National Academy of Public Administration

NASA

MAINTAINING THE PROGRAM BALANCE

A Report by an Academy Panel
Examining the Distribution of NASA Science and Engineering
Work between NASA and Contractors
and the Effect on NASA's In-House Technical Capability

VOLUME I

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PREFACE

The National Academy of Public Administration is pleased to submit this report on its assessment of the broad allocation of technical work performance between the National Aeronautics and Space Administration (NASA) staff and its support contractors, and to a degree within NASA itself. The allocation of technical work is characterized as "Program Balance."

As NASA proceeds with the many and varied research and development projects in its inventory, it must contemplate the status of its internal technical capability to execute those projects and to confront the national desire to do even more as embodied by the President's Space Exploration Initiatives.

To provide guidance to its research staff, the Academy appointed a panel of six experts in the management of scientific organizations and in the civil space program. The panel drew significant conclusions from the results of that research and developed recommendations for the Administrator of NASA based on that work.

The panel and the research staff greatly appreciate the full access to senior NASA and contractor managers. Their willingness to openly express their views has been of great benefit to the study.

With over 12,500 scientists and engineers on its payroll, NASA represents a significant national technical capability in aeronautics and space. This report seeks to assist NASA in building upon that established capability.

Ray Kline
President

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In March of 1990, the NASA Administrator asked the Academy to perform a study to address these questions: Has NASA contracted out too much of its technical work to remain a "smart buyer" of technical products and services from industry? Has NASA's in-house technical capability eroded over time? Is in-house hands-on engineering and scientific work truly important to the development of fully competent scientists and engineers and, if so, does NASA have enough hands-on work opportunities available? Have the number and diversity of NASA's programs and projects caused the in-house science and engineering capability to be "stretched too thin?" Is NASA still able to attract high quality scientists and engineers, both at entry and higher levels?

This study is not a staffing requirements review, a personnel management review, an organizational structure review, or a review of what the space program of the nation should be. The questions relate primarily to the allocation of technical work and responsibility between NASA and its support contractors, within the agency itself, and the effects of that allocation on NASA's in-house technical capability to effectively accomplish its assigned activities. We have labelled that allocation as "program balance."

The task was approached by seeking the insight of those best in a position to have informed views on the questions posed. First, since the in-house technical capability of NASA rests in its field centers, we focused our direct interview research on current and former senior NASA managers in those centers and on senior contractor managers supporting those centers. Second, a survey questionnaire was issued to over 2,200 NASA scientists and engineers at Grades 12 and 15 - selected because from the Grade 12s will come the middle management of tomorrow, and from the Grade 15s will come the senior center management of tomorrow. A total of 1,567 of those surveyed responded, and approximately half of the respondents volunteered written commentary. That response represented 42 percent of NASA's total number of engineers and scientists at Grades 12 and 15. Finally, NASA's data base on functional utilization of scientists and engineers, and its annual manpower summary of civil service and support contractor scientists and engineers covering fiscal years 1972 through 1990 were reviewed.

In terms of contracting technical work NASA has, at various centers, engaged support contractors to do more and more work in areas previously performed by civil service personnel - developing technical requirements and specifications, project management, program control (monitoring contractor progress against overall contract requirements), supporting source evaluation boards (a procurement-related activity), monitoring the technical performance of prime contractors, and performing systems engineering and integration (involving the work of multiple contractors). While the use of contractors in support of such activities may be appropriate, the panel concludes that the trend toward greater contractor utilization in these areas poses important questions relating to government and contractor accountability for program results and indicates a need for greater policy clarification by agency management.

The balance of expertise in certain technical disciplines has shifted to support contractors. Those identified by NASA managers include avionics, stress, thermal, gyros, structural analysis, software development, computational fluid dynamics, aerothermodynamics, and systems engineering.

NASA's in-house scientist and engineer population has remained within a range of 11,500 to 13,000 over the last eighteen years. Its support contractor scientist and engineer population remained in a band of 5,000 to 6,500 from fiscal year 1972 through fiscal year 1987 and dramatically increased in the last three years to a current total of approximately 13,000. Of the Grade 12 and 15 survey respondents, 58.5 percent believed that the future roles of contractors should be more limited than presently and 65.7 percent said the public interest would be best served if less technical work were contracted out.

With evidence of technical functional and technical discipline strength movement to support contractors and the dramatic shift in the ratio of NASA to support contractor engineers and scientists, the panel concludes that NASA may be losing its ability to operate as a smart buyer of technical products and services, and to control and oversee that work in all technical respects.

The agency's program and project work has grown and is more diverse. This growth in number and diversity is largely due to the cargo-carrying capability of the Space Shuttle and the resulting growth in defense, science and applications payloads and experiments. The field centers have gradually expanded their program activities over the years into what, for them, were new and different technical fields. Seventy-six percent of the grade 12 and 15 survey respondents observed that the variety and complexity of work has increased at their center. The panel concludes that NASA is stretched too thin in terms of technical management of and technical support to its wide variety of complex science and engineering activity.

Between 1980 and 1990, at all but one center, there has been a gradual decline in the number of civil service scientists and engineers assigned to the core functions of research, design, test, and evaluation as a percent of total scientists and engineers. The center-by-center decline ranged from three percent to fourteen percent. During the same time period, the total scientist and engineer population has increased at all centers. The NASA personnel information system reveals that the growth has taken place in the field of project development, which is NASA's most highly contracted technical activity. Special analyses provided for this study by some centers indicate that the shifts from core science and engineering activities have been into project management, flight program and research facility operations, and the fields of reliability, quality, and safety. The development centers have most heavily felt the impact on their core science and engineering capabilities by the movement of scientists and engineers into operations support of pre-launch processing and post launch activities required by long-term flight programs and projects, such as the Space Shuttle and its many payloads. The panel concludes that growth of the flight program operations role has caused NASA to shift a sufficient number of its scientists and engineers into performance of that role as to be detrimental to the core science and engineering capabilities of the development centers.

There is almost unanimous agreement that hands-on science and engineering work experience is essential to developing scientists and engineers with a level of knowledge that provides a sixth sense for spotting problems early, for being a smart buyer of technical products and services, and for being astute overseers of the work of technical contractors. Hands-on experience is essential not only for new engineers and scientists, but to keep current the skills of those more senior. While several NASA centers have programs underway to provide more hands-on opportunities, most believe that they are not doing enough. Over 90 percent of the survey respondents agreed that hands on work is necessary to acquire and maintain proficiency, and more than 80 percent said that NASA needs to do more to provide such opportunity. The panel concludes that the value of and need for hands-on science and engineering work is essential to the professional development of NASA scientists and engineers to effectively perform the work of the agency, and that the agency needs to provide more of it.

A number of agency management process requirements tend to dilute the amount of time NASA's scientists and engineers have available to do technical work in their specialties. Among those is the management of Cost Plus Award Fee contracts which cover 62 percent of the agency's contract dollars. This contract type is preferred by NASA managers because of its rigorous process orientation and the required detailed and often daily interaction between NASA technical employees and contractor employees. The contract type is accepted by the contractor community, but with the observation that there is too much involvement by NASA in detailed administrative matters, and less involvement by NASA technical specialists in technical performance issues. This type of contract heavily consumes technical staff time on both sides in the regularized and repetitive fee determination process. The general outcome is fees in the range of 7 to 8 percent and no adjective ratings below "Excellent." The panel concludes that there is little differentiation in contractor evaluations and that the amount of technical time consumed in the award fee evaluation process is not justified by such narrow results.

Other internal management practices impacting NASA scientists and engineers include highly formal reviews of technical program status, complex technical organization structures, limited delegation of authority for resource and technical decision making, extensive cross coordination and "sign-off" requirements on the way to technical and resource decision making, and an atmosphere of risk avoidance. The panel concludes that the agency should be able to increase the technical utilization of its scientists and engineers by improving its technical program management processes.

NASA has no difficulty in attracting high quality entry level scientists and engineers, with an aggregate grade point average of 3.2. The agency has experienced some difficulty in attracting engineers and scientists with more professional experience, principally due to non-competitive salaries. The panel believes that the recently enacted pay reform legislation, particularly as it relates to geographic pay adjustments and the possibility of hiring at above the first step of the pay grade, should in the near term help to resolve NASA's recruiting difficulties at mid-level. Retention of scientists and engineers in the agency is not a problem. Over 64 percent of the survey respondents consider NASA to be their lifetime career. The loss rate, discounting retirements, is in the range of 2 - 3 percent. The panel concludes that, in the area of recruiting and retention of scientists and engineers, NASA has a good track record and a good system in place, but should vigorously pursue all management flexibilities available through the pay reform legislation.

On the general question of whether NASA's in-house technical capability has eroded over time, NASA and contractor managers believe that it has, by a ratio of four to one. At the grades 12 and 15 level, only 22.5 percent of all respondents agreed that NASA's scientific and engineering capabilities are as strong as in the past. On the basis of functional and discipline movement to contractors, growth in diversity of project work, the need for more hands-on work opportunities to improve technical skills, internal practices limiting technical time available for work in specialty areas and the direct responses on the issue of NASA's in-house science and engineering capabilities, the panel concludes that NASA's in-house technical capability is eroding and is in need of rebuilding.

The critical technical strength of NASA has long resided in the civil service scientists and engineers at the centers. Pressures to reduce government employment, to support a more diverse array of technical activities, and to convert functions to contractor performance have resulted in important changes throughout NASA. Most important has been the gradual erosion of NASA civil service technical capability at the centers.

The panel recognizes that there are various ways and combinations in which government research and development activities can be carried out. It is the panel's strong preference given the history, culture, and past performance of NASA, that the agency take actions to rebuild its civil service in-house technical capability. If circumstances dictate a civil-service/support contractor technical performance mixture it is imperative, in the panel's judgment, that such a mixture be in accordance with a plan and NASA guidance to the centers on which technical functions are important to be performed consistently by civil service scientists and engineers. The panel believes that the guidelines contained in the 1962 "Report to the President on Government Contracting for Research and Development," by David Bell and others, still provides a sound basis for such a plan.

The panel recommends that the Administrator of NASA:

1. **Prepare and issue guidance on technical functional areas to be reserved for in-house civil service performance.**
2. **Convert contracted technical functions essential to in-house capability from support contractors to in-house performance and rebuild strength in specific technical disciplines critical to agency programs and objectives. Ceiling relief should be sought if required.**
3. **Provide policy guidance to the centers to retain in-house sufficient project, experiment, advance development, and research activities to provide more hands-on technical work by civil service scientists and engineers.**
4. **Examine the project mix at each center against agency and center goals and objectives. Select those with marginal contributions and/or staffing for cancellation or transfer. Assess all projects for suitability of specific center assignment.**
5. **Institute an annual critical position review for all technical disciplines, identify the number and professional levels of in-house coverage that are essential to maintaining a reasonable degree of technical expertise in each critical discipline, and adjust recruiting and/or contracting plans accordingly.**
6. **Modify the agency's contractor accountability processes by tightening controls on attendance/participation in formal reviews, simplifying the award fee determination process, increasing the use of unannounced contractor site visits, and rotating NASA personnel stationed in contractor plants.**

7. Seek opportunities for greater delegation of resources/technical decision making authority, reducing multi-party sign-off requirements with encouragement of reasonable risk taking, and improving lines of authority, responsibility, and accountability in the technical management organization.

INTRODUCTION

In early 1990, Admiral Richard Truly, Administrator of the National Aeronautics and Space Administration, asked the National Academy of Public Administration to undertake a study centered on several questions involving the state of NASA's in-house technical capability. The questions were:

1. Has NASA contracted out too much of its technical work to remain a "smart buyer" of technical services from industry?
2. Has NASA's in-house technical capability eroded over time?
3. Is in-house hands-on work really important to the development and maintenance of fully competent scientists and engineers? If so, does NASA have enough hands-on opportunities available?
4. Is NASA still able to attract high quality scientists and engineers to work for the agency at entry level and at the experienced level?
5. Is NASA in-house technical capability stretched too thin by its number and diversity of programs and projects?

These are important questions to be addressed by any research and development agency. They reflect a genuine concern by NASA senior management to assure that their stewardship of the public investment in the nation's civil space and aeronautics program is effective in meeting the public's expectations for continued high performance in that national program.

This study was not approached as a staffing requirements review, as a personnel management review, as an organizational review, nor as a review of what the space program of the future should be. Its focus is limited to the basic question of the distribution of engineering and scientific work and the effect of that distribution on NASA's in-house technical capability, as seen through the eyes of those managing NASA's work at the centers, those supervising segments of the work at the branch and division levels in the centers, those civil servants actually performing the work early in their careers, and contractors supporting the work in the field.

Data collection was based on interviews with approximately 100 senior NASA and contractor managers mainly at the field center level, a detailed survey instrument administered to a stratified sample of over 2,200 and completed by 1,567 NASA scientists and engineers at Grades 12 and 15, and a review of NASA in-house data on scientists and engineers, their recruiting, retention, and utilization. In addition, centers were asked to submit special analyses on their scientist and engineer populations, tracing movement from core research and engineering functional activity into project management, operations, and other major fields significant to their center. Through these collection techniques the research staff gained the perspectives of a cross section of the present senior center managers, the well experienced center management of the future (GM-15s) and those on the firing line who generally represent five years or less in experience at NASA but who are the middle management of the future (GS-12s). The contractor manager interviews were intended to provide a counterpoint to the views of the civil servants.

NASA was established in 1959 with the National Advisory Council on Aeronautics (NACA) as the nucleus. Soon thereafter elements were transferred to NASA from the Army and the Navy. The initial result was five of the present NASA Centers - Marshall Space Flight Center and the Jet Propulsion Laboratory from the Army, and three from NACA - Langley Research Center, Lewis Research Center, and Ames Research Center. Four of the present centers have been established since then - Goddard Space Flight Center, Johnson Space Center, Kennedy Space Center and Stennis Space Center. Each field center presents a distinct image, culture, and operating style. To assume that there is a consistent and universally applicable NASA story on in-house technical capability or use of support contractors based on commonality of purpose would be a mistake. The differing nature of the centers and the diversity of the work that they perform makes that assumption unrealistic.

An understanding of the organizational environment in NASA led the research staff to conclude that on-site visits and interviews with top NASA and contractor managers at the various centers would be necessary to gain center by center insight into the question of program balance and in-house technical capability. All centers but Stennis were visited.

The sections that follow outline the results of staff research at all the NASA centers, commentary on the meaning of that research in the NASA context, and panel conclusions and recommendations.

Appendix A presents the full results of the survey of NASA engineers and scientists at grades 12 and 15.

SECTION 1

PROGRAM BALANCE - NASA AND SUPPORT CONTRACTORS

In-House Functions

A principal issue in addressing the program balance between NASA and the support contractor community is an assessment of what functions are believed to be essential for performance by government employees in-house to foster and maintain NASA capability and to assure the proper management and oversight of the publicly funded research and development programs entrusted to the agency. In 1962, David Bell, Director of the Bureau of the Budget led a study group that issued its "Report to the President on Government Contracting for Research and Development." Other members of the study group included John W. Macy, Chairman, Civil Service Commission; Robert McNamara, Secretary of Defense; Dr. Glenn T. Seaborg, Chairman, Atomic Energy Commission; Dr. Allen T. Waterman, Director, National Science Foundation; James E. Webb, Administrator, National Aeronautics and Space Administration; and Jerome B. Wiesner, Special Assistant to the President for Science and Technology. Their report stated the following conclusion:

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

In subsequent testimony before the Congress in hearings on the group's report, Mr. Bell summarized their view that it was essential that the government not contract out:

> ...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 are expected to be, and 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 why, and how can it be corrected . . .

The panel recognizes that the Bell guidelines are twenty-eight years old, and that the issue of what functions are essential to be performed by the government is a current topic in 1990. The panel believes that the guidelines stated by the Bell study group still capture the essence of agency responsibility and accountability for the execution of public research and development programs using public funds.

In exploring this topic with the senior NASA and contractor managers interviewed, the research staff found that there is not a consistent use within or among NASA centers of the term "in-house capability." In response to the question, "How do you define in-house?," there was a wide range of answers including civil service only, civil service and support contractors who work on site, and civil service plus all support contractors, whether on site or not. Some specific comments were, "The in-house work force includes both civil servants and support service contractors. The two are used almost interchangeably," and "I define 'in-house' in NASA as civil service only. In NASA, the civil service technical workforce tends to stay put, and it is NASA's technical memory." These differing interpretations illustrate that within NASA, discussions of "in-house capability" may result in misunderstandings between the parties, leading to decisions with unanticipated consequences.

For purposes of this study, the researchers defined the term "in-house capability" to mean NASA civil service employees only. As expected, there was general acceptance that budgeting, civil service hiring decisions, quality inspection services and other basic federal functions are considered to be among those that must be performed by NASA government employees. Senior managers acknowledged that NASA must continue to plan, budget, and manage the funds, to handle the procurement process, and to retain sufficient hands-on opportunities for new engineers to develop their capabilities to properly oversee large technical contract efforts. They also believed that contractors should not perform NASA program control functions nor assist in Source Evaluation Board work. Another view was that malfunction analysis capability (what went wrong) is an essential in-house role.

Although some managers believe that there is no technical work that must absolutely be done in-house, several NASA and contractor managers identified specific items that they believe should always be maintained in-house:

- o Systems Engineering
- o Development of requirements and specifications
- o Project management and program control
- o Cross cutting technologies such as materials
- o Cost estimating
- o Procurement
- o Facilities design requirements
- o A research base for each essential technical specialty in NASA

Contractors and NASA managers added that NASA should not contract out project integration, and that it should pay particular attention to areas of high technical risk. One contractor manager gave what amounts to a concise summary of views expressed by several contractors, "NASA should maintain control of its programs. That would include cost and schedule control, contract control, the establishment of technical performance requirements, and monitoring of those. Also, NASA must keep enough hands-on work in-house to train new technical employees."

The panel believes that while all the functions mentioned are important, the concept of always performing them in-house is not a black and white issue. There are control and support roles associated with each. The key issue is whether NASA has sufficient numbers of strong and capable scientists and engineers to make the best decisions and oversee the resulting work on the public's behalf. Other than for major procurement actions which obligate government funds, there is some room for argument on the degree of in-house execution and control NASA must have over the items listed.

One area that seems especially relevant to the question of balance is the determination of technical requirements and specifications. One could argue that if NASA does not have the ability clearly to state what its technical requirement is, and the performance expectations and limits within which the end product should operate, then NASA is not ready to procure anything and needs to do some more homework. The panel believes that there are exceptions here as well. If NASA is seeking to solicit the private sector for an item or system that is a variation of something widely used and normally available from the vendor community, then it might be acceptable to communicate to a support contractor the broad outlines of the need and the performance expectations and for NASA to task the support contractor to develop the requirements document and specifications. Again the issue is control by the government, and the presence in the government of the strong and able scientists and engineers who can judge and be certain that the requirements and specifications documents produced indeed meet all the technical aspects of their desires, and that the specifications indeed reflect the performance expectations for the item. In such a case, the panel believes that use of support contractors would be suitable.

Similar analyses can be made of some of the other areas listed such as systems engineering and cross-cutting technologies, always coming back to the need for NASA to be in scientific and engineering control throughout. Concerning project management, program control, cost estimating, maintaining a technology base, and expertise in key disciplines the panel leans more toward in-house capability and performance, though there may still be room for limited contractor support.

Nonetheless, there is a belief among the senior managers interviewed that the functions listed should be governmental in determination of objectives, performance, and control. There is considerable sentiment that NASA should retain the basic systems engineering and systems integration roles using contractors in support roles only. There is agreement that NASA should retain research and engineering capability in all key technical disciplines that it considers critical to exercising its responsibilities.

The next logical inquiry is NASA's present use of support contractors, the relationships established, and whether NASA is presently contracting for any of those functions that are generally perceived as belonging in-house.

Use of Support Contractors

Contracting consumed 88 percent of the NASA budget in fiscal year 1989, a large absolute number of dollars - in excess of ten billion. This percentage is consistent with NASA's history of contracting.

To keep matters in perspective, it must be remembered that there has always been close interaction between NASA and contractor personnel. Civil servants work closely with contractors at all levels and in many capacities. NASA and contractors generally operate in a team mode and support contractors are often considered part of the "in-house" team. However, some aspects of the relationship between NASA and contractors are troublesome.

Interviewees noted some erosion of government control over the technical decision processes, and greater distance of civil servants from direct personal involvement in issue identification and resolution. There appeared to be a consensus that senior managers fill voids with support service contractors. Support service contractors are almost totally integrated into the work force in several centers, and in most centers there is a clearly stated openness or willingness to share information and work between the civil servants and the contractors. As one senior NASA manager put it, "Engineering problems respond to the laws of physics, and the laws of physics are not bound by the color of a badge."

Centers were careful to point out that although support contractors sometimes perform contract management tasks involving other contractors, they are not allowed to issue change orders unilaterally. Formal contract management and the application of time tested management controls come from the civil servants.

Although NASA managers expressed many positive opinions concerning the effective conduct of work by support contractors, they also discussed problems. For example, many NASA managers believe that the use of support contractors involves considerable inefficiencies, that the mixed work force has demoralizing effects on the civil service staff, that consensus decision making is of great concern, and that systems of checks and balances are not operating independently.

NASA officials pointed out to the research staff that there are, of course, legal constraints and rules for what can and cannot be done by contractors. For example, only a civil servant can instruct a contractor to do a task that will affect the cost of a contract or in any way affect the contractor's fee. Contractors cannot be involved in personnel matters or serve on Source Evaluation Board (SEB) teams. Nevertheless, objectivity and proper distance are not always maintained. Under some circumstances, contractors are believed to be performing functions that should be performed by NASA. Project program control functions (planning, scheduling, configuration control, etc.), for example, are being done by support contractors at several centers. Contractors are increasingly monitoring other contractors. Several centers are using support contractors to develop requirements and specifications. There was some use of support contractors in support of Source Evaluation Boards.

Some senior contractor officials observed that for many contracts it is difficult to tell contractor personnel from civil servants. Other contractors believed that absorption of contractors into the civil service/contractor team concept has been a positive step because it has cut through hierarchical lines and resulted in direct contract liaison and integration.

Several contractors mentioned that NASA initially played a very strong role in determining what was done and how it was done. Performance of activities by parties was clear cut. Long range planning was done, for the most part, by civil servants.

Originally, NASA operated its laboratories with civil service technicians and engineers. Over the years many laboratory functions were shifted to exclusive performance by contractors. Then, with the continuing pressure to reduce the overall number of NASA employees, almost all of the technicians disappeared.

Contractor and NASA managers noted that NASA now depends more on contractors for short and long range planning, trade off studies, laboratory operations and technician support and that NASA could not operate currently without that support.

Senior contractor officials observed that industry is often faced with mixed motives. If they are too cooperative, they can get into difficulties because government contracting officers may look upon their behavior as competitively disadvantageous. Another difficulty is that the government often asks for much more work than the amount covered by the contract funding. When NASA does preliminary designs for projects in-house industry believes it must closely follow NASA designs or run the risk of offending someone. Similarly, if NASA does a cost estimate in-house, industry reportedly tends to agree with the figure rather than risk the loss of a potential contract.

Several contractors suggested that there should be a clearer separation of responsibility and accountability between NASA and the contractor. NASA should select tasks that they do entirely themselves or turn the entire task over to the contractor. Many contractors object to NASA doing parts of tasks, and then turning them over to contractors.

Finally, some contractors believe that the present use of Award Fee Contracting has established an adversary environment between NASA and industry. They believe that government people take a very guarded approach when dealing with their counterparts in industry... too guarded.

Returning to the topic of whether any of the areas identified as belonging in-house have moved to contractors, NASA managers cited several technical areas in which the NASA in-house capability had diminished substantially and moved to the contractor workforce.

At one center, a senior engineering manager stated that almost all avionics engineers are contractors, almost all structural analysis people are contractors, and only one civil servant is a gyro expert. At another center, a senior engineering manager stated that the in-house civil service facility design capability has completely eroded.

Another senior center official pointed out that many of the latest technological advances in aerodynamics involve computational fluid dynamics. He noted that the automation expertise required to implement computational fluid dynamics generally rests in the university community or with certain contractors.

Several interviewees and survey respondents that provided narrative comments to the written questionnaire were concerned about NASA's capability in software development. They did not believe that NASA's technical abilities in these key areas of sophistication paralleled the growing abilities in industry and believe that improved skills in these areas need to be assimilated into the NASA organization.

A NASA engineering manager at a development center said that the lack of technical help forced the project directorate to hire and use support contractors in roles previously filled only by in-house civil servants. For example, project level management positions just below project manager positions are now filled at that center by support contractor personnel. He believes that this situation does not guarantee that the government benefits from the long-term dedication and technical competence of civil service engineers in key decision-making jobs. It also leads to the loss of the "smart buyer" capability. He speculated that project discipline engineers (optics, thermal, etc.) will eventually lose their problem solving capability by becoming totally dependent on support contractor personnel through task orders. On that same point, interviewees suggested that there has been a decline in the agency's technical capability that was accelerated by the writing of broad, overarching contracts. "It has become easy to add tasks traditionally handled by the civil service work force," a NASA manager stated. Narrative comments on the survey questionnaire revealed that the personal experience of many scientists and engineers coincided with the interviewees' observations about the ease in adding tasks to existing contracts.

The Ames Research Center provided specific data for fiscal years 1971 and 1988 on what they term as "areas of research excellence." The areas covered such disciplines as aerothermodynamics, spacecraft systems, gravitational biology, computational chemistry, and intelligent systems. In fiscal year 1971, Ames had 162 civil service scientists and engineers in those disciplines supported by 67 support contractors. In fiscal year 1988, Ames had 131 civil service scientists and engineers - a decline of 19 percent - supported by 156 support contractor scientists and engineers - a gain of 133 percent.

At another research center a senior manager noted that, "The center has hired about 800 researchers on support contracts in recent years. I believe they have gone too far in this direction. I am concerned that continuation of the process of hiring the more experienced researchers on contracts will eventually result in the support contractor personnel supervising the less experienced civil servants. The number of support contractors as principal authors on research papers is increasing. About 25 percent of the contract researchers are now principal authors." He went on to add that many discipline engineers at the center are now project managers and much of the discipline engineering is being done by contractors.

Erosion of in-house capability in systems engineering was repeatedly pointed out by interviewees. A senior NASA manager observed, "Technical capability in systems engineering has eroded.

Numbers have eroded in other skills, limiting the amount of contractor penetration that can be performed." Although systems engineering is widely perceived as a key factor in the success of NASA, a contractor interviewee observed that NASA thinks of systems engineering simply as the management of interfaces while it should consider treating spacecraft as integrated pieces of hardware. Systems engineering should incorporate trade-offs that must be done in an integrated design and provide for testing, integration, planning and execution.

At another center, an interviewee expressed the belief that the contractors have greater expertise in most flight mechanical systems - except engines. He also expressed discomfort with the level of NASA in-house systems engineering capability in relation to propulsion and power, mechanical, and guidance and control.

Supplemental examinations of the use of contractors were provided by answers to several questionnaire items. Nine hundred and ten, or 58.5 percent of the Grade 12 and 15 scientist and engineer respondents, said that they agreed that the future roles of contractors should be more limited than presently. Fourteen percent disagreed and the rest were neutral. On a center basis, the three centers who most strongly believed that contractors' roles should be limited were the Kennedy Space Center, the Marshall Space Flight Center and the Goddard Space Flight Center with respective percentages of 68.7 percent, 63.0 percent, and 61.9 percent. More than half (56.6 percent) of NASA scientist and engineer respondents agreed that contractors have assumed many roles that are governmental, while 16.5 percent disagreed. Examples of governmental roles were the committing of government resources (22.7 percent), defining work assignments (37.9 percent) and representing NASA at meetings (58.4 percent). Five hundred and eighty-two (34 percent) of those who responded to the survey agreed that many important management decisions are being made by contractors, not civil servants; 30.6 percent of the respondents were neutral and 35.5 percent disagreed.

A strong plurality of survey respondents (65.7 percent) said the public interest would be best served if less technical work were contracted to the private sector; 12.6 percent of the respondents disagreed.

In addition to responses to specific questions respondents at all sites added written comments on contracting. Comments stressed that contracting has led to a demise in the in-house capacity to run programs, to inadequate controls on contracts, and to the loss of accountability to the public. Several stated that contractors now do critical work that should be done by civil servants thus leading to a deterioration of NASA's in-house capability and an irreversible dependency on contractors. Other respondents pointed out that, in many cases, contractors perform more interesting tasks than civil servants.

Several respondents suggested that allocations of work between civil servants and contractors should be examined on a task by task basis and that patterns and ratios of personnel working in support of scientists and engineers, such as skilled craftsmen and shop and production workers need to be examined.

Many of the written comments reflected the general belief that NASA has turned over critical tasks to contractors and has lost the ability to critique contractor designs, tests, and operations. The bottom line of the many narrative comments relating to roles of contractors is that it is in the best interest of NASA to have more control over its work and more input into it.

The final source of data for assessing NASA's use of support contractor scientists and engineers was the annual workforce analysis prepared by NASA. It breaks the civil service workforce and the support contractor workforce into skill areas, including science and engineering for fiscal years 1972 through 1987. After fiscal year 1987, the report does not break the support contractor data into skill areas.

The data show that the civil service scientist and engineer population in the agency has remained in a band between 11,500 and 13,000 throughout the entire eighteen-year period. The data also show that the support contractor scientist and engineer contingent has remained in a band between 5,000 and 6,500 for fiscal years 1972 through 1987. In fiscal years 1988 through 1990, there was a dramatic increase in the overall support contractor population - on the order of 10,000. A senior manager at agency level advised that 6,000 of the 10,000 were scientists and engineers. That led the research staff to believe that the support contractor S&E population now approaches parity with the civil service S&E population - approximately 12,500 apiece. The trend is clearly a significant increase in the number of science and engineering support contractors leading to a natural presumption that there is more science and engineering work moving in that direction from NASA centers.

The panel concludes that NASA is using support contractors in varying degrees to assist in or execute technical functional areas such as project management, program control, support to source evaluation board activities, technical oversight of other contractors, systems engineering, and development of requirements and specifications. While the panel believes that there is room for judgment in that use, and that contractor capability in those areas can be of help to NASA, functions such as those outlined are in need of detailed review by NASA to assure that sufficient technical expertise for decision making and control is, in fact, in the hands of the government.

The panel also concludes that there has been considerable erosion in NASA in-house strength in technical disciplines such as avionics, stress, thermal, gyros, structural analysis, software development, computational fluid dynamics, aerothermodynamics, and systems engineering. The panel suspects there are other such disciplines that were simply not used by managers as examples in the course of the interview process.

The panel does not believe that NASA must have knowledge superior to industry in all of these disciplines, but does believe that sufficient understanding of each must exist within NASA in order that it can effectively weigh the technical options and approaches, decide the course of action, oversee execution of the work, evaluate the results, and maintain technical control. Consequently, the panel considers erosion in key disciplines to have a detrimental effect on NASA's in-house technical capability.

The panel recommends that the Administrator of NASA:

- **Prepare and issue guidance on technical functional areas to be reserved for in-house civil service performance.**

- **Convert contracted technical functions essential to in-house capability from support contractors to in-house performance and rebuild strength in specific technical disciplines critical to agency programs and objectives. Ceiling relief should be sought if required.**

SECTION 2

PROGRAM BALANCE - INSIDE NASA

To review the allocation of technical work within NASA, the research staff focused on the program/project mix and work diversity in the agency, and searched for trends in movement from core science and engineering work to areas such as project management and operations of various types. The research staff also reviewed the results of diversification strategies employed by some centers, and the value of hands-on experience to science and engineering work.

In reviewing the agency's formal staffing and utilization data, the research staff focused on the functional utilization of NASA's engineers and scientists. Finally, the staff examined the impact of NASA's long-term flight program operations role on the utilization of agency engineers and scientists.

Program/Project Mix

At the outset of the study, NASA management raised the issue of whether NASA has more projects underway than can be adequately handled, and whether the diversity of those projects was having a negative effect on the agency's ability to manage them.

NASA and contractor senior managers were almost unanimous in their belief that the number and diversity of program and project activities in the agency has increased. They also commented on the increased complexity of some projects, and on the increased time required to accomplish project tasks. One NASA manager illustrated the point, "There are more program activities in NASA now than during Apollo, and the complexity is much greater. For instance, there are now many more channels of data requiring reduction and analysis. This means that the complexity is not just in design, launch, and orbital operations but in ground crew time and talent required to handle the data." Others noted that NASA now has much more complex defense and science payloads, resulting in more complex payload management and processing activities for each Shuttle flight.

Centers' workloads have also become more diverse. Lewis Research Center, one of the three NACA research centers forming the nucleus of NASA, moved first into launch vehicle development, then energy related activities, applications work and satellites, and now is responsible for development of the Space Station Power System while continuing traditional aeronautical research work.

The Marshall Space Flight Center (MSFC) was originally a propulsion and launch vehicle center. Now their programs range from science payloads involving optics to x-ray to plasmas coupled with responsibility for the Shuttle main engines, external tank, and solid rocket boosters; major involvement in the Space Station Freedom; and principal responsibility for Spacelab. By some estimates, there are now 50-70 active, diversified project activities at MSFC, not including many experiments managed by and sometimes built at the center. Other centers have similar stories.

Several interviewees stated that programs now take longer to accomplish. Some of the causes for the extended time are the decrease in the number of wage grade technicians and craftspersons available to assist engineers and scientists, increases in the period to complete procurements, inexperience of younger personnel, increases in documentation requirements, increases in replanning exercises for re-scoped projects, burdensome procedures, and matrix management schemes.

Senior contractor managers also tended to agree that the project mix at the centers they serve has increased, together with the complexity and the length of time to complete. One measured the increase by growth in staffing of his own contract saying, "The number of projects has increased as evidenced by our personnel going from about 200 to 2200 over the years." Another commented about the situation at the Kennedy Space Center, "NASA suffers from program diversity; there are so many projects going on at KSC that you cannot list them on two sheets of paper." And finally, another contractor observed, "We believe that there are many fragmented programs in NASA now. Each small project takes as much effort to manage as a large one." Contractors were in agreement that projects take longer to complete because of procurement lag time and internal NASA decision making processes.

To solicit the views of grade 12 and 15 scientists and engineers about the diversity of programs, the survey asked, "Since joining NASA, has the diversity (e.g., variety and complexity of work) increased at your center?", 1,537 respondents answered. Of those, 1,168 (76 percent) answered "Yes." The highest percentage of major center respondents who answered yes were 81 percent from Marshall, 80 percent from Johnson, 78.3 percent from Langley, 78.1 percent from Lewis, 73.5 percent from Ames, and 64.7 percent from Kennedy. Although the consequences of growing program complexity were not explicitly requested, many narrative comments observed that as projects have become more comprehensive and larger, they call for more interdisciplinary talents; more formal reporting systems are required; and financial and administrative processes proliferate.

Many times, narrative comments on the diversity of programs turned into cases against large projects. Some respondents believed that large projects are generally poorly conceived, unfocused, inadequately funded and never seem to get completed. They said the breadth and depth of large projects lead to unrealistic expectations, greater inefficiencies, and the dedication of large parts of the project budget to administrative matters. Some noted that the excess of planning and tracking data for large projects has resulted in information overload. Woven through these observations was the need to set priorities for work and strive for balanced allocations between big and small projects.

The panel concludes that the number, diversity, complexity, and length of time to complete program activities in NASA have increased. The various workload preservation strategies adopted by some centers, principally after the completion of Apollo, resulted in major diversification in technical program activities carried out by the centers. The effect of the Shuttle, and its ability to place a number of payloads - large and small - into space on a single flight, has greatly increased the amount of project activity at certain centers, especially in managing and processing science and applications payloads and experiments.

The panel recommends that the Administrator of NASA:

- **Examine the project mix at each center against agency and center goals and objectives. Select those with marginal contributions and/or staffing for cancellation or transfer. Assess all projects for suitability of specific center assignment.**

Hands-On Experience

During management interviews the notion that experience gained by direct and personal execution of design, analysis, prototyping, test, and evaluation is essential to the full development of engineering skills and a "sixth sense" for recognizing potential design flaws affecting production or operations was explicitly stated. Only two of the interview subjects suggested that young engineers could gain necessary experience by reviewing the work of others and by observing outcomes.

Generally, views of the managers interviewed were intensely stated. An illustrative view was, "There is a direct relationship between hands-on experience and contractor oversight capability. One has to know from experience how to get a drawing out, how to process a part, how to manage a budget, etc." And from another, "If one does not work on a project from cradle to grave one loses the ability to track the manufacturing of products. This, in turn, affects the reliability of products. Engineers may go to the floor and not perceive problems." The sum and substance of all the responses on this subject is that hands-on experience and exposure is absolutely necessary. It is important for newly hired engineers to be able to convert theory into practice by being involved in a project involving the entire design/prototyping/test/checkout process.

Concerning views of the newer NASA scientists and engineers, one manager reported that "Both co-op students and recent hires define hands-on capability as problem solving. They believe they have to perform technical tasks to solve certain problems. They note that NASA is contracting out too many problem solving activities. Many recent hires believe that they are managing work performed by contractors rather than performing it themselves. Challenging tasks, they observed, are often handed off."

NASA contractors echoed NASA managers' views about the value of hands-on experience and there was broad agreement among the contractors that NASA should always keep enough hands-on work in-house to keep their technical people sharp. One contractor observed that when the NASA engineers dealing with his contract are weak, it makes his job much more difficult. He would far prefer to see strong technical capability in NASA.

Specific programs have been instituted at some of the centers to deal with this issue, but managers believe that there is still not enough hands-on opportunity to meet the developmental needs of all young engineers. Notable are the efforts at the Marshall, Kennedy, and Goddard centers.

At the Marshall Space Flight Center, young engineers are trained on several in-house projects including the Technology Test Bed for liquid engine R&D; use of solid rocket test facilities at the center; design & development of the Aeroballistic Flight Experiment; several Spacelab experiments where the hardware is built at the center; design and development of the Space Station environmental control system; and many supporting research and technology projects.

At the Kennedy Space Center a program assigns new engineering hires to the Level IV payload integration program for a time. In that program, the engineers have to understand the flight experiments, design, develop, build, and test the apparatus required to install the experiment in the Shuttle and support its operation. Engineers assigned to Level IV do not want to leave. They become so engaged in this aspect of preparing hardware for flight, that they do not wish to move to positions where they are monitoring the engineering work of others. Because of this, all new engineers have not been able to participate in this program.

At the Goddard Space Flight Center, a former center director began keeping one or more projects in-house to provide hands-on training to young engineers. This policy, which began in the late 1970s, is still in effect and is considered by some center officials to be strongly contributing to the recovery of in-house technical capability at Goddard. The $200 million Cosmic Background Explorer (COBE) project was done in-house and the Small Explorer Program (SMEX) is being done in-house at this time.

In response to a survey item as to whether NASA scientists and engineers should perform hands-on work once in a while to maintain their proficiency, over 90 percent of the respondents agreed that such work should indeed be done. A subsequent question, focusing on the statement that people with direct problem solving experience get the best results elicited an agreement rate of 89.7 percent. Eighty-three percent of the respondents agreed that hands-on experience is required to understand how to manage and evaluate contractors' efforts.

A large number of Grade 12 and 15 scientists and engineers (1,289 or 83.2 percent) agreed that NASA needs to expand or initiate more in-house project work to provide for hands-on experience.

The vast majority of scientists and engineers responding to the narrative part of the questionnaire reinforced the perception concerning the loss of in-house capability and reemphasized the need to perform more hands-on tasks. The doing is considered essential to learning. One engineer noted that engineers are not as sensitive to hardware as they should be because they are "absorbed in program status presentations and don't get any hands-on experience beyond the utilization of copying machines." Another engineer said, "Once engineers become contract monitors, not doers, the appeal of their jobs fade, unless opportunities for real direction are part of the monitoring effort."

Employees from several centers also noted that contracting resulted in not only the deterioration of hands-on experience but also the loss of institutional memory within NASA. Several employees pointed out that there appears to be an absence of a foundation upon which to base certain decisions and contended that an indigenous repository of knowledge helps to establish strong professional identities. Although individuals may develop specialized knowledge through reading and research, "know-how" is generally acquired through considerable hands-on experience.

In the judgment of many respondents it would be beneficial if researchers and model makers, for example, could work closely together to enhance their mutual understanding of the work. Such understanding can only be developed through actual practice.

According to respondents, keeping more project work in-house will: (1) promote a sense of pride, (2) enhance control, (3) develop skills, (4) ensure accountability, (5) attract capable people, (6) contribute to the retention of employees and (7) regain the creative spirit.

The panel concludes that hands-on work experience is invaluable to honing technical skills, developing a "sixth sense" for identification of technical problems, serving as a "smart buyer" of technical products, becoming a skilled project/program manager, and more effectively monitoring contracted work.

The panel recommends that the Administrator of NASA:

- **Provide policy guidance to the centers to retain in-house sufficient project, experiment, advance development, and research activities to provide more hands-on technical work by civil service scientists and engineers.**

Internal Dynamics Of NASA Technical Workforce

The purpose of examining the internal dynamics of NASA's engineer and scientist population at the centers was to ascertain whether there had been movement away from core science and engineering activities such as research, design, test, and evaluation. These are the technical functions that provide hands-on work to strengthen technical capability. Data on this subject was sparse, but revealing.

The NASA Personnel Management Information system (PMIS) data reveals that for the period 1980 through 1990, the number of NASA scientists and engineers assigned to the PMIS categories of research, design, test, and evaluation has gradually declined as a percentage of the total number of NASA scientists and engineers (down 3 percent overall), while the total number of NASA scientists and engineers has risen 15 percent over that same period. The earliest PMIS data available on this topic is for 1980.

Center trends derived from PMIS data vary markedly. The only gain (4 percent) registered for scientists and engineers assigned to research, design, test, and evaluation as a percentage of total S&E population was at Langley Research Center. The greatest decline (14 percent) was at Lewis Research Center.

As expected, the research centers - as opposed to the development centers - operate with a much higher percentage of scientists and engineers assigned to these core functions (38 percent at Lewis to 59 percent at Langley in 1990). In the development centers, Goddard Space Flight Center has the highest percentage of total scientists and engineers in those functions (23 percent), the Johnson Space Center has the lowest (8 percent), with the Marshall Space Flight Center at 12 percent.

Although the research staff realizes that in-house development is an important part of the core scientific and engineering function of NASA, the structure of the PMIS data base does not permit disaggregation of the overall development category. During the period (1980 - 1990), the number of NASA scientists and engineers coded to development has risen at all centers, with the highest rise at Lewis Research Center (141 percent) and the lowest rise at Langley Research Center (2 percent). Some of that increase reflects the efforts of NASA centers to increase the amount of in-house development work that they can do, but the NAPA research staff believes that the greatest use of that increase is in oversight of development work underway by contractors, and in engineering support to long-term flight project operations, areas for which no PMIS categories exist.

To distinguish between utilization in program/project management, program operations, and core functions, NAPA asked each center to analyze its civil service and support contractor science and engineering workforce and provide a breakout covering the period 1972 to the present, if possible. The Marshall, Johnson and Kennedy Space Centers, which represent approximately 50 percent of the civil servant scientist and engineering workforce, responded to the data request with information that conformed closely to it. They made it clear that center data is not regularly maintained in such a way and the responses represented their best efforts at satisfying the request.

a. Marshall Space Flight Center. The MSFC data is for civil service scientists and engineers only and shows four categories of utilization from fiscal years 1971 through 1990. Over that period the category "experimental design and analysis" (which represents the MSFC"core" capability) shows a decline from 1,994 to 1644 - a drop of 18 percent. Project management shows a decline from 385 to 350 over the period, a drop of 9 percent. Operations support shows an increase from 50 to 125, a growth of 150 percent. MSFC added a fourth category, Institutional Support, which shows growth from 82 in fiscal year 1971 to 267 in fiscal year 1990 - an increase of 226 percent. Most of that growth occurred from fiscal year 1986 through fiscal year 1990 and represents increasing numbers of scientists and engineers allocated to reliability and quality assurance activities. The center's total S&E complement declined over the period from 2,511 in fiscal year 1971 to 1900 in fiscal year 1981 - a drop of 24 percent. The center has, in recent years, built that workforce back to a fiscal year 1990 level of 2,386 - still down 5 percent from the fiscal year 1971 level.

b. Johnson Space Center. JSC provided data for both civil service and support contractors for fiscal years 1973 through 1990 in three categories: project management, operations, and core:

1. Project Management. Civil service scientists and engineers allocated to this function increased from 341 in fiscal year 1973 to 607 in fiscal year 1990, a growth of 78 percent. Support contractor scientists and engineers in project management increased from 377 in fiscal year 1973 to 923 in fiscal year 1990, a growth of 145 percent.

2. Operations. Civil Service scientists and engineers allocated to operations increased over the period from 545 to 622, a growth of 14 percent. Support contractor scientists and engineers assigned to this function increased from 1,586 in fiscal year 1973 to 2,420 in fiscal year 1990, a growth of 53 percent.

3. Core. Civil Service scientists and engineers allocated to core functions decreased from 1,140 in fiscal year 1973 to 1,050 in fiscal year 1990, a drop of 8 percent. Support contractors assigned to this function increased over the same period from 1,348 in fiscal year 1973 to 2,595 in fiscal year 1990, a growth of 93 percent.

The JSC total civil service S&E complement has increased from 2,026 in fiscal year 1973 to 2,279 in fiscal year 1990 - growth of 12 percent. The center's support contractor scientist and engineer complement, over that same period, has grown from 3,311 in fiscal year 1973 to 5,938 in fiscal year 1990 - an increase of 79 percent.

c. Kennedy Space Center. KSC provided supplementary data for fiscal years 1980 through 1990 for both civil service and support contractor scientists and engineers. KSC divided operations into three subgroups - flight operations, mission support operations, and cargo operations, however, they have been aggregated into a single group for this analysis. KSC also provided a breakdown of Program/Project Management and Engineering Design/Analysis.

1. Program/Project Management. KSC civil service scientists and engineers allocated to this function have decreased from 113 in fiscal year 1980 to 77 in fiscal year 1990, a drop of 32 percent. KSC shows no support contractor scientists and engineers allocated to this function.

2. Operations. KSC civil service scientists and engineers assigned to operations have increased from 740 in fiscal year 1980 to 1,018 in fiscal year 1990, a gain of 38 percent. KSC support contractor scientists and engineers assigned to this function have increased from 1,116 in fiscal year 1980 to 3,195 in fiscal year 1990, a growth of 186 percent.

3. Engineering Design/Analysis. Civil Service scientists and engineers assigned to this function at KSC have remained stable with 289 in fiscal year 1980 and 292 in fiscal year 1990. Support contractor scientists and engineers assigned to this function have decreased from 635 in fiscal year 1980 to 109 in fiscal year 1990, a drop of 83 percent.

The KSC total civil service Science and Engineering complement has grown from 1,142 in fiscal year 1980 to 1,387 in fiscal year 1990 for a gain of 21 percent. The support contractor scientist and engineer complement has grown over that same period from 1,751 in fiscal year 1980 to 3,195 in fiscal year 1990, a gain of 82 percent.

The data from Ames Research Center show changes in ratios for 1970 and 1990 in the functional activities of scientists and engineers as a percentage of total Ames civil service S&E population. Most telling is the shift from 10 percent to 30 percent of total involved in program/project management and the accompanying decline of those involved in engineering from 28 percent in 1970 to 15 percent in 1990.

The research staff concludes from NASA's personnel management information system (PMIS) data that NASA civil service scientists and engineers engaged in research, design, test and evaluation are in decline as a percentage of total scientists and engineers in the agency, while the total agency population of scientists and engineers is on the increase. From that same data, the research staff notes that utilization of civil service scientists and engineers in the category of development, the most heavily contracted technical function of NASA, has increased at all centers except KSC and SSC.

From the supplemental data, the research staff notes that at MSFC, JSC and KSC there is a marked upward trend in assignment of civil service scientists and engineers to Operations, while core engineering functions are declining. At JSC, there is also a marked increase in assignment of civil service scientists and engineers to project management functions.

The Operations Support Role

The topic of "Operations" elicited many comments from senior managers in NASA and in the contractor interviews. There is no consistent use of the term "operations" within the NASA community. In the development centers and at the Kennedy Space Center, the topic is addressed as it relates to pre-launch, launch, and post launch operational support of flight projects. There is broad recognition that NASA has a number of programs that will require long-term commitment of scientists and engineers to pre and post-launch support such as the Shuttle, Hubble, AXAF, Galileo, and Magellan, and eventually the space station. These result in large and continuing requirements for data reduction and analysis.

At the front end of operations support to flight projects, there is agreement that the multiplicity and technological variety of large and small payloads place additional demands on technical staffing for managing and processing those payloads. The recovery, refurbishment, acquisition of replacement elements, assembly and stacking of the shuttle itself is seen as a major and continuing operational activity. Mission Operations is seen as more sophisticated with astronauts and mission scientists both on board and doing a variety of complex work with complex equipment, often in an interactive mode with engineers and scientists on the ground, sometimes in multiple geographic locations.

At the research centers, the term "Operations" is more often associated with the operation and use of technical facilities connected with research activities - wind tunnel operations for instance. At all centers, engineers involved in facility planning, design, and acquisition regard their work as operations in support of the institution.

Included in this section are observations from NASA and contractor managers on NASA's use of scientists and engineers in pre-launch, launch, post launch, and spacecraft operating needs and for operations support of certain technical research facilities.

One senior NASA manager observed, "Operations is a major issue at this center...for instance, the present demands are related to the Shuttle and the Hubble, with Space Station coming on. Then, there will be Magellan and Galileo. All require long-term operational support. Operations can consume all."

From another perspective, a NASA manager noted, "The requirement for personnel and management attention on the very complex shuttle program makes the payload and space station business secondary. I worry a little that Space Station will not get the attention or manpower that it needs. Operations people are in short supply now for Spacelab. Space Station is, of course, in a growth mode across the agency."

From the standpoint of research facility operations, a research center manager observed, "Operational requirements have grown with the addition of new facilities such as the Numerical Aerodynamic Simulator (NAS), the Artificial Intelligence Laboratory, and the Space Manned Vehicle Research Facility. In the case of NAS, 80 percent of the time on the computer system is dedicated to users other than those at the center including other parts of NASA, industry, and the academic community. This increases the need for manpower."

Finally, the long-term effect of shuttle engineering demands was summed up thus, "The Shuttle should not be tying up center people now, but change papers on the Space Shuttle Main Engine and the Solid Rocket Booster are higher now than at the start of the program. The chance of any change working the first time is 80 percent."

Some senior contractor managers also had observations and concerns about the implications of operations on NASA's in-house technical capability. During the contractor interviews, there was a singular interpretation of the term "Operations" as meaning flight program operations as opposed to research support or institutional facilities. In general, contractors perceived a shift of NASA technical personnel into operations and, as expected, several believed more operations should be contracted.

Grades 12 and 15 scientists and engineers were asked to list their primary and secondary work activities. Operations was the fourth largest category, with 13.7 percent of all respondents claiming it as their primary work activity and 11.4 percent claiming it as their secondary work activity. When viewed by grade level, operations moves into second place (behind applied research) for the GS-12's with 18.9 percent claiming it as their primary work activity. On a center basis, the largest number of total respondents claiming operations as primary were at Kennedy (35.5 percent) and Johnson (20.1 percent). Langley was lowest with 4.2 percent.

Commentators who provided written responses generally agreed that operational activities have had great influence on NASA's ability to perform its mission because they represent a significant commitment of organizational resources. Several noted that immense undertakings such as the Shuttle program have resulted in transitional difficulties and warned that preparations necessary for operations are expensive financially, administratively and technically. Some suggested that operations can be more effectively served by different organizational arrangements and more stable funding streams.

The panel concludes that there has been and is a trend away from applying NASA's scientists and engineers to research and development work toward their utilization in project management and operations. Given NASA's relatively fixed number of scientists and engineers (remaining in a band between 11,500 and 13,000 from 1972 through 1990) the panel concludes that the agency has had no choice but to make these shifts.

The panel recommends that the Administrator of NASA:

- Institute an annual critical position review for all technical disciplines, identify the number and professional levels of in-house coverage that are essential to maintaining a reasonable degree of technical expertise in each critical discipline, and adjust recruiting and/or contracting plans accordingly.

SECTION 3
INTERNAL TECHNICAL MANAGEMENT PROCESSES

This topic deals with two types of pressures that tend to limit the amount of time that NASA scientists and engineers have for technical work or to greatly alter the nature of that work. The first is the heavy time-consumption of scientists and engineers in contract monitoring, oversight, and reporting requirements. The second relates to changes in the way NASA conducts its internal technical management of work.

Contract Types and Performance Accountability Processes

Senior NASA managers observed that different types of contracts affect the behavior of contractors in different ways. For example, incentive systems result in better performance than traditional cost reimbursement contracts. The more responsibility contractors are given, the better they perform.

Sixty-two percent of NASA's contract dollars, for fiscal year 1989, were under the Award Fee contract type. This is the principal vehicle used for support contracts. This type requires active, continuous involvement with the contractor, although it can be adapted to provide for precise and measurable incentives - on cost control, schedule adherence, and technical performance expectations - with lessened requirement for daily involvement.

Many NASA and contractor managers believed that the NASA contractor management methods are generally effective, but that they are carried to extreme in day-to-day involvement in contractor activities, are time consuming of technical talent on both sides, and are heavily rigorous in terms of documentation requirements. In earlier days, contractor performance was monitored and measured in the three areas: cost, schedule, and technical performance. Today, cost is seen as the principal driver and technical performance monitoring is seen as weaker than before.

In award fee contracts the fee determining official and members of the award fee board need to be very familiar with the program. Award fees should be based on clearly expressed milestones, not time periods. If they are based on time periods it was asserted by NASA managers that contractors become adept at hiding problems until after evaluation dates, hoping to solve those problems before the next evaluation period ends.

A more detailed description of the Award Fee process was provided by another NASA manager. "The process is overseen by an Award Fee Board. The board has appointed a committee for each major contract, which the appropriate directorate head chairs. The directorate head is the technical contract manager. Performance criteria are provided by NASA to each contractor every six months. Within each directorate, monitors assess specific aspects of the contract. The monitors prepare strength and weakness reports, against the performance criteria, and send them to the committee. Mid term report cards are provided to the contractors at three month intervals. Each six months, the committee makes an assessment for the board. The board then reviews the assessment and arrives at an award fee score. The score converts to an award fee amount. If the contractors believe that a modification is in order, the contractors have the option of appearing before the board, or submitting a written statement to the board. Some do. Grades are usually close to 90 on most of the contracts; the range has been from 84 to 95 in the last three years."

It was generally agreed that on-site personnel in the contractor's plant don't work well unless rotated frequently. There was a general belief that if people are not rotated yearly, they begin to think like the contractors. Objectivity is not feasible. Eventually, they lack the ability to play an adversarial role and their knowledge of the extent of problems suffers.

Several commented on NASA's move to consolidate support contracts at some centers. The interviewees questioned whether the intended economies had been realized. One senior NASA manager noted, "Consolidation also moves the interface higher in both organizations, and makes it more difficult for people at lower levels to influence management of the work."

Many interviewees noted that NASA's ability to know more than contractors, let alone subcontractors, has diminished. The need for stronger program control was called for by the managers and by 54.1 percent of the survey respondents.

On-going penetration of contractors, it was noted by several interviewees, may be constrained by the lack of travel money and available personnel. Travel limitations also prevent bringing new employees to contractor plants for training.

Several contractors talked about the dynamics of contract supervision. In trying to hold contractors accountable for their work, they acknowledged that much depends on the individual projects and individual NASA interfaces. NASA people, they submitted, display suitable technical knowledge and are able to penetrate as far as their knowledge goes, but in the final analysis, they must trust the contractor. On occasions, there are serious mismatches between the customer and the contractors. In the experience of some contractors, there is not a lot of difference in contractor technical management among NASA centers, with the exception of the Jet Propulsion Laboratory (JPL). At JPL, the contractor tends to get smaller pieces of the program. JPL serves as its own integrator and also builds some of its hardware in-house.

Several contractors said that NASA now has a tendency to micro-manage contractors, even to the point of signing off on company internal standard operating procedures. They observed that NASA management used to be oriented toward technical matters. Now, the contractors see a lot more budgetary and administrative orientation.

Finally, NASA and contractor interviewees noted that "performance reviews" are very large, are scheduled far in advance, and require extensive preparation by several layers of technical talent on both sides. The NAPA research staff notes that this process generally results in award fees in the 7-8 percent range, and no adjective rating under "Excellent."

The panel concludes that the Award Fee contract type as implemented in NASA consumes more technical manpower on the part of NASA and the contractors in both technical contract administration and in the fee determination process than appears to be justified by the narrow fee range (7-8 percent) and the consistent adjective rating (Excellent) that results.

The panel further concludes that there is more involvement by NASA engineers and scientists in internal contractor administrative matters than may be prudent in terms of technical time.

The panel concludes that there is a leaning in NASA toward reliance on the pre-announced, advance scheduled, heavily attended, heavily documented formal contractor performance review processes and less reliance on rotated on-site personnel or unannounced contractor-site visits as means of assuring contractor accountability.

As to the view that consolidation of support contractors has moved management interfaces higher in both hierarchies, with fewer opportunities for lower level civil servants to impact the work deficiencies, the panel sees nothing wrong with moving management interfaces higher between the parties if that was the intended result of contract consolidation. If, however, it was an unintended result and has indeed caused delays in the identification and resolution of technical issues between the parties at lower levels, then the panel believes the consolidation concept to be worthy of further examination by NASA for adjustment in form or operation if needed.

Program Decision Making and Coordination

In the view of many interviewees, NASA has gradually increased its organizational layering, lowered the dollar thresholds on decisions that require senior management approval, and greatly increased its formal procedural requirements, both technical and managerial. Numerous interviewees said the program office funding and approval process has grown too complex and inflexible, with justification of amounts as small as $70,000 having to go to

Washington. These changes have diverted much technical time and talent to meeting the requirements of a much more complex administration environment than existed earlier in NASA's history.

NASA managers said that there is more emphasis on the schedule rather than technical performance and cost, people are more process rather than object oriented, there is too much bureaucratic management of contractors and not enough technical management. One manager observed, "There are more controls on our work, more milestones, and more review processes that take time and delay work. There is too much management at higher levels." Another said, "People are not working as a team. There are too many interfaces and too many people fighting over too few resources." And finally, "There are too many meetings with viewgraphs. There are no engineering reports presented for in depth review. There are no ways to get a feel for accuracy of the data. Decisions are based only on information presented."

The topic of risk aversion was also on the minds of many managers and scientists and engineers. Several commented on the NASA decision to require vastly increased contractor sign-offs at various stages on the way to launch, spreading accountability and increasing launch processing time. Interviewees noted that upper management of both contractor and civil service organizations seem to lack confidence in their technical workforce, and that there is a reluctance to do anything for fear of doing something wrong. There is less tolerance for failure within and outside the agency. Challenger caused significant changes in the agency - more complex organization and control and more information sharing mechanisms. According to many scientists and engineers who responded to the narrative section of the written questionnaire, responsibility is not always clearly defined and people are not held accountable for all project phases and activities.

Contractor executives expressed similar misgivings about the amount of technical documentation, complex organization and management issues, and the growing risk aversion in NASA. Comments from the contractor community include, "NASA is becoming more process oriented than product oriented, and documentation takes precedence over getting the job done," and "There is a reluctance in NASA to shift appropriate management decisions to lower levels in the organization. The aging bureaucracy is unwilling to take appropriate risks anymore."

Other contractors believed that there is excessive attendance by NASA people at Preliminary Design Reviews. They noted that NASA people are generally accompanied by their support contractors. Thus, it is not uncommon for hundreds of people to attend. Up to 6000 Review Item Discrepancies (RIDs) may be produced, at a single review, many of which relate to decisions made long ago and are thrown out. Contractors consider numerous RIDs to be an indication of the lack of understanding most attendees have of what is going on in the project being reviewed. The excessive attendance is also seen as an indication that NASA people spend much effort protecting themselves from future criticism. The contractors believe that a better job could be done by a smaller team of experienced senior people. On that same point, another senior NASA manager observed, "The RID system is very paper intensive. There is no direct exchange between the designer and the critic. The whole review process has become very non-personalized, involving form rather than substance."

The panel observes that it is not unusual for engineers and scientists to voice displeasure over involvement in administrative activities, excessive paperwork, budget exercises, excessive management, insufficient delegations of authority, need for cross-coordination, etc. The decibel level of the comments in NASA suggests, however, that there is more time pressure from these sources than usual. The panel concludes that NASA's technical management practices should be redesigned to reduce the amount of time that scientists and engineers must spend on non-technical activities, or on an excess of paperwork.

The panel also questions whether the increased "sign-offs" required of multiple contractors and NASA are really effective in increasing quality and reliability and to what extent they weaken personal accountability.

The panel recommends that the Administrator of NASA:

- Modify the agency's contractor accountability processes by tightening controls on attendance/participation in formal reviews, simplifying the award fee determination process, increasing the use of unannounced contractor site visits, and rotating NASA personnel stationed in contractor plants.
- Seek opportunities for greater delegation of resources/technical decision making authority, reducing multi-party sign-off requirements with encouragement of reasonable risk taking, and improving lines of authority, responsibility, and accountability in the technical management organization.

SECTION 4
RECRUITING AND RETENTION

Is NASA still able to attract high quality engineers and scientists to the agency and retain them? Does the provision of hands-on work opportunities influence hiring and retention? These questions were also pursued through the NASA senior management interviews and through the survey instrument administered to NASA grade 12 and 15 scientists and engineers.

There is a perception, among senior managers as well as other scientists and engineers that NASA is successful in hiring high quality fresh-outs but has problems in hiring experienced people. With senior people NASA is hard pressed to meet the salary requirements, especially on the west coast.

It should be noted that NASA was able to hire 1,531 scientist and engineers in 1989, twice as many as the previous year. Scientists and engineers comprise approximately 55 percent of the total work force. Normally about 600 scientist and engineers are hired annually. Many hires have participated in the co-op program although interviewees and the surveyed scientists and engineers at the Grade 12 and 15 levels believed that recruiting should be more diverse.

Although interviewees acknowledge that NASA still has an aura with respect to recruitment, there are reservations about whether NASA is hiring the "best" new graduates, because NASA salaries are not competitive. For example, NASA pays a new engineer about $26,000 per year and the average starting industry salary for an engineering graduate $32,000.

In the opinion of interviewees, people are attracted to NASA because of the mission. Nearly 70 percent of the survey respondents came to work for NASA because of the space program and the challenges presented. The ability to obtain hands-on experience is not perceived to be a primary factor in recruiting freshouts.

Fifty-five percent of the respondents thought that the good points of working for the government outweigh the bad points. Only 14 percent disagreed.

The research staff also investigated the quality of new hires as gauged by the educational preparation received and the work attitudes of new hires once on board.

Since NASA freshouts have an aggregate 3.2 grade point average, the selectivity in NASA recruiting is already established. One observation, which was stated in different ways by many of the interviewees was, "The quality of new hires today is as good or better than in earlier periods. A great deal of knowledge transfer has occurred from those involved in early space efforts to the major schools of aerospace engineering. As a consequence, the graduate today is much further along in understanding the environment of space and the adjustments in thinking that are required by it."

The quality of current hires in science and engineering was perceived by survey respondents to be as good as ever by 49.5 percent. Twenty-three percent disagreed, and the rest were neutral.

The turnover rate for scientists and engineers in NASA, discounting retirements is very low (2 or 3 percent). However, there is considerable opinion that holding trained people to retirement age will probably not be as easy in the future because of changes in the retirement laws.

Although there were a number of questions included in the survey instrument relating to retirement plans and the perception of government work, three of the issues raised in the questionnaire bear directly on retention of scientists and engineers.

"I regard working for NASA as my lifetime career" was a statement to which 64.4 percent of the respondents agreed, 20.5 percent were neutral, and 15.2 percent disagreed.

"I would quit if I found another job in the same line of work with comparable benefits" captured only 12.2 percent of the agree and strongly agree categories. About 20 percent of the replies were neutral and 68 percent disagreed with the notion of quitting.

Almost 50 percent of the respondents agreed that they are not eager to change jobs but would change jobs if they could get a better one. About 23 percent were neutral and 28 percent disagreed.

Not surprisingly, many of the narrative comments dealt with the inequity of pay and benefits accorded federal employees as compared to their private sector counterparts. This type of commentary was most prevalent at the Ames Research Center. At Ames, strong sentiments were expressed in favor of locality based pay. Because the Congress has, in October 1990, passed legislation to accomplish pay reform for federal employees, including locality pay, we have not included the numerous respondent comments on that subject.

The panel concludes that NASA's ability to recruit freshout scientists and engineers is good, that recruitment of experienced scientists and engineers has been difficult but should improve as a result of the recent pay reform legislation, especially the geographic pay features.

SECTION 5

IN-HOUSE TECHNICAL CAPABILITY

All of the topics and issues discussed thus far in this report relate to one pivotal question - has NASA's in-house technical capability eroded to such a degree that NASA is now less able to fully exercise the technical leadership, contractor selection and oversight, and in-house research and technology advancement roles expected of it? In addition to questions on all the preceding topics, specific questions on the topic of in-house technical capability were asked of the senior NASA and contractor managers, and of the Grade 12 and 15 scientists and engineers in the formal survey. This section covers the views expressed on the overall question, which supplement views expressed in connection with specific topics earlier in this report.

By a ratio of four to one, there was general agreement among NASA and contractor senior managers interviewed that NASA's in-house technical capability has diminished. Among the Grade 12 and 15 engineers and scientists responding to the survey, only 22.5 percent of all respondents agreed that NASA in-house scientific and engineering capabilities are as strong as in the past; 57.1 percent disagreed.

The NASA management interviewees and the Grades 12 and 15 scientists and engineers noted that the principal reason NASA's in-house technical capability has eroded was personnel ceilings imposed by the federal government. According to several interviewees and survey respondents, there was a ten year period (1968 - 1979) where centers were unable to hire civil servants. As a result, there was some loss of the experience base. Although centers have started hiring again, new employees have not yet developed the experience required. At one development center, it was stated that in some fields the numbers of technical people are enough, but the more experienced people are outnumbered up to 8:1 by newcomers. Another senior manager observed, "Since Challenger, the budget has increased substantially but the NASA staff has grown only from about 23,000 to 24,000. I do not believe that staffing levels need to grow in proportion to the budget, but I believe technical oversight is being pushed to the limit."

Other managers noted that in-house capability in NASA had decreased in areas ranging from the operation of laboratories and in-house problem solving to the quality of support provided by functional engineers and scientists to project personnel.

One research center manager noted, "The center has increased its capability in aeronautics and space research in recent years. The aeronautics research program is now larger than in 1970, but space research and technology is still not large enough to provide the technology base for future NASA programs."

The lack of technicians to support managers and professionals working on projects was also perceived to affect the technical capability of the staff and the culture of the centers. After the seventies, NASA began to divest itself of technicians largely in favor of contracting.

The status of NASA's in-house technical capability was also examined through the use of scaled items on the questionnaire distributed to Grades 12 and 15 scientists and engineers.

A statement that read, "NASA has in-house competence to make responsible decisions in all programs for which it is responsible," elicited agreement by 49.2 percent; 17 percent were neutral; 33.8 percent disagreed.

Narrative questionnaire comments expanded these views. Respondents from all centers noted that NASA's ability to be "a smart buyer" and to make independent judgments about the quality of the work has declined as the number of contractors has grown. Several respondents cautioned that NASA has lost its real experience base and will continue to slide unless the current trend to contract is reversed. Two specific comments capture the essence of the narrative inputs: "The question is not whether NASA has the technical expertise, but does NASA use the technical expertise appropriately?" and "As we contract out for more and more, the experience belongs more and more to the contractors."

A recent study by the agency was directed at the problem of civil service/support contractor mix. The study resulted in a need to convert many support contractor positions to civil service positions and to add additional civil servants beyond that conversion. The panel's recommendations reflect its support of that need.

SECTION 6

OBSERVATIONS ON ALTERNATIVE STRUCTURES FOR NASA

During the course of this study a limited inquiry was made by the research staff into the question of alternative forms for NASA centers such as a Federally Funded Research and Development Center (FFRDC), or a Government Owned-Contractor Operated facility (GOCO).

There was some interest at KSC by contractor and NASA managers in the GOCO approach, although the interest was at a more philosophical than practical level. An outline of the operating benefits of an FFRDC was presented by the Jet Propulsion Laboratory (which is an FFRDC). There was some interest in the FFRDC approach expressed by NASA managers at the Ames Research Center, principally because of civil service salary competitiveness issues in the San Francisco Bay area.

Whether GOCO or FFRDC, the benefits appear to the panel to be greater flexibility in personnel and pay operations, and removal from civil service ceilings, with no assertions made to reduced cost of operation or to improved technical capability beyond that which could result from greater flexibilities in hiring and ceiling relief.

The panel believes that NASA, in its basic organic form, has produced extraordinary technological results under extraordinary circumstances - and has led this nation to a position of world pre-eminence in space research, development, and exploration.

The panel believes that for NASA to embark on some other organic form for reasons other then achieving a clearly major advance in technical capability at an equal or reduced cost would not be prudent, would likely consume years of study and negotiation while present issues go less well attended, and would further dilute the presence in the government of strong and able scientists and engineers to advance and protect the public interest in this important publicly funded program.

The panel concludes that the public interest is best served by retaining the present organic form of NASA and, through cooperative efforts of the Congress and the Administration, strengthening its ability to perform its statutory role where necessary.

SUMMARY OF FINDINGS

NASA has operated with a relatively fixed number of scientists and engineers (11,500 to 13,000) for the last eighteen years, while the program/project mix and diversification of center activities has grown.

The long-term nature of some of NASA's programs, and the multiplicity of payloads and experiments requiring project management, have caused a movement out of the core science and engineering functions of research, design, test, and evaluation into project management and flight program support operations that are expected to be of continuing importance.

In efforts to exert tighter management controls after the Challenger accident, the agency has instituted internal technical management practices that are seen to consume inordinate amounts of scientist and engineer time in non-technical pursuits.

The nature of the contract type used for support contractors requires a great deal of technical time to monitor and administer, with resulting fees and adjective ratings in a very tight range. This calls into question the amount of technical effort expended and the marginal benefit provided.

The combination of those events has caused NASA to contract more and more of its technical work, until it is now in a situation where some technical functions are being performed by contractors that should be performed in greater measure by NASA. The weight of expertise in some key technical disciplines has also moved to support contractors.

NASA is able to recruit quality newly graduated scientists and engineers with no difficulty. Its difficulty in attracting more experienced scientists and engineers should be aided by the recent pay reform legislation.

NASA does not have enough hands-on technical work in-house to provide the direct developmental opportunities to its scientists and engineers necessary to hone their technical skills for later roles in conceiving new programs, managing major projects, and overseeing technical contractors.

NASA's in-house technical capability is stretched too thin, not only due to program/project mix and diversity, but also due to its growing long-term project operations support role and its internal management practices.

NASA's in-house technical capability has eroded, and is in need of immediate strengthening, preferably in NASA's present organic form.

SUMMARY OF RECOMMENDATIONS

The critical technical strength of NASA has long resided in the civil service scientists and engineers at the centers. Pressures to reduce government employment, to support a more diverse array of technical activities, and to convert functions to contractor performance have resulted in important changes throughout NASA. Most important has been a gradual erosion of NASA civil service technical capability at the centers.

The panel recognizes that there are various ways and combinations in which government research and development activities can be carried out. It is the panel's strong preference given the history, culture, and past performance of NASA, that the agency take actions to rebuild its civil service in-house technical capability. If circumstances dictate a civil-service/support contractor technical performance mixture it is imperative, in the panel's judgment, that such a mixture be in accordance with a plan and NASA guidance to the centers on which technical functions are important to be performed consistently by civil service scientists and engineers. The panel believes that the guidelines contained in the 1962 "Report to the President on Government Contracting for Research and Development," by David Bell and others, still provides a sound basis for such a plan.

The panel recommends that the Administrator of NASA:

1. **Prepare and issue guidance on technical functional areas to be reserved for in-house civil service performance.**
2. **Convert contracted technical functions essential to in-house capability from support contractors to in-house performance and rebuild strength in specific technical disciplines critical to agency programs and objectives. Ceiling relief should be sought if required.**
3. **Provide policy guidance to the centers to retain in-house sufficient project, experiment, advance development, and research activities to provide more hands-on technical work by civil service scientists and engineers.**

4. Examine the project mix at each center against agency and center goals and objectives. Select those with marginal contributions and/or staffing for cancellation or transfer. Assess all projects for suitability of specific center assignment, avoiding intercenter overlap or duplication where possible.
5. Institute an annual critical position review for all technical disciplines, identify the number and professional levels of in-house coverage that are essential to maintaining a reasonable degree of technical expertise in each critical discipline, and adjust recruiting and/or contracting plans accordingly.
6. Modify the agency's contractor accountability processes by tightening controls on attendance/participation in formal reviews, simplifying the award fee determination process, increasing the use of unannounced contractor site visits, and rotating NASA personnel stationed in contractor plants.
7. Seek opportunities for greater delegation of resources/technical decision making authority, reducing multi-party sign-off requirements with encouragement of reasonable risk taking, and improving lines of authority, responsibility, and accountability in the technical management organization.

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James Colvard: Associate Director, Johns Hopkins University Applied Physics Laboratory. Former Deputy Director of Office of Personnel Management, former Deputy Director of Civilian Personnel Policy, U. S. Navy, former Technical Director of Naval Surface Weapons Center.

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NASA INTERVIEWS (72)

HEADQUARTERS INTERVIEWS (8)

1. J. R. THOMPSON, DEPUTY ADMINISTRATOR
2. DICK KOHRS, DEPUTY ASSOCIATE ADMINISTRATOR (SPACE STATION FREEDOM)
3. ARNIE ALDRICH, ASSOCIATE ADMINISTRATOR, AERONAUTICS AND EXPLORATION TECHNOLOGY
4. STUART EVANS, ASSISTANT ADMINISTRATOR, PROCUREMENT
5. LEROY HOPKINS, DEPUTY ASSISTANT ADMINISTRATOR, PROCUREMENT
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7. DICK WISNIEWSKI, DEPUTY ASSOCIATE ADMINISTRATOR FOR INSTITUTIONS, OSF
8. STANLEY KASK, DEPUTY ASSISTANT ASSOCIATE ADMINISTRATOR, PERSONNEL MGT (WITH DOUGLAS PETERSON)

AMES RESEARCH CENTER INTERVIEWS (6)

1. DALE COMPTON, DIRECTOR
2. VIC PETERSON, DEPUTY DIRECTOR
3. DARRELL WILCOX, DIRECTOR OF ADMINISTRATION
4. MORRIS LILE, DEPUTY DIRECTOR OF ADMINISTRATION
5. KEN SOUZA, CHIEF, SPACE LIFE SCIENCES PAYLOADS OFFICE
6. JOEL SPERANS, CHIEF, SPACE EXPLORATION PROJECTS OFFICE

GODDARD SPACE FLIGHT CENTER INTERVIEWS (4)

1. JACK TOWNSEND, DIRECTOR
2. THOMAS HUBER, DIRECTOR OF ENGINEERING
3. PETER BURR, DIRECTOR OF FLIGHT PROJECTS
4. PAUL MOWATT, DEPUTY DIRECTOR FOR PLANNING AND BUSINESS, FLIGHT PROJECTS

JET PROPULSION LABORATORY INTERVIEWS (8)

1. LEW ALLEN, DIRECTOR
2. PETER LYMAN, DEPUTY DIRECTOR
3. C. R. GATES, ASSOCIATE DIRECTOR
4. KIRK DAWSON, ASSISTANT LABORATORY DIRECTOR FOR TECHNICAL DIVISIONS
5. JOHN HEIE, ASSISTANT LABORATORY DIRECTOR FOR ADMINISTRATIVE DIVISIONS
6. JOHN CASANI, ASSISTANT LABORATORY DIRECTOR FOR FLIGHT PROJECTS
7. NORM HAYNES, DEPUTY ASSISTANT LABORATORY DIRECTOR FOR FLIGHT PROJECTS
8. FRED BOWEN, CHIEF, NASA RESIDENT OFFICE

JOHNSON SPACE CENTER INTERVIEWS (12)

1. AARON COHEN, DIRECTOR
2. HENRY POHL, DIRECTOR OF ENGINEERING
3. CAROLYN HUNTOON, DIRECTOR OF SCIENCE AND MEDICAL OPERATIONS
4. DONALD ROBBINS, DEPUTY DIRECTOR OF SCIENCE AND MEDICAL OPERATIONS
5. CHARLES HARLAN, DIRECTOR OF QUALITY, SAFETY, AND RELIABILITY
6. DON PUDDY, DIRECTOR OF FLIGHT CREW OPERATIONS
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9. KEN GALBREATH, DIRECTOR OF CENTER OPERATIONS
10. JACK LISTER, DIRECTOR OF HUMAN RESOURCES
11. RICH CAMPBELL, DATA SPECIALIST, HUMAN RESOURCES
12. GENE KRANTZ, DIRECTOR OF FLIGHT OPERATIONS

KENNEDY SPACE CENTER INTERVIEWS (9)

1. FORREST McCARTNEY, DIRECTOR
2. GENE THOMAS, DEPUTY DIRECTOR
3. ANDY PICKETT, ASSOCIATE DEPUTY DIRECTOR
4. GEORGE ENGLISH, DIRECTOR OF EXECUTIVE MANAGEMENT
5. BOB SIECK, LAUNCH DIRECTOR
6. JOHN CONWAY, DIRECTOR OF PAYLOADS MANAGEMENT AND OPERATIONS
7. JIM PHILLIPS, DIRECTOR OF ENGINEERING DEVELOPMENT
8. DICK LYON, MANAGER, SPACE STATION PROJECT OFFICE
9. BILL BACKUS, DIRECTOR, CENTER TRANSITION PLANNING

LANGLEY RESEARCH CENTER INTERVIEWS (5)

1. RICHARD PETERSEN, DIRECTOR
2. PAUL HOLLOWAY, DEPUTY DIRECTOR
3. ROBERT SWAIN, DIRECTOR OF SYSTEMS ENGINEERING AND OPERATIONS
4. ROBERT WINGATE, DEPUTY DIRECTOR OF SYSTEMS ENGINEERING AND OPERATIONS
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3. JOE YUSKA, DEPUTY DIRECTOR, ENGINEERING
4. SAL GRISAFFE, CHIEF, MATERIALS DIVISION
5. CAL BALL, DEPUTY CHIEF FOR TURBOMACHINERY, PROPULSION SYSTEMS DIVISION
6. PAT SYMONS, MANAGER, CRYOGENIC FLUIDS TECHNOLOGY OFFICE
7. HENRY BRANDHORST, CHIEF, POWER TECHNOLOGY DIVISION
8. JIM SELLERS, DEPUTY CHIEF, ELECTRICAL SYSTEMS DIVISION

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2. DON BEAN, DIRECTOR, ADMINISTRATIVE OPERATIONS
3. BOB SHEPPARD, DIRECTOR, INSTITUTIONAL AND PROGRAM SUPPORT
4. PORTER BRIDWELL, MANAGER, SHUTTLE PROJECT OFFICE
5. WOODY BETHAY, EXECUTIVE ASSISTANT TO THE DIRECTOR
6. GEORGE McDONOUGH, DIRECTOR, SCIENCE AND ENGINEERING

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2. CHRIS KRAFT, RETIRED DIRECTOR, JSC
3. BILL LUCAS, RETIRED DIRECTOR, MSFC
4. CHUCK MATHEWS, RETIRED ASSOCIATE ADMINISTRATOR
5. MERV AULT, RETIRED DIRECTOR OF ENERGY PROGRAMS, LeRC
6. JOE SIVO, RETIRED CHIEF OF COMMUNICATIONS DIVISION, LeRC

PLUS 7 ADDITIONAL FROM THE RANKS OF INDUSTRY

INDUSTRY INTERVIEWS (22)

BOEING (2)

1. GEORGE DAVIS, OPERATIONS MANAGER (KSC)
2. BOB HAGER, MANAGER, HUNTSVILLE DIVISION

BROWN AND ROOT-NORTHROP (1)

1. HARRY CLAGGETT*, FORMER MANAGER, JSC SUPPORT GROUP

EG&G (1)

1. J. R. DUBAY, PRESIDENT, FLORIDA OPERATIONS

LOCKHEED (9)

1. BOB YOUNG, PRESIDENT, LOCKHEED ENGINEERING AND SCIENCE COMPANY
2. A. GUASTAFERRO*, VICE PRESIDENT, SPACE FLIGHT PROGRAMS, LOCKHEED MISSILE AND SPACE CO.
3. DOUG SARGENT, MANAGER, SHUTTLE PROCESSING CONTRACT (KSC)
4. BERT BULKIN, DIRECTOR, SCIENTIFIC SPACE PROGRAMS, LOCKHEED MISSILE AND SPACE COMPANY
5. WALT OLSTAD*, DIRECTOR, R&D PLANNING AND DEVELOPMENT, RESEARCH & DEVELOPMENT DIVISION, LOCKHEED MISSILE AND SPACE COMPANY
6. HENRY BOWES, FORMER DIRECTOR, SCIENCE AND ENGINEERING, LOCKHEED ENGINEERING & SCIENCE
7. MAURICE MILLER, LOCKHEED ENGINEERING AND SCIENCE COMPANY
8. MARV WHITE, LOCKHEED ENGINEERING AND SCIENCE COMPANY
9. ROBERT NELSON*, (RETIRED)

MARTIN-MARIETTA(1)

1. TOM YOUNG*, PRESIDENT

McDONNELL DOUGLAS(2)

1. GENE SPILGER, DIRECTOR OF SPACE STATION (KSC)
2. CHUCK JACOBSEN, MANAGER SUPPORT OPERATIONS (JSC)

ROCKWELL(4)

1. GEORGE MERRICK, VICE PRESIDENT, AEROSPACE TECHNOLOGIES AND SYSTEMS SAFETY
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3. STEVE DOMOKIS, VICE PRESIDENT (RETIRED), ROCKETDYNE DIVISION
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1. JOE ALLEN*, VICE PRESIDENT, (FORMER SCIENTIST ASTRONAUT)

TELEDYNE-BROWN ENGINEERING(1)

1. JOE MOQUIN, PRESIDENT (RETIRED)

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* NASA ALUMNI

National Academy of Public Administration

NASA

MAINTAINING THE PROGRAM BALANCE

A Report by an Academy Panel
Examining the Distribution of NASA Science and Engineering
Work between NASA and Contractors
and the Effect on NASA's In-House Technical Capability

APPENDIX A

1990 Survey of NASA
Scientists and Engineers
at Grades 12 and 15

VOLUME II

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Submitted in fulfillment of Delivery Order 19
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TABLE OF CONTENTS

Appendix A

APPENDIX A
PART I
SUMMARY OF QUESTIONNAIRE FINDINGS

A wide range of questions were posed to NASA scientists and engineers at the Grades 12 and 15 levels in the following areas:

- o Demographics
- o Nature of Work
- o Hands-On Activities/Contracting
- o Image of the Public Service; and
- o Recruitment and Retention

Part IV of this appendix presents the survey instrument, which was comprised of a number of closed-ended questions with mutually exclusive structured responses and a narrative section.

After completing the first five sections of the questionnaire, respondents were able to comment on these and other topics by providing narrative statements. In the narrative section of the questionnaire, respondents commented on many factors, including the appropriateness and types of work performed by contractor personnel versus civil servants at NASA centers, the number of opportunities for hands-on work, the impacts of the external environment, institutional and managerial shortcomings, special financing needs of space and aeronautics programs, and declining public confidence in government.

Parts II and III present the survey results from the closed and open ended parts in detail, and Part IV present the survey instrument. This section integrates principal findings derived from the areas of the questionnaire dealing with Nature of Work, Hands-On Activities/ Contracting, Image of the Public Service, Recruitment and Retention, and narrative comments.

The largest number of GS-12 and GS-15 respondents, 31.8 percent, were involved in the management or administration of research or development; the second largest number of respondents, 16.3 percent, were involved in applied research; and the third largest number of respondents, 13.7 percent, were involved in operations as primary work activities. As secondary work activities, 16 percent of respondents were engaged in development, followed by those engaged in applied research, 14.3 percent, followed by those engaged in report and technical writing, editing and information retrieval. Although each of the functions listed above requires a separate effort, each is highly related to the others and there are overlaps and merges of functions, different interpretations of functions and cyclic involvement of individuals in functional activities.

The bulk of respondents (61.9 percent) believed that the utilization of experienced scientists and engineers at their centers was good and excellent. The utilization of young scientists and engineers was perceived to be good and excellent by 63.5 percent of the respondents. Although the majority of scientists and engineers responded positively to the subjective concept of utilization, many provided written comments that dealt with the frequent failure by management to place a premium on technical quality achievement by individuals. Several respondents reported that a principal defect in the management was the inability to relate rewards to utilization of staff.

The type of technical responsibility most frequently exercised by respondents was planning and organizing projects. About 36 percent of the respondents reported that planning and organization were the most frequently exercised type of responsibility. About 18 percent of the respondents indicated problem solving as the next type of technical responsibility most frequently exercised.

The last question related to the section of the questionnaire entitled Nature of Work required a nominal response of yes or no. The question was: "Since joining NASA has the diversity (variety and complexity of work) increased at your center?" Of the 1,537 respondents who answered this question, 76 percent replied yes and 24 percent replied no. Although the consequences of growing variety and complexity of programs were not explicitly requested in this part of the questionnaire, many narrative comments were linked to this phenomenon. For example, respondents indicated that projects have become more comprehensive and longer, often calling for more interdisciplinary talents; more formal reporting systems; increased financial concerns; more time on government requirements for financial accountability; increasingly more complicated administrative processes, and so on. Many times, narrative comments on the diversity of programs turned into statements against large projects. Some respondents believed that, generally, large projects are poorly conceived, unfocused, inadequately funded and never completed. The breadth and depth of large projects, it was noted, led to unrealistic expectations, greater inefficiencies and the dedication of large numbers of project staff to administrative matters. A few people noted that the plethora of data stemming from planning and tracking of large projects has resulted in information overload. It was also observed that pre-contract competition absorbs a considerable number of scientific and engineering personnel, especially in connection with large projects. Weaving ways through these troublesome observations were the needs to set work priorities and to consciously strive for balanced allocations between "big" and "small" projects. Many narrative statements pointed out that decisions pertaining to missions and roles have been approached as primarily budgetary matters.

The third part of the questionnaire focused on hands-on activities and contractor support. Duties performed by contractor personnel that were reported most frequently include representing NASA at meetings (58.4 percent of respondents), reviewing progress (49.4 percent), defining assignments (37.9 percent), and monitoring performance (35.7 percent). Comparatively few comments were made on the quality of contractor performance in specific program areas except for space station and the impacts of contractor performance on government decision making.

Many narrative comments focused on employing contractors in inappropriate areas. Respondents said that contractors are performing more significant tasks than NASA employees, and there were pleas for reform. They also cited discontent with contractor accountability, responsiveness, efficiency and effectiveness.

When those surveyed were asked which types of support provided by contractors exceed what should be provided by the private sector, 33.1 percent of the respondents replied none. However, 37.8 percent noted excesses in engineering and technical services; 29.3 percent cited excesses in research and development and 21.8 percent said there were excesses with program control. Many of the narrative comments stated that contractors perform critical work that should be performed by civil servants, and that this had resulted in the deterioration of NASA's in-house capability and in an irreversible dependency on contractors. In spite of some narrative comments on the exodus of government experts to private firms, over half of the respondents (53.7 percent) disagreed and strongly disagreed that NASA is less efficient than industry.

Over 90 percent of the respondents saw a strong positive relationship between hands-on experience to proficiency, and 85 percent said that direct experience, or learning by doing, is tied to the best results. Narrative comments stated the need to acquire technical competence through "hands-on" experience. Such experience, it was noted, can effectively convey "lessons learned" to managers and staff and result in more effective contract monitoring and control, dramatically reducing the likelihood of project failure. "To the extent that project managers do not understand what is happening on their projects due to the lack of direct experience, problems will continue to surface," a respondent wrote.

Although 80 percent of the respondents stated that NASA provides challenging work, almost 75 percent of the respondents said that a great deal of challenging work is performed by contractors, not NASA. Another statement, used to check the responses to the prior question in less vague terms, also elicited large amounts of agree and strongly agree votes. The statement was: "The trend toward expanding the use of contractors has shifted challenging tasks from NASA to contractors". It resulted in a combined agree and strongly agree response rate of 80.9 percent. Although one of the hardest tasks facing senior managers in NASA is to strike a balance between work performed by NASA and work performed by contractors, a large number of scientists and engineers stated that they did not believe in tight controls with respect to the number of contractors and believed that overly rigid controls on the numbers of government and private sector employees would result in disbenefits. Respondents also said it would be a serious mistake to sacrifice reasonable flexibility and adopt the alternative of formal staffing requirements, in the form of personnel ceilings. Respondents recognized that in an attempt to reduce the size of government, NASA has achieved an imbalance; offering strict limitations on what the private sector should do however, will not solve the problem of "shadow government."

When respondents were asked whether they strongly agreed, agreed, were neutral, disagreed or strongly disagreed to the affirmation that the future roles of contractors should be more limited, 58.5 percent of the respondents agreed and strongly agreed. As mentioned, many commentators pointed out that finding new and improved ways to control the growth of contractors will be extremely difficult. Prescriptive remedies aimed at devising a way to achieve a balance between the public and the private performances of research and development in aeronautics and space do not exist.

The bottom line of many narrative comments relating to roles of contractors is that it is in the best interest of NASA to have more control over its work and more input into it. Respondents suggested that work allocations between civil servants and contractors should be examined on a task by task basis. They also noted patterns and ratios of personnel working in support of scientists and engineers, such as skilled crafts workers and shop and production workers, need to be examined.

A strong plurality of respondents (65.7 percent) said that the public interest would be better served if less technical work were contracted out to the private sector. Narrative reflections to this sentiment were furnished by employees who noted that consequences of contracting need to be fully appreciated and new means for assuring accountability need to be investigated. "Given the nature of the space business" one respondent wrote, "no ideal solutions to satisfying the public interest are likely to come to pass." Several respondents provided negative comments about attempts to curb waste and abuse that stem from contracting methods such as incentive contracts.

When asked to agree or disagree with a statement that in-house management/administrative capabilities of NASA are as strong as in the past, 48.8 percent of the respondents disagreed and strongly disagreed. It was also argued that although scientists and engineers may be in the proper supply and strength in some areas there is a shortage of more creative and capable individuals in other areas. This outlook was reinforced by narrative comments that underscored specific weaknesses of NASA management and that spelled out the need to match the management of complex, changing technologies with the art of leadership. One example frequently cited was the need for individuals to anticipate and to be more adaptive to change rather than to simply react to events.

In addition, 73.5 percent of respondents strongly agreed and agreed that too much of the scientific and engineering efforts in NASA are spent preparing and selling programs. Selling programs was a salient complaint of a great number of people who wrote comments. ("Selling" includes internal as well as external advocacy efforts.) Although commentators acknowledged the uncertain nature of NASA funding streams and the fact that budgetary constraints are paramount problems of our time, commentators noted the increasing position of selling and the politicization of centers and the agency as a whole. They said this had resulted in: disturbing consequences such as multiple and fragmented functions and tasks with too little interlock; unbalanced and inadequate coverages of work in research and development, operations, management and administration; confusion about objectives of work; and diminished motivation for technical work.

Respondents also said the competition among centers has weakened the central authority of Headquarters, leading to what was termed an excess of "home rule." Several people observed that a sense of community and cohesion is missing and that this will not occur unless central direction, coordination and leadership are supplied by strong agency management. Several respondents pointed out that it would be highly prudent to strengthen the capabilities of Headquarters.

Finally, 71.1 percent of the scientists and engineers responded positively to the statement that engineers should be able to acquire cradle to grave experience on projects or be able to accompany projects through all phases of their life cycles. Respondents believed that accompanying a project throughout its cycle of design, development, and test, offers valuable experience that is essential to developing program management skills. They also pointed out that generally very large projects are not conducive to cradle to grave experience opportunities because they result in the isolation of technical groups.

Many narrative commentators pointed out that at the Goddard Space Flight Center and the Marshall Space Flight Center, efforts were underway to ensure that a number of projects or project component developments and system tests are undertaken in-house and that similar efforts should occur at other installations. Some scientists and engineers also linked the notions of hands-on experience and cradle-to-grave project involvement to acquiring systems engineering and project integration skills. "Hands-on capabilities can hasten the achievement of systems integration," a survey participant observed. Although people recognize that work patterns have changed because of computer-based technologies, the conventional approach of developing "hands-on" capabilities is still considered to be highly desirable. In fact, the acceleration of research and innovation by machine may have increased the need for added "hands-on" learning, according to several staff.

Fifteen strongly agree - strongly disagree items comprised the next section of the questionnaire, which was aimed at collecting observations about the health and viability of NASA and the government as a whole.

Although 67.6 percent of the respondents disagreed and strongly disagreed that the government, as an employer, rates higher than other sectors, over 76 percent of the respondents said they would recommend NASA as an employer and 84.0 percent said they were doing important work as NASA employees. The premium NASA employees place on important work and standards of excellence was a central feature of the written comments.

Without going into detail, the responses to this section of the questionnaire, together with the narrative comments, clearly show that the government is perceived as an inadequate employer. However, NASA employees see significant differences between themselves and other government employees who, they believe, are less able to cope with their responsibilities. The government, as a whole, was described as not up to the task of successfully implementing programs for which it is responsible. There was the strong perception, however, that the private sector does not provide a promising alternative to accomplishing R&D tasks and that NASA must regain control over the balance and direction of its programs.

NASA employees cast a more important role for themselves than for other federal employees. In fact, they stated that aeronautics and space research and development requires more responsibility, individual creativity, and productivity than other government activities. Over 40 percent of the respondents agreed and strongly agreed that most scientific and engineering students would prefer working for the private sector. Slightly over 40 percent of the respondents disagreed and strongly disagreed that government research and development is less efficient than the private sector. The primary advantages of the private sector, in the respondents' views, were pay, benefits, and lessening of red tape.

In narratives, many employees observed that the rhetoric and reality of recent program failures suggest that NASA is becoming more like the rest of the government, but the majority still believed NASA was more satisfying and meaningful than other federal departments and agencies. A few warned that unless NASA defined priorities and pursued fewer initiatives it would turn into an agency characterized by continual conflict, risk aversion, bureaucratic politics and program flaws, thus discrediting its reputation and exhausting its credit.

Although some scientists and engineers pointed to adverse federal governmental trends that have affected the way NASA does business, the majority of respondents perceived that NASA's own administrative system is weak and that NASA employees do not posses the same work ethic and sense of commitment as previously. They suggested that old values were shaken or shattered by the Vietnam War, the baby boom generation, and so on, and that new ones have not risen to replace them. Respondents also said that team work is essential to a successful NASA and that it is not as strong as it should be. Of fundamental significance to the notion of the project team is the relationship among centers. Barriers between scientific and engineering personnel at different centers have been erected. Respondents saw these barriers as largely communication ones that have emphasized differences among organizations rather than unity of purpose and common goals.

In another connection, the relationship between NASA and Congress was cited as a dimension constraining the functional abilities of NASA. It would, according to respondents, be improved if legislation stabilized expenditures for technological projects, quality and continuity of technical efforts, and if it were orientated toward long run objective.

Finally, NASA was thought to be limited because its resources are limited. Respondents said the scale of its activity does not constitute a manageable expense. One employee viewed the problem differently. "Space exploration," he noted, "costs a great deal; of late, it also has accomplished too little. If NASA continues to disappoint the public, the search for an alternative may be sought rather aggressively."

The last topic of the questionnaire dealt with recruitment and retention, which do not appear to be serious problems at NASA. In fact, 74.9 percent of the employees who responded to the questionnaire are satisfied with their progress at NASA and 64.4 percent regard working for NASA as their lifetime career. This is not to say that a larger than desirable number of scientists and engineers at some centers do not resign; but even at the Ames Research Center, where inadequate salaries are a major concern, only 21 percent of the respondents did not regard NASA as their lifetime career. In sum, in the context of NASA, shortages and dislocations of people do not appear to be a cause for great concern. In fact, at some centers, narrative respondents saw stagnation as more of a problem.

A word about salary and benefits. Although some employees at each center cited low levels of satisfaction with pay, a very large percentage of Ames employees voiced strong opinions about the need to receive more money and better benefits. In support of the objective of assuring high levels of professional competence in the NASA establishment, they believed Congress should promptly enact proposals for higher salaries at certain geographical locations. Retention of scientist and engineers at other centers was not generally tied to money; the central importance of challenging work was the main reason for joining and remaining at all NASA installations.

APPENDIX A
PART II
CLOSE-ENDED QUESTIONNAIRE RESULTS

The Survey Design

A written questionnaire was used to collect data for this study. The stratified sample of 2,243 GS-12 and 15 NASA scientists and engineers at nine installations was drawn from among the 3,661 Grades 12 and 15 scientists and engineers on the Personnel Management Information System (PMIS) roster. The confidence interval for the mean of each of the samples was 95 percent; thus, the standard error of each of the samples was .05 or 5 percent. Table 1 reports the composition of both populations and samples of Grades 12 and 15 scientists and engineers by NASA installation.

Table 1
Sizes of Survey Populations and Samples of Grades 12 and 15 Scientists and Engineers by NASA Installation

NASA Installation	Population Grade 12	Population Grade 15	Sample* Grade 12	Sample* Grade 15
Ames Research Center	141	198	108	132
Goddard Space Flight Center	225	379	144	191
Johnson Space Center	385	331	195	180
Kennedy Space Center	292	119	169	92
Langley Research Center	186	200	127	132
Lewis Research Center**	272	161	162	118
Marshall Space Flight Center	264	192	159	132
Stennis Space Center	22	8	22	8
Headquarters	3	283	3	165

*The sizes of some of the samples were slightly modified to augment the number of subjects within each sample with the additions of five to eight subjects because of the prevalent opinion that individuals might be on vacation during the month of August and would not have opportunity to be included in the sample.

**The method for data collection was transmission of the questionnaire by personnel offices at each center, accompanied by letters of explanation and return envelopes. At the Lewis Research Center, 280 questionnairs were initially distributed to employees who were not necessarily Grades 12 and 15 scientists and engineers. As a result, 280 additional questionnaires were coded and delivered to Grades 12 and 15 scientists and engineers with a request stating that if respondents had completed questionnaires earlier they were not to fill out questionnaires. It should be noted that all of the returns from Lewis were carefully monitoried and processed. The total response rate takes into account the 560 questionnaires distributed to Lewis employees during two stages.

The purpose of this study was to examine the balance between NASA employees and contractors and to discover the impacts of the current mix on NASA's in-house capability. The researchers and members of the Academy panel believed that Grades 12 and 15 scientists and engineers would provide a worthwhile vantage point for investigating the phenomena under study. To capture the dynamics of situation, Grade 12 scientists and engineers who were expected to be employed by NASA less than five years and Grade 15 scientists and engineers who generally have been employed for a longer period of time and thus would be able to discuss changes over a longer period of time, were designated as respondents.

The survey instrument consisted of six parts: Demographics, Nature of Work, "Hands-on"/Contracting, Image of the Public Service, Recruitment/Retention and a Concluding Statement. The self-administered instrument was comprised of 83 items that called for nominal, ordinal and interval data. Several of the items were closed questions with five point rating scales and descriptions such as excellent, good, fair, poor and very poor. There were many disagree - agree items with statements located at the ends of continuums. Checking boxes or circling numbers were the main tasks required.

Questions pertaining to demographics were placed in the first part of the survey because they elicited straight-forward information, thus getting respondents "into the survey." Open ended comments and observations comprised the final section of the instrument. There were different types of print to distinguish between words that were instructions and questions (e.g., upper case and lower case letters). Optional wordings on certain questions were in parentheses. No skip patterns were used. Finally, the length of the questionnaire was resolved after taking into account cost, effect on response rate, and limits of the respondents' willingness to answer questions.

Researchers submitted each of the questions to current and former NASA employees and Academy panel members for review and conducted pretests with potential respondents. The researchers promised questionnaire recipients that answers would be treated confidentially and that responses would not be associated with individuals.

Response Rates

The overall responses rate to the survey is a guide to the representativeness of the sample respondents. A total of 2,243 questionnaires were sent, and 1,615 responses were returned for an overall response rate of 72.0 percent. Forty-eight responses did not arrive in time for the data analysis phase. Generally, a response rate of 50 percent is adequate for analysis and a response rate of 60 percent or more is good. There were no follow-up mailings. The questionnaire was administered during August and September, prime vacation months.

Response rates to the questionnaire by sex were: 1,336 (85.8 percent) males and 221 (14.2 percent) females, Ten respondents did not state their sex. The eldest respondent was born in 1917. One hundred and six (6.8 percent) of the respondents were born in 1962, the year in which the greatest number of U.S. births occurred. The break down of the respondents by age shows that 463 respondents (29.9 percent) were 51 to 60 years old: 404 (26.1 percent) were 30 years old or younger; 321 (20.8 percent) were 41 - 50 years of age; 280 (18.1 percent) were 31 - 40 years of age; and 78 (5.0 percent) were 61 years of age or over. Nineteen respondents did not furnish information relating to data of birth.

The center with the greatest number of respondents was the Lewis Research Center: 278 or 17.9 percent. The rest were: The Johnson Space Center, 239 or 15.4 percent; Ames Research Center, 225 or 14.6 percent; Langley Research Center, 192 or 12.4 percent; Kennedy Space Center, 185 or 11.9 percent; Goddard Space Flight Center, 169 or 10.9 percent; Marshall Space Flight Center, 162 or 10.4 percent; Headquarters 82 or 5.3 percent; and Stennis, 21 or 1.4 percent. The number of respondents at each center who filled out the questionnaire is reported as a percentage of the entire number of respondents who responded to the questionnaire.

Table 2 reports the response rates for each installation.

Table 2
Response Rates by NASA Installation

NASA Installation	Sample Size	Response Rate Frequencies	Response Rate Percent
Ames Research Center	240	225	93.8%
Goddard Space Flight Center	335	169	50.4%
Johnson Space Center	375	239	63.7%
Kennedy Space Flight Center	261	185	70.8%
Langley Research Center	261	192	73.6%
Lewis Research Center	560	278	49.6%
Marshall Space Flight Center	291	162	55.6%
Stennis Space Center	30	21	70.0%
Headquarters	168	82	48.8%

The educational level of the respondents was high. Table 3 shows the highest levels of educational attainment and fields of study of the respondents.

Table 3
Educational Attainment of Respondents

Highest Level of Educational Attainment	Frequencies	Percent
College Graduate (Bachelor's Degree)	398	25.5%
Some Graduate Work	378	24.2%
Graduate Degree (M.S., M.A., LL.B.)	510	32.7%
Doctorate (Ph.D)	247	15.8%
Other	29	1.9%

Field of Study	Frequencies	Percent
o Agriculture,	2	(0.2%)
o Biology,	23	(1.5%)
o Engineering,	1,107	(71.3%)
o Math,	93	(6.0%)
o Education,	3	(0.2%)
o Physics,	200	(12.9%)
o Health,	9	(0.6%)
o Management and Other Fields	115	(7.4%)

The earliest date that the highest educational degree was granted was 1936. In 1985, the greatest number of respondents (119) received their highest degrees.

Exactly 1,387 (88.8 percent) respondents were in the Grades 12 and 15 categories. Six hundred and forty-eight (41.5 percent) of the respondents were Grade 12 and 739 (47.3 percent) of the respondents were Grade 15. The remaining 175 (11.2 percent) respondents ranged from Grade 7 to Senior Executive Service. They were classified as "Other." Most of the respondents in the "Other" category were Lewis Research Center employees who received the first batch of questionnaires distributed at Lewis.

Two hundred thirty-six (15.2 percent) of the respondents participated in the co-op program and later accepted NASA employment offers.

Table 4 presents the number of years respondents have worked at NASA. Five did not answer this question.

Table 4
Tenure of Respondents at NASA

Years with NASA	Frequencies	Percent
Less than 1 year	54	3.5%
1 year to less than 2 years	120	7.7%
2 years to less than 3 years	58	3.7%
3 years to less than 5 years	216	13.8%
5 years to less than 10 years	289	18.5%
10 years to less than 15 years	113	7.2%
15 or more years	712	45.6%

Respondents identified their occupations prior to joining NASA. Seven hundred and thirty-six (47.0 percent) were students; 15 (1.0 percent) worked for state or local government; 446 (28.5 percent) had been employed by the private sector; 71 (4.5 percent) had been in the military; 165 (10.5 percent) worked for another federal agency; 5 (0.3 percent) were unemployed; and 121 (7.7

percent) had been engaged in other occupations. Eight respondents did not answer this question.

Generally, the rate of non-response to individual questions was low, five or six people. Possible reasons why those who responded to the questionnaire did not provide information regarding all items were: employees were unable to fill out specific items because they did not have sufficient knowledge concerning the questions; employees did not wish to express their views because they were afraid of being identified; employees believed topics were too sensitive; employees were uncomfortable with the choices of answers provided; employees were threatened by the uses to which they felt the data would be put; or employees simply overlooked certain questions.

Nature of Work

The second section of the questionnaire was Nature of Work. The first item asked the respondents to select primary and secondary work activities from a list of thirteen items.

Table 5 shows the frequencies and percentages of employees engaged in these work activities as indications of primary work efforts.

Table 5
Primary Work Activities

Activities	Cases Frequencies	Percent
Management/Administration of Research or Development	499	31.8%
Management/Administration of Non Research or Development	243	15.5%
Teaching, training, guiding or counseling	24	1.5%
Basic Research	9	6.0%
Applied Research	255	16.3%
Development	156	10.0%
Report and Technical Writing Editing, Information Retrieval	44	2.8%
Design of Equipment, Processes, Models	85	5.4%
Quality Control, Testing, Evaluation	46	2.9%
Operations	215	13.7%
Statistical Work	9	0.6%
Computer Applications	67	4.3%
Other	82	5.2%

The number of respondents engaged in managing or administering research and development activities as a primary activity was more than the double of those involved in applied research, the next highest primary activity.

Table 6 presents cases of secondary work activities on an aggregate basis. Note that development was the most frequent secondary work activity and statistics was the least frequent primary and secondary work activities.

Table 6
Secondary Work Activities

Activities	Cases Frequencies	Cases Percent
Management/Administration of Research or Development	125	8.0%
Management/Administration of Non Research or Development	158	10.1%
Teaching, training, guiding or counseling	125	8.0%
Basic Research	100	6.4%
Applied Research	224	14.3%
Development	250	16.0%
Report and Technical Writing, Editing, Information Retrieval	44	13.9%
Design of Equipment, Processes, Models	124	7.9%
Quality Control, Testing, Evaluation	55	3.5%
Operations	178	11.4%
Statistical Work	21	1.3%
Computer Applications	139	8.9%
Other	57	3.6%

Tables 7 and 8 show primary and secondary activities by Grades 12, 15 and Other. As a primary activity, Grade 12 employees were frequently engaged in development and operations while Grade 15 employees were frequently engaged in managing or administering research and development and non-research and non-development activities. Some employees selected more than one activity as their primary activity and as their secondary activity.

Table 7

Primary Work Activities By Grade

Activities	Grade							
	GS-12		GS-15		Other		Total Cases	
	Freq	%	Freq	%	Freq	%	Freq	%
Management/Administration of Research/Development	67	10.3%	393	53.2%	39	22.2%	499	31.8%
Management/Administration of Non Research/Development	70	10.7%	152	20.6%	21	11.9%	243	15.5%
Teaching, Training, Guiding or Counseling	12	1.7%	12	1.6%	1	0.6%	24	1.5%
Basic Research	30	4.6%	47	6.4%	17	9.7%	94	6.0%
Applied Research	148	22.7%	63	8.5%	44	25.0%	255	16.3%
Development	97	14.9%	41	5.5%	18	10.2%	156	10.0%
Report and Technical Writing Editing, Information Retrieval	27	4.1%	13	1.8%	4	2.3%	44	2.8%
Design of Equipment, Processes, Models	72	11.0%	9	1.2%	5	2.3%	85	5.4%
Quality Control, Testing, Evaluation	33	5.1%	8	1.1%	5	2.8%	46	2.9%
Operations	123	18.9%	61	8.3%	31	17.6%	215	13.7%
Statistical Work	7	1.1%	2	0.3%				
Computer Applications	54	8.3%	2	0.3%	11	6.3%	67	4.3%
Other Activities	42	6.4%	27	3.7%	13	7.4%	82	5.2%

Table 8
Secondary Work Activities By Grade

Activities	GS-12 Freq	GS-12 %	GS-15 Freq	GS-15 %	Other Freq	Other %	Total Cases Freq	Total Cases %
Management/Administration of Research/Development	34	5.2%	71	9.6%	20	1.4%	125	9.0%
Management/Administration of Non Research/Development	53	8.1%	97	13.1%	8	4.5%	158	10.1%
Teaching, Training, Guiding or Counseling	48	7.4%	60	8.1%	17	9.7%	125	8.0%
Basic Research	46	7.1%	43	5.8%	11	6.3%	100	6.4%
Applied Research	91	14.0%	114	15.4%	19	10.8%	224	14.3%
Development	99	15.2%	130	17.6%	21	11.9%	250	16.0%
Report and Technical Writing, Editing, Information Retrieval	124	19.0%	63	8.5%	31	17.6%	218	13.9%
Design of Equipment, Processes, Models	69	10.6%	34	4.6%	21	11.9%	124	7.9%
Quality Control, Testing, Evaluation	31	4.8%	17	2.3%	7	4.0%	55	3.5%
Operations	67	10.3%	87	11.8%	24	13.6%	178	11.4%
Statistical Work	14	2.1%	2	0.3%	5	2.8%	21	1.3%
Computer Applications	80	12.3%	31	4.2%	28	15.9%	139	8.9%
Other Activities	24	3.7%	28	3.8%	5	2.8%	57	3.6%

Table 9
Primary Work Activities By Center

Activities	Center ARC Freq	ARC %	LARC Freq	LARC %	LERC Freq	LERC %	JSC Freq	JSC %
Management/Administration of Research or Development	79	35.0%	64	33.3%	77	27.7%	79	33.1%
Management/Administration of Non Research/Development	17	7.5%	10	5.2%	29	10.4%	58	24.3%
Teaching, Training, Guiding or Counseling	3	1.3%	3	1.6%	2	0.7%	11	4.6%
Basic Research	29	12.8%	21	10.9%	24	8.6%	1	0.4%
Applied Research	60	26.5%	61	31.8%	77	27.7%	16	6.7%
Development	15	6.6%	16	8.3%	21	7.6%	31	13.0%
Report and Technical Writing, Editing, Information Retrieval	6	2.7%	7	3.6%	9	3.2%	9	3.8%
Design of Equipment, Processes, Models	9	4.0%	13	6.8%	11	4.0%	16	6.7%
Quality Control, Testing, Evaluation	1	0.4%	2	1.0%	4	1.4%	8	3.3%
Operations	24	10.6%	8	4.2%	32	11.5%	48	10.1%
Statistical Work	1	0.4%					1	0.4%
Computer Applications	8	3.5%	7	3.6%	14	5.0%	3	1.3%
Other Activities	5	2.2%	4	2.1%	16	5.8%	14	5.9%

(Table 9 continued)

Primary Work Activities By Center

Activities	KSC Freq	KSC %	MSFC Freq	MSFC %	GSFC Freq	GSFC %	SSC Freq	SSC %
Management/Administration of Research/Development	22	11.8%	66	40.5%	60	35.3%	5	23.8%
Management/Administration of Non Research/Development	47	25.3%	21	12.9%	26	15.3%	8	38.1%
Teaching, Training, Guiding or Counseling	2	1.1%	1	0.6%	1	4.8%		
Basic Research	4	2.5%					14	8.2%
Applied Research	5	2.7%	14	8.6%	19	11.2%	1	4.8%
Development	13	7.0%	23	14.1%	27	15.9%	2	9.5%
Report and Technical Writing, Editing, Information Retrieval	5	2.7%	4	2.4%	1	4.8%		
Design of Equipment, Processes, Models	9	4.8%	9	5.5%	13	7.6%	3	14.3%
Quality Control, Testing, Evaluation	12	6.5%	9	5.5%	5	2.9%	2	9.5%
Operations	66	35.5%	16	9.8%	11	6.5%	4	19.0%
Statistical Work	5	2.7%	1	0.6%				
Computer Applications	8	4.3%	9	5.5%	15	8.8%	1	4.8%
Other Activities	17	9.1%	12	7.4%	6	3.5%	3	14.3%

Table 10
Secondary Work Activities By Center

Activities	Center: ARC Freq	ARC %	LARC Freq	LARC %	LERC Freq	LERC %	JSC Freq	JSC %
Management/Administration of Research/Development	26	11.5%	13	6.8%	20	7.2%	6	6.7%
Management/Administration of Non Research/Development	20	8.8%	9	4.7%	19	6.8%	35	14.6%
Teaching, Training, Guiding or Counseling	16	7.1%	17	8.9%	28	10.1%	25	10.5%
Basic Research	25	11.1%	16	8.3%	29	10.4%	3	1.3%
Applied Research	47	20.8%	51	26.6%	47	16.9%	23	9.6%
Development	27	11.9%	25	13.0%	29	10.4%	53	22.2%
Report and Technical Writing, Editing, Information Retrieval	27	11.9%	36	18.8%	40	14.4%	34	14.2%
Design of Equipment, Processes, Models	18	8.0%	7	3.6%	32	11.5%	15	6.3%
Quality Control, Testing, Evaluation	1	0.4%	3	1.6%	10	3.6%	4	1.7%
Operations	23	10.2%	7	3.6%	27	9.7%	33	13.8%
Statistical Work	5	2.2%	2	1.0%	4	1.4%	2	0.8%
Computer Applications	20	8.8%	16	8.3%	33	11.9%	19	7.9%
Other Activities	7	3.1%	2	1.0%	7	2.5%	12	5.0%

(Table 10 continued)

Secondary Work Activities By Center

Activities	KSC Freq	KSC %	MSFC Freq	MSFC %	GSFC Freq	GSFC %	SSC Freq	SSC %
Management/Administration of Research/Development	10	5.4%	9	5.5%	16	9.4%	3	14.3%
Management/Administration of Non Research/Development	28	15.1%	13	8.0%	12	7.1%	3	14.3%
Teaching, Training, Guiding or Counseling	8	4.3%	8	4.9%	17	10.0%	3	14.3%
Basic Research	3	1.6%	7	4.3%	15	8.8%	1	45.8%
Applied Research	9	4.8%	26	16.0%	15	8.8%	2	9.5%
Development	21	11.3%	45	27.6%	38	22.4%	2	9.5%
Report and Technical Writing, Editing, Information Retrieval	22	11.8%	25	15.3%	17	10.0%	4	19.0%
Design of Equipment, Processes, Models	16	8.6%	12	7.4%	19	11.2%	2	9.5%
Quality Control, Testing, Evaluation	16	8.6%	5	3.1%	9	5.3%	2	9.5%
Operations	36	19.4%	25	15.3%	15	8.8%	6	28.6%
Statistical Work	2	1.1%	1	0.6%	2	1.2%	3	14.3%
Computer Applications	15	8.1%	12	7.4%	15	8.8%	1	19.0%
Other Activities	10	5.4%	6	3.7%	5	2.9%	1	4.8%

As for secondary work activities, with the exception of Kennedy, Stennis, and Goddard Space Flight Centers, the majority of respondents were occupied with report and technical writing, editing and information retrieval or development. Personnel at Kennedy and Stennis Space Centers cited operations as a principal secondary activity while Goddard employees cited development, followed by design.

The next two items on the questionnaire asked respondents to characterize the utilization of the technical competence of scientists and engineers. Table 11 presents the perceptions for experienced scientists and engineers. Excellent and good technical utilization of experienced personnel accounted for 61.9 percent of the responses. The perceptions reported in Table 11 include NASA respondents from all centers.

Table 11
Utilization of Experienced Scientists and Engineers

Utilization	Frequencies	Percent
Excellent	240	15.4%
Good	726	46.5%
Fair	437	28.0%
Poor	127	08.1%
Very Poor	30	01.9%
Total	1,560	100.0%

Table 12 presents aggregate data on the utilization of young scientists and engineers.

Table 12
Utilization of Young Scientists and Engineers

Utilization	Frequencies	Percent
Excellent	228	14.7%
Good	758	48.8%
Fair	410	26.4%
Poor	114	07.3%
Very Poor	44	02.8%
Total	1,560	100.0%

Excellent and good utilization of young scientists and engineers accounted for 63.5 percent of the overall responses, a proportion similar to that for experienced scientist and engineers.

Three hundred and fifty-two Grade 12 respondents and 509 Grade 15 respondents characterized the utilization of experienced scientists and engineers as excellent or good while 323 Grade 12 respondents and 543 Grade 15 respondents shared the same perception on young scientists and engineers. On a center by center basis, the distributions of answers to each of the five degrees of utilization of experienced and young engineers were also similar. Tables 13 and 14 highlight the distributions by center.

Table 13
Utilization of Experienced Scientists and Engineers by Center

Center	Degrees of Utilization: Excellent	Good	Fair	Poor	Very Poor
Ames Research Center	12.9%	49.8%	27.6%	8.9%	0.9%
Goddard Space Flight Center	17.2%	50.9%	26.6%	4.7%	0.6%
Johnson Space Flight Center	15.1%	49.2%	27.7%	6.3%	1.7%
Kennedy Space Flight Center	9.2%	39.5%	35.7%	13.0%	2.7%
Langley Research Center	17.8%	49.2%	23.6%	7.3%	2.1%
Lewis Research Center	15.5%	44.6%	28.8%	9.4%	1.8%
Marshall Space Flight Center	23.3%	41.1%	27.6%	7.4%	0.6%
Stennis Space Center	14.3%	57.1%	28.6%		
Headquarters	12.5%	46.3%	23.8%	8.8%	8.8%

Table 14
Utilization of Young Scientists and Engineers by Center

Center	Degrees of Utilization: Excellent	Good	Fair	Poor	Very Poor
Ames Research Center	13.3%	57.8%	22.2%	4.4%	2.2%
Goddard Space Flight Center	18.0%	56.9%	18.6%	5.4%	1.2%
Johnson Space Flight Center	18.1%	41.6%	30.7%	7.6%	2.1%
Kennedy Space Flight Center	7.0%	40.5%	35.7%	10.3%	6.5%
Langley Research Center	18.8%	47.1%	28.3%	4.7%	1.0%
Lewis Research Center	12.3%	53.1%	23.1%	8.3%	3.2%
Marshall Space Flight Center	20.2%	42.9%	23.3%	11.7%	1.8%
Stennis Space Center	14.3%	42.9%	42.9%		
Headquarters	6.5%	50.6%	27.3%	9.1%	6.5%

As part of characterizing their work, respondents described the level of technical responsibility they most often exercise. Table 15 presents overall responses to ten categories of responsibility most often exercised by 1,540 respondents.

Table 15
Type of Technical Responsibility
Most Frequently Exercised by Respondents

Type of Responsibility	Frequencies	Percent
Simple prescribed procedures	18	1.2%
Sequence of prescribed procedures	40	2.6%
Specific applications	62	4.0%
Application of standard methods	100	6.5%
Generation of alternative methods	62	4.0%
Performance of complex tasks	135	8.8%
Planning/organization of projects	550	35.7%
Pioneering work	143	9.3%
Problem solving	277	18.0%
Systems analyses	153	9.9%

Planning and organizing projects was, by far, the most significant type of technical responsibility exercised by respondents to this survey. One hundred and forty-seven (26.7 percent) of Grade 12s responded 'planning and organization of projects" while 356 (64.7 percent) of the Grade 15s did the same. The second most frequently selected type of responsibility by both groups was problem solving (18 percent). The categories selected by the least numbers of respondents of both grades were simple procedures and sequence of prescribed procedures, followed by specific applications and generation of alternative methods.

The final question dealing with the nature of work required yes or no response. The question was "Since joining NASA, has the diversity (e.g., variety and complexity of work) increased at your center?" Of the 1,537 respondents who answered this question 1,168 (76 percent) answered yes and 369 (24 percent) answered no. The highest percentage of center respondents who answered yes were from Stennis (85 percent) followed by Marshall (81 percent), Johnson (80 percent), Langley (73.5 percent) and Kennedy (64.7 percent).

Grade 12 employees who believed that the diversity of work increased comprised over 37 percent of the total number of respondents who said yes. For Grade 15 employees, almost 52 percent thought this. Almost 11 percent of the employees from other grades shared the same perception.

"Hands-On"/Contracting

The third section of the questionnaire dealt with the subjects of contracting and "hands-on" work at centers. The first item asked respondents to indicate duties performed by contractors at their respective centers. The duty of representing NASA at meetings accounted for the largest number, 915 (58.4 percent) of the overall responses. It was followed by reviewing progress, which captured 779 (49.7 percent) of the responses. Table 16 describes duties performed by contractors.

Table 16
Duties Performed By Contractors

Duties	Cases Frequencies	Percent
Establish Policy	160	10.2%
Commit Government Resources	356	22.7%
Represent NASA Meetings	915	58.4%
Define Assignments	594	37.9%
Review Progress	779	49.7%
Revise Work Assignments	547	34.9%
Monitor Performance	560	35.7%

It should be noted that the individual center responses mirror the total responses, with the exception of responses from the Kennedy Space Center. At Kennedy, approximately two thirds of the respondents stated that contractors define assignments, review programs and revise assignments. Table 17 presents responses by center.

Table 17
Duties Performed By Contractors By Center

Duties	ARC Freq	ARC %	LARC Freq	LARC %	LERC Freq	LERC %	JSC Freq	JSC %
Establish Policy	16	7.1%	7	3.6%	20	7.2%	29	12.1%
Commit Resources	54	23.9%	24	12.5%	74	26.6%	55	23.0%
Represent NASA at Meeting	132	58.4%	87	45.3%	192	69.1%	174	72.8%
Define Work Assignments	84	37.2%	49	25.5%	106	38.1%	107	44.8%
Review Progress	104	46.0%	58	30.2%	154	55.4%	133	55.6%
Revise Work Assignments	77	34.1%	36	18.8%	92	33.1%	106	44.4%
Monitor Performance	79	35.0%	32	16.7%	121	43.5%	98	41.0%

Duties	KSC Freq	KSC %	MSFC Freq	MSFC %	GSFC Freq	GSFC %	SSC Freq	SSC %
Establish Policy	57	30.6%	8	4.9%	13	7.6%	2	9.5%
Commit Resources	87	46.8%	21	12.9%	23	13.5%	4	19.0%
Represent NASA at Meeting	75	40.3%	84	51.5%	102	60.0%	13	61.9%
Define Work Assignments	123	66.1%	34	20.9%	56	32.9%	12	57.1%
Review Progress	128	68.8%	65	39.9%	79	46.5%	10	47.6%
Revise Work Assignments	123	66.1%	32	19.6%	50	29.4%	12	57.1%
Monitor Performance	89	47.8%	46	28.2%	53	31.2%	9	42.9%

Duties	HDQS Freq	HDQS %
Establish Policy	7	8.5%
Commit Resources	12	14.6%
Represent NASA at Meeting	54	65.9%
Define Work Assignments	18	22.0%
Review Progress	46	56.1%
Revise Work Assignments	16	19.5%
Monitor Performance	31	37.8%

The second question in this section asked: "In your opinion, at your center, which of the following types of support provided by contractors exceed what should be provided by the private sector?" Respondents were asked to select one, several or no type(s) of support services. Table 18 shows that 593 (37.8 percent) of the respondents believed that contractor involvement in engineering and technical services was excessive, while 519 (33.1 percent) of the respondents did not believe that contractor involvement in any type of support was excessive.

Table 18
Type of Support Services With Excessive Contractors' Involvement

Types of Support Services	Frequencies	Percent
Engineering and Technical Service	593	37.8%
Research and Development	459	29.3%
Data Processing	145	9.3%
Program Control	342	21.8%
Mission Operations	264	16.8%
Other	52	3.3%
None	519	33.1%

Responses on a center by center basis (Table 19) indicated that 47.1 percent of the respondents from the Goddard Space Center believe that excessive involvement by contractors in engineering and technical services had occurred. Many respondents from the Ames Research Center shared this perception (43.4 percent). About 42 percent of the respondents from the Marshall Space Center agreed with the statement. Responses from other centers, with the exception of Headquarter, were in the 30 to 40 percentile. About 24 percent of the respondents from the Headquarters believed that involvement was excessive in this same area.

Table 19
Excessive Contractors' Involvement By Center

	Centers											
	ARC		LARC		LERC		JSC		KSC		MSFC	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Engineering and Technical Service	98	43.4%	69	35.9%	99	35.6%	88	36.8%	57	30.6%	69	42.3%
Research and Development	89	39.4%	80	41.7%	88	31.7%	57	23.8%	31	16.7%	43	26.4%
Data Processing	29	12.8%	16	8.3%	19	6.8%	17	7.1%	10	5.4%	21	12.9%
Program Control	43	19.0%	19	9.9%	51	18.3%	58	24.3%	71	38.2%	34	20.9%
Mission Operations	33	14.6%	12	6.3%	23	8.3%	59	24.7%	57	30.6%	34	20.9%
Other	6	2.7%	2	1.0%	11	4.0%	9	3.8%	8	4.3%	4	2.5%
None	65	28.8%	68	35.4%	98	35.3%	81	33.9%	62	33.3%	46	28.2

	GSFC		SSC		HDQS	
	Freq	%	Freq	%	Freq	%
Engineering and Technical Service	80	47.1%	7	33.3%	20	24.4%
Research and Development	50	29.4%	6	28.6%	11	13.4%
Data Processing	20	11.8%	1	4.8%	9	11.0%
Program Control	36	21.2%	7	33.3%	21	25.6%
Mission Operations	30	17.6%	4	19.0%	9	11.0%
Others	5	2.9%	1	4.8%	5	6.1%
None	48	28.2%	7	33.3%	41	50.0%

Items three through 37 of this section dealt with "hands-on" capability and contracting, with five-category scales with the strongly agree - strongly disagree format. Table 20 presents the perceptions of the efficiency of NASA vis-a-vis industry. Nearly 54 percent disagreed or strongly disagreed that the performance of science and engineering by NASA was less efficient than by industry.

Table 20
Efficiency of NASA vs. Industry

	Strongly Agree Freq	Strongly Agree %	Agree Freq	Agree %	Neutral Freq	Neutral %	Disagree Freq	Disagree %	Strongly Disagree Freq	Strongly Disagree %
The performance of sciences and engineering by NASA is less efficient than by industry.	107	6.9%	340	21.8%	273	17.5%	519	33.3%	318	20.4%

Table 21 presents perceptions regarding the same statement by centers.

Table 21
Efficiency of NASA vs. Industry by Center

	Strongly Agree Freq	Strongly Agree %	Agree Freq	Agree %	Neutral Freq	Neutral %	Disagree Freq	Disagree %	Strongly Disagree Freq	Strongly Disagree %
Ames Research Center	16	7.1%	47	20.9%	49	21.8%	68	30.2%	45	20.0%
Langley Research Center	9	4.7%	38	19.9%	38	19.9%	73	38.2%	33	17.3%
Lewis Research Center	18	6.5%	62	22.3%	52	18.7%	93	33.5%	53	19.1%
Johnson Space Center	15	6.3%	68	28.6%	45	18.9%	72	30.3%	38	16.0%
Kennedy Space Flight Center	20	10.8%	46	24.9%	24	13.0%	54	29.2%	41	22.2%
Marshall Space Flight Center	9	5.5%	28	17.2%	25	15.3%	62	38.0%	39	23.9%
Goddard Space Flight Center	5	3.0%	32	19.0%	25	14.9%	56	33.3%	50	29.8%
Stennis Space Center	1		3		2		9		4	21.1%
Headquarters	14	17.5%	15	18.8%	11	13.8%	27	33.8%	13	16.3%

On an aggregate basis and by center, the majority of respondents considered NASA as or more efficient than industry, although a fair number of respondents from all installations agreed that industry was as or more efficient than NASA. In fact, over 30 percent of the respondents at the Johnson, Kennedy and Headquarters installations believed that industry was as or more efficient than NASA.

The next question asked whether NASA scientists and engineers should perform "hands-on" work once in a while to maintain their proficiency. Table 22 shows that 90 percent believe this to be the case.

Table 22
"Hands-On" Work Should Be Performed to Maintain Proficiency

	Strongly Agree Freq	%	Agree Freq	%	Neutral Freq	%	Disagree Freq	%	Strongly Disagree Freq	%
Scientists/Engineers should perform "hands-on work once in a while otherwise they will lose their proficiency.	917	58.8 %	498	31.9%	82	5.3%	46	3.0%	16	1.0%

On a center by center basis, the responses are similar with 95.0 percent of the respondents from Stennis Space Center agreeing and strongly agreeing, closely followed by 93.0 percent from Marshall and 92.4 percent from the Ames Research Center. With the exception of Headquarters, over 50 percent of the respondents from centers not only agreed but they strongly agreed with the notion that "hands-on" work should be performed to maintain proficiency.

A subsequent question, focusing on the statement that people with direct problem solving experience get the best results elicited the same type of responses. Table 23 reports the results for NASA as a whole. On a center basis, answers to this question strongly resembled the total number of responses.

Table 23
Direct Experience Tied to the Best Results

	Strongly Agree Freq	%	Agree Freq	%	Neutral Freq	%	Disagree Freq	%	Strongly Disagree Freq	%
People with direct problem solving experience get the best results.	620	39.8 %	715	45.9%	167	10.7%	49	3.1%	6	.4%

Whether or not it is a good idea for engineers and scientists to specialize in a single area was the topic of the next item. In all, 568 (36.6 percent) of the respondents disagreed that specialization in a single area was a good idea; 453 (29.2 percent) were neutral; 412 (26.6 percent) agreed; 60 (3.9 percent) strongly agreed and 58 (3.7 percent) strongly disagreed.

The largest number of respondents who agreed and strongly agreed that it is a good idea to specialize came from the Lewis Research (40.3 percent) and Kennedy Space (39.2 percent) Centers.

Center employees who most strongly disagreed and disagreed with specialization, as expected, came from Headquarters, where 60.5 percent of the respondents disagreed and strongly disagreed followed by the Stennis and Johnson Space Centers where approximately 47 percent of the employees strongly disagreed and disagreed with specialization's impact on best work.

"A top notch technical background is needed for contract management" was the seventh statement of this section. Table 24 shows the distribution of total responses to this question, while Table 25 shows the breakout by center.

Table 24
A Top Notch Technical Background Is needed for Contract Management

Response Categories	Frequencies	Percent
Strongly Agree	162	10.4%
Agree	603	38.9%
Neutral	372	24.0%
Disagree	358	23.1%
Strongly Disagree	56	3.6%

Table 25
A Top Notch Technical Background Is needed for Contract Management

	Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Ames Research Center	31	13.8%	81	38.2%	49	21.9%	53	23.7%	10	4.5%
Langley Research Center	21	11.1%	83	43.9%	38	20.1%	40	21.2%	7	3.7%
Lewis Research Center	35	12.6%	124	44.8%	52	18.8%	56	20.2%	10	3.6%
Johnson Space Center	25	10.5%	85	35.7%	61	25.6%	61	25.6%	6	2.5%
Kennedy Space Flight Center	11	6.0%	59	32.1%	59	32.1%	49	26.6%	6	3.3%
Marshall Space Flight Center	12	7.5%	55	34.4%	44	27.5%	45	28.1%	4	2.5%
Goddard Space Flight Center	20	11.9%	75	44.6%	47	28.0%	20	11.9%	6	3.6%
Stennis Space Center	1	4.8%	7	33.3%	5	23.8%	7	33.3%	1	4.8%
Headquarters	3	3.8%	29	36.3%	17	21.3%	25	31.3%	6	7.5%

"NASA provides challenging work assignments" was the next strongly agree - strongly disagree item. One thousand two hundred and fifty-two (80.5 percent) of the total number of survey respondents strongly agreed and agreed, 193 respondents (12.4 percent) indicated that they were neutral, and only 110 respondents (7 percent) disagreed and strongly disagreed. The distribution of responses on a center basis were very similar.

"Most productive researchers do not want to manage contractor efforts" was the next measure of "hands-on" work. A total of 1,062 (68.5 percent) people agreed and strongly agreed, 336 (21.7 percent) were neutral and 153 (9.9 percent) disagreed and strongly disagreed. As for center respondents, 81.3 percent of Ames employees agreed or strongly agreed followed by 73.3 percent of Marshall employees. The lowest percentage of people agreeing and strongly agreeing came from Headquarters, 53.1 percent.

The next statement was, "Contract management, within the context of NASA, requires more technical capabilities than administrative skills." Seven hundred and four respondents (45.5 percent) agreed and strongly agreed, 397 (25.6 percent) were neutral and 44.7 (28.9 percent) disagreed and strongly disagreed with this statement. Percentages who agreed and strongly agreed, by center, are:

Langley Research Center	50.0 percent
Headquarters	53.1 percent
Marshall Space Center	53.9 percent
Ames Research Center	44.3 percent
Lewis Research Center	40.8 percent
Johnson Space Center	44.5 percent
Kennedy Space Center	41.0 percent
Goddard Space Flight Center	44.9 percent
Stennis Space Center	38.1 percent

Item 11 probed whether or not a great deal of challenging aeronautics and space work is performed by contractors, not NASA. One thousand one hundred and sixty-five NASA scientists and engineers (74.9 percent) agreed and strongly agreed; 223 (15 percent) responded neutrally; and 158 (10.1 percent) disagreed and strongly disagreed. Between 70 and 80 percent of the respondents at all centers agreed and strongly agreed. Positive responses ranged from 83.2 percent at Kennedy to 71.0 percent at Langley.

Just over 63 percent of the respondents said systems analysis capabilities and integrative skills are highly valued in NASA. Twenty-three percent answered neutral, and 13 percent disagreed and strongly disagreed. The distribution of responses by center closely resembled the distribution of NASA responses as a whole, although the Stennis employees (76.2 percent) and the Marshall employees (75.8 percent) agreed most strongly.

The trend toward expanding use of contractors has shifted challenging tasks from NASA to contractors, 1,256 (80.9 percent) of NASA employees agree and strongly agree. One hundred and seventy-eight respondents (11.5 percent) checked neutral and only 119 (7.7 percent) disagreed or strongly disagreed. At Kennedy, 88.1 percent answered agree and strongly agree and at Goddard 83.3 percent did so. At all of the other centers, agree and strongly agree categories had over 75 but less than 80 percent of the respondents' votes.

Over 68 percent of the respondents said that the distinction between contractors and civil servants is blurred at NASA sites. Only 20.1 percent disagreed and strongly disagreed while 11.7 percent indicated neutrality. On a center basis the Langley Research Center perceives the most blurring (81 percent). At Kennedy, 39 percent of the people agreed and strongly agreed with the blurring of workforces. At the majority of other centers, approximately 60 to 70 percent of the respondents thought this.

A strong 83 percent of agreed and strongly agreed that hands-on experience is required to properly manage and evaluate contractors' efforts. Only 6.7 percent of the respondents disagreed and strongly disagreed while 9.5 percent were neutral. Respondents from all centers answered agree and strongly agree above the 70 percent mark.

When asked to comment on, "NASA should hire more scientists and engineers with privates sector experience," 973 (56 percent) of the respondents answered agree and strongly agree. Only 7.4 percent checked disagree and strongly disagree; however, 36.6 percent of the respondents were neutral. The Stennis respondents agreed and strongly agreed at 66.4 percent, followed by Johnson at 59.7 percent. About 50 to 55 percent of all other center respondents agreed and strongly agreed.

Nine hundred and ten (58.5 percent) of the respondents said that they agree and strongly agree that the future roles of contractors should be limited. Four hundred and twenty-five people (27.3 percent) were neutral and 220 (14 percent) disagreed and strongly disagreed. On a center basis, the three centers who most strongly believed that contractors roles should be limited were the Kennedy, Marshall and Goddard Space Flight Centers with respective percentages of 68.7, 63.0, and 61.9 percent. Johnson had the greatest number of respondents who voiced negative opinions on limiting the future roles of contractors.

"Contractors have assumed many roles that are governmental," 56.6 percent of NASA scientists and engineers agreed and strongly agreed. However, 27 percent checked neutral and 16.5 percent disagreed or strongly disagreed. Over 65 percent of the Stennis and Headquarters employees agreed and strongly agreed while 19.1 percent of those at Marshall did so making Marshall the chief objector to the statement.

A little less than half of NASA respondents agreed and strongly agreed that NASA program managers spend too much of their time exercising oversight responsibilities. Slightly over thirty 30 percent were neutral and approximately 18 percent disagreed and strongly disagreed. The Ames and Kennedy employees ranked the highest in terms of agree and strongly agree, at about 55 percent. The majority of center respondents answered positively around 50 percent of the time. Headquarters respondents had the lowest percentage of agrees and strongly agrees at 40.7. It should, however, be noted that 40.7 percent on a five point scale is considered vigorous.

A statement which read, "NASA has in-house competence to make responsible decisions in all programs for which it is responsible," elicited a reply of 49.2 percent in the agree and strongly agree categories. Exactly 17 percent of those who answered this question were neutral, while 34 percent disagreed and strongly disagreed. The individual center responses with the highest rates of agreement were Kennedy (65.4 percent) and Marshall (61.1 percent). The center that disagreed and strongly disagreed the most was Ames (47.6 percent), followed by Goddard and Stennis respondents with about 38 percent.

Only 22.5 percent of all respondents agreed and strongly agreed that NASA in-house scientific and engineering capabilities are as strong as during the past. Just over 57 percent disagreed and strongly disagreed and 20.4 percent of the respondents were neutral.

The center respondents who most disagreed were from Lewis (67.2 percent), followed by Ames (66.8 percent) and Goddard (61.1

percent). The two centers that disagreed the least were Stennis (33.3 percent) and Kennedy (49.7 percent).

Regarding management and the perception of whether management is as strong as in the past, 48.8 percent of the respondents disagreed and 21.6 percent agreed that it was as strong as during the past. Almost 30 percent were neutral. By center, the percentage of disagrees generally were the highest at Ames and Headquarters (a little over 50 percent).

About 40 percent of all respondents agreed and strongly agreed that NASA program managers have the right mix of technical and administrative skills to successfully complete jobs. About 35 percent of the respondents disagreed and strongly disagreed. Over 28 percent were neutral. Ames respondents most frequently disagreed with the current skill mix (46 percent). The most favorable reaction to skill mix came from Marshall respondents (53 percent).

The next statement was, "A large number of scientists and engineers in NASA are malutilized (e.g., unreasonable time demands on the job)." Over 52 percent of the respondents agreed and strongly agreed, 21 percent disagreed and strongly disagreed and 26.5 percent were neutral. On a center basis, Johnson employees had the highest percentage of agree and strongly agree (59.3 percent) followed by Goddard (55.1 percent). The disagree grouping ranged from 29 percent at Kennedy 14.3 percent at Stennis.

A similar phrase concerning underutilization was stated. Seven hundred forty-four (48 percent) of the respondents agreed and strongly agreed that underutilization of scientists and engineers occurs, 20.7 percent were neutral and 31.2 percent disagreed and strongly disagreed. Light technical demands were cited as a form of underutilization. Highest percentages of underutilization were reported by Kennedy (62.0 percent) and Marshall employees (57.4 percent). About 43 percent of the Ames Research Center employees disagreed and strongly disagreed that underutilization occurs, while 38 percent of Ames Employees agreed and strongly agreed. The lowest percent-age of disagreement occurred at the Kennedy Space Center (14 percent).

A strong plurality of respondents (65.7 percent) said the public interest would be best served if less technical work were contracted out to the private sector, 21.6 percent of them were neutral and 12.6 percent of the respondents did not concur. Goddard employees most agreed and most strongly agreed (72.8 percent) followed by Stennis (71.4 percent). Except for Headquarters' personnel, who had a 52.5 percent rate of agreement, other centers generally agreed at rates in the range of 65 to 70 percent.

Only 342 (22 percent) members of the scientific and engineering professional categories believed that the private sector provides a climate for greater creativity and productivity of scientists and engineers than the public sector. Three hundred and thirty-eight (21.8 percent) of the respondents were neutral and 873 (55.7 percent) of the respondents disagreed and strongly disagreed. The highest disagreement rate was from the Langley Research Center (71.4 percent). The highest agreement rate can be traced to the Kennedy Space Center (36.1 percent).

The majority of people who responded to the statement: "NASA does a good job of identifying, developing and assigning people capable of playing key roles in the technical direction of projects," agreed and strongly agreed (43.9 percent). About 27 percent were neutral and about 29 percent disagreed and strongly disagreed. By center, the largest amount of employees who agreed and strongly agreed came from Marshall (49.0 percent) followed by Goddard (47.6 percent). The largest number of responses in the disagree and strongly disagree classifications was from Headquarters (47.5 percent) followed by Lewis (36.2 percent).

A very high number (1,289) of Grade 12 and 15 scientists and engineers, (83.2 percent) agreed and strongly agreed that NASA needs to expand or initiate more in-house projects to provide for hands-on experience. Only 11.9 percent of respondents checked neutral and 5 percent checked disagree and strongly disagree. All of the centers, with the exception of Headquarters, agreed and strongly agreed in the 70 to 90 percent range. At Headquarters 67.6 percent of the respondents agreed and strongly agreed.

The rate of agreement among respondents was high with regard to the statement, "Too much of scientific and engineering efforts in NASA is spent in preparing and selling programs." One thousand and one hundred and forty (73.5 percent) agreed and strongly agreed. About 18 percent were neutral and about 8 percent disagreed and strongly disagreed. In the strongly disagree category, there were only 6 responses and in the disagree category 71 responses. On a center basis, the greatest number of agree and strongly agree marks came from the Stennis (85.7 percent), followed by the Ames (84.3 percent).

The rate of consensus dropped with the following statement, "When people leave NASA,they rarely leave because the work does not have enough "hand-on" characteristics (e.g. development and fabrication of prototypes, testing, production)." About 26 percent of the respondents disagreed and strongly disagreed, about 34 percent were neutral (the largest single category of responses to this question), and 6.1 percent agreed while 33.7 percent strongly agreed adding up to an agreement rate of nearly 40 percent. The highest agree and strongly agree rate was at the Langley Research Center (54.5 percent). The highest disagree and strongly disagree rate was at Kennedy (55.9 percent).

The following statement regards support personnel. "Greater numbers of personnel working in support of NASA scientists and engineers (technicians, model makers and other skilled workers and production workers) should be civil servants." Of the total responses to this question, 57.9 percent of the scientists and engineers agreed and strongly agreed, 25.9 percent was neutral and 15.1 percent disagree and strongly disagree. Goddard and Langley led the agree and strongly agree categories (approximately 65 percent). The highest disagreement rate was from Stennis (38.1 percent). However, only eight employees constituted this 38.1 percent figure.

Five hundred and eighty-two (34.0 percent) of those who filled in surveys agreed and strongly agreed that many important management decisions are being made by contractors, not civil servants; 30.6 percent of the respondents answered neutral and 35.5 percent disagreed and strongly disagreed with the statement. By center the highest composite agreement rate was at Kennedy (59.1 percent) and the lowest rate was Langley (20.4 percent). The highest composite disagree rate occurred at the Marshall Space Flight Center (40.4 percent).

The need for stronger program control was endorsed by 54.1 percent of the respondents who agreed and strongly agreed to such an item. About 36 percent of the respondents voted neutral and a little over 10 percent disagreed and strongly disagreed. The strongest endorsement of the need for more program control came from Stennis (80.9 percent) followed by the Kennedy, Marshall, Johnson and Lewis Centers, in respective order. The highest composite disagreement rate came from the Ames Research Center (81.1 percent). When the statement, "Few individuals in NASA possess skills involving the artful blending of technology and administration" was posed, 44.6 percent of the respondents were in accord, 20.3 percent indicated neutral and 35.1 percent disagreed and strongly disagreed. Distribution of individual center responses closely paralleled the overall distribution of responses.

About 29 percent of the respondents agreed and strongly agreed that modern tools, such as computer assisted design, do not provide scientists and engineers with an intuitive feel for hardware. Approximately 32 percent of the responses to this scaled item reflected neutrality and about 39 percent of the respondents disagreed and strongly disagreed. At Stennis 66.6 percent of the respondents disagreed and strongly disagreed; all of the other centers were in the 30 to 40 percent range. The strongest composite agreements came from the Lewis and Langley Research Centers which were followed closely by the Marshall Space Flight Center and Ames Research Center. All had agreement rates in the 30 - 40 percent range.

The final statement in this section of the questionnaire was, "Engineers should be able to acquire "cradle to grave" experience on projects." The composite agreement rate was 71.1 percent, the composite neutral rate was 17.7 and the composite disagreement rate was 8.2 percent. Lewis employees had the strongest disagreement rate (13.2 percent). This compares to Lewis' agreement rate of 65.3 percent. The strongest agreement rate occurred at Goddard (86.3 percent). Goddard's disagree figure was 2.4 percent.

Image of the Public Service

Section IV of the questionnaire was comprised of 15 strongly agree - strongly disagree items that dealt with public service image.

The first item was, "I would recommend NASA as an employer." Slightly over 76 percent of the respondents agreed and strongly agreed, about 13 percent were neutral and about 10 percent disagreed and strongly disagreed. Center distributions to this statement closely approximated the total number of NASA responses.

One thousand three hundred and twelve respondents (84.0 percent) believed they were doing important work as NASA employees; 155 (9.9 percent) checked the neutral classification; and 94 (6.0 percent) did not feel they were doing important work. The respondents with the lowest rate of agreement were from the Kennedy Space Center and Headquarters (77.3 and 78.8 percent respectively).

About 40 percent of the respondents agreed and strongly agreed that government service is a place to gain experience for a better job. About 34 percent replied neutral and 24 percent disagreed and strongly disagreed. The agreement rates were in the fiftieth and upper fortieth percentiles at Stennis, Goddard and Ames installations. Highest rates of disagreement were at Kennedy, Headquarters and Marshall, with rates of 25 to 30 percent.

There was a perception that there is more red tape in the government sector than the non-government sector. About 68 percent of the respondents agreed and strongly agreed. The strongest rates of agreement were from Kennedy (72.4 percent) and Langley (70.7

percent). The strongest disagreement rate was at Stennis (19 percent) followed by Johnson (13.8).

Four hundred and seventy-six (30.6 percent) of the respondents agreed and strongly agreed that government research and development is less efficient than the private sector. Almost 28 percent were neutral and close to 41 percent replied disagree and strongly disagree. On a center basis, the highest rates of disagreement were at Marshall and at Langley. The lowest rate of disagree and strongly disagree occurred at Johnson. The highest composite agreement rates that the government research and development is less efficient than the private sector were at Headquarters (35.8 percent) and at the Johnson Space Center (37.8 percent).

In reply to the statement, "Most science and engineering students would prefer working in the private sector," 40.3 percent of the respondents agreed and strongly agreed, 32.6 percent said neutral and 27.1 percent disagreed and strongly disagreed. The responses of the centers mirrored the total distribution with the exception of the Stennis Space Center where 13 (61.9 percent) of the respondents agreed.

Thirteen hundred forty-seven (86.3 percent) of the scientists and engineers agreed and strongly agreed that government scientists and engineers are as important as their counterparts in the private sector. About 9 percent of the respondents were neutral and the remainder of those surveyed disagreed and strongly disagreed. The distribution of responses by center was very close to the overall distribution.

A related statement asserted that government scientists and engineers are, on the whole, as capable as scientists and engineers in other sectors. A preponderance, 1,320 (85.1 percent) agreed and strongly agreed, 8.8 percent said they were neutral and 6.1 percent disagreed and strongly disagreed. The three centers that had the greatest numbers of agrees and strongly agrees were Stennis (95.2 percent), Lewis (90.7 percent), and Marshall (90.2 percent). The center that had the largest proportion of disagree and strongly disagree was Kennedy (9.7 percent).

The statement, "The best scientists and engineers leave the government for other jobs" elicited the strongest response from those who replied neutral (over 30 percent) when each of the five response categories were considered independently. The combination of the agree and the strongly agree categories captured 35.9 percent of the vote and the disagree and the strongly disagree categories garnered 33.0 percent of the vote.

The assertion that, "Government workers are as carefully selected and recruited as private sector workers," solicited an aggregate agree and strongly agree response rate of 46.7 percent. About 20 percent of the respondents were impartial and the others disagreed. The highest rate of discord was at Kennedy (37.6 percent). The highest rate of accord was at Goddard (54.4 percent).

In response to the declaration that, "The government attracts freshouts as capable as the freshouts that the private sector attracts", 41.5 percent of the total feedback was in the agree and strongly agree groupings; 17 percent was in the neutral grouping; and 41.5 percent was in the disagree and strongly disagree groupings. The Kennedy respondents agreed the most (51.9 percent). The Headquarters' respondents most disagreed and strongly disagreed (60 percent).

About 55 percent of the respondents observed that the good points of working for the government outweigh the bad points, 30 percent were neutral and about 14 percent disagreed and strongly disagreed. Those who coincided most with the positively phrased statement were from Stennis (85.7 percent), followed by Johnson (67.8 percent). Those who were most at variance with the statement were from Headquarters 24.4 percent and at Ames (27.8 percent). About 30 percent of the respondents had no opinion, although the range of responses in the neutral category by center included a high of 38.7 percent at Ames and a low of 14.3 percent at Stennis.

The statement, "Scientists and engineers working for the government have good chances to get ahead," elicited a concurring response of 51.3 percent, a neutral response of 25.6 percent and a divergent response of 13.1 percent. The strongest agreement came from Stennis employees (71.4 percent) followed by Goddard (57.1 percent). The strongest disagreement came from Langley employees (29.5 percent) followed by Headquarters (23.7 percent).

Reactions to a statement that government employees have as much of a chance to develop as private sector counterparts earned a 58.3 positive response rate, a 20.0 percent neutral response rate, and a 21.7 percent negative response rate. Center responses were about the same as overall responses, although the lowest agree and strongly agree rate was from Headquarters (44.4 percent).

The last assertion was, "Considering political, economic and social trends, the government as an employer rates higher than other sectors." Table 26 shows the responses across the five categories ranging from strongly agree to strongly disagree.

Table 26
The Government, as an Employer,
Rates Higher than Other Sectors

Responses Categories	Frequencies	Percent
Strongly Agree	36	2.3%
Agree	322	20.6%
Neutral	535	34.3%
Disagree	519	33.3%
Strongly Disagree	148	9.5%

On a center by center basis, the least favorable response to rating the government higher than other employers came from Ames employees (53.0 percent), followed by Headquarters' employees (48.4 percent). The largest number of employees who agreed and strongly agreed with the statement came from the Johnson Space Center (29.3 percent). However, the neutral category was selected most often.

Recruitment/Retention

The fifth section of the questionnaire pertained to recruitment and retention. It consisted of two items with lists of six measures spelling out response options and ten scaled items placed on five point scales, consisting of strongly agree to strongly disagree.

The first item asked respondents to indicate how many years it will take before they are eligible for retirement. Table 27 presents the findings for all respondents.

Table 27
Number of Years Before Retirement Eligibility

Years	Frequencies	Percent
Currently eligible	199	12.9%
Under 5 years	297	19.2%
5 to 7 years	110	7.1%
8 to 10 years	94	6.1%
10 to 15 years	134	8.7%
16 or more years	713	46.1%

The largest number of respondents, 713 (46.1 percent) will only be eligible for retirement in 16 or more years, followed by 496 (32.1 percent) respondents who are currently eligible or will be eligible in less than 5 years.

By center, please note that the Stennis Space Center and the Kennedy Space Center will have over 60 percent of their employees eligible for retirement in 16 years or more while the Lewis Space Center and the Marshall Space Center currently have the largest percentages of people eligible for retirement (about 17 percent). Table 28 presents retirement eligibility data by center.

Table 28
Years to Retirement by Center

	Now Eligible Freq	%	Under 5 Years Freq	%	5 TO 7 Years Freq	%	8 TO 10 Years Freq	%	10 TO 15 Years Freq	%	16 OR More Years Freq	%
Ames Research Center	25	11.2%	35	15.6%	25	11.2%	8	3.6%	31	13.8%	100	44.6%
Langley Research Center	24	12.6%	34	17.9%	16	8.4%	13	6.8%	17	8.9%	86	45.3%
Lewis Research Center	48	17.4%	50	18.1%	20	7.2%	19	6.9%	16	5.8%	123	44.6%
Johnson Space Center	23	9.7%	43	18.1%	18	7.6%	16	6.8%	17	7.2%	120	50.6%
Kennedy Space Flight Center	13	7.1%	33	17.9%	6	3.3%	10	5.4%	11	6.0	111	60.3%
Marshall Space Flight Center	27	16.7%	34	21.0%	5	3.1%	7	4.3%	9	5.6%	80	49.4%
Goddard Space Flight Center	25	15.2%	33	20.0%	10	6.1%	8	4.8%	16	9.7%	73	44.2%
Stennis Space Center			5	23.8	1	4.8			2	9.5%	13	61.9%
Headquarters	13	16.0%	27	33.3%	8	9.9%	12	14.8%	14	17.3%	7	3.6%

The second item was: "How long do you plan to work at NASA". Table 29 presents aggregate responses across centers:

Table 29
Number of Years Planning to Work at NASA

Years	Frequencies	Percent
Under 5 years	310	20.1%
5 to 7 years	188	12.2%
8 to 10 years	128	8.3%
10 to 15 years	133	8.6%
16 or more years	301	19.5%
Undecided	485	31.4%

The bulk of respondents, 485 (31.4 percent) were undecided although 310 (20.1 percent) said they plan to work at NASA for less than five years.

By center, the largest number of people who were undecided about the number of years they plan to work at NASA were from the Lewis Space Center, 83 (30.3 percent) respondents. However, 70 respondents (42.2 percent) of Goddard and 74 respondents (31.1 percent) at Johnson also indicated indecisiveness. Sixty (21.9 percent) respondents from Lewis noted that they plan to leave in the next five years or less. Table 30 shows the years employees plan to work for NASA by center.

Table 30
Years Planning to Work For NASA by Center

	Under 5 Years		5 TO 7 Years		8 TO 10 Years		10 TO 15 Years		16 OR More Years		Undecided	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Ames Research Center	52	23.3%	36	16.1%	18	8.1%	21	9.4%	30	13.5%	66	29.6%
Langley Research Center	35	18.4%	25	13.2%	22	11.6%	15	7.9%	39	20.5%	54	28.4%
Lewis Research Center	60	21.9%	31	11.3%	18	6.6%	29	10.6%	53	19.3%	83	30.3%
Johnson Space Center	40	16.8%	30	12.6%	18	7.6%	20	8.4%	56	23.5%	74	31.1%
Kennedy Space Flight Center	37	20.1%	17	9.2%	16	8.7%	12	6.5%	38	20.7%	64	34.8%
Marshall Space Flight Center	24	15.0%	18	11.3%	9	5.6%	11	6.9%	46	28.8%	52	32.5%
Goddard Space Flight Center	32	19.3%	18	10.8%	13	7.8%	11	6.6%	22	13.3%	70	42.2%
Stennis Space Center	2	9.5%	2	9.5%	2	9.5%			8	38.1%	7	33.3%
Headquarters	26	31.7%	9	11.0%	12	14.6%	12	14.6%	9	11.3%	14	17.1%

The first scaled item on this section of the questionnaire was: "My progress at NASA has been satisfactory." One thousand and one hundred and sixty-five (74.9 percent) of the respondents agreed and strongly agreed, 147 (9..5 percent) were neutral and 244 (15.6 percent) disagreed demonstrating a high degree of satisfaction with career progress. By center, the responses closely echoed the aggregate responses although the composite rate of disagreement at Lewis was slightly higher than at other centers, 22 percent, followed by about 19 percent at Stennis. The other centers averaged about a 14 percent rate of disagreement, comprised of disagree and strongly disagree choices.

When asked to react to the statement, "My job fits in well with my future goals", 72 percent of the respondents agreed and strongly agreed, 17 percent were neutral and 11 percent disagreed and strongly disagreed. The distributions of responses by center were very similar to the distribution of total responses.

"I regard working for NASA as my lifetime career" was a statement to which 64.4 percent of the respondents agreed and strongly agreed, 20.5 percent was neutral, and 15.2 percent disagreed and strongly disagreed. Headquarters' and Lewis' employees most strongly regarded NASA as the place of their lifelong careers. Ames' employees were most inclined to disagree (21.0 percent).

The quality of current hires in science and engineering was perceived to be as good as ever by 49.5 percent of the respondents who agreed and strongly agreed. About 27 percent replied neutral and about 23 percent disagreed and strongly disagreed. The disagreement rate was highest at the Ames Research Center (36.0 percent) and lowest at the Johnson Space Center (15.9 percent). Agreement rates were high at Goddard, Marshall, Langley and Kennedy installations where over 50 percent of the respondents expressed agreement, and lowest at Headquarter where 37 percent of the respondents agreed.

About 33 percent of the respondents agreed and strongly agreed that they feel less satisfied with their work now than in the past, 17 percent were neutral, and 50 percent disagreed and strongly disagreed that they are less satisfied now than in the past. By center, employees from Ames and Kennedy agreed and strongly agreed the most with the observation that they are currently less satisfied with their work. Disagreement ran the highest at the Stennis, Marshall and Johnson Centers where over 50 percent of the employees disagreed and strongly disagreed.

"I would quit if I found another job in the same line of work with comparable benefits" captured only 12.2 percent of the agrees and strongly agrees, indicating high commitment. About 20 percent of the respondents were neutral and 68 percent of the respondents disagreed and strongly disagreed. Disagreement indices at

Headquarters and the Marshall Space Flight Center lagged by about 10 to 15 percent behind indices of other centers.

Almost 50 percent of the respondents agreed that they are not eager to change jobs but would change jobs if they could get a better job. About 23 percent were neutral and 28 percent disagreed. The highest number of agrees and strongly agrees came from Stennis, Johnson and Headquarters respondents while the highest number of disagrees and strongly disagrees came from the Marshall, Goddard and Lewis respondents.

When the statement, "Scientists and engineers at NASA need to perform more "hands-on" work" appeared, 80.7 percent of the respondents agreed and strongly agreed, 14.4 percent were neutral and 4.8 percent disagreed and strongly disagreed. The array of responses by center was similar to the responses across centers.

About 54 percent of the respondents agreed and strongly agreed that the majority of scientists and engineers with whom they work will retire as soon as they are eligible, about 25 percent were neutral, and about 21 percent disagreed and strongly disagreed. Responses by center, which vary slightly from the distribution of total responses, are presented in Table 31.

Table 31
The Majority of S&ES Will Retire As Soon As They Are Eligible

	Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Ames Research Center	33	14.7%	92	40.9%	59	26.2%	39	17.3%	2	.9%
Langley Research Center	23	12.1%	87	45.8%	36	18.9%	42	22.1%	2	1.1%
Lewis Research Center	29	10.5%	97	35.1%	67	24.3%	77	27.9%	6	2.2%
Johnson Space Center	35	14.7%	110	46.2%	52	21.8%	38	16.0%	3	1.3%
Kennedy Space Flight Center	35	18.9%	74	40.0%	47	25.4%	29	15.7%		
Marshall Space Flight Center	15	9.2%	57	35.0%	48	29.4%	39	23.9%	4	2.5%
Goddard Space Flight Center	21	12.6%	59	35.3%	45	26.9%	36	21.6%	6	3.6%
Stennis Space Center	2	9.5%	4	19.0%	9	42.9%	6	28.6%		
Headquarters	16	19.8%	33	40.7%	20	24.7%	12	14.8%		

The final agree - disagree item of the questionnaire said: "Most NASA scientists and engineers often talk of changing jobs." Exactly 24.8 percent of the respondents agreed and strongly agreed, 25 percent responded neutral and 50.2 percent disagreed and strongly disagreed. At Headquarters, 35.8 percent of the respondents agreed and strongly agreed, followed by the respondents at the Kennedy Space Center (32.9 percent) and the respondents at the Ames Research Center (31.6 percent). The disagree and strongly disagree categories were most strongly represented by Lewis employees (57.7 percent) followed by Langley employees (56.5 percent).

APPENDIX A
PART III
NARRATIVE COMMENTS TO THE QUESTIONNAIRE

Introduction

The narrative section of the questionnaire was at the end of the written survey administered to 2,243 grades 12 and 15 Scientists and Engineers. The total number of responses were 1,615 (72 percent). Of these respondents, 752 provided written comments on a range of topics. Table 1 reports response rates to the narrative part of the questionnaire by grade level and NASA installations.

Table 1
Narrative Comments: Frequencies and Percentages of Narrative Responses by Installations and Grade Level

Center	Frequencies	Percent
Ames Research Center	133	17.7
Langley Research Center	78	10.4
Lewis Research Center	134	17.8
Johnson Space Center	125	16.6
Kennedy Space Center	85	11.3
Marshall Space Flight Center	67	8.9
Goddard Space Flight Center	74	9.8
Stennis Space Center	11	1.5
Headquarters	39	5.2
Unidentified by Center	6	.8

Grade Level	Frequencies	Percent
Grade 12	312	41.5
Grade 15	352	46.8
Other Grades (GS 13, 14, SES, et.)	87	11.6
Unidentified	1	
Total	752	100.0

Table 2 reports the ages of those who responded to the narrative section of the questionnaire. The largest number were in the 51 - 60 age group while the smallest number were in the 61 or above age group. This corresponds to the approximate age distribution of NASA scientists and engineers.

Table 2
Narrative Comments: Frequencies and Percentages by Age

Age Group	Frequencies	Percent
30 or Under	190	25.3
31 - 40	151	20.1
41 - 50	163	21.7
51 - 60	202	26.8
61 or Above	36	4.8
Unidentified	10	1.3
Total	742	100.0

Methodology

The narrative section consisted of the last page of questionnaire with the following phrase, "Do you wish to comment on this questionnaire or add any observations concerning any of the topics which this questionnaire emphasized?" Comments dealt with working environments, management processes, the mission and goals of NASA as a whole as well as individual centers, the relationship between contractors and government personnel, inherently governmental functions, recruitment and retention of personnel, survey methods and a host of other topics such as advocacy of programs and the amount of paper work. We divided these comments into 56 topical categories. They were then streamlined and regrouped into 11 subject categories.

Site order matrices, based on the location of nine NASA installations, were developed as a first step in analyzing comments from different centers. Comments on specific matters were attributed to many informants, several informants, a few informants, or one informant at each site. Many respondents typed one to four pages on a variety of topics. The vast majority of comments were reflective; they were written at a more inferential or analytical level than usual narrative data and were often accompanied by a logical chain of factors or explanations that provided a basis for explaining observations or experiences.

A review of survey literature reveals that the range of respondents who generally provide narrative comments on written questionnaires include a broad spectrum of people ranging from reflective and constructive people to dissatisfied members of the work force to employees with emotional problems that range from mild distress to acute psychiatric problems. Even so, informants will typically craft their responses to be amenable to researchers and to protect their self-interests, resulting in bias. In a few cases, the researchers were viewed as seeking information that would likely result in little or no change or as contractors contributing to the problem of deterioration of in-house capability.

Response bias related to narrative comments is a concern for three reasons. First, because 752 of 1,567 respondents furnished written comments, the response rate is not statistically as representative as the response rate to the closed questions and Likert scale statements on the questionnaire. It is likely that the sample of 752 scientists and engineers is not perfectly representative of the larger population of scientists and engineers at NASA. Second, there is not only the broader social scientific one of generalizations, but, also one of class bias. Although scientists and engineers are the group of informants most directly involved in the focus of this study, and are, as previously noted, knowledgeable and close to the processes with which the researchers are concerned, weight given to their comments should be tempered by managers' judgments, contractors' opinions, and other sources' views. Third, the external validity of the narrative data may have been influenced by previous sections of the survey instrument and recent events, including the Advisory Committee currently engaged in a review of NASA policies and practices. Thus, the researchers assign a weight of lesser relative importance to the narrative data than to information obtained from the closed questions and scaled items of the mailed questionnaire.

Findings

Findings are presented in 12 categories across all sites. The last category contained a number of matters that merit consideration, but that diverged from the rest of this study. If one or more of the particular centers contributed, on purely statistical grounds, more strongly to a given subject, a particular center(s) is cited. If there were notable variations among centers, variations are described although no attempts are made to comment on the implications or reasons for the variations. To discover the significance and causes of site variations we would have to analyze the dynamics of the individual centers.

Contracting

The vast majority of respondents at all sites commented on contracting. The greatest number of comments stressed that contracting has led to a demise in the in-house capacity to run programs, adequately control contracts, participate in the decision making process, evaluate the results of contractors' work and be directly accountable to the public. The following remarks focused on the negative effects of support service contracting:

> I am personally convinced that the recent failures NASA has had were caused by the lack of in-house, hands-on experience caused by contracting. Excessive contracting has reduced in-house expertise.
>
> The technical competence within NASA has been allowed to erode (due to private sector involvement in space projects); this condition must be corrected if we are to achieve a viable program of space exploration.
>
> The relationship between NASA and its contractors has evolved into an unproductive environment.
>
> NASA needs to accept responsibility of poor contractor performance by recognizing that (1) the contractor has his own interests in mind and (2) NASA does not always know how to manage the contractor to ensure NASA's interests come first.
>
> As we contract for more and more work, the expertise will belong more and more to the contractor. The NASA civil servant will become, more and more, a contract administrator.
>
> The ratio of contractor employees to NASA employees is too high.

A number of respondents pointed out that in many cases, contractors perform more interesting tasks than civil servants. For example, one employee stated: "The vast number of "good jobs" are contractor positions." Another stated that the "more challenging assignments are given to contractors."

Several respondents, mainly from research centers, were critical of contractor support service personnel background and training for assignments while others noted that contractors often "fill spots with paper credentials rather than with real accomplishments." Others, however, noted that contractors are competent and dedicated. At the three research centers, the capability of contractors was more often questioned than at the space flight centers. Respondents from all centers noted that NASA's ability to be a "smart buyer" and to make independent judgments about the quality of the work has declined as the number of contractors has grown. NASA, has lost its real experience base and will continue to slide unless the current trend to contract is reversed.

Employees from several centers noted that contracting resulted in not only the deterioration of hands-on experience but also the loss of institutional memory within NASA. Several said that there appears to be an absence of a foundation upon which to base certain decisions and contended that an agency-based knowledge helps establish strong professional identities. Although individuals may develop specialized knowledge through reading and research, "know-how" is generally acquired through considerable hands-on experience.

A few people mentioned that in terms of continuity, contractor personnel were fairly unstable, and a few others pointed out that contractors have worked for the agency for decades and are virtually indistinguishable from civil servants.

Many employees mentioned that the use of contractors is closely tied to special interests and that contracting has emerged as a form of pork barrel politics. "Contracts have," an employee noted, "become forms of local political patronage."

A few employees noted the lack of competition among contractors and difficulties associated with procurement. "The escalation in the amount of red tape associated with procurement is an attempt to make a process rational that is not very rational after all," an engineer wrote. A few pointed out that a great deal of time and energy is wasted during the procurement process.

A few respondents from the Lewis Space Center mentioned that senior managers always perceive contractors as correct and tend to ignore in-house staff. There was a general feeling(expressed by several respondents) that as NASA managers have turned over critical tasks to contractors they have lost the ability to critique contractor designs, tests and operations.

Several respondents mentioned that government employees responsible for contract monitoring tend to develop close relationships with contractors and thus the government's interests may not be maintained. Many contractor personnel, they noted, are former NASA employees. "Cozy relationships result in the inappropriate use of contractors," several respondents noted. Others expressed views that tasks that involve significant value judgments or assurance that the public interest is paramount should not be turned over to contractors; nevertheless such tasks are sometimes performed by contractors. A few employees who have been with the NASA for a number of years believed that although contractor personnel's efforts have expanded, problems do not exist with the size of the contractor work force as much as with the quality of their work, the incentives and the compensation.

Personnel Ceilings

Respondents stated that the principal reason for losing technical expertise has been the imposition of arbitrary personnel ceilings by OMB and Congress. Ceilings were imposed, many respondents noted, because of the erroneous belief that contracting would save money and the view that the size of the government would be reduced. Several respondents said that contracting is often more expensive because the private sector pays higher salaries and provides better benefits. While most engineers and scientists conceded that it is unrealistic and undesirable for civil servants to perform all tasks, they believed that NASA has contracted out the performance of many critical functions, thus losing control, diluting responsibility and avoiding accountability. While respondents did not believe it is feasible to precisely define a set of functions that should be reserved for government employees, many suggested reducing the number of contractors and increasing the number of civil servants.

Paperwork

A large number of respondents at all centers, with the exception of the Stennis Space Center, complained about the amount and nature of the paper work. Employees noted that in the past

NASA did not resemble the rest of the government with respect to the amount of red tape, but one employee noted that it has lately become "more process oriented and less object oriented." Center personnel complained about the amount and irrelevance of paper work associated with writing and awarding contracts, the amount of paper work associated with selling programs, and the number of rules and regulations required to manage and track resources. "Administrative micromanagement is rampant and its links to technical management are adverse," one employee observed. Headquarters' employees complained far less about the amount of paper work than did field center employees although meetings, justifications, purchase requests and other administrative tasks were characterized as excessive by employees from all locations.

Pay and Benefits

A number of employees at all installations compared the salaries and benefits of civil servants and private sector employees. In addition, 90 percent of respondents at the Ames Research Center raised the issues of pay and benefits. Respondents from Ames tied attrition to the pursuit of better pay and benefit packages and noted that the core factor motivating decisions to change jobs is pay. Although they acknowledged that NASA has been at the mercy of pay policies formulated at higher levels of the federal government, they pointed out that the challenging work will not be able to offset the high costs associated with living in California communities. Despite the compelling logic of their position, they feel pessimistic about decreasing pay differentials between the two sectors. A key ingredient of their pessimism is the belief that NASA will not be able to break away from the compensation policies and practices of the federal government as a whole. The potential for obtaining pay differentials, according to respondents, appears low in spite of the accumulation of evidence that the cost of living on the West Coast is increasingly more than in the rest of the nation. The following comments briefly state the positions of Ames employees:

Salary is the primary reason for the loss of some of NASA's best scientists and engineers.

Most of the manpower problems at NASA are related to pay.

The pay at NASA is poor, both in relative and absolute terms.

NASA pay scale, relative to industry, makes it very difficult to recruit and retain top quality scientists and engineers.

This questionnaire omitted what is the single most important issue to NASA employees in high cost of living areas such as the San Francisco Bay area: pay!

The pay and compensation problem was also an recurring concern to employees at the Goddard Space Center who often tied professional commitment to pay. The subject of pay attracted no comments at the Stennis Space Center and little attention at other centers.

Politicization

A number of respondents at all centers talked about increasing politicization of NASA and the resultant advocacy of programs. NASA, they noted, is increasingly driven by the motivations, interests, and strategies of managers, industry representatives and politicians who dominate decisions rather than by the interests and demands of the scientific and engineering communities and the public. Because NASA is subject to erratic funding and budget constraints, it spends a great deal of time building political constituencies and delivering services in ways that enable politicians to reap rewards and claim credits.

Funding and budgeting problems have resulted in a "grab bag" mentality at each of the centers, and the name of the game is to obtain as much new work as possible. These actions made a number of respondents oppose growth and created cleavages between those who believed that centers should engage in a limited number of projects and those who believed that centers should expand into a number of new areas. The costs of inducements offered by growth in many areas, respondents worried, may lead to net losses in terms of quality.

Others stressed that growth has led to powerful center management structures with the specific mission of selling new initiatives. Managers within these structures may pursue initiatives to solidify their jobs and salaries and to prepare themselves for future employment with the private sector without being aware of the impacts of their actions. Most prominent among opinions was the belief that selling of programs has led to competition among centers to enlarge their own budgets and loyalty to particular centers rather then to NASA as a whole. One respondent raised an important question, How long and how far can centers stake out independent positions? Another simply stated, "Program decisions are politically driven."

Leadership

Respondents firmly believed that competition among centers has resulted, in part, from the lack of direction by senior managers. Respondents from all centers highlighted two unresolved issues: the lack of direction from Headquarters and the lack of competence and credibility of senior managers. Several respondents noted that senior managers are no longer perceived as knowledgeable and expert. Some perceptions of senior managements' lack of direction and credibility follow:

> Senior managers are out of touch with the priorities, technologies, and requirements for advanced technical productivity.
>
> No focused realistic plans are made and organizational changes seem to be the norm.
>
> There appears to be no commitment to excellence. Policy wording is not consistent with management's actions.
>
> NASA needs leaders with technical competence in areas they are supposed to manage.
>
> The biggest problem is not with working scientists and engineers but with senior managers.

NASA's problems can be traced to a lack of leadership coupled with a surfeit of management.

In-House Capability and Hands-On Work

The vast majority of scientists and engineers responding to the narrative part of this questionnaire commented on the loss of in-house capability and the need to perform more hands-on tasks. Many believed all scientists and engineers should have hands-on training opportunities, saying without this employees cannot learn how to recognize opportunities or solve problems. One engineer noted that engineers are not as sensitive to hardware as they should be because "they are absorbed in program status presentations and don't get any hands-on experience beyond the utilization of copying machines." Another engineer said, "Once engineers become contract monitors, not doers, the appeal of their jobs fade, unless opportunities for real direction are part of the monitoring effort."

In the judgment of many respondents it would be beneficial if researchers and model makers, for example, could work closely together. The resulting mutual understanding can only be developed through practice. According to respondents, keeping projects in-house will (1) promote a sense of pride, (2) enhance control, (3) develop skills, (4) ensure accountability, (5) attract capable people, (6) contribute to the retention of employees and (7) cultivate a creative spirit.

Several respondents pointed out the value of hands-on experience appears to have been recognized and that several centers have developed training assignments to engage young engineers in the design, prototype testing, and check out of projects on a small scale. They pleaded for the expansion of such activities.

Larger Project vs. Smaller Projects

A limited number of employees at all centers commented on the presence of large, unfocused programs that are poorly conceived, inadequately funded and never completed. Employees suggested that working on smaller projects would enhance quality and productivity and minimize organizational interfaces. "The pursuit of grandiose projects results in greater inefficiencies and less technical depth" one employee pointed out. "More time is required to deal with the restrictions and red tape that accompany such projects," another mentioned. Many other aspects of management practice, organizational structure, and organizational processes, it was noted, are affected by the breadth and complexity of large projects.

Several employees observed that NASA does not reject new projects. "Presumably, this behavior characterizes organizations that are uncertain about outcomes," a scientist wrote. The process of getting rid of projects is a difficult one, others observed. Fewer than ten respondents noted that small projects are as administratively burdensome as large projects.

Image of the Government and NASA

Several respondents said that NASA employees have energy, drive and ambition but lack the opportunity to advance the interests of the organization because NASA is a part of the governmental sector. Respondents also noted that negative public opinion and bureaucrat bashing are likely to persist in view of recent difficulties stemming from the Hubble Telescope and the Shuttle. They acknowledged that events have determined opinion about NASA more than words. By and large, respondents were pessimistic about enlightening the public about space exploration and indicated that the lack of confidence in the government and NASA itself will not easily shift.

Challenging Work

Many respondents talked about the challenging work at NASA and the important contributions they have made. Several respondents noted that they are pleased with the work that marks NASA's increasingly sophisticated leadership in space and expressed loyalty to NASA. A few discussed the continuing need to achieve performance that will stand public scrutiny and fulfill NASA's responsibility.

Employees ranked the nature of the work and the opportunity to utilize a variety of skills and talents as NASA's greatest advantages in comparison to the private sector and other government agencies. A number of employees emphasized excellent relationships with co-workers as an important asset and the reputation of NASA within the scientific community as a major advantage.

The largest number of respondents who commented on both the existence of challenging work and the absence of challenging work came from the Goddard Space Center. For example, one Goddard employee wrote, "Goddard is still unique and wonderful" and another Goddard employee wrote, "NASA needs to find challenging work or more engineers and scientists will leave."

Survey

Several respondents complimented the Academy on the design and content of the questionnaire, which they believed examined the most important issues confronting NASA. A few complained about the ambiguity of specific items and a few believed that the questions were biased. Many respondents believed that the results of the questionnaire would not be utilized and noted that previous questionnaires did not result in changes. Typical responses were: "I don't know why I have taken the time to respond to this survey. It will never result in changes." "Questionnaires of this kind are irrelevant to decision making." Some respondents expressed the hope that the results of this questionnaire would be important in evaluating information and integrating this data with other data to make correct choices. Several people suggested that the administrator personally meet with employees to discuss the topics that appear in this questionnaire.

Other Issues

Several commentators noted that the work ethic, generally defined as dedication and commitment among NASA employees, has declined. The majority of respondents who discussed this topic compared the work ethic of the 1960s and 1970s to the work ethic of the 1980s. A number of older employees talked about the behavior and attitudes of U.S. youth and their concern with the attainment of self realization through means other than work.

Some employees talked about the unreliable yardsticks used in performance appraisals, and believed that success at NASA is linked to a measure of achievement known as the ability to play the political game. "Routes to the top," one employee stated, "are not apt to hold the keys to leading, changing, innovating, developing or even working with people. They are based on political considerations."

At the Lewis Research Center, an number of people pointed out that employees were hired because of their gender and ethnicity rather than because of their merit. Some employees commented that the government has difficulty competing for highly qualified members of minority groups and suffers the consequences of hiring some with lesser qualifications.

Some respondents complained about excessive amounts of work and others complained about underutilization; often these remarks were, admittedly, tied to unrealistic expectations.

Some respondents suggested that NASA recruit more people with prior industry experience. A few indicated that the popular practice of hiring fresh-outs needs to be reviewed and that dependence on co-op recruits should be reduced. A few people also complained about arrested career progress.

Several people said that more authority to hire, promote and fire is needed to get superior results from employees.

Some people discussed NASA's emphasis on short term goals as a philosophy and an attitude. Strategic planning was viewed as an exercise or process, not as an effort to make long range plans. One respondent noted that, "Every year a new five year plan is developed, not merely reviewed and revised on an annual cycle." A few people linked the lack of planning to the fact that decision making in government is forged on the political anvil. The majority of respondents attributed the lack of planning to NASA senior managers who, "... are unable to formulate basic missions, purposes and objectives." As a result NASA "muddles through." A single respondent suggested that the solution to this problem was to eliminate NASA and start over.

Many Headquarters employees commented on low morale; but only, a few, from other installations raised the subject.

Many respondents noted that NASA employees have become reluctant to take risks, resulting in excessive caution, non-decision, and a reactive rather than proactive stance. "Favorable opportunities," a single respondent said "are often not exploited due to a predisposition toward covering all steps." Excessive control of risks, it was also noted, may also result in performance failures.

Other comments dealt with the need for White House support, the complexity of the procurement process, the benefits of mentorships, and the feeling that operational activities have overshadowed research and development activities. Regarding these comments, there were few, if any, disparities in perceptions among personnel from different centers.

CONCLUSION

Scientists and engineers represent a significant resource for the agency. Although a number of the problems they described are driven by forces outside of NASA's control, many are amenable to agency influence. Insights of scientists and engineers regarding contracting indicate that senior NASA management should pay attention to the amount of contracting, goals, incentives, contractor performance, and modifications that alter the relationships between NASA and contractors. Other areas that merit further examination are: opportunities for hands-on training; centers' roles and missions, responsibilities and actions of senior managers; and politicization of NASA.

APPENDIX A

PART IV

SURVEY INSTRUMENT

I DEMOGRAPHICS

Please provide one response for each question unless otherwise directed. In some cases, you will need to fill in the blanks; in other cases, you will need to draw a circle around a letter preceding the most appropriate response. Note that when the word "other" is listed, you are asked to write a response after the term if you select that alternative. After responding to this questionnaire, please place in the envelope labeled National Aeronautics and Space Administration, NAPA, Washington, D.C., 20546.

1. Are you:

    a. Male
    b. Female

2. What year were you born? ______

3. What was your principal reason for joining NASA?

    a. Salary/prospects for future earnings.
    b. Chance to work on aeronautics/space projects.
    c. Interest and challenge potential of the work.
    d. Geographical location.
    e. Had friends or family working for NASA.
    f. Job security.
    g. Desire to perform government service.
    h. Good working facilities.
    i. Good training/educational opportunities.
    j. Chance for promotion and growth within the organization.
    k. Fringe benefits.
    l. Chance to work with the best people in my field.
    m. Other *(please specify)*: ______________________

4. What is your highest educational level?

    a. College graduate (B.A., B.S. or other Bachelor's degree).
    b. Some graduate school.
    c. Graduate degree (M.S., M.A., LL.B.)
    d. Doctor of philosophy (Ph.D.)
    e. Other *(please specify)*: ______________________

5. Which of the following categories is most related to the field of study at your highest degree level?

   a. Agriculture
   b. Biological Sciences
   c. Engineering
   d. Mathematical Sciences
   e. Education
   f. Physical Sciences (including Space Science)
   g. Health Sciences
   h. Other *(please specify):* ______________________________

6. What year did you attain your highest degree? _________

7. What center do you work for?

   a. ARC
   b. LaRC
   c. LeRc
   d. JSC
   e. KSC
   f. MSFC
   g. GSFC
   h. SSC
   i. HDQS

8. What is your organization code (triple letters)? __ __ __

9. What is your grade level? _______

10. Immediately prior to joining NASA what were you doing?

    a. Student
    b. Worked in state/local government
    c. Worked in private sector
    d. Military
    e. Worked for another federal agency
    f. Unemployed for more than a year
    g. Other *(please specify):* _________________________________

11. How long have you worked for NASA?

    a. Less than one year.
    b. One year, but less than two years.
    c. Two years, but less than three years.
    d. Three years, but less than five years.
    e. Five years, but less than ten years.
    f. Ten years, but less than 15 years.
    g. Fifteen years or more.

12. Did you participate in the co-op program?

a. Yes
b. No

II NATURE OF WORK

1. From the activities listed below, select your primary and secondary work activities for your principal job, in terms of time devoted for a typical week. Enter the letter P for primary work activity and S for secondary work activity.

_____ a. Management or administration of research or development.

_____ b. Management or administration of activities other than research and development.

_____ c. Teaching, training, guiding or counseling employees or trainees.

_____ d. Basic research - that is, effort directed toward gaining scientific knowledge primarily for its own sake.

_____ e. Applied research - that is, effort directed toward gaining scientific or engineering knowledge in an effort to meet a recognized need.

_____ f. Development - product, process, and technical development. That is, direction of knowledge gained from research toward production of materials, devices, systems and methods.

_____ g. Report and technical writing, editing, information retrieval.

_____ h. Design of equipment, processes, models.

_____ i. Quality control, testing, evaluation, or inspection.

_____ j. Operations - facility, system, mission, installation

_____ k. Statistical work - survey work, forecasting, statistical analysis.

_____ l. Computer applications.

_____ m. Other activities *(please specify)*:________________

2. During a typical week, approximately what percent of working time do you devote to each of the following activities? *Please indicate the amounts of time in percentages.*

a. ______% Management & administration
b. ______% Design
c. ______% Basic research
d. ______% Testing/evaluation
e. ______% Applied research
f. ______% Development
g. ______% Teaching/training
h. ______% Operations
i. ______% Computer applications
j. ______% Paperwork: RTOP Preparation, work statement, proposals preparation and progress reports.
k. ______% Contractor oversight
l. ______% Other

100.0% Total

3. How would you characterize the utilization of technical competence of ***experienced scientists and engineers*** with whom you work (at your center)?

a. Excellent utilization
b. Good utilization
c. Fair utilization
d. Poor utilization
e. Very poor utilization

4. How would you characterize the utilization of technical competence of ***young scientists and engineers*** with whom you work (at your center)?

a. Excellent utilization
b. Good utilization
c. Fair utilization
d. Poor utilization
e. Very poor utilization

5. In your present job, please characterize the level of technical responsibility you most often exercise.

a. Simple prescribed procedures
b. Sequence of prescribed procedures
c. Specific applications
d. Application of standard methods
e. Generation of alternative methods
f. Performance of complex tasks
g. Planning/organization of projects
h. Pioneering work
i. Problem solving
j. Systems analyses

6. Since joining NASA, has the diversity (e. g. variety and complexity) of work increased (at your center)?

a. Yes
b. No

III "HANDS-ON"/ CONTRACTING

1. At your center, do contractors perform any of the following duties? *Please circle all items that apply:*

a. Establish policy
b. Commit government resources
c. Represent NASA at meetings
d. Define work assignments
e. Review progress
f. Revise work assignments
g. Monitor performance

2. In your opinion, at your center, which of the following types of support provided by contractors exceed what should be provided by the private sector. *Please circle all items that apply:*

a. Engineering and technical services
b. Research and development
c. Data processing
d. Program control
e. Mission operations
f. Other
g. None

A number of statements dealing with various aspects of work are listed below. In the columns on the right side please indicate the extent to which you agree or disagree with each statement by placing a check under the appropriate response. Please check only one of the five alternatives for each item.

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
3. The performance of sciences and engineering by NASA is less efficient than by industry.					
4. Scientists/engineers should perform "hands-on" work once in a while otherwise they will lose their proficiency					
5. People with direct problem solving experience get the best results.					

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
6. It is a good idea for NASA scientists and engineers to specialize in a single area.					
7. A top notch technical background is needed for contract management.					
8. NASA provides challenging work assignments.					
9. Most productive researchers do not want to manage contractor efforts.					
10. Contract management, within the context of NASA, requires more technical capabilities than administrative skills.					
11. A great deal of challenging aeronautics and space work is performed by contractors, not NASA.					
12. Systems analysis capabilities and integrative skills are highly valued in NASA.					
13. The trend toward expanding use of contractors has shifted challenging technical tasks from NASA to contractors.					
14. There is a blurring of distinction between contractors and civil servants on NASA sites.					

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
15. Hands-on experience is required to understand how to manage and evaluate contractors efforts.					
16. NASA should hire more engineers and scientists with private sector experience.					
17. The future roles of contractors should be more limited than what they currently are.					
18. Contractors have assumed many functions that are inherently governmental.					
19. NASA program managers spend too much of their time exercising oversight responsibilities.					
20. NASA has in-house competence to make responsible decisions in all programs for which it is responsible.					
21. NASA's in-house scientific and engineering capabilities are as strong as in the past.					
22. NASA's in-house management/administrative capabilities are as strong as in the past.					
23. In general, NASA program managers have the right mix of both technical and administrative skills necessary to successfully complete jobs.					

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
24. A large number of scientists and engineers in NASA are malutilized (e.g. unreasonable time demands on the job).					
25. A large number of scientists and engineers in NASA are underutilized (e.g. light technical demands).					
26. The public interest would be better served if less technical work were contracted out to the private sector.					
27. The private sector provides a climate for greater creativity and productivity of scientists and engineers than the public sector.					
28. NASA does a good job of identifying, developing and assigning people capable of playing key roles in the technical direction of projects.					
29. NASA needs to expand or initiate more in-house projects to provide for hands-on experience.					
30. Too much of scientific and engineering efforts in NASA is spent in preparing and selling programs.					

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
31. When people leave NASA, they rarely leave because the work does not have enough "hands-on" characteristics (e.g., development and fabrication of protypes, testing, production).					
32. Greater numbers of personnel working in support of NASA scientists and engineers (technicians, model makers and other skilled workers, and production workers) should be civil servants.					
33. Many important management decisions are being made by contractors, not civil servants.					
34. Within NASA, program control functions need to be strengthened.					
35. Few individuals in NASA possess skills involving the artful blending of technology and administration.					
36. Modern tools such as computer assisted design do not provide scientists and engineers with an intuitive feel for hardware.					
37. Engineers should be able to acquire "cradle to grave" experience on projects.					

IV IMAGE OF THE PUBLIC SERVICE

Please indicate how strongly you agree or disagree with the following statements.

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
1. I would recommend NASA as an employer.					
2. I am doing important work as a NASA employee.					
3. Government service is a place to gain experience for a better job.					
4. In the government, there is more red tape than in non-governmental sectors.					
5. Government R&D is less efficient than the private sector.					
6. Most scientific and engineering students would prefer working in the private sector.					
7. Government workers are as important in science and engineering as any other group of workers.					
8. On the whole, government scientists and engineers are as capable as scientists and engineers in other sectors.					
9. The best scientists and engineers leave the government for other jobs.					

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
10. Government workers are as carefully selected and recruited as private sector workers.					
11. The government attracts fresh-outs as capable as fresh-outs which the private sector attracts.					
12. The good points about working for the government outweigh the bad points.					
13. Scientists and engineers working for the government have good chances to get ahead.					
14. Government employees have as much of a chance to develop as their private sector counterparts.					
15. Considering political, economic and social trends, the government, as an employer, rates higher than other sectors.					

V RECRUITMENT/RETENTION

1. How many years will it take before you are eligible for retirement?

   a. Currently eligible.
   b. Under five years.
   c. Five to seven years.
   d. Eight to ten years.
   e. Ten to 15 years.
   f. Sixteen years or more.

2. How long do you plan to work at NASA?

   a. Under five years.
   b. Five to seven years.
   c. Eight to ten years.
   d. Ten to 15 years.
   e. Sixteen years or more.
   f. Undecided.

Please indicate how strongly you agree or disagree with the following statements.

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
3. My progress at NASA has been satisfactory.					
4. My job fits in well with my future goals.					
5. I regard working for NASA as my lifetime career.					
6. The quality of current NASA hires in science and engineering is as good as it has always been.					
7. I feel less satisfied with my work as time goes on.					

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
8. I would quit my job if I found another job in the same line of work with comparable benefits.					
9. I am not eager to change my job, but I would change it if I could get a better job.					
10. Scientists and engineers at NASA need to perform more "hands-on" work.					
11. The majority of scientists and engineers with whom I work will retire as soon as they are eligible.					
12. Most NASA scientists and engineers often talk of changing jobs.					

VI CONCLUDING STATEMENT

Do you wish to comment on this questionnaire or add any observations concerning any of the topics which this questionnaire emphasized?

Thank you for your cooperation!