO), 23 May 1968.

[117] See note 114 above, p. 10.

[118] Booz, Allen and Hamilton, Inc., *Study of the Effectiveness of NASA Incentive Contracts*, vol. 1. This study was done under NASA contract NASw–1277. The final report, on which the remainder of this section is based, was submitted on 5 Aug. 1966; a summary report was submitted on 15 Sept.

[119] The contracts (and the prime contractors) were as follows: Pioneer spacecraft, Orbiting Geophysical Observatories, and Follow-on Orbiting Geophysical Observatories (TRW Systems Group); Gemini spacecraft (McDonnell Aircraft); biosatellite spacecraft (General Electric, Re-entry Systems Department); Orbiting Astronomical Observatories (Grumman); Delta vehicles (Douglas Aircraft); Lunar Orbiter spacecraft (Boeing); instrumentation units and prototype guidance computer and data adapters (IBM Federal Systems Division); ST-124M stabilized platform (Bendix Corporation); crawler transporter for launch complex 39, KSC (Marion Power Shovel Company); Manned Spaceflight Tracking Network operation and maintenance (Bendix Field Engineering Corporation); base support services for KSC launch complex (Trans-World Airlines); support services for MSC (Brown & Root/Northrup).

[120] *Summary Report*, pp. 2–3.

[121] *Study of the Effectiveness of NASA Incentive Contracts*, p. 51.

[122] *Procurement Program* (31 Oct. 1966), p. 20.

[123] *Study of the Effectiveness of NASA Incentive Contracts*, p. 72.

[124] Sapolsky has noted the same contradiction in the development of weapons systems. "Unlike cost-plus contracts, the targets and their rankings in incentive contracts are supposedly fixed for the length of the contract and, thus, can reflect only the conditions that exist at the beginning of the development effort or that can be then anticipated. . . . Yet, unpredictable changes in political conditions affecting major weapon acquisitions seem to require constant alterations in project targets and their rankings. . . . It seems unrealistic to expect the development and procurement targets of major weapon systems . . . will remain fixed." Harvey Sapolsky, *The Polaris System Development*, p. 214.

[125] *Study of the Effectiveness of NASA Incentive Contracts*, pp. 80–94.

CHAPTER 5

[1] From 57 500 at the end of June 1961 to 115 500 one year later and to 218 000 one year after that. *NASA Data Book*, table 3-26.

[2] This is the figure given by Seamans for the third quarter (Jan.–Mar.) of FY 1966. House Science and Astronautics Committee, *1968 NASA Authorization*, 90th Cong., 1st sess. (1967), p. 111.

[3] NASA Personnel Division, *Personnel Division Report: The In-House Work Force*, Sept. 1969, p. 3. All figures are as of 30 June. The employment figures are divided between contractor and in-house employees as follows: 1966, 360 000 contractor and 36 000 in-house; 1967, 273 000 and 34 000; 1968, 235 000 and 33 000; 1969, 186 000 and 32 000. The 11-percent decline in the NASA work force from 1966 to 1969 conceals the variations between one center and another in personnel reductions.

[4] NPD 1240.1, "Functional Management," 13 June 1966.

[5] Memorandum, Ray Kline to members of NASA Personnel Management Review Committee, 21 Feb. 1968, "Consolidation of Comments on Items in the Civil Service Inspections Report," p. 2. These comments were omitted in the Committee progress report of Apr. 1968.

[6] The remainder of this and the whole of the next paragraph are based on a paper by Leonard Carulli, management analyst in the Organization and Management Planning Division, "Establishing and Filling Excepted and Super-Grade or Key Positions," 5 May 1967. The quotation immediately below is from p. 4.

[7] Ibid., p. 6. Adams is Mac Adams, who succeeded Raymond Bisplinghoff as Associate Administrator for Advanced Research and Technology in 1965. Holmes is Brainerd Holmes, Director of Manned Space Flight from 1961 to 1963. Harry Goett was fired as Director of Goddard in July 1965 in the wake of disagreement with general management over the proper amount of supervision of the center by headquarters. Goett thought that there was too much supervision, if not downright interference; Associate Administrator for Space Science Newell and Seamans, that in the existing external climate they could do no less.

[8] This section draws extensively on the notes and memorandums assembled by Howard N. Braithwaite, staff assistant to the NASA Executive Salary Committee from 1958 to 1967. Two items were particularly useful: "A Summary of Major Developments . . . ," Jan. 1967 (cited as "Summary"), and a paper addressed to Associate Deputy Administrator Willis Shapley, 23 Apr. 1968, titled "History of Super-Grade Positions, NACA/NASA" (cited as "Super-Grade Positions"). I would also like to thank Bill Lee, of the NASA Personnel Office, for making less mysterious the intricacies of NASA's use of excepted positions.

[9] Braithwaite, "Super-Grade Positions," p. 4. "P-8," on the old civil service professional scale, was equivalent to GS-15 on the new "general schedule."

[10] Ibid., pp. 4, 3. Italics and inverted commas omitted.

[11] Victor K. Heyman, "Government by Contract: Boon or Boner?" *Public Administration Review* 21 (Spring 1961): 63.

[12] Ibid.

[13] These were the positions from grade GS-16 and above that were actually *filled,* rather than simply authorized. There were 341 nonquota GS-16 positions, 355 excepted positions (out of 425), and 11 Public Law 313 positions for a total of 707 positions filled. One important point is that *all* nonquota positions were filled at the GS-16 level. As a matter of policy, NASA used its allotment of excepted positions to appoint at grades GS-17 and GS-18 in order to avoid having to justify such appointments to the Civil Service Commission.

[14] Braithwaite, "Summary," p. VII.

[15] Braithwaite, "Processing of Actions for Excepted and GS-16/18 Positions," 15 Nov. 1963, p. 1.

[16] Braithwaite, "Executive Personnel Program," p. 46.

[17] Braithwaite, "Summary," p. IV.

[18] Memorandum from John W. Macy, Jr., Chairman, U.S. Civil Service Commission, 14 Oct. 1966, to heads of executive departments and agencies.

[19] Macy to Webb, 29 Aug. 1966.

[20] Braithwaite memorandum, 22 Feb. 1968, p. 10.

[21] Comparisons of employment figures for different agencies are notoriously difficult because of the lack of uniform definitions of occupational groups. For what they are worth, the data collected by the National Science Foundation (NSF) show that in 1969 the 7 Federal agencies employing the greatest number of scientists and engineers were DOD (76 026), Agriculture (25 783), Interior (15 340), NASA (13 918), Commerce (6 293), Health, Education, and Welfare (6 123), and Transportation (5 049). Thus NASA employed more scientists and engineers than all but three Federal agencies, and these three had much greater total employment than NASA. Source: National Science Foundation, *Scientific, Technical and Health Personnel in the Federal Government, 1969* (NSF 70–44), table 6. Even more remarkable is that the percentage of NASA scientists and and engineers *actually engaged in R&D* has been consistently higher than that of any other Government agency. The data collected by NSF at two-year intervals from October 1967 to October 1973 show that the percentage of NASA scientists and engineers in R&D has ranged from a low of 51.7% in 1967 to a high of 53.3% in 1973. By comparison, the figures in those years for DHEW and DOD, with the next highest percentages were DHEW, 45.9% and 44.5%; and DOD, 33% and 33.8%. Figures for other agencies are much lower. I am indebted to Joseph Gannon of the NSF Manpower Utilization Studies Group for this information.

[22] This definition is included as part of NASA's reply to a series of questions submitted by Senator Gaylord Nelson (D-Wis.), chairman of the Subcommittee on Employment and Manpower, Committee on Labor and Public Welfare. NASA assembled a number of papers and tables and titled the collection *Reply to Sen. Gaylord Nelson* (1965). This definition is taken from the *Reply,* p. 12-1.

[23] Rosholt, *Administrative History,* p. 267.

[24] Ibid, pp. 267–268.

[25] *Reply to Sen. Gaylord Nelson,* p. 12-3, which is based on the same source as that for table 3.

26 Ibid, p. 12-6. The last figure is an estimate from budget projections for FY 1966.
27 Executive Order 11246, "Equal Employment Opportunity," p. 1.
28 U.S. Senate, Committee on Appropriations, *Subcommittee on HUD, Space, Science, Veterans and Certain Other Independent Agencies—Part I,* 93rd Cong., 2d sess. (1974), pp. 108–109. See pp. 1–156 for a general review of NASA policy on EEO. The remainder of this paragraph and the whole of the next are based on material submitted at these hearings.
29 See Adm. W. Fred Boone (USN, Ret.), *NASA Office of Defense Affairs: The First Five Years* (NASA HHR-32, Dec. 1970), pp. 42–60, for an account of NASA's use of military detailees. See also Edgar E. Ulsamer, "USAF Professionalism—A National Resource," *Air Force Magazine* (Dec. 1967): 101–106. Retired military officers who have worked for NASA include Adm. Boone, Lieut. Gen. Frank Bogart (USAF), who was Deputy Associate Administrator (OMSF) before becoming Associate Director of MSC; Maj. Gen. Robert Curtin (USAF), who became the first Director of Facilities in May 1968; and Lieut. Gen. Duward Crow (USAF), who was appointed Associate Deputy Administrator of NASA in 1975.
30 *NASA Data Book,* table 3-6.
31 Boone, *NASA Office of Defense Affairs,* p. 55.
32 For information on astronaut selection, see note 28 above, pp. 122–131.
33 Memorandum for the record, 5 Feb. 1968. Subject: Trip by [Personnel Management Review Committee] to Lewis Research Center on January 26, 1968. Memorandum was written by Ray Kline, executive secretary to the Committee.
34 For material on patterns of support service contracting at the Manned Space Flight centers, see Office of Programming (Program Reports Division), *Procurement Program,* 27 Oct. 1964, pp. 21–23.
35 House Government Operations Committee, Military Affairs Subcommittee, *Missile and Space Ground Support Operations,* 89th Cong., 2d sess. (21 Mar. 1966), p. 63.
36 Webb to Kermit Gordon, Director, Bureau of the Budget, 14 Dec. 1964.
37 *Annual Report of the Comptroller General of the United States for Fiscal Year 1964* (Washington: USGPO, 1964), p. 19.
38 Interview with Walter Shupe, Director, GAO Liaison Activities, 6 Dec. 1976.
39 Joseph P. Harris, *Congressional Control of Administration* (Washington, D.C.: The Brookings Institution, 1964), p. 141. Emphasis added.
40 House Committee on Government Operations, Military Affairs Subcommittee, *Government Operations in Space,* 89th Cong., 1st sess. (4 June 1965), p. 14.
41 *Annual Report of the Comptroller General . . . 1964,* pp. 291–292, 436. In Aug. 1971 the Pratt & Whitney Division of United Aircraft Corporation filed a formal protest with the GAO against the award of the contract for the main engine of the space shuttle to the Rocketdyne Division of North American Rockwell. *Astronautics and Aeronautics, 1971* (NASA SP-4016, 1972), pp. 218, 233.
42 These reports are drawn from the lists of audit reports published in the annual reports of the U.S. Comptroller General.
43 In a memorandum of 1 Apr. 1966, Deputy Associate Administrator Earl Hilburn notes that "a high percentage of the GAO draft reports have been cancelled (dropped) because of NASA's replies. Recent examples are the case with respect to the Douglas fee on subcontractors' work in connection with the Delta, the Nerva case dealing with the contracting arrangement between Westinghouse and Aerojet, and several cases involving reasonableness of costs at contractor's operations (LTV, Rocketdyne,Douglas, etc.)."
44 Office of the Executive Secretary (Program and Special Reports Division), *Audit Program,* 31 Oct. 1966, pp. 15–16.
45 Transcript of taped meeting of Webb, Seamans, and all the center directors, 28 Sept. 1966, p. 35. Staats, of course, had recently left the Bureau of the Budget, of which he was Deputy Director, to head the GAO.
46 "Considerations in the Management of Manpower in NASA," p. 1.
47 On the "Marshall problem," see ibid., pp. 3–4.
48 Ibid., p. 10.
49 Ibid., p. 13. See section on "Aligning Manpower and Program Requirements," pp. 13–20.
50 Ibid., p. 15.
51 Ibid., p. 18.
52 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, Code B–133394. This report was submitted to Congress, and copies were sent to Webb. For figures on Marshall and Goddard contracts, see tables, pp. 9, 23.
53 Ibid., p. 34.
54 *Aviation Week and Space Technology* (30 Oct. 1967), p. 20.

[55] For NASA response to the GAO report and the Pellerzi decision, see House Committee on Science and Astronautics, Subcommittee on NASA Oversight, *Support Service Contracting by the National Aeronautics and Space Administration*, 90th Cong., 2d sess., (Apr. 1968), pp. 5, 7–8, 19, 23–25.
[56] NASA News Release, "NASA Contractor Conversion Plan," 27 Dec. 1968.
[57] *Annual Report of the Comptroller General . . . 1969*, pp. 146–148. For changes at Marshall, see briefing by von Braun for the Administrator's Management Advisory Panel, 11? Apr. 1969, pp. 14–15.
[58] For 1962 review, see Rosholt, *Administrative History*, pp. 268–269.
[59] From cover letter, Macy to Webb, 10 Oct. 1967.
[60] Memorandum for the record by Ray Kline, "Discussion of Personnel Management Review Committee with Mr. Webb on January 8, 1968," 9 Jan. 1968.
[61] NASA Personnel Division, *Personnel Division Report: The In-House Work Force*, Sept. 1969, pp. 52–55. A "high" or "low" rate was one higher or lower than the NASA-wide percentage. In FY 1969, Langley had the lowest accession *and* the lowest separation rates in NASA.
[62] NMI 1152.26, sec. 3.
[63] Personnel Management Review Committee, *Progress Report*, Apr. 1968, p. 23.
[64] Ibid., p. 2.
[65] For these recommendations, see ibid., pp. 19, 22, 15, 3.
[66] Ibid., p. 2.
[67] James E. Webb, "NASA As An Adaptive Organization," John Diebold Lecture on Technological Change, Harvard University Graduate School of Business Administration (Boston: 30 Sept. 1968), pp. 47–48.
[68] Briefing by von Braun for Management Advisory Panel, p. 8.
[69] "Considerations in the Management of Manpower in NASA," p. 4.
[70] Von Braun briefing, pp. 8–11.
[71] Personnel Management Review Committee, *Progress Report*, p. 21.
[72] The average age of permanent employees had risen to 41, up 1.6 years since 1968. The greatest net loss had been for those under age 25. NASA Office of Personnel, *The In-House Work Force*, Sept. 1970, pp. 20–21.
[73] Paine to Mayo, 18 Aug. 1969, pp. 2–3.
[74] Ibid.
[75] Finger to Assistant Administrator for Administration William Lilly, 25 Sept. 1968.
[76] See note 73 above.
[77] MSC, "Background . . . of the Reduction-in-Force at the Manned Spacecraft Center during FY 68 . . . ," (n.d.), pp. 5–6.
[78] See note 33 above.
[79] Paper in files of Personnel Management Review Committee, based on discussion by Seamans with the Committee, 18 Jan. 1968.
[80] Seamans Exit Interview, p. 51.
[81] Memorandum for the record by Ray Kline, "Discussion with OSSA Top Management on January 29, 1968," 30 Jan. 1968.

CHAPTER 6

[1] Webb to Chet Holifield (D-Calif.), 20 May 1964.
[2] Joint DOT-NASA Report, *Civil Aviation Research and Development Policy Study* (Mar. 1971), pp. 2-5/2-6. Italics omitted.
[3] NASA Headquarters Management Seminar, Unit II, "The Planning and Approval Process" (Nov. 1964), p. 5.
[4] "Report on Excepted Positions in the Office of Programming," 12 Mar. 1965.
[5] Exit interview with DeMarquis Wyatt, conducted by Eugene Emme, John Sloop, and William Fleming, 21 June 1973, p. 97.
[6] This paragraph and the next are based on a memorandum from Fleming to Seamans, 11 Sept. 1964.
[7] "Staff Paper on Proposed Space Science Data Center Concept," 8 Nov. 1965.
[8] Seamans to Newell, 15 Nov. 1965.
[9] Raymond A. Bauer and Richard F. Meyer, *NASA Planning and Decision Making—Final Report* (typescript contractor report, Jan. 1970), vol. I, p. III-12. On the problems involved in assigning the Saturn IB/Centaur to either Lewis or Marshall, see draft memorandum, Seamans to Mueller, Newell, and Bisplinghoff, "Considerations Concerning Management of Saturn IB/Centaur," 2 Feb. 1965.
[10] Seamans to Program Associate Administrators, "Selection of Contractors for Advanced Studies," 24 Oct. 1963.

[11] The varied nature of these studies should be stressed. A study might be *exploratory*, which systematically analyzes an idea for a new program or system; it might be an examination of *feasibility* to determine "the practicability of accomplishing, within a specified period, a given space project, program or major component"; it might be *parametric*, a study of tradeoffs between the different elements of a program; it might be a *preliminary design* study, which makes detailed assessments of the assumptions underlying earlier study phases; or it might be a *detailed engineering design*, in which the design could be specified to the point where it was possible to let contracts for hardware production. Citation is from the Office of Plans and Program Evaluation, "Review of NASA's Advanced Study Program," Oct. 1963, p. 7.

[12] *NASA Data Book*, table 4-23. See also a staff paper, "NASA Advanced Studies Mission," 1 May 1963.

[13] For further guidelines, see Seamans to Program Associate Administrators, "Award of Contracts for Advanced Systems and Mission Studies," 14 Apr. 1966.

[14] Interview with William Fleming, 8 Feb. 1977.

[15] Transcript of tape, "Meeting with Mr. Webb on Budget Discussion, 11 Aug. 1967, pp. 28–29.

[16] Bauer and Meyer, *NASA Planning and Decision Making*, vol. I, pp. III-31/32.

[17] At a staff meeting in the summer of 1967, Associate Deputy Administrator Willis Shapley announced that "Dr. Seamans has authorized a major inhouse study on the space station concept. OSSA wants this study and considers such a station as NASA's most important potential contribution. This view is not shared by others." From notes of functional staff meeting taken by NASA Executive Officer Lawrence A. Vogel, 20 July 1967.

[18] This account is based on Adm. W. Fred Boone (USN, Ret.), *NASA Office of Defense Affairs* (NASA HHR-32, Dec. 1970), pp. 88–96, and House Committee on Government Operations Committee, Military Affairs Subcommittee, *Government Operations in Space*, 89th Cong., 1st sess. (4 June 1965), pp. 84–91.

[19] *Government Operations in Space*, p. 90.

[20] Boone, *NASA Office of Defense Affairs*, p. 88.

[21] Ibid., p. 92.

[22] *Government Operations in Space*, p. 90.

[23] Office of Plans and Program Evaluation, "Review of NASA's Advanced Study Program," Oct. 1963, pp. 3, 13.

[24] Seamans to Program Associate Administrators, "Guidelines for FY 1965 Contract Advanced Mission Study Program," 12 Oct. 1964.

[25] Fleming to George Trimble, Director, OMSF Advanced Manned Mission Program, 19 June 1967.

[26] Seamans to Program Associate Administrators, "Advanced Mission Studies," 30 Aug. 1967. This action was preceded by a memorandum from Fleming to Webb dated 22 Aug., recommending that he withdraw approval, and by the discussion of advanced studies cited in note 15 above. On the MSC study contract for a Mars-Venus flyby, see *Science* 158 (24 Nov. 1967): 1028.

[27] The Air Force approach to R&D planning is set forth in the Air Force Systems Command 375 series of manuals.

[28] NASA Headquarters Management Seminar, Unit III, "Budget Formulation and Execution" (Nov. 1964), p. 26. It should be noted that the 506 green was issued by Seamans to the program offices; they, in turn, issued a 506 white authorizing resources to the centers.

[29] Wyatt to headquarters offices, 29 May 1963. Subject: Revision of Project Approval Document System.

[30] See note 28, p. 24.

[31] This paragraph is based on the following sources: Memorandum, Hilburn to Seamans, 30 Aug. 1965. Subject: Establishment of Office of Finance; Program Review Document, *Financial Management Program*, 31 Oct. 1966; and NASA, *Management Effectiveness Report to the President of the United States for Fiscal Years 1971 and 1970*, submitted to the Office of Management and Budget, 13 Oct. 1970, to meet the requirement of the Office's Circular A–44.

[32] See Hilburn memorandum cited in note 31.

[33] Wyatt to Paine, 10 Apr. 1969. Subject: NASA Cost Projections.

[34] Ibid. In a study of twelve major weapons projects, Peck and Scherer found that average costs exceeded estimates by a factor of 3.2. Peck and Scherer, *Weapons Acquisition Process*, table 16.1, p. 429.

[35] See note 33.

[36] Harvey Sapolsky, *The Polaris Systems Development* (Cambridge: Harvard University Press, 1972), pp. 125, 246.

[37] Erasmus Kloman, *Case Study of the Surveyor Program* (typed manuscript, June 1971), p. 216.

[38] Memorandum, T. Hechler, Jr., to Fleming, 4 Mar. 1965. Subject: Cost Relationship Study, Project Gemini. Also, interviews with Fleming, Bernard Maggin dated 1 Feb. 1977, and DeMarquis Wyatt, 9 Mar. 1977.

[39] Notes and daily logs of Cost Validation task force members. June 1963.

[40] For an account of NASA costing techniques, see DeMarquis Wyatt, "Cost Models for Complex Programs," a lecture delivered at the National Conference on the Management of Aerospace Programs at the University of Missouri, Columbia, 17 Nov. 1966, and issued as a NASA news release.

[41] Memorandum, Dixon Forsythe to J. L. Mitchell, 27 May 1965. Forsythe was program manager of the Advanced Orbiting Solar Observatory. Emphasis in original.

[42] Assistant Administrator for Industry Affairs Bernhardt Dorman to Wyatt, 9 June 1967, citing a letter from von Braun of 27 March.

[43] The principal management instructions were NPD 7000.1, "Authorization and Control of Agency Programs and Allocation of Resources," issued 16 Mar. 1968; NPD 7121.1A, "Phased Project Planning," 2 May 1968; NHB 7121.2, "Phased Project Planning Guidelines," final draft, 28 Feb. 1968, issued Aug. 1968; and NMI 7100.4, "Authorization and Control of Research and Development Programs, Projects, Other Activities, and Resources Related Thereto," 15 Aug. 1968.

[44] As illustration of the confusion in defining and authorizing projects, consider the anomalies of facilities planning. To avoid the cumbersome authorization process, many centers funded their facilities out of R&D money by distinguishing between nonseverable facilities, which were funded out of "construction of facilities" (COF) money, and severable facilities, which could be funded out of R&D money. The flooring or heating ducts of a building cannot be severed from the building itself; the chairs and furniture can. A center could build a shell for $100 000 under COF and then install millions of dollars worth of equipment under R&D because the equipment was severable from the building in which it was contained. One reason for reestablishing the Facilities Office in May 1968 was to control such construction funding.

[45] Transcript of Webb's remarks at meeting of Management Advisory Panel, 19 Apr. 1968, p. 58.

[46] Exit interview with Harold Finger, 16 Apr. 1969, p. 24.

[47] Finger cited a Centaur PAD sent up by OSSA. "Here we were in the middle of a budget reduction process. We were cutting money out of the Centaur program . . . and a PAD change comes in that includes a budget number for fiscal year 1970 that I know is higher than the one that we're going to be handling. So I said I'm not going to sign the PAD. So the Office of Space Science and Applications got very upset. Well, we don't know that's the final number. . . . I said yes we do, you know darn well it isn't going to be the right number. And I said I'm not going to ask the Administrator. In fact, I won't allow the Administrator to sign something that he knows is wrong." See Finger exit interview, p. 32.

[48] Ibid., p. 33.

[49] This section is based on interviews with Frederick Bryant and Richard Stock (3 Feb. 1977) and Robert Rapp (11 Feb. 1977), all of OTDA, and *Review of Tracking and Data Acquisition Program,* hearings before the House Committee on Science and Astronautics, Aeronautics and Space Technology Subcommittee, 93rd Cong., 1st and 2d sess. (Oct. 1973–Jan. 1974). I have used the present tense for most of this section, since OTDA's current organization and operating philosophy are very close to what they were in the mid-1960s.

[50] For background of the decision to build one large antenna, see testimony of DSN Director Eberhardt Rechtin, in House Committee on Science and Astronautics, Manned Space Flight Subcommittee, *1967 NASA Authorization,* 89th Cong., 2d sess. (1966), pp. 762–763.

[51] Source: Rapp interview.

[52] See chapter 4, note 59.

[53] *Review of Tracking and Data Acquisition Program,* p. 58.

[54] House Committee on Science and Astronautics, *1964 NASA Authorization,* 88th Cong., 1st sess. (1963), p. 1882.

[55] See Edwin P. Hartman, *Adventures in Research* (NASA SP-4302, 1970), especially pp. 397, 399, 404–407, 411–412.

[56] Finger to Ray Romatowski (Director, Organization and Management Planning Division), 22 May 1967. Subject: OART Management and Control System Proposal for SRT.

[57] Richard L. Chapman et al., *Project Management in NASA* (NASA SP-324, 1973), pp. 28–30.

[58] Program Review Document, *Mission Analysis Division Programs,* 21 Sept. 1967.

[59] Information supplied by Assistant Associate Administrator for Center Operations Paul Cotton, 22 Feb. 1977. Cotton was Director of the Program and Resources Division from 1967 to 1970.

[60] Memorandum, Bisplinghoff to OART Division Directors and Staff, 28 May 1964. Subject: Organizational Changes in OART.

[61] See minutes of 3rd meeting of NASA Management Committee, 27–28 Oct. 1963, section on SRT—Revised Assumptions.

[62] Memorandum, Associate Administrator for Advanced Research and Technology James Beggs to Finger, 27 June 1968.

[63] Memorandum, Dr. Leo Packer (special assistant to Associate Administrator, OART) to Willis Shapley, 7 Aug. 1969. Subject: Observations on OART.

[64] See note 62 and Chapman, *Project Management in NASA,* p. 41.

[65] Principal sources for this section include a Program Review Document, *Science and Applications Management,* and an interview with Dr. Homer E. Newell, 1 Feb. 1977.

[66] Norriss P. Hetherington, "Winning the Initiative: NASA and the U.S. Space Science Program," *Prologue* (Summer 1975): 105.
[67] See briefing by Newell to Science Advisory Committee, 8 July 1966; Report of the Committee of the Administrator, 15 Aug. 1966; memorandum, Newell to Seamans, 20 Dec. 1966, commenting on the report; and *Interim Response to the Report of the Ad Hoc Science Advisory Committee,* 7 June 1967, which incorporated most of Newell's criticisms.
[68] *Report on Advisory Boards,* 15 Jan. 1968, p. 41.
[69] Senate Committee on Aeronautical and Space Sciences, *Scientists' Testimony on Space Goals,* 88th Cong., 1st sess. (10–11 June 1963), especially comments of Dr. Philip Abelson at p. 11 and Prof. Martin Schwarzschild at pp. 160–161.
[70] See statement of Dr. John Naugle in *Science and Applications Management,* p. 46.
[71] House Committee on Science and Astronautics, Space Science and Applications Subcommittee, *1966 NASA Authorization,* 89th Cong., 1st sess. (1965), p. 1054.
[72] Newell, draft of "Functions and Authorities of Program Managers and Project Managers in Office of Space Science and Applications Flight Programs," 10 Feb. 1966. This followed by one week a reorganization of OSSA that established a Program Review and Resources Management division in each program office and set up a Manned Flight Experiments Office to work with OMSF.
[73] See transcript of briefing for Webb by Goddard officials on OAO-I failure, 4 Nov. 1966, p. 53.
[74] Presentation by Goddard officials to NASA Headquarters management as part of an "Institutional Base Study," 12 June 1971, p. 83.
[75] Sources: Newell interview and memorandum, Hilburn to Seamans, 21 July 1965, in which Hilburn said that after a long discussion with Newell the consensus was to "remove Harry at once." And they did.
[76] *Science and Applications Management,* p. 45.
[77] The following sources have proved useful: the 1966 Apollo Program Development Plan and the 14-volume survey of Apollo Program Management issued by the Apollo Program Office, Nov. 1967–Jan. 1968.
[78] Seamans exit interview, p. 53.
[79] Open-ended missions "are designed to continue so long as astronauts' safety is not impaired, until a series of objectives are reached with the option at each step of terminating the mission." Statement of George Mueller, House Science and Astronautics Committee, *Apollo Program Pace and Progress,* staff study for Subcommittee on NASA Oversight, 90th Cong., 1st sess. (17 Mar. 1967), p. 3.
[80] Seamans exit interview, pp. 115–116.
[81] Ibid., p. 115.
[82] 21st meeting of Manned Space Flight Management Council, 24 Sept. 1963.
[83] Apollo Program Office (KSC), *Apollo Program Management,* vol. 4, Kennedy Space Center (15 Jan. 1968), p. 3-1.
[84] Apollo Program Office, *Apollo Program Management,* vol. 3, Marshall Space Flight Center (Dec. 1967), p. 1-2.
[85] *Astronautics and Aeronautics, 1963* (NASA SP–4004, 1964), pp. 190, 420.
[86] House Science and Astronautics Committee, *1965 NASA Authorization,* 88th Cong., 2d sess. (1964), p. 447.
[87] Gilruth to E. Z. Gray, 5 Aug. 1964. Emphasis added.
[88] Seamans to Program Associate Administrators, "Management Responsibilities for Future Manned Flight Activities," 26 July 1966.
[89] Although the evidence is not conclusive, the decision to develop the supersonic transport (SST) was probably of this sort. The pressure for an SST program came from within Government rather than from the civil aviation industry, which insisted that the Government foot the bill for proving the concept. The prime movers for an SST—the House Committee on Science and Astronautics, NASA, and FAA officials (together with DOD officials)—signed an agreement in June 1961 to study the feasibility of a supersonic transport, which was two years before President Kennedy, in June 1963, authorized Congress to fund an SST program.

CHAPTER 7

[1] Senate Committee on Government Operations, *Financial Management in the Federal Government,* 87th Cong., 1st sess. (13 Feb. 1961), p. 131.
[2] Aaron Wildavsky, *The Politics of the Budgetary Process* (Boston: Little, Brown and Co., 1964), pp. 11–13, 57–60. When this was published, the Budget Bureau had not yet metamorphosed into the Office of Management and Budget.
[3] Downs, *Inside Bureaucracy,* p. 251.

[4] For a history of these and other proposals, see *Financial Management in the Federal Government,* and Joseph P. Harris, *Congressional Control of Administration* (Washington, D.C.: The Brookings Institution, 1964), pp. 104–127.
[5] For an account of the Bureau's reorganization and its powers and authorities prior to 1970, see Lewis Fisher, *Presidential Spending Power* (Princeton: Princeton University Press, 1975), pp. 44–51, and Peter Woll, ed., *Public Administration and Policy* (New York: Harper and Row, 1966), Part III.
[6] William S. Beller, "Decision-Making in Washington," *Space/Aeronautics* (Dec. 1967): 83–98, and Donald F. Hornig, "The President's Scientist: A Private Diary," *Bulletin of the Atomic Scientists* (Apr. 1977): 62–64.
[7] BOB staff paper, "FY 1966 NASA Budget Review," 12 Nov. 1964, p. 1-4.
[8] House Government Operations Committee, Military Operations Subcommittee, *Government Operations in Space,* 89th Cong., 1st sess. (4 June 1965), p. 106.
[9] House Science and Astronautics Committee, Subcommittee on Manned Space Flight, hearing on *GAO Report on Analysis of Cost of Space Shuttle Program,* 93rd Cong., 1st sess. (26 June 1973), p. VII.
[10] As shown by NASA Administrator James C. Fletcher's reply to U.S. Comptroller General Elmer Staats, reprinted in ibid., pp. 94–97.
[11] On NASA's use of cost-benefit and cost-effectiveness studies, see Senate Independent Offices Appropriations Subcommittee, *Hearings—Part I,* 93rd Cong., 1st sess. (1973), pp. 510–512. This includes NASA and GAO correspondence pertaining to such studies, and selected lists of cost-benefit studies at pp. 511, 513, and 518–519. Note that the difference between cost-benefit and cost-effectiveness analyses is that the former are those "in which benefits are measurable in terms of dollars." The GAO study concluded that while "only certain NASA programs are susceptible to cost-benefit analysis involving dollar-measurable benefits . . . we believe that all NASA programs are susceptible to cost-effectiveness analysis." Ibid., pp. 511–512.
[12] NASA Assistant Administrator for Administration William Lilly to Elmer Staats, 16 Nov. 1967.
[13] House Science and Astronautics Committee, *Authorizing Appropriations to NASA,* 89th Cong., 1st sess., Rep. No. 273 (3 May 1965), p. 118.
[14] Without citing an authority, Lewis Fisher has noted that $35 000 in R&D funds was set aside as a contingency fund for national security purposes. See *Presidential Spending Power,* pp. 207–208. This is apparently an erroneous reference to sec. 1(f) of the 1969 and 1970 NASA Authorization Act, which permits the Administrator to use up to $35 000 in R&D appropriations "for scientific consultations or extraordinary expenses . . . and his determination shall be final and conclusive upon the accounting officers of the Government." This is the Administrator's "champagne money" and has nothing to do with national security.
[15] NHB 7330.1, "Approval of Facility Projects" (July 1966), p. 25.
[16] Paine to Speaker of the House, 15 Jan. 1969, enclosing copy of draft bill to authorize appropriations for NASA.
[17] 1966 NASA Authorization Act, sec. 4(3). Emphasis added. However, the act did provide that such programs might be funded if the Committee was notified in advance and gave approval.
[18] Senate Committee on Aeronautical and Space Sciences, *1966 NASA Authorization,* pp. 947–950.
[19] Wyatt to William McCandless (Assistant Director for Budget Review, BOB), 12 Mar. 1964.
[20] Memorandum for the record by Adm. Rufus E. Rose (USN, Ret.), "General Management Involvement in Formal Budget Process," 1 Sept. 1965.
[21] Donald Crabill (Economics, Science, and Technology Division, BOB) to BOB Director Charles Schultze, 27 Oct. 1967.
[22] BOB Director Robert Mayo to Paine, "1971 Budget Appeal Procedures," 20 Oct. 1969.
[23] NASA staff paper (draft), "The NASA Programming Process," 24 Jan. 1966, p. 8.
[24] Minutes of NASA Management Committee meeting, 17 Jan. 1966, and paper on "NASA Incremental Funding Study," 20 Apr. 1966.
[25] Senate Committee on Aeronautical and Space Sciences, *Space Launch Vehicles,* 89th Cong., 1st sess. (26–27 Jan. 1965), pp. 10–17, 25–30.
[26] Logsdon, *Decision to Go to the Moon,* p. 91.
[27] Transcript of meeting of Webb, Seamans, and all the center directors, 28 Sept. 1966, p. 35.
[28] PPBS generated an enormous literature between 1965 and the early 1970s. Besides the sources cited below, two compendia are especially useful: "Planning-Programming-Budgeting-System: A Symposium," *Public Administration Review* 26 (4) (Dec. 1966); and U.S. Congress, Joint Economic Committee, Subcommittee on Economy in Government, *The Analysis and Evaluation of Public Expenditures: The PPB System,* 3 vols., 90th Cong., 2d sess. (1969).
[29] In a 21 June 1971 memorandum accompanying its Circular A-11, the Office of Management and Budget stated that "agencies are no longer required to submit with their budget submissions the multi-year program and financing plans, program memoranda and special analytical studies . . . or the schedules . . . that reconcile information classified according to the program and appropriation structures."

[30] This was Public Law 84-863 (1 Aug. 1956), for which see *Financial Management in the Federal Government*, pp. 92–97.
[31] Alain C. Enthoven and K. Wayne Smith, *How Much is Enough? Shaping the Defense System, 1961–1969* (New York: Holt, Harper and Row, 1971), p. 25.
[32] Harvey Sapolsky, *The Polaris System Development*, pp. 180–181.
[33] Enthoven and Smith, *How Much is Enough?* p. 48.
[34] Ibid., p. 52.
[35] The phrase is Allan Schick's in his "A Death in the Bureaucracy: The Demise of Federal PPB," *Public Administration Review*, 33 (2) (Mar./Apr. 1973): 146.
[36] Milton Margolis and Stephen Barro, "The Space Program," in David Novick, ed., *Program Budgeting*, 2d ed. (New York: Holt, 1969), pp. 125, 127. This essay is an attempt to apply PPB techniques to NASA. Among the authors' proposals are the amalgamation of NASA and DOD space budgets, the introduction of a new Launch Capability category, and the elimination of aircraft technology from the budget. NASA officials were understandably unenthusiastic about these proposals.
[37] Shapley to William McCandless, Harry Rowen, Samuel Cohn, "Notes for discussion of approach for NASA on proposed revisions to the budget process," 14 May 1965. This memorandum was written shortly before Shapley transferred to NASA.
[38] Novick, *Program Budgeting*, p. XIX.
[39] Joon Chien Doh, *The Planning-Programming-Budgeting System in Three Federal Agencies* (New York: Praeger, 1971), p. 154.
[40] Webb to Schultze, 13 July 1966.
[41] Doh, *The Planning-Programming-Budgeting System*, p. 155.
[42] Schick, "A Death in the Bureaucracy," p. 148.
[43] Richard R. Nelson, *The Moon and the Ghetto: An Essay on Public Policy Analysis* (New York: Norton, 1977), p. 34.
[44] BOB Bulletin 66-3, "Planning-Programming-Budgeting," 12 Oct. 1965. More detailed guidelines were issued as Bulletin 68-2, 18 July 1967, and Bulletin 68-9, 12 Apr. 1968.
[45] See BOB memo cited in note 21 above.
[46] Schultze and Califano to Johnson, 19 Aug. 1967. On 21 Aug. Johnson signed the bill and issued the statement.
[47] Schultze to Webb, 7 Aug. 1967.
[48] Schick, "A Death in the Bureaucracy," p. 151.
[49] Richard F. Fenno, Jr., *The Power of the Purse: Appropriations Politics in Congress* (Boston: Little, Brown and Co., 1966), pp. 71–73.
[50] Two other subcommittees deserve a passing mention: the Subcommittee on NASA Oversight, which, among other things, investigated the Ranger 6 failure and the Apollo fire; and the Subcommittee on Science, Research, and Development, established in 1963 to examine the policy issues created by Federal R&D spending. This subcommittee was chaired by Representative Emilio Q. Daddario (D-Conn.) from 1963 to 1970.
[51] Senate Committee on Aeronautical and Space Sciences, *Report on 1970 NASA Authorization*, 91st Cong., 1st sess., Rep. No. 91-282 (26 June 1969), pp. 86–87, and authorization hearings for 1970, pp. 128–131. For elimination of excess authorizations, see 1970 Authorization Act, sec. 1(i); for prior notice of facilities spending, see sec. 1(d).
[52] Sec. 5 of 1964 and subsequent NASA authorization acts.
[53] Shapley to Wyatt, "NASA Responsiveness to House Reports," 18 May 1966. Report itself is dated 25 May. Except where noted, all examples in this and the next paragraph are drawn from this paper.
[54] James R. Kerr, "Congress and Space: Overview or Oversight?," in Nelson, *The Politics of Science*, pp. 176–189.
[55] Murphy, *Science, Geopolitics, and Federal Spending*, pp. 207–210.
[56] Ibid., p. 218.
[57] Beller, "Decision-Making in Washington," p. 98.
[58] Remarks of Congressman Joseph Karth (D-Minn.), Chairman, Space Science and Applications Subcommittee, in House Science and Astronautics Committee, *1964 NASA Authorization*, 88th Cong., 1st sess., (1963), pp. 1662–1664.
[59] See note 27, p. 37.
[60] National Science Foundation, *National Patterns of R&D Resources: Funds and Manpower in the United States, 1953–1976* (NSF 76-310), p. 1.
[61] National Science Foundation, *An Analysis of Federal R&D Funding by Budget Function* (NSF 71-25), p.1.
[62] Ibid., p. 24.
[63] Ibid., p. 6.

[64] James L. Penick, Jr., Carroll W. Pursell, Jr., et al., eds., *The Politics of American Science, 1939 to the Present* (Cambridge, MIT Press, 1972), p. 343.
[65] Charles L. Schultze, "Federal Spending: Past, Present and Future," in Charles L. Schultze and Henry Owen, eds., *Setting National Priorities: The Next Ten Years* (Washington, D.C.: The Brookings Institution, 1976), p. 335.
[66] *Analysis of Federal R&D Spending*, p. 2.
[67] Ibid., p. 4.
[68] Ibid., p. 11.
[69] Data cited are from Fleming to Newell, 24 Oct. 1968. We do not touch on the related question of how the NASA budget might have been affected by changes in the budgets of other agencies, e.g., that portion of the Atomic Energy Commission for the jointly run Space Nuclear Propulsion Office. There were also programs funded as NASA line items that were to all intents and purposes in support of DOD, e.g., the XB-70 flight research program, at least part of the entry for "supersonic aircraft technology," and the item for "Special Support (OSS & A)" for NASA's "Limited Warfare Program" discussed in chapter 8.
[70] *Astronautics and Aeronautics, 1967* (NASA SP-4008, 1968), pp. 189–190. Also Senate Committee on Aeronautical and Space Sciences, *1966 NASA Authorization*, 89th Cong., 1st sess. (1965), pp. 605–606.
[71] This is discussed in chapter 9. The Report of the Future Programs Task Group is printed in the Senate hearings cited in note 70, at pp. 1029–1102, with the Committee's criticisms at p. 1015.
[72] NASA officials knew this quite well. At the Administrator's staff luncheon of 6 July 1966, it was agreed that " 'preeminence in space' has probably outlived its usefulness as a main argument to make in support of NASA programs. We are possibly entering a period where 'uses of space' should rather be emphasized." From notes taken by NASA Executive Secretary Lawrence Vogel.
[73] A memorandum from Seamans to Finger, the Program Associate Administrators, and other key headquarters officials, 15 Sept. 1967, announced that Saturn IB production would end with the sixteenth vehicle and that there would be no Saturn V production beyond the fifteenth in 1968. The final decision to discontinue Saturn V production was announced in Feb. 1970. *Astronautics and Aeronautics, 1970* (NASA SP-4015, 1971), p. 37.
[74] Another problem during the late 1960s was the exceptional length of the later stages of the budgetary cycle. The 1970 Independent Offices Appropriations Act was not signed by the President until 26 November 1969. In August 1970 President Nixon vetoed the FY 1971 Independent Offices Appropriations bill, and the revised bill was not signed into law until 17 December. Because of the delays, NASA was under a "continuing resolution," an interim appropriation limiting the agency to the rate of operation of the previous fiscal year, effectively prohibiting new starts until appropriations were voted.

CHAPTER 8

[1] Space Act, sec. 102(b) and 102(c) (6).
[2] Willis H. Shapley, "United States Space Program," in Hugh Odishaw, ed., *The Challenge of Space* (Chicago: Praeger, 1962), p. 166.
[3] Milton Rosen, "Military Significance of Surveyor," 15 June 1966. Rosen was senior scientist, NASA Office of Defense Affairs (changed to Office of DOD and Interagency Affairs in Jan. 1968), 1963–1972.
[4] Michael H. Armacost, *The Politics of Weapons Innovation: The Thor-Jupiter Controversy* (New York: Columbia University Press, 1969), p. 231.
[5] House Government Operations Committee, Military Affairs Subcommittee, *Government Operations in Space*, 89th Cong., 1st sess. (4 June 1965), p. 54.
[6] For a history of Project Advent, see House Government Operations Committee, Military Operations Subcommittee, *Satellite Communications (Military-Civil Roles and Relationships)*, 89th Cong., 1st sess. (17 March 1965), pp. 123–158, from which this account is drawn.
[7] Ibid., p. 16.
[8] Ibid., p. 17.
[9] *Government Operations in Space*, p. 103.
[10] *Satellite Communications (Military-Civil Roles . . .)*, pp. 13–15.
[11] Theodore W. Bauer and Harry B. Yoshpe, *Defense Organization and Management* (Washington, D.C.: Industrial College of the Armed Forces, 1971), pp. 72–73.
[12] *Satellite Communications (Military-Civil Roles . . .)*, pp. 148, 152–153.
[13] This was DOD Directive 5160.32, reprinted in House Science and Astronautics Committee, *Defense Space Interests*, 87th Cong., 1st sess. (1961), pp. 2–3.

[14] Testimony of Assistant Secretary of Defense (Comptroller) Charles J. Hitch in ibid., p. 82.
[15] Bauer and Yoshpe, *Defense Organization and Management*, p. 127.
[16] DOD Directive 5030.18, 24 Feb. 1962. Subject: Department of Defense Support of National Aeronautics and Space Administration.
[17] A list of eighty-eight major NASA-DOD agreements for the period 1 Oct. 1958-31 Dec. 1964, with brief descriptions of each, is printed in *Government Operations in Space*, pp. 123-133. Except where noted, agreements for that period discussed in the text are excerpted from this list.
[18] The 1959 agreement states, "When either agency places a contract through the other, reimbursement is limited to direct costs. . . . when either assigns a contract to the other for administration, the direct costs involved are reimbursable. . . . construction undertaken by DOD for NASA is charged directly to NASA funds; when either agency is a tenant on an installation of the other, all direct costs attributable to such tenancy are reimbursed, but rent or depreciation are not charged for the use of each other's facilities." House Government Operations Committee, Military Affairs Subcommittee, *Government Operations in Space*, p. 101.
[19] The full text of this agreement is reprinted in House Science and Astronautics Committee, Subcommittee on NASA Oversight, *The NASA-DOD Relationship*, 88th Cong., 2d sess. (26 March 1964), pp. 10-11.
[20] *Government Operations in Space*, p. 126.
[21] Ibid., p. 129. For the earlier agreement of 24 Aug. 1961, see p. 127.
[22] Provisions of the Gemini agreement are in Adm. W. Fred Boone (USN, Ret.), *NASA Office of Defense Affairs: The First Five Years* (NASA HHR-32, Dec. 1970), pp. 83-84. Hereafter cited as *NASA Office of Defense Affairs*.
[23] *Aviation Week* (22 July 1963): 25.
[24] *NASA Office of Defense Affairs*, p. 28.
[25] Ibid., p. 35.
[26] House Government Operations Committee, Military Affairs Subcommittee, *Missile and Space Ground Support Operations*, 89th Cong., 2d sess. (21 Mar. 1966), p. 28.
[27] *Astronautics and Aeronautics, 1964* (NASA SP-4005, 1965), pp. 430-431.
[28] The National Range Division was established in January 1964 as a division of the Air Force Systems Command and was charged with planning and management of the Eastern Test Range and that portion of the Western Test Range previously transferred from the Navy to the Air Force. The commander of the National Range Division was designated as DOD's point of contact with NASA for manned spaceflight support. For details, see NASA, *Astronautics and Aeronautics, 1964*, pp. 3, 164; and House Government Operations Committee, Military Affairs Subcommittee, *Missile and Space Ground Support*, p. 18.
[29] Harvey Sapolsky, *The Polaris System Development* (Cambridge: Harvard University Press, 1972), p. 224.
[30] See *NASA Office of Defense Affairs*, pp. 122-162, for an extremely detailed account of the funding issue, and pp. 163-195 for NASA and DOD policy statements.
[31] In practice, most of DOD's space launches, especially those using the Titan III, took place at the Western Test Range. The breakdown of the NASA-DOD *workload* at the Eastern Test Range in 1966 was about fifty-fifty, even though three-quarters of the launches there were missiles. House Government Operations Committee, *Missiles and Space Ground Support Operations*, pp. 20-21.
[32] On the funding of NASA laboratories, see Webb to Schultze (9 Aug. 1967), which sets forth the NASA position on reimbursement for services at the Eastern Test Range. NASA's viewpoint on supporting other agencies is set forth in encl. B.
[33] Ibid., encl. A, p. 7.
[34] *NASA Office of Defense Affairs*, p. 144.
[35] Ibid., p. 150.
[36] Ibid., p. 205.
[37] See statement of OTDA Director Edmond C. Buckley in Senate Committee on Aeronautical and Space Sciences, *1966 NASA Authorization*, 89th Cong., 1st sess. (1965), p. 447.
[38] This was the position of the House Government Operations Committee in *Missile and Space Ground Support*, p. 49.
[39] *NASA Office of Defense Affairs*, pp. 207-209.
[40] For details of the agreement, see ibid., pp. 74-76; *Government Operations in Space*, p. 131; and *Missile and Space Ground Support*, pp. 37-38.
[41] See note 37, p. 448.
[42] *NASA Office of Defense Affairs*, p. 66. Emphasis in original.
[43] See, e.g., Webb's statement in Senate Committee on Aeronautical and Space Sciences, *Space Launch Vehicles*, 89th Cong., 1st sess. (26-27 Jan. 1965), pp. 17-18.
[44] PSAC, *Report of the Ad Hoc Booster Panel on Large Rocket Boosters for Space Exploration*, 5 June 1961.

[45] *Summary Report, NASA-DOD Large Launch Vehicle Planning Group*, 24 Sept. 1962. This was also known as the Golovin report, after Nicholas Golovin, NASA cochairman, and subsequently a staff member of the Office of Science and Technology. One of the most important results of the group's work was its October 1961 recommendation that DOD proceed to develop the Titan III launch vehicle to meet its own and NASA's needs.
[46] On the history of LLVPG, see foreword to LLVPG *Summary Report*, and Courtney Brooks et al., *Chariots for Apollo: A History of Lunar Spacecraft* (comment draft, Aug. 1976), pp. 80–87.
[47] It should be noted that the Webb-Gilpatric agreement applied only to *development* of new vehicles or stages, not to studies of proposed improvements. How far it applied to modification of existing stages was less certain. The usual procedure was for AACB cochairmen to decide whether such improvements came within the terms of the agreement, and then to invoke it or not, as the case determined.
[48] These were the four-stage Jupiter C; the improved Jupiter C, known as Juno II; the Thor-Able, which combined the Thor booster with the second and third stages of the Vanguard; the Thor-Hustler, which had a liquid-propellant upper stage using the Hustler engine; the Atlas intercontinental ballistic missile; and the Atlas-Able, combining the Atlas and Vanguard second and third stages. The only nonmilitary vehicle, the Vanguard, was built by the Navy for the International Geophysical Year. From Homer E. Newell, *Space Science in NASA*, Ch. 11, work in progress.
[49] Statement of Deputy Secretary of Defense Cyrus Vance in *Space Launch Vehicles*, p. 43.
[50] See, e.g., minutes of 29th AACB meeting, 28 Aug. 1964; minutes of 30th AACB meeting, 20 Oct. 1964; and paper by Rosen, "Statement of Launch Vehicle Cost Effectiveness," 26 Jan. 1965, especially pp. 2–3.
[51] See Senate Committee on Aeronautical and Space Sciences, *1966 NASA Authorization*, pp. 605–606, and *Space Launch Vehicles*, pp. 124–125, for a chronology of the large-solid-motor program.
[52] *Space Launch Vehicles*, pp. 16–18, 28–30.
[53] On guidelines for launch vehicle study, see Seamans and Brown to Chairman, AACB Launch Vehicle Panel, "Guidelines for Study of NASA and DOD Launch Vehicle Requirements," 19 June 1964. For interim summary of the study, see Hilburn to Seamans, "Brief Summary of Findings to Date on Launch Vehicle Cost Study," 4 Nov. 1964. The unclassified portion of the final report was summarized by Assistant Air Force Secretary (R&D) Alexander Flax in *Space Launch Vehicles*, pp. 81–89, 95.
[54] *Space Launch Vehicles*, pp. 8–9.
[55] *Government Operations in Space*, p. 100. Of 900 space medicine tasks reviewed, 335 were found valid, 55 were canceled, 2 were assigned further examination, and 488 "were considered outside the scope of mutual interagency decision since they were necessary to the peculiar needs of the respective agency." Ibid.
[56] "NASA/DOD Coordination of FY 1970 Facility Projects," encl. 1 of minutes of 49th AACB meeting, 30 Jan. 1969.
[57] Minutes of 50th AACB meeting, 29 May 1969, item 4.
[58] Minutes of 51st AACB meeting, 3 Oct. 1969, NASA Status Report to AACB.
[59] Ibid., p. 5 of minutes.
[60] See especially the memorandum for the record prepared by Albert J. Evans, Acting NASA Director of Aeronautics (OART), "XB-70 Research Program . . . ," 27 Feb. 1964. One passage (crossed out in pencil) stated that "the Air Force had come to the conclusion that the XB-70 can no longer be justified on the basis of a weapon system, and believed that a study should be made to insure that the large investment of the Air Force in the program would produce research results of the maximum value possible." On 1967 agreement, see *Astronautics and Aeronautics, 1967* (NASA SP-4008, 1968), pp. 74–75.
[61] On this program, see *NASA Office of Defense Affairs*, pp. 249–253; *Astronautics and Aeronautics, 1967*, p. 366; and Boone to Seamans, "Assumption of Your Limited Warfare Support Role by Dr. Adams," 7 Dec. 1967.
[62] *NASA Office of Defense Affairs*, p. 9.
[63] The NASA position is set forth in a "talking paper" on Project Gemini drafted by Boone, 9 Jan. 1963.
[64] Webb to Seamans, 18 Jan. 1963.
[65] Barton C. Hacker and James Grimwood, *On the Shoulders of the Titans: A History of Project Gemini* (manuscript draft, Oct. 1973), p. 208.
[66] Webb to Johnson, 30 July 1963.
[67] Webb to NASA Executive Officer Col. R. P. Young (USA), 1 Mar. 1963.
[68] *New York Herald Tribune*, "The Death of the Dyna-Soar Project," 26 Dec. 1963.
[69] *Missile/Space Daily*, 11 Dec. 1963, p. 4.
[70] Donald Hornig, PSAC subcommittee chairman, to President's Science Advisor Jerome Wiesner, "PSAC Space Panels' Evaluation of the Requirements for a Manned Space Station," 22 Nov. 1963.
[71] Draft "Discussion Paper" on MOL and extended Apollo, forwarded from Shapley to Seamans, 19 Nov. 1964, pp. 5, 6, 7.

[72] Ibid., p. 7.
[73] *Missiles and Rockets,* 16 Dec. 1963, p. 15.
[74] See NASA MOL paper summarized in *Space Daily,* 6 Jan. 1964, p. 20. Also memorandum prepared by M/G David Jones (USAF), Deputy Associate Administrator for Manned Space Flight (Programs), "MOL Congressional Hearings," Jan. 1966; and memorandum prepared by William Schneider, Director, Apollo Applications Program, "Answers to Questions from Congressional Hearings," 18 Mar. 1969.
[75] See attachment to memorandum, Boone to Seamans, "NASA-DOD Coordination with Respect to the MOL Program," 16 Nov. 1965.
[76] Memorandum, E. Z. Gray, Director, Advanced Manned Missions Program, to Mueller, "Space Station Programs," 31 Aug. 1964.
[77] See, for instance, the draft responses to questions circulated by Vice President Hubert Humphrey at Space Council meeting, 9 July 1965. Moreover, one year after the MOL was finally approved, a top official told Webb at a meeting of NASA center directors that "I think that it is the military that needs to justify the position and they could be put in a rather awkward position with respect to MOL. MOL is a rather poor program at best and they have never justified it properly. Now, you haven't wanted to attack them . . . because I don't think McNamara is a nice guy to attack, he is rough." Webb: "Well, hell, he has attacked MOL worse than I have." Official: "Well, my point is that MOL is a very poor program. At one time it would have been a halfway decent program but it is way out of date now. . . . I was trying to get rid of a program that they got rid of later which was no good, Dyna-Soar, because I said that program was no good a long time ago. I say it right now that MOL is no good. They are always too late." Transcript of tape of meeting on budget changeover, 28 Sept. 1966, pp. 59–60.
[78] See draft responses to question of why Saturn/Apollo was not being used for MOL, Space Council meeting, 9 July 1965.
[79] Gordon's memorandum is summarized in memorandum from Boone to Seamans cited in note 75. Note that the "Discussion Paper" cited in note 71 had been drafted only three weeks earlier.
[80] *Aviation Week and Space Technology* (7 Dec. 1964): 16.
[81] NASA News Release, "Decisions on Manned Orbiting Laboratory and Other Matters," 25 Jan. 1965.
[82] *Government Operations in Space*, p. 17.
[83] *Astronautics and Aeronautics, 1965* (NASA SP-4006, 1966), p. 396.
[84] Another reason for the delay was a struggle between the Central Intelligence Agency and the Air Force over who would exercise mission control. Donald E. Fink, "CIA Control Bid Slowed Decision on MOL," *Aviation Week*, 20 Sept. 1965. The charge was officially denied by the Air Force on 5 Oct. *Astronautics and Aeronautics, 1965*, p. 463.
[85] Information supplied by Willis Shapley.
[86] Hilburn to Seamans, "MOL Decision," 24 June 1975.
[87] *Missile and Space Ground Support*, p. 46.
[88] Boone to Webb, Seamans, Dryden, 12 July 1963, p. 3.
[89] Sapolsky, *Polaris System Development*, p. 204.
[90] Boone memorandum cited in note 88, p. 4.

CHAPTER 9

[1] U.S. Senate Committee on Aeronautical and Space Sciences, *Policy Planning for Aeronautical Research and Development,* 89th Cong., 2d sess. (19 May 1966), p. 8.
[2] For a summary of research on space stations up to 1969, see *Compilation of Papers Presented at the Space Station Technology Symposium* (NASA Langley Research Center, 11–13 Feb. 1969), especially the paper on MSC studies by Maxime Faget and Edward Olling, pp. 43–98, and the historical sketch of Marshall studies at pp. 99–120.
[3] Ibid., and Space Station Requirements Steering Committee, *The Needs and Requirements for a National Space Station—Summary Report,* 15 Nov. 1966.
[4] Boone, *NASA Office of Defense Affairs,* pp. 324–325.
[5] Task Team on Management and Integrated Information Systems, "Outline of Interim Report," 16 Sept. 1963, pp. II-2/II-3. See also draft of "The NASA Programming Process," 24 Jan. 1966, p. 2.
[6] Frank W. Anderson, Jr., *Orders of Magnitude: A History of NACA and NASA, 1915–1976* (NASA SP-4403, 1976), p. 65.
[7] Arthur L. Levine, *The Future of the U.S. Space Program* (New York: Praeger, 1975), pp. 118–119.

[8] The group's summary report is reprinted in Senate Committee on Aeronautical and Space Sciences, *1966 NASA Authorization,* 89th Cong., 1st sess. (1965), pp. 1029-1102. The President's letter is at ibid., pp. 1016-1017, and Webb's interim replies are at pp. 1017-1029.
[9] Ibid., p. 1015.
[10] Transcript of tape of briefing on Apollo Extensions Systems, 22 Sept. 1965, pp. 48, 50-51, 52-53.
[11] See e.g. "Ground Rules for Apollo Extension," 20 Oct. 1964, which were confirmed by Seamans' memorandum for the record, "Apollo Program Decision—Manned Apollo Flights and Apollo Applications Program Plans," 17 May 1967.
[12] E. Z. Gray to Gilruth, 18 Aug. 1964.
[13] Mueller to Francis Smith, 28 Apr. 1964, and Senate Committee on Aeronautical and Space Sciences, *National Space Goals for the Post-Apollo Period,* 89th Cong., 1st sess. (23-25 Aug. 1965), pp. 76-104.
[14] Mueller to Charles Townes, Chairman, Science and Technology Advisory Committee, 14 Jan. 1966.
[15] W. David Compton and Charles D. Benson, *History of Skylab* (Comment edition, May 1977), pp. 53-55.
[16] Gray to Gilruth, 18 Aug. 1964.
[17] Compton and Benson, *History of Skylab,* pp. 112-115.
[18] Minutes of Science and Technology Advisory Committee (STAC) meeting at JPL, 30 Oct. 1964, p. 3.
[19] See speech of Dr. Harry Hess to a joint PSAC/STAC meeting at KSC, 20 May 1969.
[20] Compton and Benson, *History of Skylab,* pp. 112-115.
[21] Adams, Mueller, and Newell to Seamans, Dec. ? 1965, and summary minutes of Planning Coordination Steering Group, 17 Jan. 1966.
[22] This was the design approved by Seamans on 29 Aug. 1966. For further details on the origins of the orbital workshop, see Compton and Benson, *History of Skylab,* chapters 2-4.
[23] NASA Program Review, *Apollo Applications Program* (15 Nov. 1966), p. 21.
[24] Compton and Benson, *History of Skylab,* pp. 186-187.
[25] "Manned Space Flight: Summary of Roles and Missions Agreements," Aug. 1966.
[26] Newell and Cortright, 13 June 1966. Subject: NASA Future Program Planning.
[27] House Committee on Government Operations, Military Operations Subcommittee, *Missile and Space Ground Support Operations,* 89th Cong., 2d sess. (21 March 1966), pp. 46-47.
[28] Schultze to President Johnson, 1 Sept. 1966. Also, memorandum for the record by Wyatt, 27 July 1965. Subject: Director's Review with Bureau of the Budget (July 26).
[29] This paragraph is based on a NASA report, "Evolution of Advisory Counsel Structure and Practice," 15 Jan. 1968, prepared by a task force under the Office of Organization and Management.
[30] Newell to Webb, 6 Oct. 1965.
[31] Ray Romatowski (Director, Organization and Management Planning Division) to Harold Finger, 21 Apr. 1967.
[32] Bruce Murray (CalTech) to PSAC Space Panel, 10 Apr. 1967. Subject: NASA Science Management in the Planetary Program. Murray succeeded William Pickering as JPL Director in 1976.
[33] On NASA's reasons for rejecting the Ramsey report, see Newell to Seamans, 20 Dec. 1966; and "Interim Response to the Report of the Ad Hoc Science Advisory Committee," 7 June 1967.
[34] The remainder of this paragraph and the whole of the next are based on Barry Rutizer, "The Lunar and Planetary Missions Board" (NASA HHN-138, 30 Aug. 1976).
[35] Ibid., p. 15.
[36] Newell, "Notes on Science in NASA," 14 Nov. 1969, pp. 5-6. Newell, of course, was describing a position with which he did not agree.
[37] *Astronautics and Aeronautics, 1966*, pp. 17, 39, 53.
[38] Hess to Webb, 29 July 1966.
[39] President's Science Advisory Committee (PSAC), "The Space Program in the Post-Apollo Period," Feb. 1967, p. 14.
[40] Ibid.
[41] Ibid., p. 16.
[42] Quotation is from Newell, "Notes on Science in NASA," pp. 8-9. PSAC criticism of the Apollo Telescope Mount is in "The Space Program in the Post-Apollo Period," appendix C, especially pp. 73-74.
[43] PSAC Space Science and Technology Panel, "U. S. Strategy for Space Research and Exploration: Fiscal Year 1969 Program Decisions," 19 Dec. 1967.
[44] Milton Rosen to Seamans, 2 Sept. 1966. Rosen, the senior scientist in the Office of Defense Affairs, was the NASA observer to the PSAC space panels.
[45] PSAC Space Science and Technology Panel, "U.S. Strategy for Space Research and Exploration," p. 28.
[46] Finger to Romatowski, 28 Dec. 1967.
[47] Webb to Finger, 28 June 1968.

[48] Milton Rosen, "Information on NASA Activities with Respect to Titan Launch Vehicles. . . . " 24 July 1967.
[49] Newell to Webb, 22 Dec. 1967.
[50] Draft memorandum by Milton Rosen, "Launch Vehicle Working Group: Task Definition," 17 Apr. 1968. See also a memorandum by Alexander Flax, chairman of the AACB Launch Vehicle Panel, 11 June 1968.
[51] Memorandum by Rosen, 21 Mar. 1969.
[52] Senate Committee on Aeronautical and Space Sciences, *Policy Planning for Aeronautical Research and Development*, 89th Cong., 2d sess. (May 1966).
[53] Bernard Moritz (Acting Associate Administrator for Organization and Management) to NASA Deputy Administrator George Low, 23 Dec. 1969. Low had been sworn in as Deputy Administrator three weeks earlier.
[54] The members of the Post-Apollo Advisory Group were Floyd Thompson, chairman; Edmond Buckley, former Associate Administrator for Tracking and Data Acquisition, vice chairman; Goddard Director John Clark; KSC Director Kurt Debus; LRC Deputy Director Charles Donlan; MSC Director Robert Gilruth; Charles Mathews, Director for Apollo Applications; George Mueller; John Naugle, Associate Administrator for Space Science and Applications; LRC Director Abe Silverstein; and MSFC Director Wernher von Braun. The staff assistant was Ray Kline, and James Long was executive secretary.
[55] Newell, paper on "NASA Planning System," 13 May 1968.
[56] "PSG Guidelines: Center Participation in NASA PPB Process," 26 Mar. 1968.
[57] "NASA Planning System" p. 1.
[58] Some of the more important groups included the Space Science Board of the National Academy of Sciences; the Lunar and Planetary Missions Board and the Astronomy Missions Board; the Post-Apollo Advisory Group chaired by Floyd Thompson; the Group for Lunar Exploration Planning, a NASA group chaired by Wilmot Hess; the Manned Space Flight Science and Technology Advisory Committee; a Saturn Workshop study group directed by Douglas Lord of OMSF; and a NASA Life Sciences Directors Group. This list is adopted from minutes of the STAC meeting at KSC (27–28 Mar. 1968), pp. 4–5.
[59] On the role of Bellcomm in supporting the PCG, see memorandum from W. G. Stroud to Newell, 15 Apr. 1968. Stroud, who had been the Nimbus project manager at Goddard, was PSG secretary during the 1968 planning cycle.
[60] Minutes of executive session of STAC, 12 Oct. 1968.
[61] *Astronautics and Aeronautics, 1968* (NASA SP-4010, 1969), p. 213.
[62] "Post-Apollo Advisory Group: Summary of Proceedings" (20 July 1968), p. 13.
[63] See *Astronautics and Aeronautics, 1969* (NASA SP-4014), p. 167.
[64] Paine to Presidential Science Adviser Lee DuBridge, 6 May 1969. Emphasis in original.
[65] Minutes of STAC meeting at NASA Headquarters, 22–23 Mar. 1969.
[66] Briefing for the Apollo Executives Group by LeRoy Day at KSC, 15 July 1969, p. 26. Day was in charge of a group responsible for developing material for a report on space shuttles to the President's Space Task Group.
[67] NASA News Release, "AAP Orbital Workshop," 22 July 1969, and Compton and Benson, *History of Skylab*, pp. 297–302.
[68] See source cited in note 66, pp. 34–35.
[69] Newell, memorandums for the record, 18 Nov. 1968 and 11 Dec. 1968.
[70] For NASA reports prepared for the STG, see "America's Next Decade in Space" and "Goals and Objectives for America's Next Decades in Space," both dated Sept. 1969.
[71] *Astronautics and Aeronautics, 1969*, p. 224.
[72] President's Space Task Group, "The Post-Apollo Space Program: Directions for the Future" (Sept. 1969), pp. 19–23.
[73] Thomas O'Toole, "Nixon Rejects Big Outlay for Space in '70s," *Washington Post* (11 Jan. 1970), p. A1.
[74] Newell to Low, 9 Feb. 1970, p. 5. Subject: Evolution of NASA's Long-Range Planning.
[75] Ibid., pp. 4–5.
[76] Seamans to Mueller, 20 July 1967.
[77] Briefing by Newell for the Administrator's Management Advisory Panel, 25 Oct. 1968, pp. 40–41.
[78] Newell to Low, 9 Feb. 1970, p. 3.
[79] Moritz to Low, 23 Dec. 1969.
[80] See especially his memorandum to Newell and Paine, 18 June 1968, and the summary of notes from his discussion with the Administrator's Management Advisory Panel, 16 Sept. 1969.
[81] Moritz to Low, 23 Dec. 1969.
[82] Ad Hoc NASA Manpower Utilization Committee, "Considerations on the Management of Manpower in NASA," 8 Sept. 1966, p. 4.

[83] This paragraph is based on a briefing by Goddard officials for the Associate Administrator for Organization and Management, 12 June 1971, one of a number held at the centers as part of an "Institutional Base Study."
[84] Ibid., p. 47.

CHAPTER 10

[1] Raymond Bauer et al., *Second-Order Consequences: A Methodological Essay on the Impact of Technology* (Cambridge: MIT Press, 1969), p. 21.
[2] For examples of the "legislative veto," see Joseph P. Harris, *Congressional Control of Administration* (Washington, D.C.: The Brookings Institution, 1964), chap. 8.
[3] Harvey Sapolsky, *The Polaris System Development* (Cambridge: Harvard University Press, 1972), p. 244.
[4] Summary report of "General Management Discussion of Policy and Management Matters During the General Management Program Review," 22 Sept. 1964.
[5] William J. Normyle, "Post-Apollo Space Plan Drafted," *Aviation Week & Space Technology* 81 (21 Oct. 1968): 26.
[6] Alan Dean and staff of Federal Aviation Administration, "The Decentralization of the Federal Aviation Agency," pp. 77–78. This unpublished study was presented as the subject of the third meeting (19 June 1968) of a study group of the National Academy of Public Administration.
[7] From notes of Mueller's discussion with the Administrator's Management Advisory Panel, 16 Sept. 1969.
[8] On the analogy between the space program and social welfare programs, see Richard R. Nelson, *The Moon and the Ghetto: An Essay on Public Policy Analysis* (New York: W. W. Norton & Co., 1977).

Appendix A

A Note on Sources

No one who investigates segments of NASA's history will underestimate the difficulty of finding out what happened and why. Particularly in the study of organization and management, the researcher is pretty much on his own. Organization charts and management instructions are the visible tip of an immense mass of submerged documentation. Researchers who enjoy the thrill of the chase will find themselves fully occupied, and not least among their problems will be locating primary sources. They will have to contend with the sources' dispersal throughout headquarters, center offices, and the Federal Records Centers to which they are eventually retired; the absence of catalogues or data retrieval systems comparable to those maintained by NASA for indexing and classifying aerospace literature; and the lack of uniformity in those records inventories that are available. There has never been a central file or filing system at NASA Headquarters. The responsibility for maintaining, inventorying, and retiring records rests with each office. The only general guide to NASA internal documentation is GSA form 135, which every Federal agency fills out before retiring records. The same caution applies to these forms as to the documents they describe: some are detailed and precise, others are cursory at best.

These deficiencies are not ameliorated by the published material. When one has eliminated promotional literature, spaceflight stories "as told to" Able and Ham, and the kind of learned lumber that spares the reader no smallest detail, one is left with a residue of works that attempt to deal with the space program in a scholarly way. Yet, with one exception, no book tries to get the whole of NASA between two covers. The exception, Frank W. Anderson, Jr.'s *Orders of Magnitude* (NASA SP-4403, 1976), is brief—less than 100 pages—concise, well written, and one of very few works that treat the histories of NACA and NASA together. But no work that was prepared as a chapter for a bicentennial history of public works in the United States can claim to be definitive. In short, an essay on NASA administrative history must draw on a multitude of sources without relying too heavily on any one of them.

There remain the periodic official reports on U.S. space activities. Three of these, sponsored by NASA, may be ranked in ascending order of usefulness:

1. The twenty-two semiannual reports issued by NASA from 1959 through 1969. They provide brief summaries of agency programs and policies, with little comment or analysis.
2. The annual report of the President to the Congress on U.S. aeronautical and space activities. Originally prepared by the Space Council before it was abolished in 1973, the "President's report" has been the responsibility of the NASA History Office since 1975. Each report deals with aeronautics and astronautics, agency by agency. Although more than half of the report covers NASA and DOD, there are also sections on such unlikely agencies as the Department of Agriculture, the Department of State, and the U.S. Arms Control and Disarmament Agency. Each chapter is prepared by the agency in question.
3. The *Astronautics and Aeronautics* (A&As) chronologies prepared by the NASA History Office. There are separate volumes for each year since 1962, and at the time of writing (October 1979) the series was complete through 1974. A&As are enormous compendia of facts culled from newspapers, trade journals, congressional hearings, and agency press releases. Their very lack of system adds to their value. Much of the information included is hard to come by elsewhere, and much of it has a broader bearing than the volume's title would imply. Each volume offers extensive coverage of U.S. science policy, international aspects of the space program, and announcements of NASA and DOD prime contract awards. Used with an awareness of their limitations, A&As give remarkably full coverage of aspects of the space program for which printed sources are available.

Apart from interviews, congressional hearings, and the sources mentioned, the research on which this book is based rests principally on two collections: the files of the NASA History Office at NASA Headquarters in Washington, D.C., and the NASA documents housed at the Federal Records Center in Suitland, Maryland. There is no need here to describe the resources of these collections; Alex Roland's *Guide to Research in NASA History* (2d ed., NASA History Office, Nov. 1977) covers the ground most adequately. Rather, I would like to mention the ways in which I have used the material in an administrative history of an agency as large and diversified as NASA.

One limitation is the fragmentary quality of the sources. The reader who expects the documents to deal with large subjects in a large way will be disappointed. Their value consists in their confirmation of particular facts, as controls on other documents, and as bases for presentations of agency programs that were entered into the annual congressional authorization hearings. Occasionally a source gives an historical account of specific programs or organizational entities; examples include staff papers on NASA excepted positions, on the rationale of the Apollo engineering support contracts, on NASA responses to recommendations of the House Science and Astronautics Committee, and on executive recruitment. The program reviews held for Webb fall into the same category. However, such papers, most of which were never circulated outside the agency, are the exception. The gap between official statements of policy and internal decision making is often uncomfortably wide, and that gap is only partly closed by internal documents, interviews, and presentations before NASA's authorization and appropriations committees. To a degree, the historian's terms of references are bounded by the evidence; I have tried to deal with problem areas for which inadequate supporting documentation exists.

A special case is presented by the tape recordings stored at Suitland. In 1966–1967 several dozen management meetings were taped. While the purpose of the recordings is not entirely clear, most seem to have been prepared as reference material for edited transcripts and—given Webb's strong interest in the study of public administration—as source material for studies such as this book. The tapes run from forty-five minutes to three hours and cover most of NASA's substantive program reviews, as well as strategy sessions attended by NASA senior officials. Few transcripts are available, and most of the tapes have been unused and unheard since they were sent to Suitland a decade ago. Their value is less in disclosing previously unknown facts than in giving a remarkable glimpse of the give-and-take of NASA decision making at the highest level. We hear Webb, Mueller, and Phillips in a dry-run rehearsal for a congressional hearing in executive session on the Apollo fire. We hear Edgar Cortright briefing Webb on the Voyager program and explaining how the program would be parceled out among the centers. As another example, the briefing held for Webb on negotiations for renewal of NASA's contract with JPL is a franker account of NASA relations with the laboratory than anything NASA would have cared to submit in public hearings. Apart from the notorious exception of the Nixon tapes, the NASA tapes are a unique record of the decisions made by senior Federal officials. Not all the tapes are as valuable as the three just cited. But as a whole, they are an unusual and almost unknown historical resource, and it would be a service to scholars to have the best of them transcribed and edited.

Appendix B

Abbreviations and Acronyms Cited in Text*

AACB	Aeronautics and Astronautics Coordinating Board
ADP	Automatic Data Processing (Equipment)
AO	Administrative Operations
ARPA	Advanced Research Projects Agency (DOD)
ATM	Apollo Telescope Mount
BOB	U.S. Bureau of the Budget
COF	Construction of Facilities
CPFF	Cost-Plus-Fixed-Fee
CSC	U.S. Civil Service Commission
DHEW	U.S. Department of Health, Education, and Welfare
DOD	U.S. Department of Defense
DOT	U.S. Department of Transportation
DSN	Deep Space Network
EEO	Equal Employment Opportunity
FAA	Federal Aviation Agency (or Administration)
FY	Fiscal Year
GAO	U.S. General Accounting Office
GE	General Electric Corporation
JPL	Jet Propulsion Laboratory
KSC	Kennedy Space Center
LOR	Lunar Orbit Rendezvous

* This list omits abbreviations and acronyms cited only in the paragraph in which they are identified.

MOL	Manned Orbiting Laboratory (DOD)
MSC	Manned Spacecraft Center
MSF	Manned Space Flight
NACA	National Advisory Committee for Aeronautics
NASA	National Aeronautics and Space Administration
NERVA	Nuclear Engine for Rocket Vehicle Application
NMI	NASA Management Instruction
NSF	National Science Foundation
OAO	Orbiting Astronomical Observatory (NASA)
OART	Office of Advanced Research and Technology (NASA)
OMB	Office of Management and Budget
OMSF	Office of Manned Space Flight (NASA)
OSSA	Office of Space Science and Applications (NASA)
OTDA	Office of Tracking and Data Acquisition (NASA)
PAD	Project Approval Document
PCG	Planning Coordination Group (NASA)
PCSG	Planning Coordination Steering Group (NASA)
PERT	Program Evaluation and Review Technique
PFP	Program and Financial Plan
POP	Program Operating Plan
PPBS	Planning-Programming-Budgeting System
PPP	Phased Project Planning
PSAC	President's Science Advisory Committee
PSG	Planning Steering Group (NASA)
R&D	Research and Development
RFP	Request for Proposal
RIF	Reduction in Force
SEB	Source Evaluation Board
SRT	Supporting Research and Technology
SSASC	Space Science and Applications Steering Committee (NASA)
SST	Supersonic Transport
STAC	Science and Technology Advisory Committee (NASA)
STG	(President's) Space Task Group
TIE	Technical Integration and Evaluation
TWA	Trans-World Airlines
V/STOL	Vertical or Short Take-Off and Landing (aircraft)

Appendix C

Biographical Sketches of Principal NASA Officials

Hugh L. Dryden

Born in Pocomoke City, Maryland, in 1898. Received B.A. in 1916 and Ph.D in 1919 from The Johns Hopkins University. Joined the National Bureau of Standards in 1918 and during the 1920s and 1930s produced many technical papers in aerodynamics for the Bureau and for the National Advisory Committee for Aeronautics (NACA). Member of NACA Committee on Aerodynamics from 1931. Named Assistant Director of the Bureau of Standards in 1946 and Associate Director six months later. Joined NACA in September 1947 as Director of Research; became NACA Director in May 1949. Deputy Administrator of NASA from 1 October 1958 to his death on 2 December 1965.

Harold B. Finger

Born in New York City in 1924. Received B.S. in mechanical engineering from City College of New York in 1944 and M.S. in aeronautical engineering from Case Institute of Technology in 1950. Joined Aircraft Engine Research Laboratory—renamed Lewis Flight Propulsion Laboratory in 1948—in 1944, where he remained until his appointment to the NASA Headquarters staff in 1958 as Chief of the Nuclear Engine Program. Manager of the Space Nuclear Propulsion Office from its establishment in August 1960 until his assignment to headquarters early in 1967. Served as Associate Administrator for Organization and Management, 15 March 1967–1 May 1969, when he became an Assistant Secretary in the Department of Housing and Urban Development.

Robert R. Gilruth

Born in Minnesota in 1913. Earned B.S. and M.S. in aeronautical engineering from the University of Minnesota, 1935–1936. Joined Langley Laboratory in 1937; became Assistant Director in 1952. In October 1958 appointed to head the Space Task Group managing Project Mercury, the nation's first manned spaceflight program. Director, Manned Spacecraft Center, November 1961–January 1972, when he was named to the newly created position of NASA Director of Key Personnel Development. Retired in December 1973.

T. (Thomas) Keith Glennan

Born in North Dakota in 1905. After graduating from Yale University in 1927 with a degree in electrical engineering, he became involved with the new sound motion picture industry and worked in Hollywood as a sound engineer and studio manager from 1935 to 1941. Served as Administrator and then Director of the U.S. Navy Underwater Sound Laboratories, 1942–1945. President, Case Institute of Technology, 1947–1966, with two leaves of absence: first to be a member of the Atomic Energy Commission (1950–1952), then to be the first NASA Administrator (19 August 1958–20 January 1961). Member of many boards and committees, including General Advisory Committee of the Atomic Energy Commission, the Institute for Defense Analyses, and the Aerospace Corporation.

D. Brainerd Holmes

Born in Brooklyn, New York, in 1921. Received B.S. in electrical engineering in 1943 from Cornell University. Worked for Western Electric and Bell Telephone Laboratories from 1945 to 1953, when he joined the Radio Corporation of America (RCA). Served as General Manager of RCA's Major Defense Systems Division, in which capacity he was project manager for the Ballistic Missile Early Warning System, which was completed on time and within cost. Joined NASA in October 1961 as Director of Manned Space Flight. Named Deputy Associate Administrator for Manned Space Flight Centers on 30 October 1962. Announced resignation on 12 June 1963 and returned to industry as senior vice president of the Raytheon Company.

George E. Mueller

Born in St. Louis, Missouri, in 1918. Received B.S. from Missouri School of Mines in 1939, M.S. in electrical engineering from Purdue University in 1940, and Ph.D in physics from Ohio State University in 1951. Worked in Bell Telephone Laboratories before joining faculty of Ohio State University in 1946. Appointed professor of electrical engineering at Ohio State in 1952. Before joining NASA in 1963, spent five years with Space Technology Laboratories, serving successively as Director of the Electronics Laboratories, Program Director of the Able Space Program, Vice President of Space Systems Management, and Vice President for Research and Development. Associate Administrator for Manned Space Flight, NASA, from 1 September 1963 to 10 December 1969, when he returned to private industry.

Homer E. Newell

Born in Holyoke, Massachusetts, in 1915. Received B.A. and M.A. in teaching from Harvard University and Ph.D in mathematics from the University of Wisconsin in 1940. Taught at the University of Maryland from 1940 to 1944, when he joined the Naval Research Laboratory (NRL). Became head of NRL Rocket Sonde Branch in 1947 and was in charge of the laboratory's upper atmosphere research programs. Became Acting Superintendent of the Atmosphere and Astrophysics Division and was also Science Program Coordinator for Project Vanguard. Joined NASA in October 1958; became Deputy Director of the Office of Space Flight Programs. Director, Office of Space Sciences, 1 November 1961–1 November 1963, when he became Associate Administrator for Space Science and Applications. Served as NASA Associate Administrator from 1 October 1967 to his retirement at the end of 1973. Author of many papers and several books on mathematics and space science.

Thomas O. Paine

Born in Berkeley, California, in 1921. Earned A.B. in engineering at Brown University in 1942; served as a submarine officer in the Pacific during World War II. Received M.S. and Ph.D from Stanford University (1947 and 1949) in physical metallurgy. Worked as research associate at Stanford before joining General Electric Corporation (GE) in 1949. From 1963 to 1968 was manager of the GE TEMPO Center for Advanced Studies, an interdisciplinary study group. Appointed NASA Deputy Administrator by President Johnson on 31 January 1968. Became Acting Administrator following resignation of James Webb on 7 October 1968. Nominated by President Nixon to become NASA Administrator on 5 March 1969 and confirmed by Senate fifteen days later. Resigned on 15 October 1970 to return to GE; became senior vice president in 1973. Chosen president and chief operating officer of the Northrop Corporation in February 1976.

Samuel C. Phillips

Born in Arizona in 1921. Received B.S. in electrical engineering from University of Wyoming in 1942 and M.S. in electrical engineering from University of Michigan in 1950. Joined the Air Corps in 1942 as a second lieutenant, rising to Air Force brigadier general in 1961, major general in 1964, and lieutenant general in 1968. Served as Director of the Minuteman Program from 1959 to 1963; appointed Vice Commander of the Ballistic Systems Division (Air Force Systems Command) in August 1963. Detailed to NASA Headquarters in January 1964 as Deputy Director of the Apollo Program. Appointed Apollo Program Director in October 1964 and served through August 1969. Commander, Air Force Space and Missile Systems Organization, September 1969–April 1972; Director, National Security Agency, April 1972–August 1973; Commander, Air Force Systems Command, August 1973–September 1975, when he became vice president of Energy Systems Management Division of TRW, Incorporated.

Robert C. Seamans, Jr.

Born in Salem, Massachusetts in 1918. Earned B.S. at Harvard University in 1939 and M.S. and Sc.D. at Massachusetts Institute of Technology (MIT) in 1942 and 1951. From 1941 to 1955 he held teaching and project management positions at MIT. Joined RCA in 1955, becoming chief engineer of its Missile Electronics and Controls Division. With NASA from 1960 to 1968, first as Associate Administrator (1 September 1960–2 December 1965) and then, succeeding Hugh Dryden, as Deputy Administrator from 21 December 1965 to his resignation on 5 January 1968. Appointed Hunsaker Professor at MIT in 1968. Served as Air Force Secretary from February 1969 to May 1973. President, National Academy of Engineering, 1973–1974. Administrator, Energy Research and Development Administration, January 1975–January 1977. Currently Henry R. Luce Professor at MIT Alfred P. Sloan School of Management.

Willis H. Shapley

Born in Pasadena, California, in 1917. Studied at the University of Chicago, 1938–1942. Joined staff of the Bureau of the Budget in 1942, becoming a Principal Examiner in 1948, Assistant Chief (Air Force) of the Bureau's Military Division (1956–1961), and Deputy Chief of the Military Division from 1961 to 1965. In each position he was charged with reviewing research and development programs of DOD and the programs of NACA/NASA, and he was instrumental in drafting the original version of the 1958 Space Act. Served as NASA Deputy Associate Administrator from 1 September 1965 to his retirement in August 1975.

Abe Silverstein

Born in Terre Haute, Indiana, in 1908. Received B.S. in mechanical engineering from Rose Polytechnic Institute in 1929 and a mechanical engineering professional degree from the same school in 1934. Aerodynamic research engineer at Langley Laboratory from 1929 to 1940; head, Full-Scale Wind Tunnel, 1940–1943; transferred to Aircraft Engine Research Laboratory, 1943. Chief, Wind Tunnel and Flight Division, 1943–1949. In 1949 was placed in charge of all research at Lewis Laboratory. Associate Director of Lewis Laboratory, 1952–1958. Transferred to NACA Headquarters in May 1958 to help prepare the transition to NASA. Director of Space Flight Programs for NASA, October 1958–October 1961, in which capacity he contributed greatly to the development of NASA's unmanned probes and satellites. Director, Lewis Research Center, November 1961–November 1969. Became director of Environmental Planning for Republic Steel Corporation in Cleveland, Ohio, in 1970.

Wernher von Braun

Born in Wiersitz, Germany, in 1912. Attended institutes of technology in Berlin and Zurich and received doctorate in physics at the University of Berlin in

1934. Joined the rocket experimental center in Peenemunde in 1937 and was director of research until 1945; his work and that of his colleagues led to development of the V-1 and V-2 guided missiles used against the Allies during World War II. Surrendered to U.S. Army in 1945; came to the United States and worked at the White Sands Missile Range before moving to the Redstone Arsenal in Huntsville, Alabama, in 1950. Became U.S. citizen in 1955. Developed the Redstone and Jupiter-C rockets, the latter of which placed Explorer 1, the nation's first unmanned satellite, into orbit on 31 January 1958. Transferred to NASA in 1960 and was Director of the Marshall Space Flight Center from July 1960 to February 1970, when he was appointed NASA Deputy Associate Administrator for Planning. Resigned in July 1972 to become corporate vice president (Engineering and Development) at Fairchild Industries. Died in Alexandria, Virginia, on 15 June 1977. Author of many papers on rocketry and space flight, von Braun was one of the best known figures in the history of the U.S. space program and played a crucial role in the development of the Saturn rocket.

James E. Webb

Born in Granville County, North Carolina, in 1906. Received B.A. in education from University of North Carolina in 1928. Studied law at George Washington University and was admitted to the District of Columbia Bar in 1936. Joined Sperry Gyroscope in 1936, rising to vice president in 1943. Became Assistant to the Under Secretary of the Treasury in 1946; served as Director of the Bureau of the Budget from 1946 to 1949 and as Under Secretary of State from 1949 to 1952. In private business from 1952 through 1960; served as president of Republic Supply Company, as assistant to the president of the Kerr-McGee Oil Company, and as a member of the board of McDonnell Aircraft. Administrator of NASA, 14 February 1961–7 October 1968, when he returned to the private sector as a lawyer and consultant. Member, Commission on Government Procurement, March–December 1972. Member of many boards and task forces; currently a trustee of the National Geographic Society and a member of the Board of Regents of the Smithsonian Institution. Author of *Space Age Management* (New York: McGraw-Hill, 1969).

DeMarquis Wyatt

Born in St. Joseph, Missouri, in 1919. Received B.S. in mechanical engineering from Missouri School of Mines in 1941. Served as a research scientist and supervisor at the Lewis Laboratory from 1944 to 1958, specializing in aerodynamic and thermodynamic studies of advanced aircraft and propulsion systems. Served at NASA Headquarters from October 1958 to his retirement in July 1973. Director, Office of Programs, June 1961–November 1963; Deputy Assistant Administrator/Assistant Administrator for Programming, November 1963–March 1967. Assistant Administrator for Program Planning and Analysis, 15 March 1967–May 1970, when he became Assistant Administrator for Planning. Until the 1967 reorganization Wyatt's office had major responsibility for budget preparation and review of program proposals.

Appendix D

Types of Contracts Authorized by NASA*

Firm fixed price—Provides for the payment of a definite price upon the delivery and acceptance of the items or services specified in the contract. It is used when designs and specifications are firm and fair, and reasonable prices can be established before performance. With this type of contract the contractor assumes the maximum performance risk and has the most incentive to reduce his cost.

Fixed-price incentive—Has the same concept and criteria as the firm fixed-price type, except that profits may be adjusted for rewards or penalties related to the contractor's succeeding or failing in attaining prescribed goals. . . .

Fixed-price escalation—Differs from the firm fixed-price type in that specific contingencies generally related to unstable market or labor conditions are recognized by a provision which permits the price to fluctuate up or down as the particular contingencies materialize.

Fixed-price redetermination—Concept and criteria are the same as for the firm fixed price except that uncertainty as to costs may be present, which are resolved by an adjustment of the price upward or downward after a specified delivery or completion point has been reached.

Cost-plus-fixed-fee—Provides that the contractor will be reimbursed for all his acceptable costs plus a fixed amount of fee as profit. This type of contract is generally used for research, development, or studies for which the parties cannot reasonably predict the required level of effort, the parameters to be investigated, or the probable costs.

Cost-plus-incentive-fee—Similar in concept to the CPFF contract but generally with a clearer view as to the work to be done and results to be obtained. The fee in this type of contract is not fixed but is established in terms of target,

* Source: House Committee on Science and Astronautics, *1965 NASA Authorization*, 88th Cong., 2d sess. (1964), pp. 1327–1328.

maximum, and minimum within which range the contractor's earnings are governed to the extent to which he exceeds or falls short of targets in terms of cost, schedule, performance, or a combination of these.

Cost-plus-award-fee—. . . provides for a basic fixed fee for performance to a level deemed acceptable, plus an additional award fee, not in excess of a stipulated maximum, for accomplishment better than the 'acceptable' level. . . .

Cost sharing—The contractor is paid no fee and is reimbursed for only part of his cost, accepting in lieu of monetary reimbursement certain commercial or other benefits which may be found in the contract.

Cost reimbursement—The contractor receives no fee and is reimbursed only for his acceptable costs.

Appendix E

Chronology of Administrative and Other Events, 1957–1969

1957

4 October—The Soviet Union announced that it had successfully orbited an Earth-orbital satellite, Sputnik 1, as its contribution to the International Geophysical Year. This was followed by the launch of Sputnik 2, three times as large as its predecessor and carrying a dog as passenger, on 3 November.

7 November—President Dwight Eisenhower named James Killian, head of the Massachusetts Institute of Technology, as Special Assistant for Science and Technology and chairman of the President's Science Advisory Committee. On 27 November the Committee was transferred from the Office of Defense Mobilization to the Executive Office.

1958

31 January—The Army's Juno I successfully launched Explorer 1, the first U.S. Earth-orbital satellite. The payload was developed by the Jet Propulsion Laboratory, while the experiment of Prof. James Van Allen of the University of Iowa detected a hitherto unknown belt of radiation above the Earth.

7 February—Secretary of Defense Neil McElroy established the Advanced Research Projects Agency at a level above and distinct from the services. The new agency was intended to sponsor projects without immediate military application, although the military services were authorized to act as executive agents on many of its projects.

5 March—President Eisenhower approved recommendations of the Advisory Committee on Government Organization that the new civilian space agency be lodged in a reconstituted National Advisory Committee for Aeronautics.

14 April—Administration's draft legislation submitted to Congress.

15 July—The final version of the National Aeronautics and Space Act of 1958 was passed by Congress. It provided for an agency headed by a single Administrator, for a National Aeronautics and Space Council to set overall policy, and for a Civilian-Military Liaison Committee to coordinate the programs of the Defense Department and the new agency. The act authorized the Administrator to fill up to 260 "excepted" positions exempt from civil service regulations and stipulated that the agency would take title to all patents developed in the course of work performed under contract to the agency.

29 July—President Eisenhower signed the National Aeronautics and Space Act.

3 August—The National Academy of Sciences established a Space Science Board, one of whose principal functions was to advise the Space Agency on its science programs. The Board was funded jointly by the National Science Foundation and NASA until 1964, when NASA assumed sole responsibility.

15 August—The Senate confirmed the nomination of T. Keith Glennan as NASA Administrator and Hugh Dryden as NASA Deputy Administrator. At the time of their appointments, Glennan was president of the Case Institute of Technology, and Dryden was Director of the National Advisory Committee for Aeronautics.

27 August—A rider to the NASA Appropriation Act stipulated that NASA would have to seek authorizing legislation before it could request appropriations for the 1960 fiscal year. This requirement was made permanent in 1959.

30 September—The National Advisory Committee for Aeronautics went out of existence at the close of business.

1 October—NASA began its official existence. By Executive Order 10783, the President transferred to NASA all the property and civilian personnel of the Naval Research Laboratory's Vanguard Division. Also transferred were several lunar probes sponsored by the Army, the F-1 rocket engine under Air Force study, and over $100 million in unexpended funds.

7 October—Project Mercury, the nation's first manned flight program, was established. The project was to be directed by a Space Task Group stationed at the Langley Research Center and headed by Robert Gilruth.

3 December—Executive Order 10793 transferred to NASA the Jet Propulsion Laboratory's functions and Government-owned property. The laboratory, founded in 1944, was to operate as a facility of the California Institute of Technology under contract to NASA.

1959

January—The position of Associate Administrator was established at NASA Headquarters. Richard Horner, Assistant Air Force Secretary (Research & Development) was named to fill the position on 1 June.

3 April—An agreement between NASA and the Department of Defense (DOD) established a procedure for the detailing of military personnel to NASA.

13 April—The Advanced Research Project Agency's Tiros meteorological satellite was transferred to NASA.

1 May—NASA renamed its Space Center in Beltsville, Maryland, the Goddard Space Flight Center, in honor of one of the founders of modern rocketry. The center, formally established in January 1959, was largely staffed by Vanguard personnel transferred to NASA.

August—Glennan promulgated guidelines for contract awards exceeding $1 million. The Administrator, assisted by ad hoc boards, became responsible for establishing the selection criteria for each contract.

21 October—President Eisenhower announced decision to transfer the Army's Saturn project to NASA. As part of the transfer, NASA was to receive the Development Operations Division of the Army Ballistic Missile Agency, located at the Redstone Arsenal in Huntsville, Alabama.

12 November—A NASA-DOD agreement established the principles by which each agency was to reimburse the other for services rendered.

December—A headquarters reorganization created a new Office of Launch Vehicle Programs, with responsibility for Saturn and the new Huntsville installation. The new Office was headed by Maj. Gen. Don Ostrander (USAF), acting head of the Advanced Research Projects Agency.

1960

14 March—The transfer of the Development Operations Division to NASA became effective.

15 March—President Eisenhower named the Huntsville facility the George C. Marshall Space Flight Center (MSFC). The formal mass transfer of personnel and facilities from the Army Ballistic Missile Agency took place on 1 July. The new center was headed by Wernher von Braun, who had been in charge of launch vehicle development at the Redstone Arsenal before the transfer took place.

May—NASA established a Space Science Steering Committee to act as an internal advisory body for the Director of Space Flight Programs, Abe Silverstein. Following the 1963 reorganization, the Committee was renamed the Space Science and Applications Steering Committee, and its subcommittees were expanded from seven to thirteen.

June—Congress authorized an increase in the number of NASA excepted positions from 260 to 290.

28–29 July—At a NASA Industry Program Plans Conference in Washington, D.C., Silverstein announced that the agency's manned circumlunar mission project would be named Apollo.

1 September—RCA engineer Robert C. Seamans, Jr., succeeded Horner as Associate Administrator.

13 September—NASA and DOD formally established an Aeronautics and Astronautics Coordinating Board, chaired by the NASA Deputy Administrator and the Director of Defense Research and Engineering, to coordinate programs, avoid wasteful duplication, and identify problems. The agreement provided that actions based on Board consideration of matters "may be taken by individual members."

12 October—The Advisory Committee on Organization established by Glennan the preceding March submitted its final report. The Committee, headed by Lawrence Kimpton, chancellor of the University of Chicago, consisted of outsiders with extensive experience in business and Government. While the report surveyed the entire scope of NASA organization, it apparently had little effect on the conduct of operations—coming as it did at the end of the Eisenhower administration.

1961

10 January—A task force headed by Jerome Wiesner of MIT issued a report to President-elect John F. Kennedy. The report concluded that NASA had placed too much emphasis on manned space flight and not enough on unmanned space science and that NASA activities showed little sign of forward planning.

7 February—President Kennedy nominated James E. Webb, a lawyer and former Director of the Budget, to be NASA Administrator. Webb's nomination was confirmed by the Senate on 9 February.

February-August—At Webb's behest, NASA officials conducted several studies that laid the groundwork for the November reorganization.

23 February—Webb and Deputy Secretary of Defense Roswell Gilpatric agreed that NASA and DOD would not initiate development of space launch vehicles or boosters without mutual consent.

20 April—Congress approved an administration proposal to reorganize the Space Council. Public Law 87-26 transferred the Council to the Executive Office of the President, made the Vice President the chairman, reduced the Council to five statutory members, and authorized the Council to "assist" as well as advise the President.

5 May—In the nation's first manned space flight, Alan Shepard was launched by a Redstone booster for a fifteen-minute suborbital flight.

25 May—President Kennedy addressed a joint session of Congress and outlined the broad-gauged national space program prepared by Webb and Defense Secretary Robert McNamara. Kennedy proposed (a) the goal, "before this decade is out, of landing a man on the Moon and returning him safely to the Earth"; (b) the development of a nuclear rocket; (c) the development of communications and meteorological satellites. The President accompanied his message with a request for an additional $549 million, most of which was earmarked for the lunar program.

5 June—NASA announced the establishment of an Office of Programs under DeMarquis Wyatt to serve as a planning and review staff to the Associate Administrator.

28 June—A joint report issued by NASA, DOD, and the Federal Aviation Agency concluded that the development of a commercial supersonic transport aircraft was technically feasible and in the national interest, that the Government's role should be one of assistance to industry, and that "maximum feasible recovery of direct government expenditures should be sought."

20 July—A joint NASA-DOD Large Launch Vehicle Planning Group was created under the cochairmanship of Nicholas Golovin (NASA) and Lawrence Kavanau (DOD). Although the group could not resolve the question of mission mode for Apollo, it made several important recommendations, including one that the Air Force proceed with the development of the Titan III launch vehicle.

9 August—NASA announced first major Apollo contract award, to MIT's Instrumentation Laboratory for Apollo Guidance and Navigation.

24 August—NASA announced selection of site at Cape Canaveral, Florida, as site of Apollo launches. A NASA-DOD agreement provided that the site would be operated as a joint venture under single management to prevent duplication and that the Air Force would be assigned responsibility for all "range operations."

September–December—NASA announced prime contractors for the three stages of the Advanced Saturn launch vehicle: Boeing for the first stage (S-IC), North American Aviation (Rocketdyne Division) for the second (S-II), and Douglas Aircraft for the third (S-IVB).

19 September—NASA announced that a new Manned Spacecraft Center would be established at Houston, Texas, with the Space Task Group as its nucleus.

October—Congress authorized NASA to raise its ceiling of excepted positions from 290 to 425.

1 November—NASA announced a major headquarters reorganization. The following offices were abolished: Advanced Research Programs, Space Flight Programs, Launch Vehicle Programs, and Life Science Programs. Five new offices were established: Advanced Research and Technology (under Ira Abbott); Space Sciences (Homer Newell); Manned Space Flight (D. Brainerd Holmes); Applications (vacant, subsequently filled by Morton Stoller); and Tracking and Data Acquisition (Edmond Buckley). All NASA field installations were to report directly to Associate Administrator Seamans.

28 November—Despite a report from the source evaluation board rating the Martin Company higher technically, Webb, Dryden, and Seamans selected North American Aviation as prime contractor for the Apollo command and service modules.

7 December—Seamans announced the creation of a new program, Gemini, as a follow-on to Mercury. Its major purposes were to develop the technique of rendezvous in space and to extend orbital flight time.

12 December—NASA requested the Army Corps of Engineers to assume responsibility for managing its construction of new facilities, particularly at the Cape.

21 December—First meeting of the Manned Space Flight Management Council, chaired by Holmes and including the Manned Space Flight Center directors and their staff.

1962

24 January—Establishment of NASA Office of Public Affairs.

9 February—NASA announced that General Electric had been selected for a major supporting role in Apollo to provide integration analysis of the total space vehicle, assure reliability of the entire space vehicle, and develop and operate a checkout system.

21 February—Webb wrote to the president of American Telephone and Telegraph (AT&T), requesting that the Bell System provide experienced staff to prepare studies and analyses in support of the lunar landing. On 23 March AT&T announced the formation of Bellcomm, Inc., a profit-making corporation owned by AT&T and Western Electric and working exclusively for NASA.

30 April—Task force on Government Contracting for Research and Development submitted its report. The Committee, chaired by David Bell, the Director of the Budget, included Webb and McNamara. Its principal recommendations were (a) that Government salaries should be competitive with those offered for similar work by private industry; (b) that certain functions should never be contracted out; (c) that Government facilities should be used to the fullest possible extent; and that, where possible, the Government should use fixed-price rather than cost-plus-fixed-fee contracts and that provision be made for incentive arrangements.

29 May—Webb appointed a study group chaired by Walter Sohier, NASA General Counsel, to review source evaluation procedures and various methods of improving contractor performance. Throughout 1962 NASA moved toward the introduction of incentive clauses in its major development contracts.

1 July—The Launch Operations Center at Cape Canaveral was officially activated as a separate NASA field installation.

11 July—In a press conference NASA explained the choice of lunar orbit rendezvous as the Apollo mission mode. NASA also announced that an improved version of the Saturn I would be developed to test-fly the Apollo configuration in Earth orbit.

21 July—NASA selected design for the Advanced Saturn launch complex northwest of the Cape. The launch vehicles would be erected and checked out vertically and then transported to launch complex 39, already under construction.

31 August—President Kennedy signed the communications satellite bill, establishing a private corporation in charge of the U.S. portion of a future global communications satellite network.

11 October—Congress passed the Federal Salary Reform bill, which increased the rate for GS-18 from $18 500 to $20 000 and created a nonquota category of scientific and research positions to be filled by agencies, including NASA, upon approval by the U.S. Civil Service Commission.

30 October—Holmes was named Deputy Associate Administrator for the Manned Space Flight Centers. Under this arrangement, MSFC, the Manned Spacecraft Center (MSC), and the Launch Operations Center would report directly to Holmes, rather than to Seamans.

20 November—NASA named Adm. W. Fred Boone (USN-Ret.) to the newly created position of Deputy Associate Administrator for Defense Affairs.

1963

14 January—A NASA-DOD agreement provided that Merritt Island Launch Area would be operated as a NASA installation, separate and distinct from the Air Force's Atlantic Missile Range; that NASA would be responsible for master planning of Merritt Island; and that DOD would remain responsible for operation and management of range facilities of Atlantic Missile Range as a national asset, providing common range service to DOD and NASA.

17 January—NASA's budget request for FY 1964 was sent to Congress and included $5 million for land acquisition and engineering services for an Electronics Research Center in the Boston area.

21 January—NASA-DOD agreement confirmed NASA's role as Gemini project manager, created Gemini Program Planning Board to plan experiments for NASA and DOD, and agreed that "DOD and NASA will initiate major new programs or projects in the field of manned space flight aimed chiefly at the attainment of experimental or other capabilities in near-earth orbit only by mutual agreement."

25 February—Memo from Seamans to all center directors recommending that requests for proposals, including the incentive clause, "contain the precise language of the *definitive* contract terms."

March—Establishment of NASA Office of Industry Affairs, with the Procurement Division placed under it. At the same time, the Industrial Applications Division of the Office of Applications was renamed the Technology Utilization Division and charged with disseminating information on the commercial applications of space technology.

15–16 May—Astronaut Gordon Cooper's twenty-two-orbit flight concluded the Mercury program.

5 June—Delivering Air Force Academy commencement address, President Kennedy said, "It is my judgment that this Government should immediately commence a new program in partnership with private industry to develop at the earliest practical date the prototype of a commercially successful supersonic transport superior to that being built in any other country of the world." In a 14 June letter to Speaker of the House he described the proposed supersonic transport development.

12 June—D. Brainerd Holmes announced his resignation as Deputy Associate Administrator for the Manned Space Flight Centers. Dr. George E. Mueller, Vice President for R&D of Space Technology Laboratories, was named to succeed him on 23 July.

24 September—At meeting of the Manned Space Flight Management Council it was resolved that the monthly program review and the monthly Management Council meetings should be combined and that the size of the Council should be decreased.

14 October—First meeting of the NASA Management Committee, chaired by Seamans and attended by key headquarters functional officials, including the heads of the Offices of Industry Affairs, Public Affairs, International Affairs, and Administration.

29 October—At meeting of Manned Space Flight Management Council, Mueller stressed the importance of an approach to meeting schedules that would "maximize 'all-up' systems flight tests." He also said the philosophy should include obtaining "complete systems at the Cape . . . and scheduling both delivery and launch dates." (Minutes of Management Council).

1 November—Major reorganization of NASA Headquarters became effective, consolidating the program offices and delineating certain staff functions. George Mueller was named Associate Administrator for Manned Space Flight, with MSC, MSFC, and the Launch Operations Center reporting to him; Homer Newell became Associate Administrator for Space Science and Applications, with the Jet Propulsion Laboratory, Goddard Space Flight Center, and Wallops Station reporting to him; while Raymond Bisplinghoff, the Associate Administrator for Advanced Research and Technology, directed the Ames, Flight, Langley, and Lewis Research Centers. These program managers would report to the Associate Administrator. Also reporting to Seamans would be the Deputy Associate Administrators for Industry Affairs, Administration, Programming, and Defense Affairs.

29 November—President Lyndon B. Johnson signed executive order changing the name of the Launch Operations Center to the John F. Kennedy Space Center (KSC).

10 December—Defense Secretary McNamara announced cancelation of the Dyna-Soar manned aero-spacecraft project. Some of the funds saved would be diverted into long-range exploration of the military uses of man in space, the chief project of which would be a Manned Orbiting Laboratory (MOL) using Gemini-type spacecraft.

1964

9 January—NASA and the Federal Aviation Agency (FAA) signed a memorandum of understanding on supersonic transport. FAA was to be responsible for direction and management of design and evaluation of proposals; NASA, for conducting background research, providing technical advice, making resources available to FAA, and vehicle flight testing.

14 January—NASA-DOD agreement on instrumentation ships provided that ships required to support NASA and DOD programs would be placed in pool operation on behalf of both agencies, and that the Navy would be the lead agency on ship modification and conversion.

30 January—In letter to Webb, President Johnson requested that NASA outline its post-Apollo plans. NASA established Future Programs Task Group under Francis Smith to reply to President.

30 January—Basic agreement between NASA and U.S. Weather Bureau to establish a National Operational Meteorological Satellite System. The Weather Bureau would determine overall requirements, operate command and data acquisition stations, and process data for integration into weather analyses. NASA would design and launch spacecraft, operate launch sites, and conduct launch operations.

April—NASA issued NPC 401 on use of contracts for nonpersonal services.

20 April—NASA-DOD agreement assigned responsibility to DOD for providing contract administration services within the Philadelphia region. This agreement served as prototype for NASA use of DOD contract administration services throughout the United States.

27 April–4 May—House Science and Astronautics Committee's Subcommittee on NASA Oversight held hearings on failure of Ranger 6 lunar probe.

July–December—Joint study conducted by AACB Launch Vehicle Panel confirmed NASA decision to use the Saturn rather than the Titan III launch vehicle for Apollo.

1 September—NASA Electronics Research Center at Cambridge, Massachusetts, was formally activated.

15 September—A task force headed by NASA Deputy Associate Administrator Earl Hilburn issued first report on *Studies Relating to Management Effectiveness in Scheduling and Cost Estimating.* Second report submitted on 15 December.

10 December—Webb, McNamara, Donald Hornig, the President's Science Advisor, and Kermit Gordon, the Director of the Bureau of the Budget, reached preliminary agreement on the purpose and scope of the MOL.

1965

January—Future Programs Task Group issued final report. This outlined future program possibilities, but did not specifically choose among them. In a letter to the President of 16 February, Webb endorsed the exploration of Mars by unmanned vehicles and the use of the Saturn booster and the lunar module for a variety of missions.

25 January—Webb and McNamara announced NASA-DOD agreement on MOL. Both agencies would conduct cooperative studies to identify experiments that might be conducted in conjunction with the military program, while DOD continued intensive studies aimed at defining primary military objectives.

22 May—NASA-DOD agreement outlined principles in the management of colocated tracking stations.

22 July—Harry Goett dismissed as Director of Goddard Space Flight Center after persistent disagreements with senior NASA management. Dr. John Clark, director of Sciences in the Office of Space Science and Applications, named Acting Director.

6 August—Saturn/Apollo Applications directorate established within Office of Manned Space Flight to plan and direct programs utilizing technology developed in Apollo.

25 August—At a White House news conference, President Johnson announced approval of DOD development of the MOL at a cost of $1.5 billion. First unmanned flights, launched by a Titan IIIC, would begin late in 1966 or early 1967. At the same press conference, he announced that he was extending the DOD system of planning-programming-budgeting to civilian agencies, including NASA.

1 September—Willis Shapley, formerly Deputy Chief of the Military Division of the Bureau of the Budget, became NASA Associate Deputy Administrator.

28 October—NASA officially instituted its policy of phased project planning. Research and development process divided into four stages: advanced studies, project definition, design, and development/operations.

2 December—Hugh Dryden, NASA Deputy Administrator since 1958, died at age 67.

29 December—NASA Headquarters reorganization plan disseminated throughout NASA. The plan provided for the following changes: establishment of Office of the Administrator, in which the Administrator and Deputy Administrator would be supported by the Associate Deputy Administrator with a strong secretariat; and establishment of operating pattern whereby the Deputy Administrator, Dr. Seamans, would serve as general manager. Among other changes, Director of Office of Tracking and Data Acquisition would be made Associate Administrator for Tracking and Data Acquisition, and heads of all functional staff offices as well as the four program offices would report to Deputy Administrator.

1966

14 January—Webb invited Norman Ramsey, a Harvard physics professor, to form a committee to evaluate NASA's advisory structure.

21 March—A report of a subcommittee of the House Government Operations Committee recommended that NASA's Apollo Applications and the Air Force's MOL be merged in order to avoid wasteful duplication.

19 May—A report of the Senate Committee on Aeronautical and Space Sciences questioned the adequacy of NASA funding for aeronautical R&D and suggested a separate budget for aeronautics as a possible solution.

5 August—The consulting firm of Booz, Allen and Hamilton submitted its report to NASA on the effectiveness of the agency's incentive contracts. Based on a study of fifteen major contracts, the report concluded that incentive contracts were more effective than cost-plus-fixed-fee in holding down costs but that NASA still had much to learn about their benefits and limitations.

15 August—Ad Hoc Advisory Committee chaired by Norman Ramsey submitted its report to the Administrator. Its principal recommendation, that NASA establish a general advisory committee of non-NASA scientists reporting to the Administrator, was rejected by Webb and Newell.

29 August—Seamans signed project approval document authorizing Apollo Applications proposal. The approved plan called for launching the fueled upper stage of a Saturn IB, which would then be outfitted by the astronauts as an orbital "workshop."

8 September—A NASA task force led by Wesley Hjornevik submitted its "Considerations in the Management of Manpower in NASA." Purpose of report was to consider "possible methods by which Center complements could be adjusted by management to meet the needs of changing roles and missions."

15 November—With successful flight of Gemini 12, NASA's Project Gemini officially ended.

1967

27 January—Three-man crew for NASA's first manned Apollo spaceflight died when flash fire swept through the Apollo 1 spacecraft on the launch pad at KSC. Victims were Virgil Grissom, one of seven original Mercury astronauts, Edward H. White, and Roger B. Chaffee. NASA appointed Apollo 204 Review Board, chaired by Floyd Thompson, Director of Langley Research Center, on 28 January.

February—In its report on *The Space Program in the Post-Apollo Period,* the President's Science Advisory Committee rejected the idea of selecting a single major goal as focal point for U.S. post-Apollo program and urged instead a "balanced program based on the expectation of eventual manned planetary exploration."

15 March—NASA carried out a major headquarters reorganization, the fourth since 1961. Harold B. Finger, Manager of NASA-Atomic Energy Commission Space Nuclear Propulsion Office since its formation in 1960, was named to new position of Associate Administrator for Organization and Management. Reporting to Finger would be the Assistant Administrators for Administration, Industry Affairs, Technology Utilization, and University Affairs. DeMarquis

Wyatt became Assistant Administrator for Program Plans and Analysis. Budget and programming functions previously under Wyatt were transferred to the Office of Administration, headed by William Lilly, where they would be integrated into a NASA-wide system for resources management and budgeting.

9 April—Apollo Review Board submitted final report. While Board was unable to pinpoint exact ignition source, it did identify many engineering and design deficiencies that led to the disaster.

10 April–10 May—House Science and Astronautics Committee's Subcommittee on NASA Oversight held hearings on Apollo fire. It adjourned without issuing a report. Senate Committee on Aeronautical and Space Sciences held concurrent hearings but issued no report until January 1968.

1 May—NASA established the Lunar and Planetary Missions Advisory Board to assist in developing a general strategy for manned and unmanned lunar and planetary missions. Board would work with all senior officials involved in such missions and would report to the Associate Administrator for Space Science and Applications. An Astronomy Missions Board with similar responsibilities for space astronomy was established on 13 November.

9 May—At hearing before Senate Committee on Aeronautical and Space Sciences, Webb announced that NASA was extending Boeing Company's responsibilities to include integration of command and service module and lunar module with Saturn booster system.

17 May—In memorandum for the record, Seamans recorded decisions taken several days before by senior management: (a) main Apollo program to take priority over Apollo Applications; (b) all Apollo hardware to be configured for mainline mission; (c) Apollo Applications flight schedules and mission requirements to remain tentative pending further progress on mainline Apollo and further definition of payloads.

18 May—Bernard Moritz appointed Assistant Administrator for Special Contracts Negotiation and Review, with special responsibility for such major contracts as those involving the Apollo command and service modules and the Saturn S-II stage.

June—U.S. General Accounting Office issued report concluding that certain support service contracts at the Goddard and Marshall Space Flight Centers were excessively costly and that the Government could have saved money by using civil service employees.

25 August—NASA announced that Homer Newell would become Associate Administrator, effective 1 October. He would be succeeded as Associate Administrator for Space Science and Applications by Dr. John Naugle.

September—Owing to reductions in the NASA budget request, NASA suspended production of the Saturn V rocket beyond the fifteenth vehicle and canceled the Voyager unmanned mission to Mars and the NERVA II nuclear rocket program.

October—Leo Pellerzi, General Counsel to the U.S. Civil Service Commission, declared certain NASA support service contracts illegal, chiefly because contract personnel were performing the regular work of the agency. During the next few months, NASA issued guidelines to bring such contracts under tighter central control.

October—U.S. Civil Service Commission submitted its "Evaluation of Personnel Management" to Webb. The report concluded that there were a number of problem areas in NASA personnel management: lack of headquarters leadership in supervisory training and promotions, lack of understanding by supervisors of their personnel management responsibilities, and lack of management support for equal opportunity programs. To reply to the report, Webb established an internal Personnel Management Review Committee on 21 November.

2 October—Webb announced resignation of Deputy Administrator Seamans, effective 5 January 1968.

9 November—Successful launch of Apollo 4. This was the first launch of the Saturn V rocket, as well as the first launch from KSC.

1968

January—Establishment of NASA Management Council, chaired by Newell and attended by representatives of all the headquarters program and functional offices.

26 January—Resignation of Edmond Buckley as Associate Administrator for Tracking and Data Acquisition. He was succeeded by his deputy, Gerald Truszynski.

27 January—In a memorandum to all key NASA officials, Webb outlined a revised system for project approval and control. A NASA operating plan would serve as an official statement of resource plans for the current year, and each item in the plan would be covered by project approval documents, all of which would be reviewed by the Office of Organization and Management.

11 March—Associate Administrator Newell announced that the project status reviews before top management would become "general management reviews" to be attended by all key headquarters officials.

2 May—NASA issued revised guidelines for phased project planning. The four phases were now designated preliminary analysis, definition, design, and development/operations.

16 September—At a White House press conference, James Webb announced his resignation as NASA Administrator, effective 7 October. Thomas Paine, who had been named Deputy Administrator by President Johnson the preceding February, became Acting Administrator.

December—President-elect Richard M. Nixon named Dr. Charles Townes to head a task force to make recommendations in space planning.

1969

February—President Nixon established a Space Task Group to draft a plan for the next decade of the U.S. space program. Chaired by Vice President Spiro

Agnew, the task group included NASA Administrator Paine, Secretary of the Air Force Robert Seamans, and Lee DuBridge, the President's Science Advisor.

5 March—President Nixon announced nomination of Acting Administrator Paine to be NASA Administrator. Nomination confirmed by Senate on 20 March.

20 March—Appointment of NASA Associate Administrator for Organization and Management Harold Finger to be Assistant Secretary for Urban Research and Technology, Department of Housing and Urban Development. Nomination confirmed by Senate on 25 April.

May—NASA "procurement lead time" study uncovered major delays in the processing of NASA R&D contracts.

7 May—NASA announced establishment of task group on manned space stations under Dr. George Mueller, Associate Administrator for Manned Space Flight, and of task group on space shuttle under Charles Mathews, Mueller's deputy.

1 June—Report of task force headed by Dr. Townes recommended continuation of $6 billion space effort, disapproved of any commitment to large orbiting space station, and urged commitment to unmanned planetary probes.

10 June—Deputy Secretary of Defense David Packard announced cancelation of MOL because of cuts in defense spending and advances in unmanned satellite systems.

20 July—Apollo 11 astronauts Neil Armstrong and Edwin Aldrin landed on Moon.

22 July—NASA announced revised plans for first orbital workshop, with 1972 launch using first two stages of Saturn V to launch workshop and Apollo Telescope Mount together. Workshop would be outfitted on ground and would arrive in Earth orbit equipped for immediate occupancy by astronauts and with Apollo Telescope Mount attached.

1 September—Lt. Gen. Samuel Phillips (USAF), Apollo Program Director since 1964, resigned to become Commander of Air Force Space and Missile Systems Organization. He was succeeded by Rocco Petrone, Director of Launch Operations at KSC since 1966.

15 September—President's Space Task Group presented report *The Post-Apollo Space Program: Directions for the Future* to President Nixon. Report recommended goal of balanced manned and unmanned programs; increased emphasis on utilization of space technology; and development of new systems and technology space operations that emphasized commonality, reusability, and economy through development of new space transportation capability and space station modules. Report outlined three possible NASA programs for manned Mars landing before end of the century.

10 November—NASA announced resignation of Dr. George Mueller as Associate Administrator for Manned Space Flight, effective 10 December. No successor was named.

13 November—President Nixon sent to Senate nomination of Dr. George M. Low as NASA Deputy Administrator. At the time of his nomination, Low was

Apollo spacecraft manager at MSC. Senate confirmed nomination on 26 November, and Low was sworn in on 3 December.

29 December—NASA announced decision to close Electronics Research Center at Cambridge, Massachusetts, owing to budget cuts.

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