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Chapter 18

THE APOLLO GENERATION: A PROFILE OF NASA'S FIRST ENGINEERS*

Sylvia Doughty Fries†

The study described in this paper originated with the perception that the single most important event now occurring in the U.S. space program is the passing of technological and managerial leadership from one generation to the next. Although the *Challenger* accident of January 1986 and the intense public scrutiny resulting from that tragedy have captured the headlines, a leadership transition during the next decade will affect the future of the U.S. space program even more profoundly. That transition will reconfigure U.S. space policy and technology, just as the first "pioneering" Apollo generation supplied the leadership, which helped to shape not only U.S. policies for space exploration, but the technology and management strategies used to implement those policies. This judgment does not disparage the roles of the U.S. Congress and the White House in determining U.S. space policy; rather, it assumes that national policy for space is a continuous balancing between the technologically possible and the politically desirable, and that what is technologically possible is determined for any given era by its engineers.

STUDY OBJECTIVES

The principal objective of this study is thus a group profile of the engineers who laid the technological and organizational foundations of the Apollo program. Such a profile should provide insights into the following dimensions of the first quarter century of the U.S. venture into space: the origins, motivations, and careers of NASA's first generation of aerospace engineers; the role of that generation in establishing the agency's professional culture during one of its most innovative periods as well as its current leadership; the relationships of science, engineering, and management in the early U.S. space program; and changes within NASA during and after the Apollo program.

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† Dr. Sylvia D. Fries at the time of the presentation was Chief Historian and Director, NASA History Office, Washington, D.C.

SCOPE AND METHODOLOGY

Capturing the experiences of an entire generation can be accomplished in various ways. The historian can extrapolate from demographic data—if good demographic data are obtainable—valuable information about socio-economic origins, education, income, geographic and employment distribution, and similar objective characteristics. Another approach is to examine literary sources—fiction, nonfiction, and visual portraits—of a particular generation. A master of this approach was the novelist John Dos Passos, whose trilogy, *U.S.A.* (1930-1937), is a classic portrait of the generation of the 1920s and 1930s. Yet another approach is the oral history, whose most successful practitioner may be Studs Terkel, author of *Working* (1974), a group profile of the U.S. workforce based largely on excerpts from oral histories. Most of what we know in any systematic and thus generalizable fashion about engineers (or scientists) comes from studies combining demographic analysis, oral histories and social theory—studies such as Ann Roe's *The Making of a Scientist* (1953), Robert Perucci's and Joel E. Gerstl's *Profession Without Community: Engineers in American Society* (1969), and more recently, Robert Zussman's *Mechanics of the Middle Class: Work and Politics among American Engineers* (1985).

Reliance upon oral histories alone, when one's subject is a group of engineers approaching the end of their careers in a single organization, entails the risk of hagiography. Anecdotes and subjective memories may make for satisfying reading, but they are not likely to provide the systematic as well as personal exploration that our subject deserves. Thus the methodological approach of our study combines the analysis of demographic information with oral histories of a cross section of NASA's first generation of engineers. It goes one step further. Interested not only in the actual career experiences of the Apollo generation of NASA engineers, but also in NASA's leadership and prevailing engineering culture, this study examines demographic and interview data about the group as a whole *as well as* demographic and interview data about a subselection of the group identified by the agency's leadership as "representative" of "the NASA engineer."

A study of this kind necessarily relies heavily on demographic information available from NASA's personnel records. This information does not distinguish between scientists and engineers; rather, it includes "professional scientific and engineering positions . . . engaged in aerospace research, development, operations, and related work, including the development and operation of specialized facilities and supporting equipment" [1]. Thus our demographic analyses are based on refinements of NASA data for scientists and engineers by sub-categories of educational fields of specialization and actual occupational areas.

Throughout our study we have distinguished between two categories of Apollo-generation engineers: a general or total population of 9,875 engineers in permanent positions that came to NASA between 1958 and 1970 and still worked for the agency in 1980; and a subset, or "nominee" group of 621 engineers designated by the agency's leadership as "representative" of the NASA engineer of the Apollo Era. In soliciting nominations, we deliberately avoided elaborating on the meaning of "representative," as the purpose of the "nominee" category was to identify, so far as possible, the *cultural norm* of the Apollo generation engineer remaining with NASA, and to test that norm against the *statistical norm* of the same population. Both groups were subjected to comparable demographic analyses and both groups were equally represented in the interview program.

PRELIMINARY FINDINGS: DEMOGRAPHIC ANALYSIS

Available statistical data allow us to make some general observations about (1) NASA's scientists and engineers (S & Es) in the context of total NASA employment during the Apollo decade, (2) those of the Apollo generation of NASA scientists and engineers who remained with the agency at least until 1980, and (3) the Nominee Group of that generation, that is, those designated by NASA's current leadership as "representative" of the Apollo-generation engineer, and thus embodying the agency's cultural norm for engineers throughout the twenty-year period. These general observations, in turn, suggest themes to be explored in our study about NASA as an organization, and about the men and women who built the agency. NASA's personnel statistics for the Apollo decade (1958-1970) show the enormous expansion of the agency as it responded to the challenge of the manned lunar landing program. From a nucleus of nearly 8,000 employees, who entered NASA when it was created in 1958, the new space agency expanded to more than four times that number by 1967, or in less than ten years. Expansion stopped, however, after 1967, and by the end of the decade NASA's total civil service employment declined to slightly over 30,000, the level of 1963-1964. The rate of increase, which reached 70% in 1961—the year President Kennedy announced the Apollo program—declined to less than 1% in 1967, and by the end of the decade NASA lost more personnel than it hired.

Estimated totals of NASA's contractor employees show an even more dramatic pattern of growth and decline, increasing twelvefold from around 30,000 at the beginning of the period (1960) to 360,000 in 1966, and then dropping to about one-half of that number (170,000) by 1970. Thus the ratio of NASA's contractor to in-house personnel increased from roughly 4 to 1 in 1960 to 10 to 1 in 1966, and then declined to roughly 5 to 1 in 1970.

Rapid expansion in personnel, followed by an equally rapid contraction, was matched by the turnover rate, which hovered at around 10% through 1963, rose to 13.6% in 1966, and then declined to 5% in 1970. A decrease in the number of NASA's civil service employees toward the end of the decade was matched by a stabilization in the number of employees who remained with the agency. Declining turnover was affected by reductions in the agency's authorized personnel ceilings. Thus, as the agency was stabilizing in terms of its core workforce, it was less able to take advantage of the reinvigorating potential of new talent.

During the same decade NASA necessarily hired a large number of scientists and engineers. However, with the exception of 1960 and 1961, the rate at which NASA hired scientists and engineers consistently exceeded the rate at which NASA hired other employees. As a result, the proportion of NASA's total in-house permanent workforce consisting of scientists and engineers gradually increased from one-third in 1958 to slightly less than one-half in 1970, in spite of the fact that after 1967 NASA experienced significant declines in both in-house and contractor employees.

General NASA personnel data for 1958 through 1970 thus exhibit trends that raise some interesting questions. The growth of the agency's work force from 1958 to 1967 included a disproportionately large increase in scientists and engineers as distinct from other kinds of employees, and an even more disproportionate increase in contractor employees. But when NASA was forced to reduce its workforce after 1967, the reduction occurred primarily among non-scientists and non-engineers (See Figure 1). Conventional wisdom holds that bureaucratic or administrative burdens on all federal agencies—including NASA—increased by several magnitudes during the 1960s and 1970s. If we assume that those burdens, at worst, remained steady throughout the Apollo decade (and it is more probable that they increased), it becomes apparent that administrative burdens in NASA were borne increasingly by NASA's scientists and engineers. Thus we must ask whether a "Gresham's Law" of bureaucracies began to affect NASA by 1970: that is, that routine (i.e., administrative) work began to push out creative work. The significance of this phenomenon, if it occurred, is increased by the fact that turnover had decreased markedly by 1970, depriving the agency of the fertilization that occurs when a research organization acquires new employees.

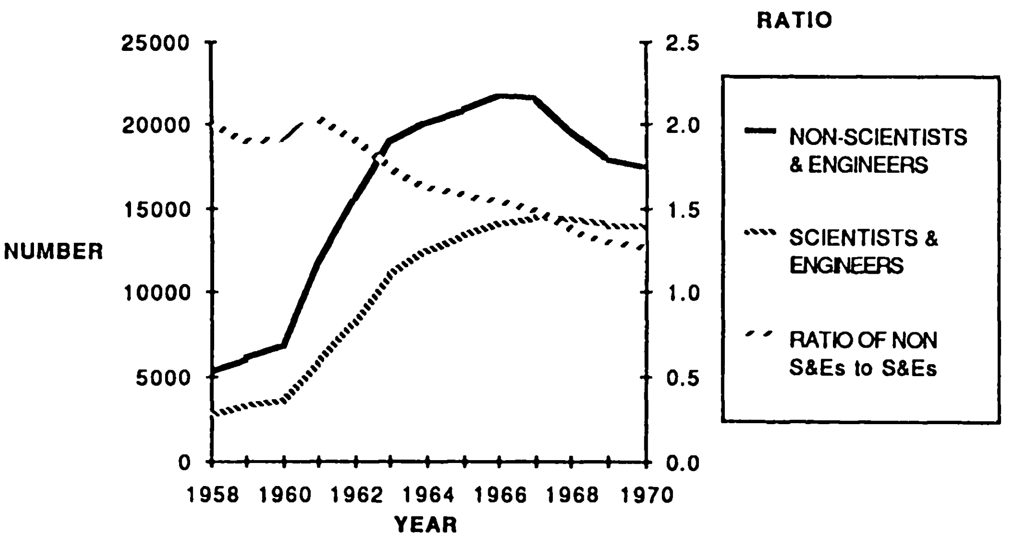

Figure 1 NASA Personnel by Categories.

Turning to those NASA scientists and engineers who entered the agency between 1958 and 1970 and remained to make their careers with NASA (the population which we call the "Apollo generation"), we find that, first of all, the critical mass of that population (or 7,787 out of 9,875) arrived at NASA before 1966. How many of this generation were in fact engineers as distinct from scientists? NASA personnel data do not distinguish between scientists and engineers, but distinctions can be inferred by examining the fields of highest degree and the actual occupations of the agency's Apollo generation scientists and engineers. This data we do have, and it tells us that 60% received their highest degrees in engineering fields;

about 75% have been working in engineering occupations and about 20% are in non-scientific or non-engineering occupations that include administrative work.

If we look at these data more closely, we find interesting differences among Apollo-generation scientists and engineers who arrived at NASA before 1960, between 1961 and 1965, and between 1966 and 1970. The highest percentage of engineering occupations (78.3%) occurs among the oldest group and declines to 72.7% and 73.2% respectively among the middle and youngest group. What were the others doing? They were not going into non-scientific or engineering occupations; in fact, the number in those occupations declined from a high of 22% for the middle group to 17% for the youngest. Rather, an increasing proportion, from 3.5% to 8.5%, entered and remained in space-science and life-science occupations. Thus, as the number of scientists (persons trained in scientific disciplines) increased among the Apollo generation, so did the number of S & E entrants who went into space-science and life-science occupations. Throughout the period, however, S & Es trained in science consistently outnumbered those in scientific occupations; hence, the ranks of NASA's engineers were augmented by trained scientists, rather than the reverse.

Meanwhile, notwithstanding the fact that the agency's administrative burdens in all probability increased, not only did its non-scientific and non-engineering personnel decline, but the number of NASA's scientists and engineers assigned to administrative occupations also declined. And, by the very nature of a federal agency's administrative responsibilities, those burdens cannot have been substantially shifted to contractor personnel, whose numbers, as we have seen, also declined significantly. Thus one of the themes that begs to be explored, as we complete our study, is the bureaucratization of a research organization, and the possible bearing of the process on the actual work being done by its scientists and engineers, as well as the vitality of the organization as a whole.

Another theme that emerges from our data is the character of NASA's leadership. More than 95% of the Apollo generation remaining with NASA achieved, by 1980, the civil service rank of GS-12 or above, including an average of nearly 17% in the civil service ranks of GS-15 through SES (Senior Executive Service). Of the 435 members of NASA's Senior Executive Service in 1980, 338 or more than 75% were scientists and engineers of the Apollo generation. (The significance of the preponderance of that generation in NASA's leadership at the end of the 1970s is all the more apparent when one realizes that NASA's Senior Executive Service in 1980 represented only 1.8% of the total NASA civil service workforce.) Furthermore, the highest proportion, or 161 of the Apollo generation's senior executives, came from that group which had entered by 1960. Since almost 95% of NASA personnel, when the agency opened its doors in 1958 came from the research centers of the National Advisory Committee for Aeronautics (NACA)—Langley Research Center, Ames Research Center, and Lewis Research Center—it is a safe assumption that engineers from the original NACA centers contributed significantly to the composition of NASA's leadership during its first two decades.

When we turn to the nominee group—members of the generation designated by NASA's leadership in 1984 as "representative"—we find roughly the same proportion in GS-12 and above, with one important difference: whereas nearly 17% of the total population had achieved grades over GS-15 by 1980, twice that proportion in the nominee group were in grades GS-15 through SES when nominated. Moreover, the nominee group was twice as frequently represented among the SES ranks when nominated than was the total population in 1980. Thus as we complete our study we will be developing a portrait not only of NASA's first generation of engineers, but also of those who constituted the agency's leadership through the early 1980s—and who will be replaced in the next ten years by a new generation of NASA scientists and engineers with the historical burden of reshaping the agency (See Figure 2).

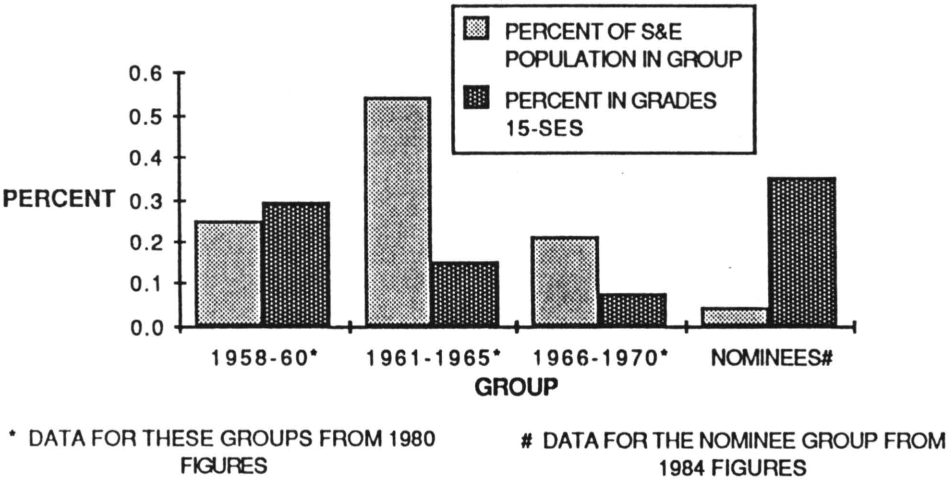

Figure 2 NASA Scientists & Engineers Percent of Population in Group Versus Percent in Grades 15-SES.

What, then, can we say at this preliminary stage about NASA's leadership, other than that it has been shaped by the experience of NASA's first decade? To begin with, the Apollo generation was predominantly white and male. Only in the most recent period (1966-70) did new S & E accessions include as much as 4% females. American Indians were the least represented ethnic minority, never achieving—among those who remained with NASA—more than 1% representation. The best represented were Blacks, whose representation increased from 1.5% to 3% during the period, while Asians and Hispanics accounted for between 0.4% and 1% of the Apollo Era scientists and engineers who remained with NASA. When selecting the most "representative engineers" (nominee group), NASA's leadership was evidently sensitive to the increase in number of non-whites, selecting almost 10%; but the individuals selected were still overwhelmingly (96.2%) male.

Judging from their levels of education, NASA's Apollo generation, and its core leadership was increasingly better educated. Whereas only 30% of those entering the agency by 1960 had degrees beyond the bachelor's, more than 40% of those who came to work for NASA between 1966 and 1970 held post-graduate degrees. The nominee group, however, includes more of the older entrants, slightly more than 30% of whom had post-graduate degrees. This difference is consistent with the difference in average ages of the two groups: the nominee group is older, on the average, than the generation as a whole. Whereas less than a third (60.7%) of the Apollo generation was born before 1940, almost three-fourths (73.4%) of those nominated as "representative" were. When asked to select "representative" engineers, the agency's leadership generally looked toward the oldest of their generation. Similarly, the nominee group has been with the agency longer (85.7% served fifteen years or longer) than the generation as a whole, for which less than 80% had been with the agency as much as fifteen years.

The engineering specialties or sub-disciplines, represented by both the total population and the nominee group, reflect not only interesting differences between the two, but also developments within the discipline of engineering itself. The largest proportion of both categories received their highest degrees in the older, broader specialties of electrical engineering and mechanical engineering. Electrical and mechanical engineers are, however, slightly more predominant among the nominee group than among the total population. Only among those Apollo-generation engineers who came to NASA between 1961 and 1965 – during the most rapid buildup of NASA's total S & E workforce – does the proportion of electrical and mechanical engineers (43%) approximate the proportion of electrical and mechanical engineers in the nominee group (41.7%). This slight variation affirms the possibility that those engineers judged "representative" by NASA's leadership were those associated with the Apollo program itself.

The growing importance of space technology is more clearly reflected in a comparison of the categorization of highest degree fields between NASA personnel data collected in the 1960s and the same data collected in the 1980s. The earlier data lists "aeronautical engineering" as a degree field, and a declining percentage (from 16% to 9.5%, between 1960 and 1970) is listed as having received their highest degree in that field. Almost one tenth (9.9%) of the nominee group, however, is identified as having obtained its highest degree in "aerospace engineering." The actual trend within engineering education of subsuming aeronautical within aerospace engineering is thus reflected in the more recently identified degree field of NASA's scientists and engineers.

Personnel data thus enable us to make some general observations about those among the Apollo generation who remained to make their careers with NASA and serve as the agency's core leadership. First, they consist primarily of two cohorts: those who transferred to the new space agency in 1958 from the research centers of the NACA, and those who entered NASA before 1965, or during the build-up for the Apollo program. The preponderance of the older, pre-1965 group suggests other attributes that we may compare with the agency's core leadership as reflected in the nominee group. That leadership is predominantly white and male; it is slightly less well educated (as measured by degree level) than the generation as a whole, and it tends to represent the older engineering disciplines. Finally, the generation as a whole shares at least two significant experiences: involvement in NASA's first major program – the manned lunar landing program – and the bureaucratization of a research and development organization. For the effect of those experiences, and any others that shaped that generation and NASA's leadership, we must turn to oral history.

ORAL HISTORIES

Demographic data permit us to make some generalizations about the Apollo generation as a whole, and about the "cultural norm" of the NASA engineer as perceived by the agency's current leadership. However, to achieve a more personal sense of the character and experience of that important generation, our study involves an extensive program of interviews with a cross section of both the total population and the nominee group. When completed, we will have interviewed nearly 50 NASA engineers representing the Apollo generation. Our two lists—the larger population of 9,875 and the smaller group of 621 nominees—were narrowed down through random sampling. We then selected, within each of the smaller lists, individuals representing a variety of experiences and achievements. For example, the small percentage of women and ethnic minorities might not have appeared on a random sample list; we made a point of selecting at least a few women and minorities when we could identify them. Likewise, we sought a range within educational and GS grade levels. The interviews we have thus far completed suggest a few themes and characteristics that the remaining interviews will either confirm or disprove.

NASA's first generation of engineers had its origins in almost every part of the American landscape. They came from the mines of Mexico, the railroad yards of the Southern Pacific and the New York Central; they came from the streets of Chicago, the middle-class neighborhoods of Brooklyn and the Great Plains of the mid-west. They were the sons of European immigrants, of grocers and haberdashers, of small businessmen and, in a very few cases, of scientists and engineers. Their education was in the American public school and state university, and some were the first in their families to receive more than a high school education. While they were predominantly the children of service workers, and the makers and dealers and keepers of things, they were the beneficiaries of that era (1920-1950) which saw a fourfold increase in the number of young Americans who entered college. They were thus among the first of the new middle-class which proved so important to the culture and politics of the 1950s. What they were not were the children of "old families" and "old money"—of Southhampton, of Grosse Point, of Westchester County. Very few saw the inside of an exclusive boarding school or the Ivy League. Few, if any, were the sons of lawyers, doctors, brokers or bankers; the world of America's social and economic elite and its intelligentsia was, by and large, foreign to them—and they to it.

Many of the older ones were true sons of the Depression, and the deprivation of the "working class," from which many of them came profoundly influenced their desire to find a profession, a profession that might offer them some security and status, while still enabling them to be makers and fixers of things. For the older ones, World War II presented the most important opportunity—the opportunity of a technical education, for the U.S. government actively supported the education of promising scientists and engineers. Few, if any, saw active service. Some consciously avoided the draft by entering an engineering program. Others enlisted and, qualifying for post-graduate engineering training, were sent to school by the Army and the Navy.

The older ones of the Apollo generation could not have known when they began their careers that they would be part of the space program. Many began their careers as aeronautical engineers, and to know why they went to work at NACA, and not somewhere else, is to know the wonder of a small boy in 1927 standing on the baseball diamond in a small New England town as the umpire proclaimed Charles Lindbergh's landing at Le Bourget Air Field outside Paris. The older ones typically remember when and where they saw their first airplane fly. Many made and flew model airplanes, and knew they wanted to be in aeronautics by the time they left high school. "I always got excited by airplanes." "What kept them in the air?" "Why did they look like they look?" One way to find out was to become an aeronautical engineer. Aeronautical engineering also offered, for some, something in addition to a captured romance: an apparently new, glamorous and expanding field, it offered a way out of the small towns and limited prospects of the worlds from which some of them came. If the romance of flight was central to the aspirations of the older engineers, it may have been less so for the younger ones who came to maturity after the War, along with the airplane.

Convention combines science and engineering, as if they are alternate sides of the same coin. The Apollo generation defies that convention. For these engineers the choice between science and engineering was fundamental. Scientists were analytical, they sat back and theorized. Engineers were the ones who actually went out and did things, made things work. Attempting to define the difference between scientists and engineers, they refer occasionally to an extrinsic as well as intrinsic difference: scientists are "the Oppenheimers, the Einsteins, those kind of people. . ." or "the really bright lights in the theoretical fields." Scientists are, to them, the romantic heroes, the famous. They become so by making the great theoretical breakthroughs. One suspects more: that scientists, when these engineers were young men, inhabited a remote cultural realm to which (they thought) they could not aspire. But any bright, industrious boy could go to the state university, work hard, and become an engineer.

That was their prevailing perception of science and engineering when they were young and thinking about careers. But the distinction between science and engineering began to break down for those who became involved in advanced technological research. As they talk about their work and reflect on the science vs. engineering question, their talk turns to research, and how research is the crucible in which the boundaries between science and engineering dissolve. "Some compartment of his [the research engineer's] being has got to be scientific, [for] the essence of engineering is to ask good questions and devise good ways of answering them, and then be able to recognize the significance of what you see, even though it may differ from what you expected to see." Not all, however, spent their NASA careers in engineering research. Many either did routine engineering work—setting specifications and testing—while others (as we have seen from our demographic data) became caught up in the routine administrative work of R & D management. The relative importance to the agency's culture of technological innovation and the preoccupations of bureaucratic management thus promises to be one of the themes of our study.

While our interviews attempt to explore the full range of these engineers' careers, we will describe only a few of the issues that have surfaced thus far. Prominent among them is what happens when an engineer realizes that "success"—certainly as measured by salary, rank, and influence—means going into management, even in a research institution. While some wanted to go into management and saw engineering as a path to management careers, others entered management reluctantly. "That just is not what I was trained to do in college," observed one engineer, who refused a management spot to return to a staff engineer position. "You come out of a technical environment [but] in order to advance faster, you generally go into management. But you're not *really* trained for that, and I'm not really convinced that engineers make the best managers." Why? "Engineers tend to be not always the kind of 'people persons' who good managers should be. It's a difficult world for an engineer . . . though I was able to do the job, I wasn't enjoying it that much. And so I decided to get into something that I do enjoy." This engineer's view is shared by another, who chose to remain in research: "anybody that goes into management has got to be crazy. . . . The paperwork that flows out of Headquarters and the requirements for what goes on—it would drive me up the wall."

The engineers we have interviewed are nearly unanimous in their perception of management. Moreover, this perception is partly the result of the view that the nature of management itself within NASA has changed since the end of the Apollo decade. An older engineer who reluctantly accepted a management appointment in 1963, did so only because it was "a necessary evil," one of those jobs that has to be done, so the good citizen must take his turn. This same veteran observed, "in the recent history of NASA, there's been a movement toward professional managers [who] . . . almost take pride in not being technically [involved]." He dates the shift to around 1970, and attributes it to "modern management schools and their influence." "In the early day," he recalls, the top management at the NACA laboratories "felt that by putting the most competent technical people in charge of running the research . . . they would get the best research laboratory." He concedes that not all engineers have the required "people" skills, but "enough *do*." The best research management, he insisted, "amounts to leadership by example." One of the younger engineers is more harsh in his judgment of what management means in NASA: "Once you get above a branch chief . . . you don't do anything [technical]." What managers do is "marketing." NASA management is a "marketing operation. [NASA managers] have to lobby headquarters for money. Their main job is to secure funds, keep the place going."

NASA has not been oblivious to the fact that attaching the highest grades and salaries to management positions might draw some of its best engineers away from engineering and, as a result, experimented early with the "twin track" career ladder. In theory, an engineer could achieve the same "super grades" and high salaries earned by top managers. But the success of this scheme has been mixed, and varies from center to center. In the view of an engineer at one of the older centers the theory never worked in practice. "In twenty eight years" at his center it has occurred "only once." Not only hasn't the idea worked, it won't work, because "no employee should make more than his boss." And then, an important concession: "if the person is responsible, with a lot of people under him, directing everything, and he is a GS-15, then an engineer who is working independently, why should he be a 15? He has no responsibility."

Management—or the heavy burden of bureaucratic accountability—is one of the themes to which the engineers we have interviewed to date often return when asked about the changes they have seen in NASA since they came. A number worked originally with the aeronautical laboratories of the NACA, and thus joined the fledgling space agency along with their laboratories. They remember "early days" when one "could have a nodding acquaintance with everybody," when everyone was young, dedicated, and enthusiastic, notwithstanding low pay and few amenities. The older ones remember the "doldrums" that set in right after the War until, in the early 1950s, aeronautical research tackled the problems of transonic flights. Then, in the late 1950s, came not only the excitement of space, but new areas of aeronautical research: among them supersonic flight and vertical take-off and landing craft. To the older engineers at NASA's aeronautical laboratories inherited from the NACA, the Apollo program meant new, and often unwelcome, competition for funds and public attention. Some moved easily into space-related research, others didn't. But they come back again, in their recollections, to the accretions of bureaucracy and paperwork and—new with NASA—the shift from in-house to out-of-house contract work. "In the late '40s and '50s," recalls an engineer at one of the old NACA laboratories, "the [aircraft] companies didn't engage in a lot of exploratory research work. They were pretty narrowly directed toward specific airplane projects." What has changed is that "now it was not so much outside people coming in for answers but coming in looking for contracts. . . . There was that shift . . . big aircraft companies [now] would be just as often approaching NASA with proposals for research work that they do, rather than proposing work that NASA do . . . in-house." And with that shift came another shift important to the engineers" the transformation of research engineer into contract manager.

As is apparent from our preliminary findings, the fortunes of NASA's first generation of engineers, and of the U.S. space agency itself, were—and remain—closely intertwined. The Apollo program was the work of not only a new generation of engineers, it was one of the most visible accomplishments of a new American middle-class. NASA's leadership has been recruited largely from two cohorts in that generation: those who came to NASA from the aeronautical research laboratories of the NACA, and those who joined the agency during its dramatic build-up for the Apollo program. Finally, preliminary analysis of both demographic and (as yet incomplete) interview data indicates that the bureaucratization of an R & D organization, and its increasing reliance on contract rather than in-house engineering work, may be two organizational phenomena of critical importance to the historical understanding of the U.S. civilian space program during its first quarter century.

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