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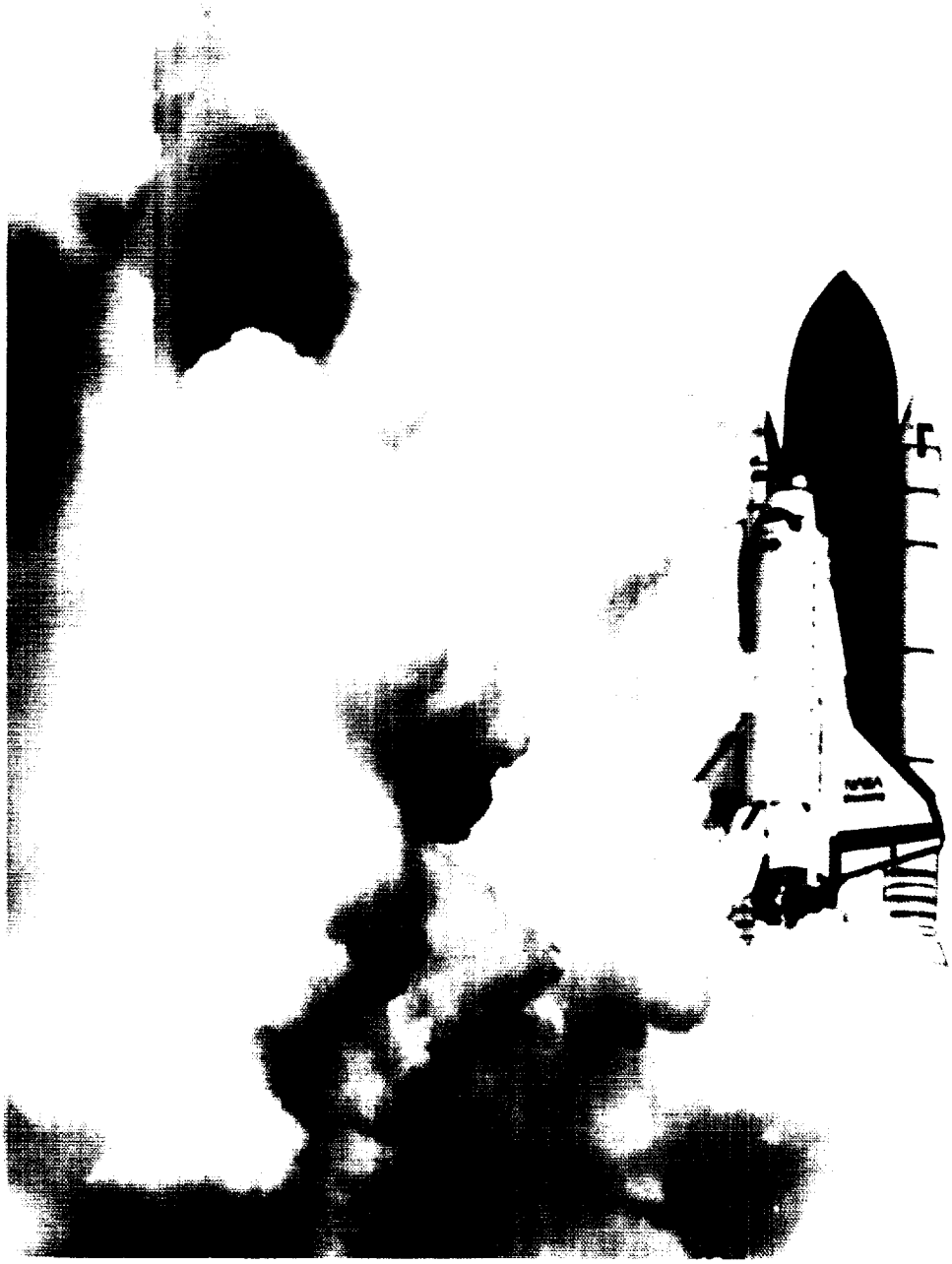
National Aeronautics
and Space Administration

Review of Issues Associated with Safe Operation and Management of the Space Shuttle Program



Aerospace Safety Advisory Panel

November 1996

ACKNOWLEDGMENTS

The Aerospace Safety Advisory Panel appreciates the efforts of all of the NASA and contractor personnel who contributed information used in the deliberations for this report. Without their thorough and energetic cooperation, this study would have been significantly more difficult. It must be noted, however, that the observations and opinions expressed herein are those of the Panel and not necessarily those of the people interviewed.

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Review of Issues Associated with Safe Operation and Management of the Space Shuttle Program

November 1996

National Aeronautic and
Space Administration

Headquarters
Washington, DC 20546-001

Reply to Attn of: Q-1

November 21, 1996

Honorable Daniel S. Goldin
Administrator
NASA Headquarters
Washington, D.C. 20546

Dear Mr. Goldin:

In accordance with the charge you presented us in your letter of June 7, 1996, The Aerospace Safety Advisory Panel is pleased to submit to you our final report for transmittal to the White House. This report covers the scope detailed in the study Terms of Reference.

Overall, we have concluded that the efforts to streamline the Space Shuttle program have not inadvertently created unacceptable flight or ground risks. We call your attention, however, to the multiple observations and recommendations in the report which address the clear need for NASA to take steps to ensure the availability of a skilled and experienced civil service workforce in sufficient numbers to meet ongoing safety needs. These personnel issues are challenging and have the potential to adversely impact risk in the future.

It must also be noted that synergism among the studied issues as well as interactions with other major ongoing activities not specifically studied also have the potential to generate safety problems. For example, the need to schedule any Reduction in Force during the initial assembly of the International Space Station is a significant concern. Likewise, unrealistic funding levels and imposed schedules which are not based on the true maturity of systems can place undue pressure on NASA and contractor managements. Meeting the demands of these externally applied pressures can force decisions which increase safety risks. The Panel believes that it is essential for NASA and its contractors to examine continuously the cumulative as well as the individual effects of all of these factors and to voice any concerns which may result. These concerns, in turn, should be dealt with positively and non-punitively by the Executive and Legislative branches of government in the interest of maintaining NASA's essential human space flight programs at acceptably low safety risk levels.

Very truly yours,

Paul M. Johnstone

Paul M. Johnstone
Chairman
Aerospace Safety Advisory Panel

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EXECUTIVE SUMMARY

At the request of the President of the United States through the Office of Science and Technology Policy (OSTP), the NASA Administrator tasked the Aerospace Safety Advisory Panel with the responsibility to identify and review issues associated with the safe operation and management of the Space Shuttle program arising from ongoing efforts to improve and streamline operations. These efforts include the consolidation of operations under a single Space Flight Operations Contract (SFOC), downsizing the Space Shuttle workforce and reducing costs of operations and management.

The Panel formed five teams to address the potentially significant safety impacts of the seven specific topic areas listed in the study Terms of Reference. These areas were (in the order in which they are presented in this report):

- Maintenance of independent safety oversight
- Implementation plan for the transition of Shuttle program management to the Lead Center
- Communications among NASA Centers and Headquarters
- Transition plan for downsizing to anticipated workforce levels
- Implementation of a phased transition to a prime contractor for operations
- Shuttle flight rate for Space Station assembly
- Planned safety and performance upgrades for Space Station assembly

The study teams collected information through briefings, interviews, telephone conversations and from reviewing applicable documentation. These inputs were distilled by each team into observations and recommendations which were then reviewed by the entire Panel. The main observations and all of the recommendations are presented in the balance of this summary.

OBSERVATIONS

Maintenance of Independent Safety Oversight

The ongoing transitions were assessed with respect to their potential impacts on the independence of the Safety and Mission Assurance (S&MA) organizational structure of both NASA and its contractors, the existence of independent reporting paths for safety concerns and the existence and strength of independent assessment functions.

Organizational independence has not changed significantly as a result of the ongoing transitions. NASA's S&MA organization remains independent of its line operations. The new SFOC contractor, United Space Alliance (USA), retains the same organization as its predecessor in which the S&MA function does not report independently of line operations. Hence, the status quo with respect to the organizational independence of both the NASA and contractor S&MA functions has been maintained.

The withdrawal of NASA personnel from day-to-day interfaces with their contractor counterparts has the potential to eliminate a significant independent reporting path. Even though NASA plans to retain a strong presence on the work floor and in contractor facilities, some of the team aspect of the NASA/contractor relationship will surely be lost. This may reduce the likelihood of contractor personnel utilizing their NASA associates to elevate issues they are reluctant to raise to their own management. Also, given the long established working relationships of most of the current individuals in the NASA and contractor contract management positions, the extra layer of management imposed by the SFOC structure should not represent an impediment to accurate or timely reporting. A problem could arise, however, with any successors to the incumbents who may not have the same depth of working relationship upon which to rely.

The independent assessment functions of both NASA and the contractor have been broadened. This will provide somewhat increased evaluation of processes and promulgation of lessons learned but is not intended as a total replacement for the NASA in-line S&MA activities which have been eliminated.

In the longer range outlook, independence may be further eroded through the loss of critical skills and experience among NASA personnel. NASA should not be misled by the apparent initial success of all of the transition efforts. A major test of the robustness of the new approach will likely be faced after there is significant turnover among incumbents at all levels. It is therefore important to maintain an adequate level of independent assessment and surveillance even after it appears that the transitions have been successfully accomplished.

Lead Center/Communications

NASA has transitioned the Space Shuttle program to a Lead Center management organization. The essence of the Lead Center type management is the delegation to a single NASA field center of the overall program management authority for an activity that involves the participation of other NASA field centers. This concept is not new to either NASA or the Space Shuttle program.

The Lead Center management mode for the Space Shuttle is working well under the leadership of the existing managers. To date, the project and element managers appear generally satisfied with the arrangement and seem to be active participants in it. This can likely be attributed to the fact that these individuals have been working together for over a decade and have come to know, respect and trust one another.

A multiplicity of formal communications channels exist and are used for transmitting information both upward and downward in the program. In addition, horizontal informal communication is encouraged and keeps counterparts and other interacting individuals among the several organizations in daily contact about events and issues of mutual interest.

The center directors involved are generally satisfied with their roles under the Lead Center mode. Their ability to quickly deploy their center's resources against emerging problems is especially appreciated. Some did express a concern about the

impact of "full cost accounting" and the potential of having to re-program their budgets before taking necessary actions.

As yet, the governing documents that are the formal mechanisms for establishing and describing the Lead Center mode of management have not been issued. It is understood that there are teams working on the development of such documents, and they are nearing completion. It is vital that these documents clearly define the scope of authority of all levels of managers so as to minimize micro-management from above.

The managers of the projects and elements are, for the most part, long-term NASA employees, many of whom are approaching the age for voluntary retirement. It was agreed by those interviewed that it is not too soon to take steps to assure the availability of well-trained successors experienced in the Lead Center management mode.

Downsizing

NASA is projecting a significant "downsizing" of its civil service workforce in response to budgetary pressures and the reorganization of government departments. It is clear that this downsizing represents a substantial management challenge and a potential safety concern as the agency shifts program management responsibility from Headquarters to field centers and implements the Space Flight Operations Contract for managing the Space Shuttle.

The downsizing plans raise four separate but closely related questions:

(1) Are the projected personnel levels in the fiscal year 99/00 timeframe at NASA and the United Space Alliance (USA) acceptable in terms of maintaining safety?

(2) Do NASA and USA have the appropriate skills and experience mix to maintain acceptable safety levels during this period of downsizing?

(3) What management tools and incentives are needed to achieve the projected personnel levels during this period while still maintaining the requisite skills and experience mix?

(4) Will the downsizing process itself become a significant disruption and obstacle to successful Space Shuttle and International Space Station (ISS) operations?

Although the Johnson Space Center (JSC), Marshall Space Flight Center (MSFC), and Kennedy Space Center (KSC) will all be hard pressed to meet out-year personnel targets without an involuntary Reduction in Force (RIF) and its attendant disruption, the circumstances that confront NASA management and employees at KSC are particularly difficult. NASA top management had previously explored with the Office of Management and Budget (OMB) and the Congress an enhanced buyout provisions that would have provided between 50 percent and 80 percent of current salary to NASA personnel who were eligible for retirement, but this version was rejected. Amounts of $50,000 and $35,000 were also explored and rejected. Instead, the earlier buyout incentive of $25,000 was renewed. Linking the

current buyout to innovative part-time work or phased retirement arrangements such as the Career Plus Program at JSC will improve the attractiveness of the $25,000 amount as well as keeping experienced NASA employees available for part-time work. However, these linkages will require a legislative change to permit persons who accept any buyout to have the opportunity to continue part-time NASA employment. This approach could provide NASA the flexibility needed to attempt to reach targeted personnel cuts and maintain a balance of skills and experience during this period of intense activity and transition.

Space Flight Operations Contract

In order to reduce costs through efficiencies believed to be inherent in the private sector and reorient NASA's focus from operations to research, development and technology, NASA has implemented a plan for privatizing space flight operations for the Space Shuttle. The first phase of that plan is a consolidation of a majority of Space Shuttle processing support contractors and some NASA operational activities into a single Space Flight Operations Contract negotiated with United Space Alliance.

Based upon the *Program Management Plan* and the personnel, organization and management philosophies of the United Space Alliance, the Space Flight Operations Contract appears to be a comprehensive and workable document espousing safety as paramount throughout.

Overall, the documentation reviewed and discussions held reflect minimal adverse safety implications, especially in the short term. This is largely because the people currently in place are dedicated to making the new scheme work. There is some uncertainty about the future, however. Careful and continuous monitoring by top management and the safety organizations of both NASA and USA will be required to ensure continued safe operations as new people come on the scene, budget pressures continue to mount and the profit imperative increases on the part of the contractor.

Further reductions of funding could derail an otherwise well planned SFOC implementation. This could wreak hardships on people and foster an over confident or "workaround" attitude, either of which could have serious safety implications. While "safety" is a popular byword in the Space Shuttle program, dollar constraints may limit the ability to perform the tasks necessary to minimize risk. It is not evident how a situation such as this would be handled should it develop.

Manifest/Shuttle Enhancements

The manifest for the next six years is challenging. The planned schedule of seven launches per year, with surges to eight, is feasible with current personnel levels. An augmented schedule, at a rate of eight or nine launches per year, may be feasible only with additional resources, but it is probably too early to make a proper judgment in view of all of the changes underway. In any case, slips of several months for individual launches should be expected.

There is no additional safety risk related to the present manifest which arises from the move to a single operations contractor. However, the rewards and penalties of the incentive SFOC may motivate the contractor to actions which are unanticipated by either party today and which may pose additional risks to safe operations in the future.

The planned program for Space Shuttle enhancements appears well conceived and capable of meeting the needs of the International Space Station (ISS). Many of the changes being incorporated reduce risk as well which provides an overall safety benefit to the program. While the changes all seem conceptually sound, adequate testing and certification are required before they are used.

RECOMMENDATIONS

Maintenance of Independent Safety Oversight

Recommendation 1.
NASA and USA should retain the present S&MA processes with respect to safety critical operations until surveillance results and the performance of USA as the SFOC contractor clearly indicate that safety controls, including the maintenance of realistic independent safety reporting channels, are well established. Thereafter, sufficient surveillance and independent assessment activities should remain so that any difficulties arising from subsequent personnel turnover can be identified.

Recommendation 2.
NASA should retain a physical presence on the work floor at the space flight centers and at all contractors performing safety critical operations. True insight into safety practices requires personal interfaces and assured access to work in process at all times. Periodic independent assessment activities, audits and analyses of metrics are not sufficient to provide the degree of independent safety oversight required to operate the Space Shuttle program at minimum risk levels in the absence of a NASA physical presence on the work floor.

Recommendation 3.
NASA should evolve its independent safety oversight efforts into a system in which it receives notification of ***all*** changes, anomalies and recertifications from the SFOC contractor. These notifications should carry the contractor's assessment of whether they are in- or out-of-family. NASA should retain approval authority for the contractor's classification of the action. When NASA judges a change or anomaly to be critical, it should exercise final approval authority over the contractor's plans and activities. It is considered vital to the maintenance of independent safety oversight that NASA maintain the final judgment relative to the application of the definition of in- and out-of-family events.

Recommendation 4.
The long term maintenance of independent safety oversight will require NASA to develop and implement programs for critical skills retention and for the generation of direct Space Shuttle operating experience among NASA employees.

Recommendation 5.
NASA should continue its announced policy that "anyone involved can stop a Space Shuttle launch." Together with the NASA Safety Reporting System, this should help encourage people to employ the available independent reporting pathways.

Lead Center/Communications

Recommendation 6.
The development of the governing documents for the Lead Center mode of program management should be expedited. Particular attention should be given to assure that the resulting documents establish clear and unambiguous definitions of the scope of responsibilities and authorities of all levels of management within a program. Provisions should be incorporated to preclude the possibility of micromanagement. Acknowledgment should be given to the importance of mutual respect and trust among the managers for the success of this (and any other) mode of management of complex programs.

Recommendation 7.
There should be a high level, internal, periodic review of the Lead Center management structure and its operations. This review should examine whether the concept is functioning as intended.

Recommendation 8.
Measures should be taken to assure that individuals ascending to positions of authority within the program are properly trained in the Lead Center philosophy so that deviations in management operations will not occur.

Downsizing

Recommendation 9.
NASA workforce downsizing should be preceded by successful reductions in work requirements to ensure that arbitrary employment targets do not adversely affect the safety of Space Shuttle and International Space Station operations. Field centers, especially the Kennedy Space Center, should be given latitude and flexibility in achieving scope of work reductions and revising targeted personnel levels as the work content changes.

Recommendation 10.
NASA should renew its appeal to OMB and the Congress to gain approval of an enhanced buyout provision of at least $50,000. The Congress is urged to consider the request favorably. Using the flexibility achieved through an attractive buyout package, NASA should be permitted to resume limited hiring of younger engineering and scientific personnel. An enhanced buyout provision would be an important tool to help avoid a disruptive involuntary Reduction in Force (RIF) along with the distortions in skills and experience that will likely be a direct by-product of a RIF.

Recommendation 11.
NASA should seek legislative approval to combine its buyout authority, regardless of amount, with the phased retirement, *Partners in Education*, and *Partners in*

Technology provisions of the *Career Plus* program. This approach will enhance the attractiveness of any buyout package and keep available for part-time work some of NASA's most knowledgeable employees during this period of intense activity and transition.

Recommendation 12.
The institutional and functional role of the Kennedy Space Center in the post-2000 period should be defined, and a personnel strategy for KSC and the SFOC contractor that is appropriate to that role should be devised. A prompt decision on this issue will also be of considerable value to USA as it implements the terms of the SFOC.

Recommendation 13.
NASA should continue to develop alternative employment opportunities, such as those associated with Space Shuttle upgrades and ISS integration, for KSC employees who otherwise would leave to avoid a RIF or who would be involuntarily separated through a RIF.

Space Flight Operations Contract

Recommendation 14.
Plans should be developed to assure that successor managers for both NASA and the SFOC contractor are nurtured in an environment that cultivates mutual respect and trust for one another typical of the excellent organization in place today.

Recommendation 15.
NASA should continue to monitor the transition to the SFOC to assure that all requirements are being met in an orderly way and that the safety of operations remains the prime consideration.

Recommendation 16.
Congress and NASA should provide a level of funding sufficient to assure a safe SFOC implementation.

Recommendation 17.
A periodic audit of the standards by which NASA monitors the safety performance of the SFOC contractor should be conducted by an independent group.

Recommendation 18.
NASA and USA must maintain an adequate focus on resolving current and future obsolescence and logistics support issues in order to avoid potential safety problems.

Manifest/Shuttle Upgrades

Recommendation 19.
The Space Shuttle program and the SFOC contractor should continue to emphasize safety first as a way of life and enforce the precedence of safety, manifest and cost in Space Shuttle operations.

Recommendation 20.
NASA and SFOC contractor managements should enforce the safety priority using good management judgment and, if possible, derive measures of processing and launch crew efficiency and fatigue as they affect the safety of operations.

Recommendation 21.
Any decision to move to a higher launch rate (8 or 9 per year) should be delayed until more experience is gained with the new contractual setup and some of the ISS launch constraints have been resolved.

Recommendation 22.
NASA should ensure that all enhancements and upgrades are fully tested and assessed prior to implementation. Funding profiles and schedule pressures should not be allowed to shorten any critical testing or validation processes.

INTRODUCTION

BACKGROUND

The National Aeronautics and Space Administration (NASA) is being downsized as part of overall government efforts to reduce costs. Part of NASA's response to reduced budgets has been a restructuring of the Space Shuttle program and the transfer of much of its operational responsibility to a single prime contractor under the Space Flight Operations Contract (SFOC). At the same time, efforts on the International Space Station (ISS) are reaching critical milestones with the first element launch scheduled for little more than a year in the future.

The International Space Station assembly is scheduled to begin in December 1997 and with it the potential for an increase in the yearly number of Space Shuttle launches and required supporting operations. Nevertheless, the NASA Administrator has accepted the challenge of reducing the overall costs of operating the agency. Space Shuttle operations expenditures in recent years have been reduced by more than 30 percent through the efficient use of internal changes and elimination of overhead, but even these savings will not be enough in light of increasing demands on the Space Shuttle manifest and the reduction in available funding. As a result of recommendations by various external committees and internal reviews, the NASA Administrator elected to turn a major portion of the day-to-day Space Shuttle operations over to a private contractor through the implementation of a Space Flight Operations Contract.

On August 21,1995, NASA briefed the aerospace industry on a proposal to restructure existing Space Shuttle operations contract efforts under a single prime contractor. During September 1995, NASA evaluated submittals from four potential contractors. On November 7, 1995, the NASA Administrator stated that the agency would pursue an agreement with United Space Alliance (USA) to become the single prime contractor for Space Shuttle operations. Rockwell International's Space Operations Contract and Lockheed Martin's Shuttle Processing Contract were novated, thereby establishing USA as the "single prime contractor" and allowing for an early start of operations. On September 30, 1996, USA and NASA signed a final contract designating USA as the single prime contractor for Space Shuttle operations. Under the SFOC, USA has responsibility for the day-to-day Orbiter, pre-launch, flight and ground operations and logistics support. NASA will continue to have the final launch "go/no-go" decision and ultimate responsibility for Space Shuttle safety.

The SFOC initiates a new era in the management of the Space Shuttle program, one that fundamentally reshapes the government/contractor relationship and the responsibilities for Space Shuttle hardware acquisition, pre-launch processing, launch and landing operations and flight executions. The successful execution of the contract is pivotal to the continuation of America's space effort.

In light of the rapid changes taking place within the federal government and NASA in particular, the White House, through the Office of Science and Technology Policy, requested the NASA Administrator to charge the Aerospace Safety Advisory Panel (ASAP) with the responsibility to conduct a review of the

issues associated with the transition to the SFOC and the implications arising from a reduced budget and smaller work force. This is the Panel's report in response to the request structured in accordance with the Terms of Reference (Appendix A).

APPROACH

As listed in the Terms of Reference, the review was to focus on potentially significant safety impacts of the:

- Implementation plan for the transition of Shuttle program management to the Lead Center
- Transition plan for downsizing to anticipated workforce levels
- Implementation of a phased transition to a prime contractor for operations
- Planned safety and performance upgrades for Space Station assembly
- Maintenance of independent safety oversight
- Shuttle flight rate for Space Station assembly
- Communications among NASA Centers and Headquarters

The scope of the study was delimited to those areas associated with the Space Shuttle or its support of the assembly of the ISS.

To meet the stated objectives the Panel:

(1) Received briefings from the appropriate members of each organization affected by the transition to SFOC.

(2) Organized into five teams based on the seven items listed above from the Terms of Reference:

   a) Independence of Safety

   b) Lead Center/Communications

   c) Downsizing

   d) Space Flight Operations Contract

   e) Manifest/Shuttle Enhancements

(3) Conducted interviews and discussions with senior management of both NASA and its contractors

(4) Identified potential safety impacts and issues

(5) Formed consensus recommendations and offered other guidance as appropriate.

The balance of this report presents observations and recommendations organized by the focal areas detailed on the previous page. Each focus area is presented as a separate chapter with observations and recommendations; however, the recommendations have been numbered sequentially throughout the report. Appendix B contains a detailed list of the activities conducted in support of this review. This Appendix also identifies presenters and interviewees. Appendix C contains biographies of the ASAP members and consultants.

1

Maintenance of Independent Safety Oversight

The scope in the study *Terms of Reference* includes an examination of the potential safety impacts of the state of independent safety oversight after the planned consolidation of Space Shuttle operations under a single Space Flight Operations Contract (SFOC), downsizing of the Space Shuttle workforce and reductions in budgets. This was interpreted by the study team from the Panel as encompassing three related topics:

(1) the degree to which the Safety and Mission Assurance (S&MA) functions are organizationally independent of the line functions related to preparing and launching the Space Shuttles;

(2) the extent to which an independent reporting path for potential problems will exist after the transitions have been completed; and

(3) the degree of independent assessment provided for in the new organizational structure and operating plans.

Operations Before the SFOC

The issue of the independence of the safety and quality functions in aerospace has long been debated. On one side, there are those who argue that safety and quality can only be assured if the personnel performing these functions do not report to the "production" organization. The logic is that by placing S&MA in a staff role, it will be protected from at least the schedule pressures imposed on a line organization. It also has been reasoned that arranging for the performance reviews of S&MA staffs to take place outside of the operating program they are assessing removes a major impediment to critical appraisals.

On the other hand, it has been argued that the independence of the S&MA function is of less consequence than its prominence and importance within a program. Following this reasoning, if sufficient resources are allocated to S&MA, it is staffed with qualified and motivated people and the appropriate value is placed on safety by the program, organizational and reporting independence are not necessary.

With respect to the operation of the Space Shuttle, the *Report of the Presidential Commission on the Space Shuttle Challenger Accident* ("Rogers Commission") took a strong position in favor of the independence of S&MA within the Space Shuttle Program.[1] The Rogers Commission recommended:

> *NASA should establish an Office of Safety, Reliability and Quality Assurance* [now renamed the Office of Safety and Mission Assurance] *to be headed by an Associate Administrator, reporting directly to the NASA Administrator. It would have direct authority for safety, reliability and quality assurance throughout the agency. The office should be assigned the work force to ensure adequate oversight of its functions and should be independent of other NASA functional and program responsibilities.*[2]

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[1] *Report of the Presidential Commission on the Space Shuttle Challenger Accident, June 6, 1986, finding 2, page 161.*
[2] *Report to the President—Actions to Implement the Recommendations of the Presidential Commission on the Space Shuttle Challenger Accident, July 14,1986, Recommendation IV, page 20.*

NASA responded by forming such an office to deal with agency-wide S&MA policies and issues.

The NASA Office of Safety and Mission Assurance (OSMA) has played a role in all three aspects of independence described above for the Space Shuttle program. Through policy-setting, it has established that NASA S&MA personnel at the Centers and Headquarters report to the Lead Center Director, Center Directors or Headquarters rather than to the Space Shuttle program. The very existence of the Headquarters S&MA office as well as the operation of the NASA Safety Reporting System (NSRS) for which it is responsible provides an independent reporting path concerning safety problems for both NASA and contractor personnel. Finally, in exercising its responsibility for safety across the agency, OSMA has established independent assessment functions to provide additional surveillance of program activities.

Before the transitions which prompted the present study, NASA personnel were directly involved in all aspects of the operation of the Space Shuttle. NASA S&MA personnel involved with the Space Shuttle at the space flight centers—Kennedy Space Center (KSC), Johnson Space Center (JSC), Marshall Space Flight Center (MSFC) and Stennis Space Center (SSC)—were generally in organizations independent of the program reporting to their Center Directors and matrixed to the Space Shuttle program. This was not the case, however, with all of the major Space Shuttle contractors. In particular, the Shuttle Processing Contractor (SPC), Lockheed Martin, operated with an organizational structure which had their S&MA organization reporting directly to their operations program. Nevertheless, the prevailing management philosophy throughout the government and contractor communities was that anyone involved had the power to stop a Space Shuttle launch based on safety concerns.

To compensate for the lack of independence of S&MA within the SPC, the S&MA function of the overall Space Shuttle program had several other sources of safety independence inherent in the operational structure. Principal among these was the presence of a NASA employee in most of the critical engineering and technical operations. These NASA-badged people, whether on the program or S&MA staffs, worked as a team with their SPC counterparts. These intimate working relationships exposed both the NASA and SPC staffs to potential problems and issues. If the NASA and contractor personnel disagreed on a course of action, they had totally independent management paths through which to elevate the dispute. This arrangement appears to have worked well both because it provided independence and because of the differing views of Space Shuttle operations which could be adopted by NASA and the SPC. NASA personnel could take a longer-range, "big picture" view of any problem with full knowledge that the SPC was addressing the immediate issues related to any particular Space Shuttle processing flow and launch.

Transition to the SFOC

With the currently planned transition to an SFOC contractor and the downsizing of the NASA workforce, the S&MA posture will change somewhat. NASA personnel are being withdrawn from direct, "hands on" engineering, technician and

inspection duties on tasks deemed non-critical. The total responsibility for these tasks will be turned over to the SFOC contractor, United Space Alliance (USA). Inherent in this transfer of responsibility is an increased reliance on the contractor's S&MA function. NASA is moving from what it termed as *oversight* based on government mandatory inspections to a role it characterizes as *insight* which will be based more strongly on metrics and periodic surveillance activities than on direct, day-to-day involvement in the work of preparing and launching Space Shuttles.

The NASA approach will vary slightly across the space flight centers. In general, however, the plan is for the contractor, USA, to identify problems and characterize them as "in-family" or "out-of-family." Generally, when a situation has been seen and successfully resolved before or does not involve a critical safety function ("in-family"), the SFOC contractor will have complete authority to develop and execute corrective actions to return the Space Shuttle system to its NASA-generated specifications ("return to print") without NASA's concurrence. For initial occurrences of problems and critical safety issues ("out-of-family"), the SFOC contractor must bring NASA into the deliberation on the cause and corrective action, and NASA will retain approval authority for all specification and process changes.

At least initially, the SFOC contractor will operate its Space Shuttle processing activities with respect to S&MA in much the same way as the SPC but without the presence of a NASA team member for most operations. SFOC contractor safety and quality inspectors at KSC will continue to report to the vice president who is associate program manager for ground operations responsible for the successful processing of the vehicle, but they will typically not have a NASA counterpart with an independent reporting path. USA has, however, added a corporate level vice president responsible for Safety and Mission Assurance who reports directly ("hard line") to the USA president and is independent of the operational programs. This vice president will have a staff of approximately 20 people who will conduct safety and quality audits, help establish policies with respect to S&MA and handle incident and accident investigations. The purview of this corporate level S&MA group will be all of USA's activities which include Space Shuttle processing at KSC, engineering and mission operations at JSC and sustaining engineering at the current Rockwell International facility in Downey, California.

USA has established a special toll free telephone number which goes directly to its corporate S&MA office. This line can be used by anyone in the system for reporting problems or concerns. The USA operation at KSC also plans to add additional USA personnel on critical processing steps from which NASA involvement has been withdrawn. Currently, NASA intends to maintain a physical presence on the various work floors and at major contractor facilities even though NASA personnel may not be directly involved in specific work tasks. This presence is in addition to periodic audits undertaken as part of NASA's surveillance activities and the examination of metrics which will be developed and provided by the SFOC contractor.

NASA has also recently established an Independent Assessment (IA) group for the Space Shuttle at JSC which is part of an overall independent assessment function for the Human Exploration and Development of Space (HEDS) Enterprise. The

Space Shuttle IA activity will be similar in form and function to the International Space Station (ISS) IA activity which reports directly to the Associate Administrator-OSMA and has been providing an independent monitoring of International Space Station safety issues for some time.

Overall, the transition to an SFOC contractor will add at least one additional layer in the reporting hierarchy. For example, the SPC director of flight operations at KSC reported to a NASA counterpart at KSC who provided technical direction and was the designated Contracting Officer's Technical Representative (COTR). With the SFOC arrangement, the COTR will be at JSC and the former COTR at KSC becomes a Technical Management Representative (TMR). The role of TMR involves no official approval authority over technical issues. Thus, the TMR will have to work through the COTR at JSC to issue contract technical directives.

OBSERVATIONS

An overriding observation which must be considered in assessing the possible impact of any erosion in safety independence is the sincere and deep rooted desire of all concerned to maintain the safest possible Space Shuttle operation. This was clearly evidenced in all of the discussion sessions held and in the extent of the interest shown by NASA and contractor personnel in ensuring that the Panel was given access to all relevant materials and people. It is likely that any problems which may arise will be in spite of the good efforts of all concerned.

The transition to the Space Flight Operations Contract as well as plans for downsizing the NASA workforce and reorganizing NASA's program responsibilities (discussed elsewhere in terms of the Lead Center concept) may have little immediate impact on the processing of the Space Shuttle. From the contractor's perspective, the same personnel are at work but are simply employed by a new organization, e.g., USA as the SFOC contractor instead of Lockheed Martin as SPC. To be sure, there was a period of concern within the workforce fostered by great uncertainty about the fate of jobs and organizations. Now that the first phase of transition to the SFOC structure is largely complete, however, much of this organizationally based concern has dissipated.

From NASA's perspective, there should be sufficient personnel to accomplish on-site surveillance activities at the space flight centers and contractors for the next few years. If major additional staff reductions are imposed on NASA in fiscal years 1998 and 1999, however, the agency's ability to continue on-site surveillance may be compromised.

The change from the SPC to the SFOC contractor will yield no major difference in S&MA independence from the contractor's perspective. Simply, the SPC did not have an independent S&MA function and neither does USA under the SFOC. Also, the NASA Space Shuttle S&MA function, although removed from its day-to-day operational role, continues to report outside of the program as part of its surveillance and insight activities thereby maintaining independence within the NASA organizational structure.

Unfortunately, the activities of the contractor and NASA viewed separately are not a full picture of the issue of independent safety assessment of the Space Shuttle. From the perspective of the three independence issues discussed at the outset of this section, it can be observed that:

(1) Organizational independence has not changed significantly as a result of the ongoing changes. NASA still has an S&MA organization which is independent of its line operations, and the contractor (USA rather than the SPC) does not. While the status quo has been maintained in this regard, it was observed by several of those interviewed that an opportunity to improve the situation by increasing the independence of the contractor's S&MA was lost. The Panel concurs in this sentiment. However, changing the structure of the program again at this juncture might generate an additional disruption which would be counterproductive.

(2) The withdrawal of NASA personnel from day-to-day interfaces with their contractor counterparts will weaken a significant independent reporting path which is only partially replaced by NASA surveillance activities. Even though it is currently planned to retain a strong NASA presence on the work floor and in contractor facilities, some of the team aspect of the NASA/contractor relationship will surely be lost. This may reduce the likelihood of contractor personnel utilizing their NASA associates to elevate issues they are reluctant to raise to their own management. Also, given the long established working relationships of most of the current individuals in the NASA and contractor management positions, the extra layer of management imposed by the SFOC structure should not represent an impediment to accurate or timely reporting. A problem could arise, however, with any successors to the incumbents who may not have the same depth of working relationship upon which to rely.

(3) The independent assessment functions of both NASA and the contractor have been broadened. This will provide somewhat increased evaluation of processes and promulgation of lessons learned but is not intended as a total replacement for the NASA in-line S&MA activities which have been eliminated.

In the longer range outlook, independence may be further eroded through the loss of critical skills and experience among NASA personnel. The NASA approach to insight inherently imposes a requirement that NASA have decision-makers with direct experience in the operation of the Space Shuttle. These people are currently available from among the many engineers and quality assurance personnel who have worked directly on the Space Shuttle program. As time passes and the experienced people currently in the system retire or leave, their replacements may have had less opportunity to amass Space Shuttle experience. Even though their technical skills can be maintained through assignments to other research, technology and development efforts, the Panel is concerned that the absence of direct Space Shuttle operational experience will limit their ability to exercise true insight. In

light of this probable attrition in NASA's experience base, programs for skills retention and "apprenticeships" to develop an operational background with the Space Shuttle will become extremely important.

Given the new structure and the relationship between NASA and USA, the designated reporting channels between USA personnel and their NASA counterparts have become more cumbersome since all official actions must go through JSC. This may inhibit reporting outside of a person's own organization and, hence, reduce the independence of safety oversight. Initially, this may not be a problem because of the excellent established relationships between NASA and contractor personnel as a result of their previous teaming efforts.

Consideration of the issue of succession also leads to the general observation that NASA should not be misled by the apparent initial success of all of the transition efforts. Another major test of the robustness of the new approach will likely be faced after there is significant turnover among incumbents at all levels. It is therefore important to maintain an adequate level of independent assessment and surveillance even after it appears that the transitions have been smoothly accomplished.

RECOMMENDATIONS

The preceding observations support the conclusion that independent safety oversight may be threatened by the current changes but need not necessarily be severely compromised if the implications of the changes are understood and properly managed. The following recommendations are offered in order to maintain or improve the safety oversight function of the Space Shuttle program:

Recommendation 1.
NASA and USA should retain the present S&MA processes with respect to safety critical operations until surveillance results and the performance of USA as the SFOC contractor clearly indicate that safety controls, including the maintenance of realistic independent safety reporting channels, are well established. Thereafter, sufficient surveillance and independent assessment activities should remain so that any difficulties arising from subsequent personnel turnover can be identified.

Recommendation 2.
NASA should retain a physical presence on the work floor at the space flight centers and at all contractors performing safety critical operations. True insight into safety practices requires personal interfaces and assured access to work in process at all times. Periodic independent assessment activities, audits and analyses of metrics are not sufficient to provide the degree of independent safety oversight required to operate the Space Shuttle program at minimum risk levels in the absence of a NASA physical presence on the work floor.

Recommendation 3.
NASA should evolve its independent safety oversight efforts into a system in which it receives notification of ***all*** changes, anomalies and recertifications from the SFOC contractor. These notifications should carry the contractor's assessment

of whether they are in- or out-of-family. NASA should retain approval authority for the contractor's classification of the action. When NASA judges a change or anomaly to be critical, it should exercise final approval authority over the contractor's plans and activities. It is considered vital to the maintenance of independent safety oversight that NASA maintain the final judgment relative to the application of the definition of in- and out-of-family events.

Recommendation 4.
The long term maintenance of independent safety oversight will require NASA to develop and implement programs for critical skills retention and for the generation of direct Space Shuttle operating experience among NASA employees.

Recommendation 5.
NASA should continue its announced policy that "anyone involved can stop a Space Shuttle launch." Together with the NASA Safety Reporting System, this should help encourage people to employ the available independent reporting pathways.

2
Lead Center/Communications

In early February 1996, the management structure for the Space Shuttle program was changed to what is referred to as the "Lead Center" approach. This change elicited statements of concern because this structure had previously been identified as contributing to the Challenger accident. In what follows, the Lead Center structure is described. The performance of the Space Shuttle program under this management arrangement since its adoption, as well as the maintenance of communications among program components, will be assessed.

Definitions

Before addressing these subjects, it is important to define certain relevant Space Shuttle terms:

- SPACE SHUTTLE PROGRAM—The sum of all the parts of the Space Shuttle development and operating organization (that is, all the organizations and activities responsible for the *Projects and Elements* of the Space Shuttle).
- PROJECT—The activity and/or management organization of each of the major components comprising the Space Shuttle. These include: Space Shuttle Main Engine (SSME), Solid Rocket Booster (SRB), Reusable Solid Rocket Motor (RSRM), External Tank (ET), Orbiter, Extra-Vehicular Activity (EVA), Launch & Landing (L&L) and Logistics.
- ELEMENTS—The activities and/or organizations that provide operational or other support services for the program. They include: Johnson Space Center (JSC) Mission Operations Directorate (MOD), JSC Engineering Directorate, JSC Space and Life Sciences Directorate and the Stennis Space Center (SSC).

Lead Center Concept and History

The essence of the Lead Center type management is the delegation to a single NASA field center of the overall program management authority for an activity that involves the participation of other NASA field centers. The concept is not new to NASA. NASA's predecessor, the National Advisory Committee for Aeronautics (NACA), managed the research airplane programs in a similar manner. For example, the X-15 program was managed by the Langley Research Center with inputs from the Ames and Lewis Research Centers, while its flight testing was the responsibility of the Dryden Flight Research Center (formerly the High Speed Flight Test Center). More recent examples in the NASA era would include the Lunar Orbiter and Viking programs. Both were managed by Langley with Lewis managing the launch vehicles (Atlas-Agena and Titan-Centaur, respectively) and the Jet Propulsion Laboratory operating the Deep Space Tracking Network. In both cases, the management responsibilities and authorities of the participating organizations were rigorously detailed in a Program Development Plan written in accordance with a NASA Management Instruction (NMI) concerning program management.

A key element of the plans was that the responsibility and authority for executing a field center's role in the program was *delegated to the pertinent field center director* who, in turn, would assign the day-to-day conduct of the effort to a senior member

of the field center's staff. In the case of the Lead Center, its director appointed the "project manager" (the equivalent of the current program manager). In like manner, the other center directors would appoint system managers who reported to the project manager on program and system matters. The center directors, both lead and participating, exercised technical and managerial oversight of the performance of their appointees.

The chain of command was quite clear—from system managers to project manager to a Headquarters program manager to the program Associate Administrator (AA). The program manager, in concert with the program AA, set the goals, resource allocations and major schedule milestones and acted as the advocate for the program. If a disagreement arose among system managers or between a system manager and the project manager, the issue was appealed to the field center directors involved. If agreement could not be reached at that level, the issue was escalated to the program manager and/or program AA. Such appeals were extremely rare.

The Apollo Program was, however, not managed in the Lead Center mode. There were sound reasons for this. First and foremost, no single NASA field center was ready to handle so large a responsibility. The nascent NASA was in the process of building new field centers to handle manned space programs, and it was concerned about overwhelming any one field center with too great a workload. Accordingly, a large management and engineering team was assembled at NASA Headquarters, and narrower responsibilities were assigned to the three new field centers involved in the undertaking: the Manned Spacecraft Center (later renamed the Johnson Space Center) was assigned responsibility for the Apollo Command Module and Lunar Excursion Module; Marshall Space Flight Center (MSFC) was assigned the launch vehicle development (Saturn); and Kennedy Space Center (KSC) was assigned launch operations responsibility.

In addition, because the fledgling organizations were perceived to lack systems engineering capability and experience, Bellcom was created and placed under contract to NASA Headquarters to provide this function for the Apollo program. This managerial arrangement worked very well and has frequently been recommended as a model for subsequent programs of such magnitude. However, this system was costly and employed a large number of people. Apollo also enjoyed a presidential mandate "...before this decade is out, of landing a man on the Moon and returning him safely to Earth..." so costs and staffing were secondary considerations. After completion of Apollo and its follow-on program, Skylab, congressional and internal NASA pressures were applied to reduce the size of the agency, particularly NASA Headquarters, and reduce the cost of managing major programs. In the decade it took to complete Apollo, the three manned space flight centers had been built and staffed and gained experience such that NASA had developed an in-house systems engineering capability of its own. For these reasons, the Bellcom contract was terminated. This was the situation in NASA on the eve of the Space Shuttle undertaking.

The Space Shuttle program possessed features parallel to those of Apollo: a spacecraft, a launch system and a launch operations site. Thus, it would have been

logical to employ a management scheme similar to that adopted for Apollo. However, NASA decided against this approach and adopted a Lead Center form of management with JSC as the Lead Center. JSC was selected primarily for two reasons: (1) it had developed during the Apollo/Skylab era the people and wherewithal to conduct and manage complex spacecraft operations; and (2) its staff contained a nucleus of aircraft flight research engineers from the former NACA Centers and from industry. The latter was important as the Space Shuttle is an aircraft as well as a spacecraft.

The management arrangement that was adopted for the Space Shuttle development is described in NMI 8020.18A, *Space Shuttle Program Management*, dated July 12, 1971. This arrangement was essentially that which was in effect throughout the development period from 1972 to 1983 except that in 1978 the position of program director at Headquarters was abolished and the duties assumed by the Associate Administrator for Space Flight.

The same individuals occupied the key managerial positions throughout most of the development period. They worked well together, knew and respected each other's capabilities, and followed prescribed lines of authority. This situation was to change dramatically after the first few development flights were completed. Changes occurred in the key managerial positions at Headquarters and at the field centers. Communication channels that previously had provided timely exchanges of important information were no longer utilized as effectively. In a sense, the system went underground and pertinent information that should have been passed along was withheld for fear of how it might be used.

This state of affairs would prove to be a significant factor in events that led to the Challenger accident. In fact, it was the concern that this counterproductive situation would continue that prompted a return to the Apollo-type management structure after the Challenger accident. This change did not relieve all anxiety because of the continued rapid successions of Associate Administrators of the Office of Space Flight (AA-OSF) and program managers in Headquarters and the field centers. Subsequent policy changes recognizing the need for stability of organization and implementing personnel led to the recent re-establishment of the Lead Center style of management for all NASA programs.

Former Space Shuttle Organization

Prior to February 1996, when the change to the Lead Center management approach was adopted, the management of the Space Shuttle program was centered in NASA Headquarters (NASA-HQS) under the AA-OSF. This office is responsible for the Human Exploration and Development of Space (HEDS) Enterprise which contains both the Space Shuttle and International Space Station (ISS) programs.

In accordance with NMI 7120.4, *Management of Major System Programs and Projects*, dated November 8, 1993, the AA-OSF designated a Deputy AA as program director of the Space Shuttle program. This required a significant number of both technical and business staff members to be located at NASA-HQS. The Space Shuttle program manager and a deputy program manager were resident at JSC and

KSC, respectively, but "badged" to NASA-HQS. That is, they were Headquarters employees reporting to the program director. They were, in fact, tenants at the field centers, the latter being designated "Host Field Installations." These program managers were subject to detailed day-to-day direction and oversight from the program director, and major decisions were the purview of the Deputy AA/program director.

The field centers involved were required to "support" these managers with personnel, institutional and technical resources. But, the field center directors had no authority over how these resources were employed other than the appointment of the project managers in consultation with the program manager and program director. The field center directors were, effectively, "out-of-the-loop" in the management of a program and its project(s) located at their centers although they were responsible for "oversight" of the performance of the personnel assigned to the projects as well as the overall management of their centers.

The various project managers of the Space Shuttle program located at the field centers noted above and the staffs of the project offices and any support they drew from field center organizations, reported their Space Shuttle activities directly to the Space Shuttle program manager. The performance evaluations of the project managers were, however, the responsibility of the pertinent field center director or a designee.

It may be concluded that the implementation of the Space Shuttle program under the management structure described above contained some incongruities that could result in uncertainties and irritations among the major players. In most corporate organizational structures, corporate headquarters sets policy, defines objectives and allocates resources. Implementation of programs is assigned to an operating division whose leader is given full responsibility and authority to accomplish the program. If the assigned operating division needs an assist from another division, the lead division (with corporate approval) negotiates a "contract" with the other division for a discrete task and gives them full authority and responsibility to accomplish the assignment. Such clean lines of authority and responsibility avoid the pitfalls that were present in this former Space Shuttle management structure.

Current Organization

The management of the total Space Shuttle program is now distributed among NASA Headquarters and four field centers. JSC has been designated the Lead Center. In addition to its role as the program management center, it provides project management for the Orbiter. It also provides element management for: mission operations (JSC-MOD), engineering (JSC Engineering Directorate), Extra Vehicular Activity and logistics.

MSFC provides project management for four major Space Shuttle components. These are organized into the Shuttle Projects Office which is composed of the SSME, SRB, RSRM and ET projects. The Shuttle Projects Office provides program integration of these activities and serves as a major single point of contact with the program office at JSC. The head of the Shuttle Projects Office is a member of the program office and, hence, a JSC employee located at MSFC.

KSC provides management of the launch and landing and of logistics. The Stennis Space Center provides management of the SSME test element.

As in the classic Lead Center arrangement, the several field center directors are in-line for the roles assigned to their organizations. They also participate in what might be called the "board of directors" for the program, the Lead Center Director's Program Management Council (PMC), comprising all the field center directors and the program manager. At PMC meetings, the status and progress of the Space Shuttle program are assessed, and major issues are discussed and resolved.

OBSERVATIONS

The Panel received presentations from HEDS officials and the AA of the Office of Safety and Mission Assurance at NASA Headquarters on the state of the Space Shuttle program and their views on the Lead Center organizational mode. To ascertain how the Lead Center structure was working, the field center directors involved in the Space Shuttle program, the program manager and the project managers and some of their deputies were interviewed. Also, documentation pertinent to the subject was reviewed. From these activities, the observations which follow were made.

The Lead Center management mode for the Space Shuttle is working very well under the leadership of the existing center directors and managers. To date, all the project and element managers appear generally satisfied with the arrangement and are active participants in it. Much of the satisfaction with the system of those involved at these levels and among their subordinates can be attributed to the fact that they have been working together on this program for over a decade and have come to know, respect and trust one another.

Formal communications among the centers are accomplished via the Lead Center Director's Program Management Council. Inter-center communications to develop and manage budgets, schedules and technical requirements are accomplished using both formal and informal means. The Safety and Mission Assurance organizations participate in all program forums. Among the formal program-level communications mechanisms are:

- The daily "Standup" meeting attended by project managers and program element managers in person or via a telephone conference call. Subjects discussed cover both technical and schedule issues.
- Daily Program Requirements Change Board (PRCB) telephone conferences chaired by the Manager, Launch Integration at which reports on vehicle processing status and issues are aired and changes required to configuration and other controlling documents are dispositioned by representatives of relevant program sites and contractors.
- Weekly PRCB meeting, a telephone conference call chaired by the program manager involving all program sites and contractors. This PRCB acts to consider and disposition proposals involving program budgets, schedules and technical changes.

In addition to these daily and weekly forums, there are monthly and quarterly reviews chaired by the program manager dealing with financial, technical and metrics issues. Some are conducted via telecon and others in person at venues that rotate among the centers.

Upward communications are effected via the NASA Management Council and the HEDS Management Council attended by all field center directors involved in the Space Shuttle program. In addition, for more timely communication, representatives of the NASA Headquarters staff offices participate in the daily "Standup" meeting as well as the PRCBs and the Lead Center Director's Program Management Council.

In summary, a multiplicity of formal communications channels exist and are used for transmitting information both upward and downward in the program. In addition, informal horizontal communications are encouraged keeping counterparts and other interacting individuals among the several organizations in daily contact about events and issues of mutual interest.

The field center directors involved are generally satisfied with their roles under the Lead Center mode. Their ability to quickly deploy their center's personnel and physical resources against emerging problems is especially appreciated as is the fact that they are now in-line in the program. Some of them, however, are concerned about the impact of the implementation of "full cost accounting" for all program activities. In particular, the concern is not about accounting for all the charges and hours used on the program (they do that now) but over the apparent need for budget re-programming before they can take any necessary actions.

Some of the managers expressed a concern about the possibility of the Lead Center receiving preferential budget allocations. It should be noted that those expressing concern observed that nothing of this nature has occurred to date—but they would still prefer to have a "neutral" party make the allocations.

Another concern was also raised about the degree of control that is to be exercised by the program manager over budget resources that have been allocated to a project or element. As it is currently understood, should a situation arise in which one of the managers determined that a shift of the funds within the allocation received was required, that manager would have to apply to the program manager for authorization to do so—despite the fact that it would require no additional funds. Although it would provide the program manager with immediate knowledge of what is going on, such a restriction of a manager's authority could be construed to reflect a lack of trust and might constitute an impediment to timely execution of a program.

As yet, those documents that are the formal mechanisms for establishing and describing the Lead Center mode of management have not been issued. It is understood that there are teams working on the development of such documents. Without these documents to specify the format and content required for delegations and inter-organizational agreements, it is not possible to have a common understanding of the "rules of the game." It would also be desirable to infuse these documents with counsel from senior individuals within the agency who have prior

experience in working under the Lead Center mode so that the documents can include provisions that will preclude problems that have been experienced in the past. This is of particular importance for matters like the scope of authority of all levels of managers which should be so defined as to avoid micro-management.

A matter of some concern among project and element managers is the impact of the Space Flight Operations Contract (SFOC) on the roles and responsibilities of the several projects. Although for many projects SFOC effects may not be felt for some time, there is an obvious need for near-term assessment of the issue so that provisions can be made to avoid potential pitfalls.

The managers of the projects and elements are, for the most part, long-term NASA employees. Many of them are approaching the age for voluntary retirement. Although in most cases this is at least five years in the future, it was agreed by those interviewed that it was not too soon to take steps to assure well-trained and suitably experienced replacements for the incumbents. This is vital for such a multi-faceted program which is expected to last for a decade or more.

RECOMMENDATIONS

Recommendation 6.
The development of the governing documents for the Lead Center mode of program management should be expedited. Particular attention should be given to assure that the resulting documents establish clear and unambiguous definitions of the scope of responsibilities and authorities of all levels of management within a program. Provisions should be incorporated to preclude the possibility of micro-management. Acknowledgment should be given to the importance of mutual respect and trust among the managers for the success of this (and any other) mode of management of complex programs.

Recommendation 7.
There should be a high level, internal, periodic review of the Lead Center management structure and its operations. This review should examine whether the concept is functioning as intended.

Recommendation 8.
Measures should be taken to assure that individuals ascending to positions of authority within the program are properly trained in the Lead Center philosophy so that deviations in management operations will not occur.

3
DOWNSIZING

NASA is approximately halfway through a planned reduction of 8,000 civil servants, cutting employment from 25,500 full time equivalent (FTE) employees in the early 1990s to 17,500 FTEs in fiscal year (FY) 2000. It is generally agreed that voluntary attrition will not achieve the full 4,000 reduction that remains, and that an involuntary Reduction in Force (RIF) will be needed, probably in FY 98/99. These lower personnel levels reflect the sharp budget reductions that have been projected for FY 00, reducing NASA's FY 96 budget of $13.8 billion to $11.6 billion plus inflation. Whether reductions of this magnitude will be sustained in the outyears remains to be seen.

Since FY 91, Johnson Space Center (JSC), Marshall Space Flight Center (MSFC), and Kennedy Space Center (KSC) have reduced their civil service employees by approximately 15 percent. In this same period, the Shuttle Processing Contractor (SPC) achieved a 30 percent cut (2,500 persons). Both NASA and the SPC relied heavily on buyout authority or incentivized layoffs to gain approximately one-half of their respective departures with normal attrition accounting for most of the rest. The SPC used involuntary layoffs to achieve 21 percent of its reduction. NASA did not use an involuntary RIF. Managers at JSC, MSFC, KSC, and United Space Alliance (USA) all stressed that these earlier cuts took care of the obvious or "easy" reductions.

At JSC, the civil service headcount is to decline an additional 602 FTEs (3,470 in FY 96 to 2,868 in FY 00). At MSFC, the reduction is projected to be 650 (3,138 in FY 96 to 2,488 in FY 00). At KSC, the reduction is projected to be 821 (2,266 in FY 96 to 1,445 in FY 00).[3]

Outyear personnel levels for USA are still being negotiated with NASA; however, the cuts will likely fall between 1,170 and 1,860 (9,400 today to 8,230, as proposed by USA, or 7,540, as proposed by NASA, in FY 00).[4]

These general totals do not reveal potential shortfalls in specific functional areas (e.g., Safety and Mission Assurance at KSC will lose 40 percent of its civil service employees and 100 percent of its contractor support personnel by FY 00) or the skills and experience mix among the remaining employees.

OBSERVATIONS

It is clear that the projected "downsizing" at NASA represents a significant management challenge and a potential safety concern as the agency shifts program management from Headquarters to field centers and implements the Space Flight Operations Contract (SFOC) for managing the Space Shuttle.

The downsizing plans raise four separate but closely related questions:

(1) Are the projected personnel levels in the FY 99/00 timeframe at NASA and the United Space Alliance (USA) acceptable in terms of maintaining safety?

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[3] *Estimates of current and projected personnel levels at the field centers fluctuate according to the source being used; it is impossible to find universal agreement among various sources on any given number. The numbers used here were provided by NASA Headquarters in the document NASA Workforce Streamlining Metrics, FY 1993 to FY 2000, as of July 6, 1996.*

[4] *These numbers exclude 1,365 personnel at Rockwell International, Downey, CA.*

(2) Do NASA and USA have the appropriate skills and experience mix to maintain acceptable safety levels during this period of downsizing?

(3) What management tools and incentives are needed to achieve the projected personnel levels during this period while still maintaining the requisite skills and experience mix?

(4) Will the downsizing process itself become a significant disruption and obstacle to successful Space Shuttle and International Space Station (ISS) operations?

Although JSC, MSFC and KSC will all be hard pressed to meet outyear personnel targets without an involuntary RIF and its attendant disruption, the circumstances that confront NASA management and employees at KSC are particularly difficult. Indeed, a top management representative at Headquarters and one at KSC separately and independently observed that the KSC downsizing situation was "the most difficult management challenge I've encountered in my 30-year career at NASA."

Johnson Space Center

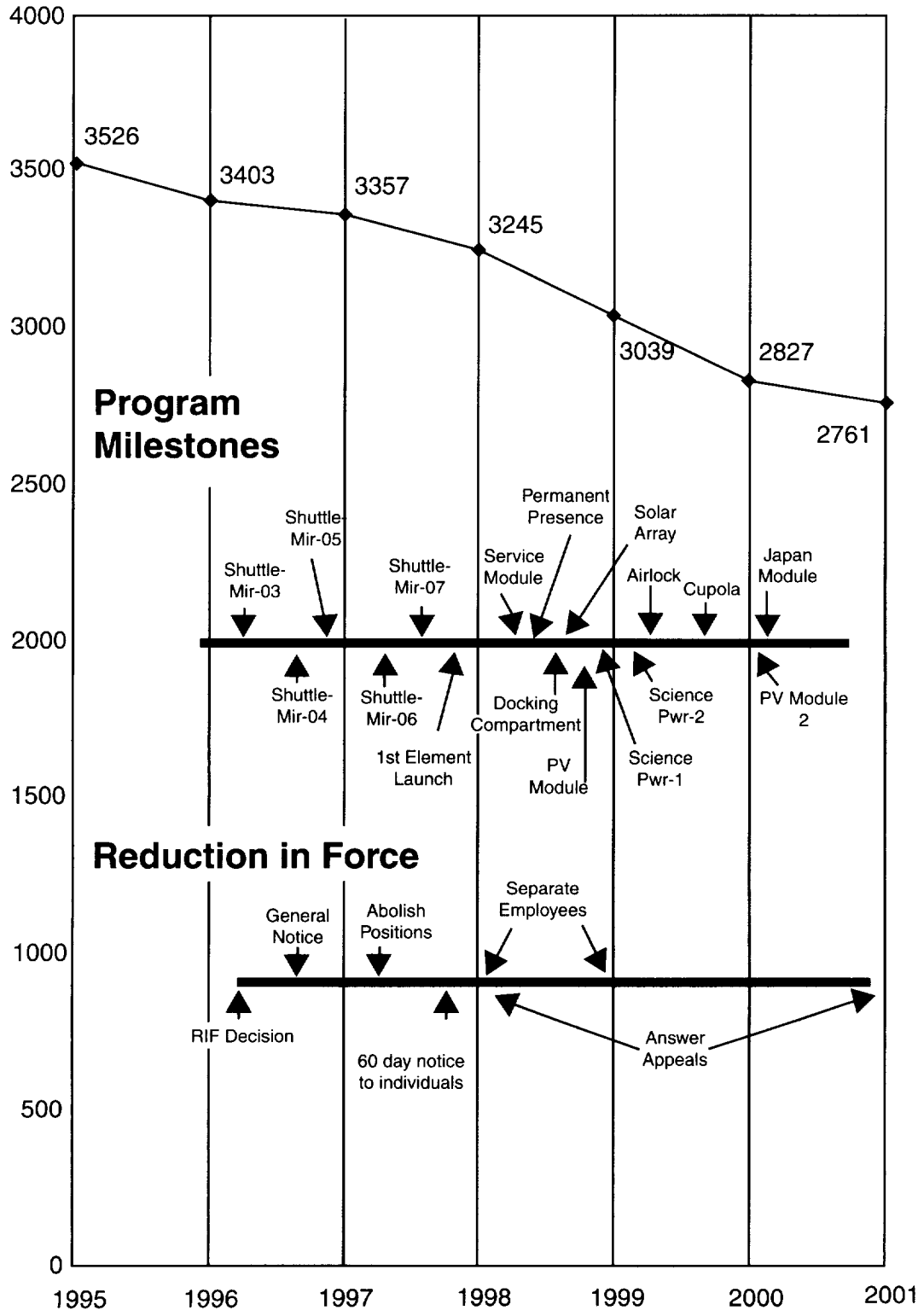
Aggressive use of the federal buyout package in FY 94/95 reduced center employment by 15 percent to approximately 3,350 employees today. Few key people were lost. No involuntary RIFs were needed. However, voluntary attrition today is extremely low, and there is little expectation that remaining cuts can be achieved without a RIF in FY 98/99. The current hiring freeze has all but stopped intake of new employees: 10 critical hires last year, about one dozen co-op students, and a new class of astronauts. If, as JSC management believes, a RIF will be needed to reach the 602 additional reductions by FY 00, it is reasonable to assume that younger engineers in greater numbers will begin looking for and accepting non-NASA employment as soon as the RIF process starts. In time, this will more than likely lead to an undesirable mix of skills and experience in the JSC workforce.

Figure 3-1, *JSC Workforce vs. Program & RIF Milestones*, illustrates the conjunction among JSC's reduced personnel levels, program milestones, and the effective dates of civil service RIF procedures. RIF'ed employees will leave JSC during the period of intense activity associated with preparations for launch of the initial ISS elements. Moreover, RIF procedures are highly disruptive to the majority of the workforce, even to those not likely to be RIF'ed. Morale is bound to suffer.

Expiration of the buyout authority last year caused JSC management to devise innovative voluntary, non-monetary incentives to encourage departures among retirement-eligible employees. Called *Career Plus*, these incentives consist of the following:

- *Trial Retirement*. Participants "try out" retirement for 12-18 months. JSC will rehire them if retirement does not work out.
- *Phased Retirement*. Participants retire and are rehired to perform JSC work on a part-time basis not to exceed 1,020 hours per year for up to 2 years.

Figure 3-1
JSC Workforce vs. Program and RIF Milestones



"Presented during Downsizing Team discussions with Harvey L. Hartman and Greg Hayes at Johnson Space Center, August 8, 1996"

- *Partners in Education*. Helps employees transition to teaching positions at educational institutions. Participants retire and are hired to teach in high schools, community colleges, or universities.
- *Partners in Technology*. Helps retirees transfer NASA technology to the private sector and enables them to use the services of a technology incubator to develop and market the technology.

These non-monetary incentive packages are designed to make retirement more attractive by providing a phased transition to new careers or by reducing the personal risk if retirement is unsatisfactory. In place for less than a year at JSC, *Career Plus* has produced an estimated 16 *Trial Retirements*, 8 *Phased Retirements* and no retirements under the education or technology options. Fifty other JSC employees are considering the *Career Plus* option.

Career Plus, taken alone, will not make it possible to avoid a RIF in FY 98/99. However, if *Career Plus* were to be linked with the current buyout package (an action that will require legislative approval of the linkage), a RIF could more than likely be avoided. In addition, JSC, as a development center, has a wider range of employment options to offer younger employees whose slots are eliminated, especially if a combined buyout/career incentive package opens up advancement opportunities for mid-career employees.

It appears likely that JSC can achieve its projected employment levels and avoid serious disruption to its civil service workforce through an involuntary RIF if the buyout package which has recently been made available is linked to *Career Plus* options. At this point, JSC management has not identified any functional areas likely to suffer critical losses by FY 00 if the further reductions can be managed positively through a buyout and associated initiatives. To avoid a growing disparity of skills and experience in the post 2000 period, authority for selective hires needs to be restored in conjunction with the current buyout.

Marshall Space Flight Center

Marshall Space Flight Center faces a situation very similar to its sister development center, JSC. Approximately 700 employees (15 percent) have already been reduced since 1991. The buyouts in FY 94 /95 accounted for more than 500 of these departures. Currently, more than 800 employees are eligible for retirement, but voluntary attrition and interest in *Career Plus*-type plans have been very low as employees waited for the present buyout program to be approved.

At present, the workforce is well balanced in terms of skills and experience. A "new skills handbook" has been prepared that identifies in detail 240 "skill categories" that will be needed at the targeted employment levels to carry out MSFC's responsibilities. If the current buyout package proves attractive, management believes a balanced workforce can be maintained at the targeted levels, and all planned responsibilities can be carried out without any compromise to safety.

The percentage of Science and Engineering (S&E) personnel at MSFC is scheduled to increase. A new highly automated EdTech center has been opened to provide cross-training in key disciplines. Mentoring relationships with younger employees are being encouraged. There is a positive and proactive program to prepare MSFC for the lower employment levels that are projected.

This year, 10 co-op students were converted to MSFC employees. Otherwise there have been no new hires. Management believes limited hiring authority will be needed to sustain a well balanced workforce in the post-2000 period.

MSFC should be able to reshape its workforce to carry out its programmatic responsibilities and maintain acceptable safety levels if the buyout provision is well received by employees. There presently are more retirement eligible employees at MSFC than the projected number of additional reductions needed. However, if an involuntary RIF is needed in FY98/99, it will more than likely produce an unsatisfactory mix of skills and experience along with the expected human problems. Limited authority for new hires should be authorized in order to sustain an orderly influx of younger talent in the post-2000 period.

Kennedy Space Center

KSC is presently being called on to reduce its workforce by 821 FTEs by FY 00. In addition to this relatively large net reduction, KSC faces several problems that make it harder to manage the projected cuts in a positive way:

- As an "operations" center, KSC has fewer job categories and positions into which employees can be moved if their current job is eliminated.
- Many of KSC's traditional occupations are changing or being eliminated under the Space Flight Operations Contract.
- KSC's institutional future in the post FY 00 period is not clear, making it nearly impossible to devise a coherent personnel strategy for either civil service or SFOC contractor employees.
- KSC is the last stop before deployment of the ISS, and problems are likely to accumulate there during launch preparations.

In view of these problems, KSC management faces a dilemma. On the one hand, if a RIF were certain in FY 98/99, it would make more sense to get it over as quickly as possible in order to avoid the additional disruptions that will take place during the intense period of initial launches associated with the ISS. On the other hand, the NASA Administrator has pointed out that it would not be fair to put employees through the trials of the RIF process in order to achieve staffing levels based on projections that are not hard and fast.

Further complicating KSC's situation, as noted above, is the transition of responsibilities from NASA to the SFOC contractor in a host of areas. NASA's skilled and experienced workforce is currently needed to accomplish this transition successfully while maintaining safety. As jobs for these people are eliminated or transferred

to the contractor, it would be desirable to shift the NASA employees, especially engineers, into new assignments. Yet, there are few such opportunities at KSC. To help address this problem, the center directors at KSC and JSC are collaborating in shifting development work associated with Space Shuttle upgrades to KSC. In addition, JSC has organized teams of KSC personnel to work with manufacturers of ISS hardware to help ensure its suitability for subsequent processing at KSC.

Unlike JSC and MSFC, the current buyout, by itself, will not resolve these interwoven problems at KSC. The scope of the cuts are sufficiently large, coupled with the center's continuing responsibilities in the transition to the SFOC, that while a buyout will likely reduce the loss of younger employees, it will also accelerate the departure of senior employees who are needed in this transition period. An imbalance of skills and experience will likely result. However, an involuntary RIF will make these problems even more difficult to resolve. The buyout is a necessary, but not sufficient answer to KSC's downsizing problems.

As KSC's center director recently pointed out in a memorandum regarding his outyear civil service ceilings, an involuntary RIF of 547 people will be required on October 1, 1998, to reach 1,445 FTEs, KSC's current outyear target. A reduction of this magnitude will halt further work by KSC on Space Shuttle upgrades and launch processing system modernization among a number of other impacts.[5] In the same memorandum, the center director also pointed out that:

- *After FY 98, KSC's core engineering skills, technical expertise and development capabilities in mechanical, automation, and checkout/control and data communications systems are seriously eroded.*
- *Insight into institutional contractor S&MA activities is not sustainable.*

This erosion of KSC's skills and experience mix is already evident. During FY 96, KSC has separated 95 persons; 68 were from Science and Engineering (S&E), the largest loss of any occupational category. Moreover, 26 persons came from Space Shuttle processing (the largest loss by organization) and 10 from Safety and Mission Assurance. Of the 95 separations, 36 were persons in the 21-30 age range (the largest loss by age group) and 25 in the 31-40 age group. Figure 3-2, *Shuttle Processing—Current Age Distribution*, illustrates for Space Shuttle processing the concentration of engineering losses in the 27-36 age range, persons who would normally assume major responsibilities by FY 00 and beyond. Figure 3-3, *Center Losses by Skill Group*, illustrates a similar trend in earlier fiscal years, with S&E absorbing the largest percentage losses at KSC. These S&E losses are not being replaced with new engineering talent due to the hiring freeze that has been in effect. Figure 3-4, *Shuttle Processing—Engineering Co-op Conversions*, illustrates that KSC's strong record of converting engineering co-op students into NASA employees ceased in FY 96 with zero hires (compared, for example, with 16 hires in FY 93).

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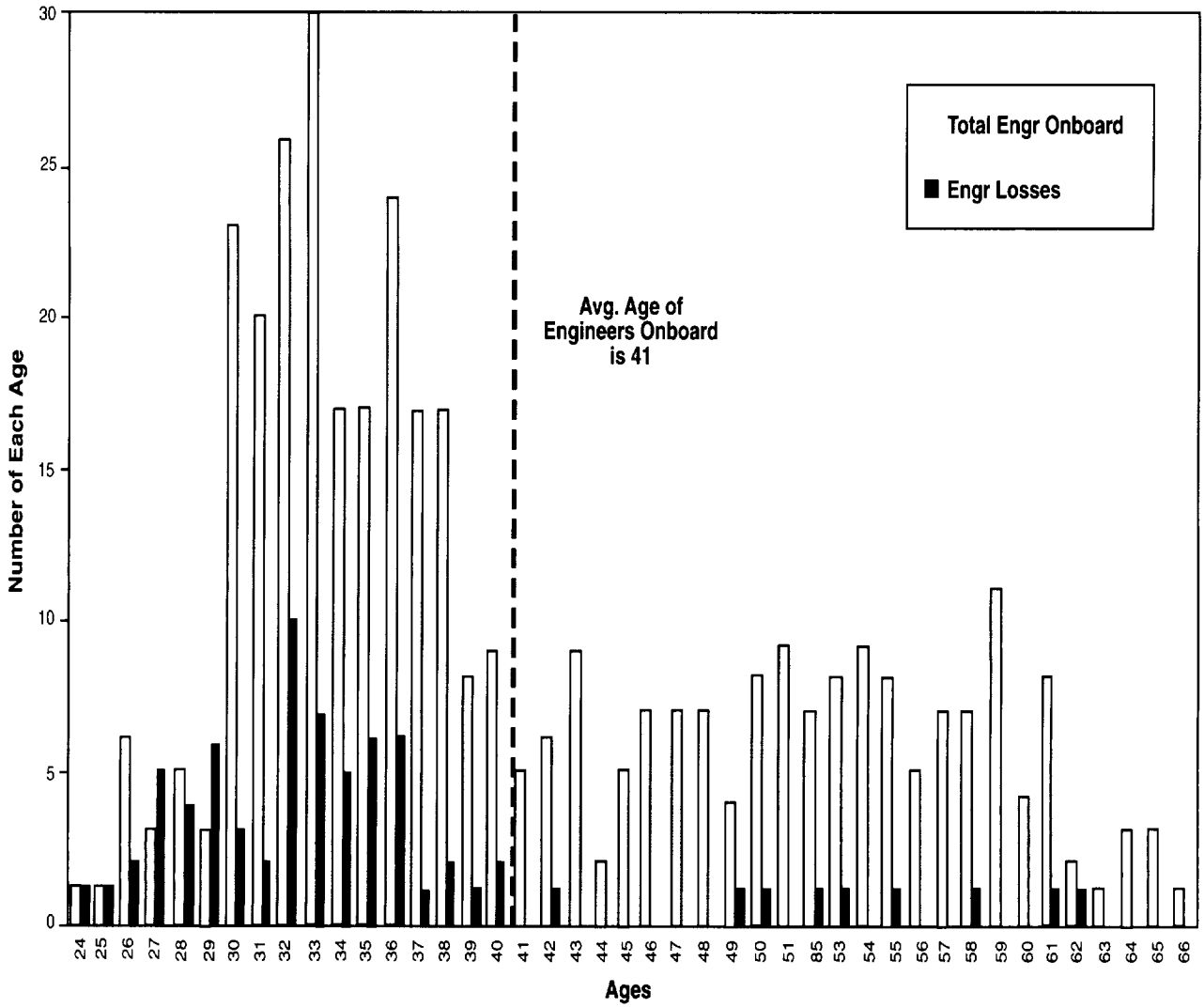
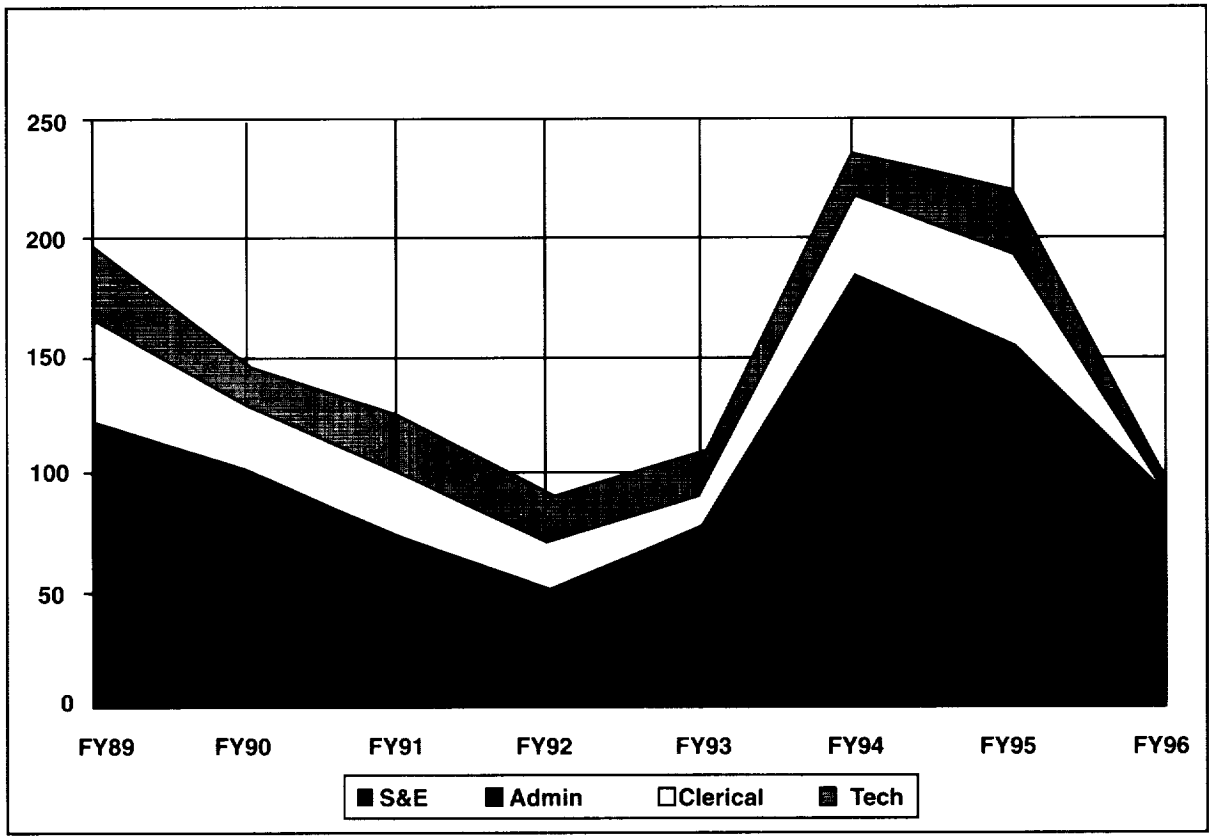
[5] *Honeycutt, Jay F. Memorandum to NASA Headquarters (Attn: M-1/Deputy Associate Administrator for Space Flight) dated August 7, 1996.*

Figure 3-2
Shuttle Processing (PH)—Current Age Distribution



"Presented during Downsizing Team discussions with Kennedy Space Center management, August 20, 1996"

Figure 3-3
Center Losses by Skill Group

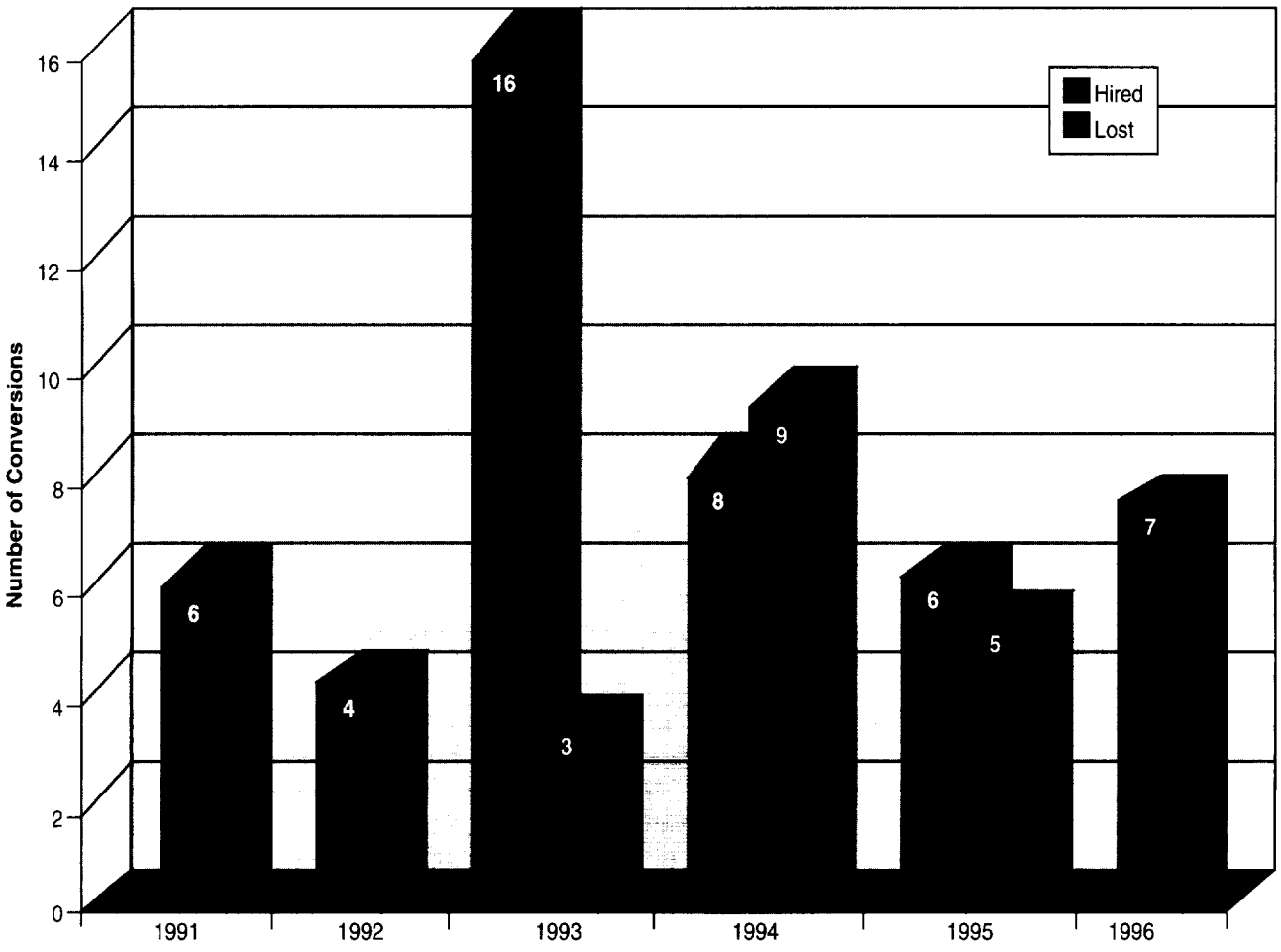


	FY89	FY90	FY91	FY92	FY93	FY94	FY95	FY96
S&E	43%	55%	52%	42%	61%	49%	50%	72%
Admin	19%	13%	6%	10%	8%	29%	20%	20%
Clerical	23%	20%	21%	24%	13%	14%	17%	4%
Tech	15%	12%	20%	24%	17%	8%	13%	4%
Tot. Losses	196	147	124	92	109	237	221	95
% of Pop.	8%	6%	5%	4%	4%	10%	10%	4%
Tot. Pop.*	2436	2466	2571	2548	2498	2352	2168	2126

*KSC full-time permanent employees

"Presented during Downsizing Team discussions with Kennedy Space Center management, August 20, 1996"

Figure 3-4
Shuttle Processing—Engineering Co-op Conversions



"Presented during Downsizing Team discussions with Kennedy Space Center management, August 20, 1996"

The root cause of KSC's dilemma can be traced to the earlier planned strategy, now abandoned, to transform the center to a Government Owned/Contractor Operated (GOCO) type operation. As KSC's center director pointed out in the same August 7, 1996, memorandum referenced earlier:

> *The Zero Base Review assumed that the Center would transition to a "GOCO-like" operation and the resulting Center operations FTE requirement was based on that assumption. Although that assumption was abandoned and the need for increased Shuttle and Space Station resources was recognized, the FTE reduction in Center Support has not changed.*

Not surprisingly, the resulting impact erodes KSC's institutional capability to sustain skills and expertise needed to provide meaningful "insight" into the operations of the SFOC and maintain key facilities and facility systems.

The important questions that remain unanswered are: *What is KSC's institutional future? How much responsibility will NASA civil servants have in the future?* As a GOCO, this responsibility would be minimal and the present personnel targets could be accommodated. But, if KSC is expected to provide continuing "insight" into the operations of the SFOC contractor, participate in Space Shuttle upgrades and ISS preparations as well as sustain KSC's institutional technical resources, it must maintain a skilled and experienced civil service workforce. Under present circumstances, this will be virtually impossible to accomplish given the magnitude of future cuts and the difficulty of maintaining needed skills and experience with these reduced numbers.

The coming crisis in downsizing KSC is generally recognized. Given the severe budgetary constraints facing NASA in FY 00 and beyond, positive action to resolve the problem has not occurred. Thus, NASA finds itself in the posture of going along with the situation in the short run (FY 97/98) in full knowledge that such action may worsen the severity of the actions that will be needed in FY 98/99, the period of initial ISS launches.

In response to the KSC center director's memorandum of August 7, 1996, the Associate Administrator for Space Flight wrote that :

> *We will focus on these out-years and adjust your FTE targets to meet appropriate safety requirements. Again, safety will not be compromised. I am committed to assuring that key positions will be fully staffed, now and in the future.*[6]

KSC faces a management challenge of major dimensions if it is to maintain a workforce of sufficient size, skills, and experience to achieve acceptable levels of safety in Space Shuttle and International Space Station operations. Until a decision is made regarding KSC's future in the post-2000 period, it is all but impossible to design a personnel strategy that will:

- Avoid serious disruptions during the period of intense launch activity associated with the ISS;

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[6] *Trafton, Wilbur C. Memorandum CD/Director, John F. Kennedy Space Center (KSC) dated September 5, 1996.*

- Work effectively with USA during the transition to the SFOC; and
- Retain a desirable mix of skills and experience.

Moreover, additional flexibility in current personnel ceilings, keyed to actual reductions in the scope of work being performed, will be needed in the post-2000 period in order to maintain adequate institutional technical resources.

Buyout Provisions

NASA top management had previously explored with the Office of Management and Budget (OMB) and the Congress an enhanced buyout provision that would have provided between 50 percent and 80 percent of current salary to NASA personnel who were eligible for retirement, but this version was rejected. Amounts of $50,000 and $35,000 were also explored and rejected. Instead, the earlier buyout incentive of $25,000 was renewed. The renewed buyout authority should provide some flexibility in sustaining an acceptable skills and experience mix. After taxes, this amounts to about $18,000 in take-home pay and, by itself, may not be sufficient to attract many employees who can earn a comparable amount of compensation in several months or less by continuing their employment.

It has been reported to the Panel that:

- A buyout provision that attracts voluntary retirements from among NASA's top civil service managers will save approximately $20,000 per person annually.
- Retirements from among employees of average grade level will produce no annual savings.
- By the time all personnel costs and staff time are added, an involuntary RIF will cost NASA approximately $40,000 for each person who is separated.
- In addition to the budgetary savings that flow from an attractive buyout along with the avoided costs of a RIF, the larger number of voluntary retirements will make it much easier to maintain a desirable skills mix and lower the median age of NASA employees. A new, younger NASA positioned to deal with post-2000 challenges will result. This must be compared to the likely result of an involuntary RIF that separates or drives away the same cadre of younger employees.

Linking the current buyout to three of the *Career Plus*-type options—*Phased Retirements*, *Partners in Education*, and *Partners in Technology*—will improve the attractiveness of the $25,000 amount as well as keeping experienced NASA employees available for part-time work. However, this combination will require a legislative change to permit persons who accept any buyout to have the opportunity to continue part-time NASA employment. This approach would provide NASA the flexibility needed to attempt to reach targeted personnel cuts during this period of intense activity and transition while maintaining an appropriate balance of skills and experience.

RECOMMENDATIONS

Recommendation 9.
NASA workforce downsizing should be preceded by successful reductions in work requirements to ensure that arbitrary employment targets do not adversely affect the safety of Space Shuttle and International Space Station operations. Field centers, especially the Kennedy Space Center, should be given latitude and flexibility in achieving scope of work reductions and revising targeted personnel levels as the work content changes.

Recommendation 10.
NASA should renew its appeal to OMB and the Congress to gain approval of an enhanced buyout provision of at least $50,000. The Congress is urged to consider the request favorably. Using the flexibility achieved through an attractive buyout package, NASA should be permitted to resume limited hiring of younger engineering and scientific personnel. An enhanced buyout provision would be an important tool to help avoid a disruptive involuntary Reduction in Force (RIF) along with the distortions in skills and experience that will likely be a direct by-product of a RIF.

Recommendation 11.
NASA should seek legislative approval to combine its buyout authority, regardless of amount, with the phased retirement, *Partners in Education*, and *Partners in Technology* provisions of the *Career Plus* program. This approach will enhance the attractiveness of any buyout package and keep available for part-time work some of NASA's most knowledgeable employees during this period of intense activity and transition.

Recommendation 12.
The institutional and functional role of the Kennedy Space Center in the post-2000 period should be defined, and a personnel strategy for KSC and the SFOC contractor that is appropriate to that role should be devised. A prompt decision on this issue will also be of considerable value to USA as it implements the terms of the SFOC.

Recommendation 13.
NASA should continue to develop alternative employment opportunities, such as those associated with Space Shuttle upgrades and ISS integration, for KSC employees who otherwise would leave to avoid a RIF or who would be involuntarily separated through a RIF.

4
Space Flight Operations Contract

In order to reduce costs through efficiencies believed to be inherent in the private sector and reorient NASA's focus from operations to research, development and technology, NASA has implemented a plan for privatizing space flight operations for the Space Shuttle. The first phase of that plan is a consolidation of a majority of Space Shuttle processing support contractors into a single Space Flight Operations Contract (SFOC) negotiated with United Space Alliance (USA). Concurrently, several of the Space Shuttle processing activities formerly performed by government employees are in the process of being assumed by USA. Because such changes are a major departure from all previous human space flight operations, there could well be safety implications.

A team of Aerospace Safety Advisory Panel members and consultants participated in briefings and conversations at NASA Headquarters, the Johnson Space Center (JSC), the Kennedy Space Center (KSC), the Marshall Space Flight Center (MSFC) and at the USA corporate headquarters. The team also benefited from discussions and shared memoranda with members of other Panel study teams; however, the principal effort was a careful review of the documentation available:

- Amendment 3 to the government Request for Proposal for the SFOC;
- Revision A (July 30, 1996) to the SFOC contractor's *Program Management Plan*; and
- The *Phase I SFOC Transition Plan* dated July 15, 1996.

The Panel has limited its concerns to safety wherever possible. Political and cost considerations as well as institutional impacts have not been addressed except as they may affect safety. Neither has the Panel addressed such non-safety issues as financial incentives or the degree of managerial autonomy and flexibility available to USA in order to achieve the challenging operational targets it has accepted. These are separate issues outside the scope of the present task.

Observations

Based upon the *Program Management Plan* and the personnel, organization and management philosophies of the United Space Alliance, the Space Flight Operations Contract appears to be a comprehensive and workable document espousing safety as paramount throughout.

Overall, the documentation reviewed reflects minimal adverse safety implications, especially in the short term. This is largely because the people currently in place are dedicated to making the new scheme work. There is some uncertainty about the future, however. Careful and continuous monitoring by top management and the safety organizations of both NASA and USA will be required to ensure continued safe operations as new people come on the scene, budget pressures continue to mount and the profit imperative increases on the part of the contractor.

Reiterating that nothing seen in the SFOC arrangement is immediately threatening to safety, and recognizing that the contract is in place and operating, the Panel nevertheless offers the following observations:

- At this early stage of the SFOC, relations between NASA and USA appear to be excellent, primarily due to the mutual faith, trust and integrity of the people involved. While excellent now, over time these relationships could deteriorate unless an adequate succession plan is developed and implemented. The present key management personnel have known and worked together for many years. However, inevitably, these people will eventually be replaced by others. It behooves both organizations to assure that successors to the current incumbents are thoroughly acquainted with the intricacies of the system and the people involved.

- While the plans for transition appear orderly, the actual transition should be carefully monitored for unexpected developments, especially in the latter stages. When these occur, flexible interpretations of the contract provisions may be essential to resolve such conflicts in implementation while maintaining the intent of the SFOC agreement.

- Diminishment of funding could derail an otherwise well planned SFOC implementation. This could wreak hardships on people and foster an over confident or "workaround" attitude, either of which could have serious safety implications. While "safety" is a popular byword in the Space Shuttle program, dollar constraints may limit the ability to perform the tasks necessary to minimize risk. It is not evident how a situation such as this would be handled should it develop.

- NASA believes it has restructured its organization in a manner to permit adequate visibility into the SFOC contractor's operations. It is not clear that the government workforce remaining after the completion of NASA downsizing and reorganization will be sufficient to carry out insight responsibilities.

- The standards and metrics by which NASA will monitor the performance of the SFOC contractor are primarily determined by the contractor, although the government does retain approval authority over the type and scope of the metrics adopted. There is little independence in this arrangement.

- The USA Safety and Mission Assurance (S&MA) directors for ground and flight operations report directly (i.e., hard-line) to the associate program managers responsible for these activities, although they are free to communicate (i.e., dotted-line) to the USA Vice President for Safety and Mission Assurance, who in turn reports to the USA Chief Executive Officer. While this arrangement does not reflect completely independent reporting of S&MA, it has been deemed acceptable, at least for Phase 1 of the transition, and is consistent with the geographical dispersion of USA operations.

- Under the SFOC, the contractor has the responsibility for dealing with obsolescence and logistics support issues. These activities will demand increased attention as time passes and could lead to the need for additional funding. USA is silent on any plans to address this issue in a period of declining budgets. While it is likely that nothing can be done about it at this time, the situation should be closely monitored by NASA as transition proceeds into the latter phases.

RECOMMENDATIONS

Recommendation 14.
Plans should be developed to assure that successor managers for both NASA and the SFOC contractor are nurtured in an environment that cultivates mutual respect and trust for one another typical of the excellent organization in place today.

Recommendation 15.
NASA should continue to monitor the transition to the SFOC to assure that all requirements are being met in an orderly way and that the safety of operations remains the prime consideration.

Recommendation 16.
Congress and NASA should provide a level of funding sufficient to assure a safe SFOC implementation.

Recommendation 17.
A periodic audit of the standards by which NASA monitors the safety performance of the SFOC contractor should be conducted by an independent group.

Recommendation 18.
NASA and USA must maintain an adequate focus on resolving current and future obsolescence and logistics support issues in order to avoid potential safety problems.

5
MANIFEST/SHUTTLE UPGRADES

Assessment of the Manifest

The Space Shuttle flight manifest for the next six years is planned, at present, to be at a rate of seven flights per fiscal year, except for FY 99 and FY 00 which have eight flights each. A recommendation has been made through the Program Operating Plan process to continue beyond FY 00 at eight flights per year with an occasional surge to nine.

The manifest as of October 4, 1996, is shown in Figure 5-1, with a summary in Figure 5-2. These show that there were eight flights in FY 96. Of the 51 flights planned through FY 03, 33 are required for the International Space Station (ISS), five for the Shuttle-Mir program, and the remaining 13 available for other opportunities. While the planned schedule does not exceed the rate achieved in FY 96 and, thus, may be viewed as an extension of a flight rate already demonstrated, this schedule is, nevertheless, challenging. There are several reasons for this. Principally, delays in the baseline schedule are beginning to be experienced in delivery of Russian and, perhaps, U.S. hardware, and the assembly sequence is strongly constrained at each stage of the process by required functionalities of each succeeding ISS payload as shown in Figure 5-3. It is important to note that the first six U.S. launches, 1A through 6A, must be in the given sequence, and that flight 4A cannot be launched until the second Russian mission, 2R, is successfully completed. Further, each of the ISS missions is unique in the requirements it places on the crew and crew training so that the potential exists for the flight rate to be limited by the availability of training facilities and trained crews.

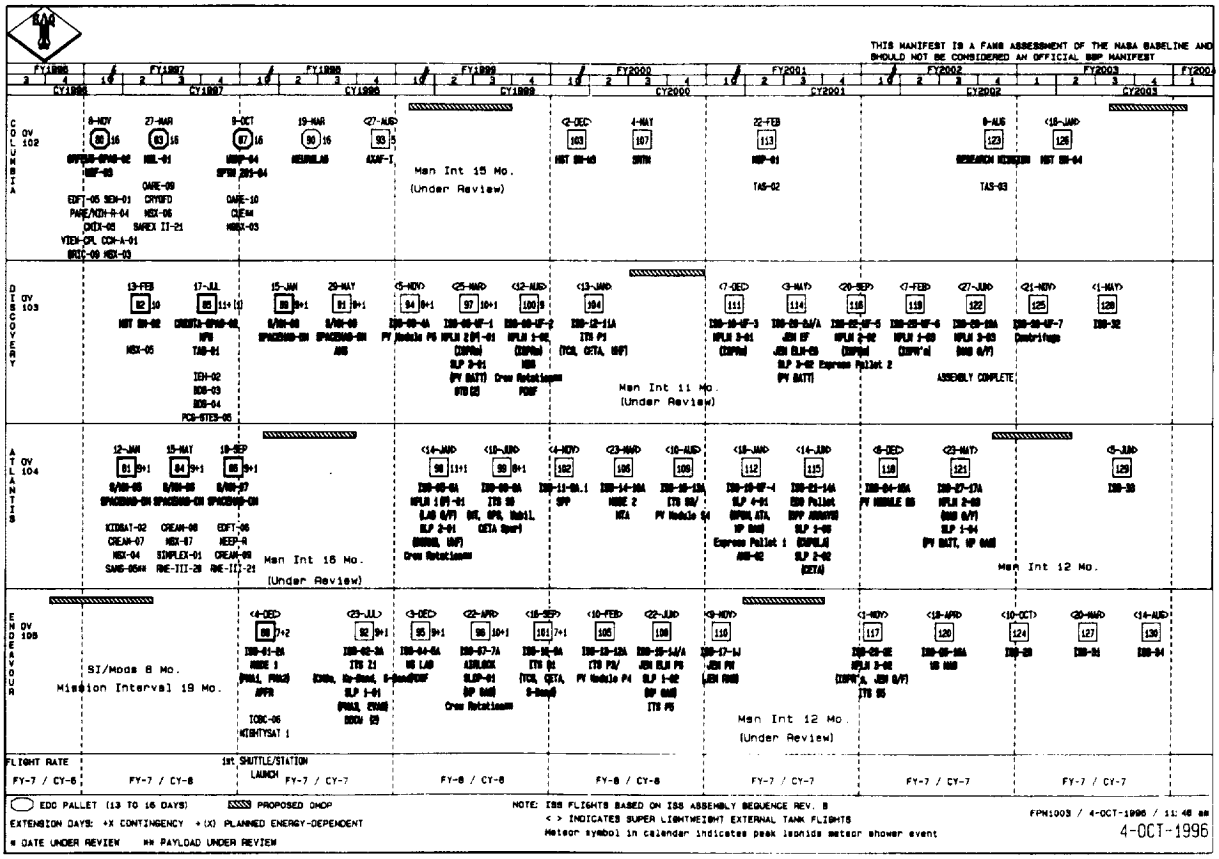
There is a concern that when launches slip there will be pressure to make up the lost time, and this will be reflected eventually in "spurts" to higher rates over periods of a few months. Because of limited personnel availability, such spurts will, of necessity, require considerable overtime with consequent fatigue and possible degradation of safety of operations.

The stated and often repeated order of priority for NASA launch operations is SAFETY, MANIFEST (i.e., schedule), and COST. The difficulty is that it is not clearly evident when striving to maintain efficient and timely operations infringes on safety. To the Panel's knowledge no effective, objective measures are available to assess this interaction.

These concerns exist even with the presently planned launch rates and levels of personnel. If an increased launch rate (e.g., 8 per year with surges to 9) is imposed, none of the contractor or NASA personnel interviewed believe that it can reasonably and safely be achieved with presently planned personnel levels. There is a belief that such a rate is feasible with increased resources; however, even more pressure would be put on training and training facilities.

All of these scenarios are predicated on no loss of availability of a Space Shuttle or Soyuz vehicle. The ISS program has recognized this and has initiated contingency planning for such loss of availability. Nearly all such contingencies result in major changes or delays to the Space Shuttle manifest and Russian launches. The Panel has not attempted to assess such major perturbations.

Figure 5-1
Flight Assignment Working Group Planning Manifest



"Supplied by Office of Space Flight, NASA Headquarters, October 5, 1996"

Figure 5-2
Space Shuttle Program

SPACE SHUTTLE MANIFEST AND SCHEDULE OFFICE

TOTAL FLIGHT RATE MANIFEST AND MARGINS

Presenter
MC/MICHELE BREKKE

Date
August 7, 1996

- **Present manifest commitments require 7 flights per year with an occasional surge to 8**
- The recommendation has been made, through the POP process, to continue flying 8 flights per year with a surge to 9* beginning FY01
- The added flights will be on OV-102 thru assembly complete (FY02)
  - The high rate of processing of OV-103, OV-104, and OV-105 makes it unlikely that another flight of any of these vehicles could be added

	FY97	FY98	FY99	FY00	FY01	FY02	FY03
POP 96 RECOMMEND (FAWG MANIFEST)	7 0/3/4	7 2/2/3	8 8/0/0	8 6/0/2	7 6/0/1	7 6/0/1	7 5/0/2

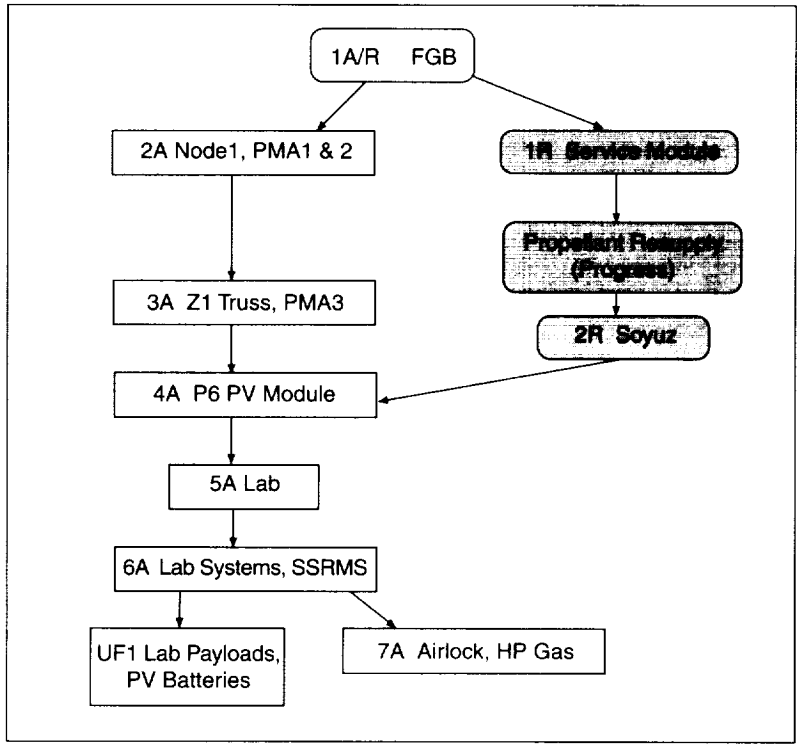
* Surge to 9 = 9 flights per year on alternating years

LEGEND:
TOTAL FLIGHTS IN FY
ISS / MIR / OTHER OPPORTUNITIES

Flightrate for lee.ppt

"Presented during discussions with Space Shuttle Program management, Johnson Space Center, August 7, 1996"

Figure 5-3
Phase 2 Assembly Sequence Dependency



"Presented during discussions with International Space Station management, Johnson Space Center, August 8, 1996"

The Influence of the Space Flight Operations Contract

The shift of operations to United Space Alliance (USA) is intended to be accomplished by transferring to the new organization a majority of the contractor personnel and equipment used in assembly and launch operations. Thus, it is initially intended that all operations will continue to be performed by the same personnel in the same facilities as in the past, only the organizational structure and, in some cases, the division of responsibilities between NASA and contractor, would change. Changes in such areas as procedures and numbers and skills mix of personnel are planned to evolve over a period of time in a controlled manner once processes are found to be stable and trackable.

To the extent that this is true, there should be no change initially and, specifically, no impact on the safety of operations. There are concerns about future personnel issues, such as aging of the workforce and replacing experienced people with newcomers, but these concerns are not unique to the SFOC and are equally applicable to the previous contractual arrangement. There is a worry that the emphasis in going to this new way of business is primarily on cost. This is a difficult influence to shake, and the structure of the incentive contract negotiated may turn out to motivate the contractor in directions unanticipated by either party and thereby compromise safety.

Shuttle Upgrades

Johnson Space Center (JSC) is the Lead Center for Space Shuttle performance enhancements and upgrades and is proceeding on the basis that vehicle/software/facility modifications are needed to support safe and cost effective Space Shuttle operations into the next century. The JSC Engineering Directorate is leading a Systems Engineering and Integration (SE&I) Team to identify and develop upgrades. Team members have been drawn from multiple organizations and field centers. This SE&I Team has now completed a comprehensive Space Shuttle review which identified 134 items for upgrade. Top priority has been given to 31 of these. JSC has defined a phased approach to upgrades which accommodates budget realities and ISS assembly commitments.

Presently, Space Shuttle upgrades can be grouped into the following main categories:

- *Category 1*—Current and ongoing funded upgrades which include both Space Shuttle performance enhancements and approved Space Shuttle safety upgrades.
- *Category 2*—Near-term candidate Space Shuttle upgrades.
- *Category 3*—Mid- to long-term Space Shuttle upgrades which include major system redesigns and concepts.

The ongoing performance improvements described in subsequent paragraphs are necessary to meet ISS assembly commitments. These upgrades capitalize on current technology to achieve safety and reliability benefits. The near term candidate upgrades address both those for safety, supportability or obsolescence and those which will reduce processing costs or increase effectiveness. The third category targets high value, major system upgrades requiring more extensive implementation, and possibly, high value upgrades to the vehicle configuration. For purposes of this report, only funded upgrades for ISS support and already planned safety upgrades were considered.

Ongoing Space Shuttle Performance Upgrades to Support ISS

The decision to place the ISS in an orbit inclined at 51.6 degrees rather than the originally planned orbital inclination of 28.4 degrees for Space Station Freedom results in a significant decrement in the payload capability for the current Space Shuttle configuration. Studies indicated that a significant increase in payload capability of the Space Shuttle was required if the number of launches was to be kept within reason and the constituent ISS assembly payload groupings were to be operationally sound. The Space Shuttle program, after further study, committed to a payload capability of 35,000 pounds into a 220 nautical mile, 51.6 degree inclined orbit which represented an increase of approximately 16,000 pounds of payload.

Achieving the payload increment required changes in hardware (weight), flight design (trajectory), and operational factors—all without reducing reliability and safety. In January 1994, a list of more than 50 candidate changes had been assembled and was carefully scrutinized. A much smaller list was derived after more

detailed evaluations that examined not only payload capability enhancement but also reliability, safety, cost, development risk and schedule factors. This list was recommended to the ISS and Space Shuttle programs and was approved by the Space Shuttle Program Requirements Change Board in March 1994.

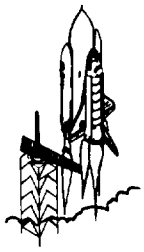
Table 5-1 lists the details of the currently approved changes to the Space Shuttle configuration and flight operations planned for performance enhancement. The list shows that the most recent assessment of performance enhancement is over 17,200 pounds. It should be noted that the list does not include the Block II Space Shuttle Main Engine (SSME) whose added weight was accounted for in the current baseline configuration for performance calculation purposes. The Block II SSME, when developed and certified, will have greater reliability and safety margin than the current engine. The selective use of 104.5 percent thrust level will provide much greater SSME safety margin than the current engine at 104 percent thrust.

The flight design changes are implemented by software updates and employ flight techniques that have been demonstrated, in large part, by other launch vehicles. The effects of flight control and sequencing changes are being verified via detailed aerodynamics, control, structural and thermal analyses to ensure that no limits are violated on the resulting trajectories.

More than half of the performance enhancement comes from hardware changes. Some of the weight reduction comes from the elimination of unused items such as extra payload wiring harnesses, cargo compartment liner and some Orbiter wiring. Substitution of lightweight crew seats for the current seats and refinement of insulation also contribute to weight reduction. The largest increments of payload capability come from the use of a "Super Lightweight Tank" (SLWT) to replace the current "Lightweight Tank" (LWT). The SLWT employs a new lighter weight alloy (Aluminum-Lithium, Al-2195) in its construction as well as an integrally stiffened "Orthogrid" structural design for the barrel sections instead of the frame, stringer and skin of the LWT. The SLWT replacement accounts for over 7,500 pounds of performance enhancement.

Another source of major weight reduction, some 3,000 pounds, is the off-loading of consumables, primarily orbital maneuvering system and reaction control system propellants. All of the potential 3,000 pounds of the consumables would not be off-loaded for every flight. The off-load, if any, would be tailored to the individual flight requirements. At a minimum, the consumable load would be determined based upon Space Shuttle experience for end-of-mission requirements plus a three-sigma reserve plus a mission contingency allowance for two additional days of operation. At present, consumables are most frequently loaded to tank capacity which allows for more than two contingency days of operation. The "Hains IMU" (High Accuracy Inertial Navigation System—Inertial Measurement Unit) entry in Table 5-1 is a reduction in the propellant requirement for control resulting from the improved accuracy of this IMU rather than an off-load and is included in this category for bookkeeping convenience.

Table 5-1
Space Shuttle Program—Space Shuttle Systems Integration Office



NASA Johnson Space Center, Houston, Texas

BASELINE PERFORMANCE ENHANCEMENTS

Presenter
MS/ROBERT D. WHITE

Date
August 7, 1996

Orbiter	**1,593**	**Crew Equip**	**382**
Orbiter Mods	1,271	Crew "Core" Equip	382
Orbiter Nose Cap Blanket	10		
Additional TPS Mods	312	**Consumables**	**3,918**
		Hains IMU	650
Lightweight Seats	**245**	Consumables Reductions	3,000
		Orb WSB H20/APU Fuel Del	120
ET	**7,592**	Add. APU Fuel/H20 Reduct	99
SLWT	7,500	Ammonia Boiler offload	49
Additional SLWT Mods	92		
		Performance (Flt Dsgn)	**2,495**
SRB	**0**	First Stage Yaw Steering	500
Lightweight SRB (Deleted)	0	SSME Variable M/R (Deleted)	0
Extended Aft Exit Cone (Deleted)	0	1st Stage Gimbal Change	270
		2nd Stage Gimbal Change	125
STS Operator	**1,002**	Constant Pitch Rate	50
P/L Wiring Harness	508	Post SRB Sep OMS Assist	250
Remove Cargo Liner	155	Lower MECO Altitude	740
Unused Orbiter Wiring	324	SRB Sep Timer Optimization	60
Orb Scar Removal	109	LO2 Press. Loading (Deleted)	0
P/L Recorder Removed	45	Selective SSME Thrust (104.5)	500
Leave Wiring for Manifesting	-139		
		TOTAL	**17,227**

"Presented during discussions with Space Shuttle Program management, Johnson Space Center, August 7, 1996"

It should be noted that, in addition to the performance enhancements given in Table 5-1, there is a Space Shuttle manager's reserve of 3,500 pounds and an International Space Station manager's reserve of 1,300 pounds which provide added margin of payload capability. These reserves can be released incrementally, if necessary, as specific mission definitions are finalized. But, by current policy, the Space Shuttle manager's reserve cannot be reduced below 700 pounds.

The Panel in its Annual Report for 1995 noted that there were potential safety issues related to the Aluminum-Lithium (Al-Li) material to be used for the primary structure of the SLWT. These included welding processes that needed to be developed and lower than expected fracture toughness of the Al-Li at cryogenic temperatures. Since then, welding procedures have been satisfactorily developed and the first test tank was successfully welded with minimum weld repairs needed.

To resolve the concern over fracture toughness of Al-Li at cryogenic temperatures, procedures have been developed to subject the procured plate and sheet material to a stringent series of tests in receiving inspection which will be used to select the material for the critical locations of the SLWT. During manufacture of the finished tank, a series of non-destructive tests, more stringent than had been used on the LWT, will be applied to the production SLWTs. Verification of these procedures is contingent upon the satisfactory testing of the production hardware.

Other Approved Upgrades

In addition to the Space Shuttle performance enhancements discussed in the previous section, there are a number of ongoing Space Shuttle safety and performance improvements presently in work such as:

- *Multi-function Electronic Display System (MEDS)*: NASA has funded the development and installation of a "glass cockpit" suite of displays for retrofit into the Orbiters with the first planned flight on OV-104 in January 1999.
- *Global Positioning System (GPS)*: The replacement of the existing Tactical Air Control and Navigation (TACAN) and Microwave Scanning Beam Landing System (MSBLS) systems with a precise positioning GPS in a triple redundant configuration has been initiated.
- *Auxiliary Power Unit (APU) Gas Generator Valve Module (GGVM)*: A new gas generator valve module is being designed and built to increase reliability and reduce maintenance.
- *Space Shuttle Main Engine (SSME)—Block I & II*: Uprating of the SSME's to increase engine safety and operability is being implemented as Block I and Block II changes. Block I engines are presently being phased into the fleet. The improved ruggedness and reliability of the Block II version, which is entering its final development testing at Stennis Space Center, is critical to the assembly and operation of the ISS.
- *Solid Rocket Booster (SRB)*: Solid rocket booster upgrades presently focus on aft skirt bracket modifications, saltwater activated release of main parachutes and fuel isolation valve poppet redesign.

- *Payload Integration Modifications:* These modifications, all of which are geared to ISS requirements, include upgrading items such as the remotely operated electrical umbilical (ROEU), docking system, remotely operated fluid umbilical (ROFU), grapple fixtures, Orbiter interface unit (1553 data bus) and some associated items.
- *Launch and Landing Systems:* These upgrades include possible replacement of ozone depleting compounds and ground system improvements.

OBSERVATIONS

The Space Shuttle manifest for the next six years is challenging. Slips of several months for individual launches are not unlikely. The constraints imposed by the order of assembly of the ISS limit flexibility and may cause the slip of one launch to impact several succeeding launches. This could cause peaking of the launch schedule in the short and medium term that will increase costs. These peaks will require all organizations to work harder, conceivably putting in extended hours and overtime, implicitly resulting in an environment that can impact safety negatively. The Panel believes that the most sensitive detector of potential safety problems arising from assembly and launch crew fatigue and overwork is the experienced manager when allowed to make an unconstrained decision. Objective measures can be an aid to such a decision but cannot substitute for it.

The planned schedule of seven launches per year, with surges to eight (7 or 8 per year), is feasible with current personnel levels as has been demonstrated over the past few years. These personnel levels may be lowered after several years by carefully controlled methods that rely on proving that processes are stable and trackable. In such an environment, achieving cost reduction goals that were set years earlier may not be possible without compromising safety.

The suggested augmented schedule with a launch rate of eight launches per year with surges to nine (8 or 9 per year), may be feasible with additional resources. It is probably too early to make a proper judgment in view of all of the changes underway.

There is no additional safety risk explicitly identifiable due to the move to an SFOC contractor. The rewards and penalties of the SFOC incentive contract may motivate the contractor to actions which are unanticipated by either party today and may pose additional risks to safe operations.

The implications of personnel reductions were discussed in more detail in the section on Downsizing. They are particularly important with respect to processing and launch crews where reduced crew size and compressed schedules can lead to longer hours worked with resulting fatigue and possible error or misjudgments.

The planned program for Space Shuttle enhancements appears well conceived and capable of meeting the needs of the International Space Station. Many of the changes in work reduce risk as well, which provides an overall safety benefit to the program. While the changes all seem conceptually sound, adequate testing and

certification are required before they are used. Budget reductions could produce pressures to shortcut these necessary steps even though the Space Shuttle program is presently committed to fully adequate testing and certification plans.

RECOMMENDATIONS

Recommendation 19.
The Space Shuttle program and the SFOC contractor should continue to emphasize safety first as a way of life and enforce the precedence of safety, manifest and cost in Space Shuttle operations.

Recommendation 20.
NASA and SFOC contractor managements should enforce the safety priority using good management judgment and, if possible, derived measures of processing and launch crew efficiency and fatigue as they affect the safety of operations.

Recommendation 21.
Any decision to move to a higher launch rate (8 or 9 per year) should be delayed until more experience is gained with the new contractual setup and some of the ISS launch constraints have been resolved.

Recommendation 22.
NASA should ensure that all enhancements and upgrades are fully tested and assessed prior to implementation. Funding profiles and schedule pressures should not be allowed to shorten any critical testing or validation processes.

APPENDICES

Appendix A
Letters/Correspondences

THE WHITE HOUSE

WASHINGTON

May 22,1996

The Honorable Daniel S. Goldin
Administrator
National Aeronautics and Space Administration
Washington, D.C. 20546

Dear Dan:

In November of 1994, you chartered a team of individuals, led by Dr. Christopher Kraft, to evaluate the Space Shuttle program. The team submitted its report in March 1995 and provided NASA with several recommendations regarding program management and implementation. Most notably, they recommended that consolidating operations under a single business entity was the most advantageous approach. You have moved out aggressively to implement this consolidation over this past year. Concurrent with this activity, the agency has been implementing its reengineering initiatives, including downsizing, in a constrained and challenging budget environment.

Times of rapid changes like these can produce risks as well as opportunities for advancement. However, in our efforts to improve and streamline the program, we must ensure that we do not inadvertently create unacceptable risks to safety. In light of the critical importance the Space Shuttle system plays in our national space program, the President has requested that I ask you to charge the Aerospace Safety Advisory Panel to conduct a review of issues associated with safe operation and management of the Space Shuttle program. The panel would review the effectiveness of the implementation of the Kraft recommendations, the potential impact of these recommendations on safety, and provide other guidance it may wish to offer. The panel should plan to provide a final report through NASA to the White House (through OSTP) by late November.

I have asked my Associate Director for Technology, Lionel S. Johns, to work with you on this important issue.

Sincerely,

John H. Gibbons
Assistant to the President
for
Science and Technology

National Aeronautic and
Space Administration

Office of the Administrator
Washington, DC 20546-001

Mr. Paul M. Johnstone
Chairman, Aerospace Safety Advisory Panel
24181 Old House Cove Road
St. Michaels, MD 21663

Dear Mr. Johnstone:

The White House has requested that I charge the Aerospace Safety Advisory Panel to conduct a review of any potentially significant safety impacts resulting from changes being made to improve and streamline Space Shuttle operations. The Terms of Reference (TOR) that outline the scope of the review is enclosed.

The panel should plan to provide a final report to the White House, through NASA and the Office of Science and Technology Policy, by late November. You can be assured of receiving the highest level of support from the NASA team during your review, and we look forward to your findings.

Sincerely,

Daniel S. Goldin
Administrator

Enclosure

May 30, 1996

TERMS OF REFERENCE

SPACE SHUTTLE REVIEW
CONDUCTED BY THE AEROSPACE SAFETY ADVISORY PANEL (ASAP)

PURPOSE: Over the past three years, NASA has made tremendous progress in reshaping the management and organizational structure of the Agency. Many of these changes have taken place within the Space Shuttle program, including the planned consolidation of operations under a single contractor, downsizing the Shuttle workforce, and reducing costs of operations and management. In light of these changes, a review is warranted to ensure that efforts to improve and streamline the Space Shuttle program do not inadvertently create unacceptable risk.

BACKGROUND: The Space Shuttle program has been in a "restructuring" mode since fiscal year 1992. Dramatic reductions in program costs (approximately 25 percent) have been realized over the last 4 years. In early 1995, a more focused set of initiatives were started that included such elements as reviewing operational requirements, reexamining the safety and mission assurance activities, consolidating contracts where possible, closing facilities as appropriate, and attempting to minimize civil servant involvement in operations. To meet these goals, several studies were initiated including the Functional Workforce Review, the Zero Base Review, internal Program/Project-manager-led assessments, and the external, independent study known as the "Kraft Review."

SCOPE: The review will focus on potentially significant safety impacts of the:

- Implementation plan for the transition of Shuttle program management to the Lead Center
- Transition plan for downsizing to anticipated workforce levels
- Implementation of a phased transition to a prime contractor for operations
- Planned safety and performance upgrades for Space Station assembly
- Maintenance of independent safety oversight
- Shuttle flight rate for Space Station assembly
- Communications among NASA Centers and Headquarters

APPROACH: The ASAP will first be briefed by NASA Headquarters. The results from previous Space Shuttle safety reviews and prior reviews/assessments of the planned changes including GAO, NASA Advisory council and previous ASAP studies will be provided.

It is anticipated that the ASAP will want to visit each of the OSF Centers to obtain insight on the implementation of management changes including:

- guidelines and policy
- status
- planned milestones and timetable
- checks and balances to assure maintenance of safety in flight operations
- problems, issues and concerns

The ASAP will be provided access to all personnel necessary to accomplish their task within the constraints of legal implications of SFOC negotiations. Additionally, the ASAP will be scheduled so that their activities will not interfere with ongoing Shuttle operations. Prior to the preparation of their findings, the ASAP will be provided an opportunity to review with NASA Shuttle management any questions or issues that were not fully answered or that may require further clarification.

ORGANIZATION: The ASAP will administratively be supported by Code Q. In addition to a flight experienced Shuttle commander, a Shuttle program point of contact (POC) will also be designated to work with the ASAP and Code Q- 1. The POC's function will be to act as the coordinator for setting up appropriate briefings (both schedule and content), identify the appropriate personnel that may be needed to provide special topic discussions/briefings, facilitate the responses to ASAP questions or provide ASAP with requested review documents.

PRODUCT: The ASAP will prepare a final report on their findings through the NASA Administrator to the White House.

SCHEDULE:

Review, preparation, and organization	June 1996
HQ briefing to ASAP	July
Visits to Shuttle Centers	August
Briefing of Findings to NASA Administrator	Mid-November
Submission of Report and briefing to OVP, OSTP, and OMB	Late November

National Aeronautic and
Space Administration

Headquarters
Washington, DC 20546-001

Reply to Attn of: Q-1

June 12, 1995

Honorable Daniel S. Goldin
Administrator
NASA Headquarters
Washington, D.C. 20546

Dear Mr. Goldin:

The Aerospace Safety Advisory Panel looks forward to conducting its assessment and advising NASA on the impact of streamlining changes to the safety of Space Shuttle operations, a subject that is vital to the future of our nation's space program. Please be assured that the Panel will do its best to provide an honest and candid evaluation.

Sincerely,

Paul M. Johnstone
Chairman
Aerospace Safety Advisory Panel

APPENDIX B
PANEL ACTIVITIES

JULY 25, 1996 NASA HEADQUARTERS

• Objectives/Scope of Study	Daniel S. Goldin, NASA Administrator
• Headquarters/Space Shuttle Program Office/ Lead Center Roles and Responsibilities	Wilbur C. Trafton, Associate Administrator for Space Flight
• Performance Upgrades	Steve Oswald, Deputy Associate Administrator for Space Flight
• Manifest/Space Shuttle Flight Rate	Steve Oswald
• Transition to a Space Flight Operations Contract (SFOC)	Steve Oswald
• Maintenance of Independent Safety Oversight	Frederick D. Gregory, Associate Administrator for Safety and Mission Assurance

AUGUST 6–8, 1996 JOHNSON SPACE CENTER

August 6, 1996

• Space Shuttle Program Management Transition to a Lead Center	George W. S. Abbey, Director, Johnson Space Center
• Maintenance of Independent Safety Oversight	Charles S. Harlan
• Operations Transition to a SFOC	Jack C. Boykin Robert B. Sieck JoAnn H. Morgan Jay H. Greene Jon C. Harpold
• Interview with Space Shuttle Program Manager	Tommy W. Holloway

August 7, 1996

• Shuttle Performance Enhancements and Upgrades	Lambert D. Austin Jay H. Greene Leonard S. Nicholson
• Space Shuttle Flight Rate for Space Station Assembly	Michelle Brekke
• Interview with Commander, STS-71 mission	Robert L. Gibson

• Interview with Associate Director (Technical)	John W. Young
• United Space Alliance (USA) Management/ Organization	Kent M. Black
• USA Program Management/Transition Plans	Glynn Lunney
• Ground Operations/Processing	Michael McCulley
• Flight Operations Transition	Harold Draughton
• Safety & Mission Assurance Transition	Harry Jupin
• Discussions/Interviews with USA Management on Downsizing/Transition to a SFOC	Kent Black Jim Adamson Joseph Hammond
• Interviews/Discussions on NASA Downsizing with JSC Human Resources Management	Harvey Hartman Greg Hayes

August 8, 1996

• Effects of NASA Restructuring on Space Station Program	Randy Brinkley
• Independent Assessment Concerns and Issue	Henry W. Hartsfield
• Contingency Plans for Delays	Dennis A. Kross Keith Reilly Frank Musil
• Space Station Hardware Fabrication	Dennis A. Kross
• Interview with Center Director	George W. S. Abbey

August 14, 1996 NASA Headquarters

• Interview with Deputy Associate Administrator, Office of Space Flight on NASA Downsizing	Richard J. Wisniewski
• Interview with Associate Administrator for Headquarters Operations on NASA Downsizing	Michael D. Christensen

August 20–23, 1996 Kennedy Space Center

August 20, 1996

• Discussions on NASA Downsizing and KSC	JoAnn H. Morgan Robert B. Sieck

August 21, 1996

• Discussions on Transition to a SFOC and and the Lead Center	JoAnn H. Morgan James A. Thomas Robert B. Sieck P. Thomas Breakfield

August 22, 1996

• Discussions on Transition of Support Facilities and Functions Under the SFOC and Maintenance of Independent Safety Oversight	Ann Montgomery Michael McCulley Gary A. Cantwell Richard H. Jolley

August 23, 1996

• Discussion on Maintenance of Independent Safety Oversight and Assessment	Robert B. Sieck JoAnn H. Morgan P. Thomas Breakfield Michael McCulley Harry Jupin Joel Reynolds James A. Thomas James A. Kelley James L. Jennings

August 27–28, 1996 Johnson Space Center

August 27, 1996

• Discussions with Space Station Program on Maintenance of Independent Safety Oversight	Randy Brinkley

August 28, 1996

• Discussions with Johnson Space Center Management on Maintenance of Independent Safety Oversight	George W. S. Abbey Charles S. Harlan Henry W. Hartsfield John Young James Wetherbee

August 29, 1996 Stennis Space Center

• Discussions with Stennis Management on Maintenance of Independent Safety Oversight and Lead Center	Roy Estess, Director, Stennis Space Center John Gasery

• Discussions with Lockheed Martin, Manned Space Systems, on Maintenance of Independent Safety Oversight	Jerry Smelser Terry L. Hibbard Earl McNail John White Harold Bencas Mike Smiles Jay Mullaly Patricia Powel Larry Knauder Robert Hieter David Schwartz

SEPTEMBER 3, 1996 JOHNSON SPACE CENTER

• Telephone Conference Call on Maintenane of Independent Safety Oversight	John H. Casper

SEPTEMBER 6, 1996 MARSHALL SPACE FLIGHT CENTER

• Discussions with Marshall Space Flight Center Management on Maintenance of Independent Safety Oversight	J. Wayne Littles, Director, Marshall Space Flight Center Robert J. Schwinghamer Alex A. McCool James H. Ehl

SEPTEMBER 6, 1996

• Lead Center/Transition to SFOC Discussions	Christopher C. Kraft

SEPTEMBER 10, 1996 MARSHALL SPACE FLIGHT CENTER

• Discussions on Downsizing	J. Wayne Littles Tereasa Washington

SEPTEMBER 11, 1996 MARSHALL SPACE FLIGHT CENTER

• Discussions/Interviews with Marshall Space Flight Center Management on Transition to Lead Center	J. Wayne Littles James H. Ehl Gerald C. Ladner Parker V. Counts James H. Kennedy V. Keith Henson Alex A. McCool

SEPTEMBER 17, 1996 DRYDEN FLIGHT RESEARCH CENTER

• Discussions on Lead Center and the Transition to a SFOC and Maintenane of Independent Safety Oversight	Kenneth J. Szalai, Director, Dryden Flight Research Center

SEPTEMBER 19, 1996 ROCKWELL INTERNATIONAL

• Discussions on Space Shuttle Performance Enhancements and the Transition to a SFOC	Robert Minor Jay H. Greene

OCTOBER 2, 1996

• Telephone Conference with KSC Center Director on Lead Center/Communications and Transition to a SFOC	Jay F. Honeycutt, Director, Kennedy Space Center

OCTOBER 8–10, 1996 MARSHALL SPACE FLIGHT CENTER

October 8, 1996

• Discussions with Solid Rocket Booster Project Management on Transitions to a SFOC and Status of Space Shuttle Enhancements	James H. Kennedy
• NASA Headquarters Office of Space Flight Presentation on Communication Plans	Russell Bardos
• Discussions with Reusable Solid Rocket Motor Project on Upgrades, Transition to SFOC and Flight Rate Surges	V. Keith Henson
• Discussions with Space Shuttle Main Engine (SSME) Project on Upgrades and Support to Flight Rates Surges	Gerald C. Ladner
• Discussions with External Tank Project on Space Shuttle Upgrades and Support to Flight Rate Surges	Parker V. Counts Mike Pessin

October 9, 1996

• Presentation by Safety and Mission Assurance on Maintenance of Independent Safety Oversight During Downsizing and Transition to SFOC	John M. Livingston

October 10, 1996

• Discussions with Director of Safety and Mission Assurance on Maintenance of Independent Safety Oversight During Downsizing, Transition to SFOC and Budget Reductions	James H. Ehl

APPENDIX C
AEROSPACE SAFETY ADVISORY PANEL BIOGRAPHICAL SKETCHES

JOHNSTONE, PAUL M. (CHAIRMAN)

Mr. Paul Johnstone spent his career in engineering design, development, acquisition, and operation of commercial aircraft. After obtaining his B.S. degree in Aeronautical Engineering from the University of Notre Dame in 1946, he joined the Douglas Aircraft Company, where he was first an aircraft performance engineer and then a stability and control engineer engaged in aircraft design and certification. After 5 years as an Operations Engineer and later head of Technical Operations for Hawaiian Airlines, he joined Eastern Airlines as Manager of Economic and Performance Analysis in the Development and Engineering Group. At Eastern, Mr. Johnstone rose to Vice President, Engineering, and later Senior Vice President, Operations Services. In those positions, he directed evaluations and was responsible for engineering, quality assurance, maintenance, inventory management and control, production planning and control and purchasing. In addition, he was corporate technical representative at all Eastern accident investigations. Mr. Johnstone is a Fellow of the American Institute of Aeronautics and Astronautics. Mr. Johnstone became a member of the Aerospace Safety Advisory Panel in September 1992, after joining the Panel as a consultant in 1991. He has been Chairman since March 1995.

BLOMBERG, RICHARD D. (DEPUTY CHAIRMAN)

Mr. Richard Blomberg is President of Dunlap and Associates, Inc. a human factors and systems analysis research and consulting firm. He has directed or been involved in the application of human engineering and systems analytic principles to aircraft design and certification, aerospace research, highway safety, product safety and the design and evaluation of human-computer interfaces. He holds a patent for a pilot workload measurement approach which has been accepted worldwide as part of the minimum crew certification of commercial aircraft. He also developed techniques used in the certification of the first "glass cockpit" in a commercial transport and an early version of the flight management system. Mr. Blomberg is also a member of NASA's Life and Biomedical Sciences and Applications Advisory Subcommittee. Mr. Blomberg became a member of the Aerospace Safety Advisory Panel in 1990 after joining the Panel as a consultant in 1987.

BRILL, YVONNE C. (MEMBER)

Ms. Yvonne Brill is presently a consultant specializing in satellite technology and space propulsion systems. Since retiring from the International Maritime Satellite Organization (INMARSAT) in 1991, Ms. Brill has served as a member of several U.S. National Research Council Committees of pertinent space transportation systems.

At INMARSAT, Ms. Brill managed the Space Segment Engineering activities on the Combined Propulsion System for the four INMARSAT-2 satellites which are now operational. Prior to INMARSAT, Ms. Brill has held several managerial and engineering positions including the Manager of the Solid Rocket Motor at NASA

Headquarters from June 1981 to June 1983. Earlier, at RCA Astro-Electronics, she managed the fabrication and qualifiifcation of a Teflon solid propellant pulsed plasma propulsion system whose successful utilization on the NOVA satellite brought electric propulsion to an operational status in the United States. Her patented invention, while at RCA, the electrothermal hydrazine thruster, is still widely used on operational commercial communication satellites manufactured by RCA/GE/Lockheed Martin Astro-Space.

Ms. Brill is a member of the National Academy of Engineering and the International Academy of Astronautics and a Fellow of the American Institute of Aeronautics and Astronautics and the Society of Women Engineers. Ms. Brill joined the Aerospace Safety Advisory Panel as a member in November 1994.

DUNN, ROBERT F. (MEMBER)

Vice Admiral Robert Dunn is the former Deputy Chief of Naval Operations, Air Warfare. He is an experienced Naval Aviator having commanded a carrier squadron, a carrier air wing, an aircraft carrier and a carrier battle group. He is presently an aerospace and defense consultant, author and commentator. VADM Dunn joined the Aerospace Safety Advisory Panel as a member in 1990.

ENGLAR, KENNETH G. (MEMBER)

Mr. Englar is currently a launch vehicle and systems engineering consultant to commercial satellite companies. Prior to his retirement from McDonnell Douglas Corporation in 1987, he was Chief Engineer and previously Chief Design Engineer of the Delta Launch Vehicle, incrementally increasing its payload to geosynchronous transfer orbit from 2,100 pounds to 4,000 pounds. He was responsible for the design and development of the current Delta II and led the engineering team that, in 15 months from design start to launch, successfully developed the Delta 180 launch vehicle for the Strategic Defense Initiative Organization. He also managed the design integration of spacecrafts on more than 70 Delta missions, including a string of 43 successive successful missions. Previously, Mr. Englar was Chief Engineer for the Laboratory vehicle of the U.S. Air Force Manned Orbiting Laboratory. He received a B.S. degree in Engineering from Columbia University and in World War II, served in the Manhattan Project at Los Alamos. Mr. Englar joined the Aerospace Safety Advisory Panel as a consultant in October 1995 and became a member in October 1996.

GLEGHORN, GEORGE J. (MEMBER)

Dr. George Gleghorn was vice president and chief engineer for TRW's Space and Technology Group overseeing design integration, reliability and product integrity of all TRW spacecraft. During his 37 years at TRW, he contributed to a wide range of distinguished spacecraft: Pioneer 1, Pioneer 5, INTELSAT III, the Orbiting Geophysical Observatories, and NASA's Tracking and Data Relay Satellite System

and numerous Department of Defense spacecraft. Dr. Gleghorn played a key role in many of TRW's record-breaking satellites, including Pioneer 10 and Pioneer 6. He was also involved in the development of the Atlas, Titan and Thor ballistic missiles for the U. S. Air Force. Prior to TRW, he worked at Hughes Aircraft and the Jet Propulsion Laboratory. In recent years, he has been a team member in design reviews and independent readiness reviews of Hubble Space Telescope, the Cassini spacecraft and mission and the Advanced X-Ray Astronomical Facility, and has chaired 2 National Research Council studies related to orbital debris. Dr. Gleghorn is a Fellow of the American Institute of Aeronautics and Astronautics and a member of the National Academy of Engineering. Dr. Gleghorn joined the Aerospace Safety Advisory Panel as a member in December 1992.

Himmel, Seymour C. (Member)

Dr. Seymour Himmel was the Associate Director of the Lewis Research Center responsible for overseeing all development and space flight projects at the Center. He joined the National Advisory Committee for Aeronautics (NACA) in 1948 as an Aeronautical Research Scientist and conducted and supervised both analytical and experimental research in a variety of fields including aero propulsion system: cycles, components, rotating machinery and dynamics and control. With the advent of NASA he focused on research into liquid and solid rocket propulsion and other space propulsion systems and their application to space flight missions. Subsequently, he managed a launch vehicle project being responsible for launching such missions as Ranger, Mariner Mars, the Orbiting Geophysical Observatory Satellite (OGOS) and Nimbus. As Director of Rockets and Vehicles at Lewis, he oversaw the launch of the Surveyor, Lunar Orbiter, Viking, Helios and Voyager missions as well as the development of the Titan/Centaur launch vehicle and the development and operation of the SERT II electric propulsion spacecraft. He served a tour at NASA Headquarters as Deputy Associate Administrator (Technology) of the Office of Aeronautics and Space Technology. Dr. Himmel has been a member and consultant to the Aerospace Safety Advisory Panel since 1975.

Krone, Norris J., Jr. (Member)

Dr. Norris Krone is currently the Executive Director, University Research Foundation, University of Maryland. Previous positions held by Dr. Krone include: Vice President for Special Projects, BDM Corporation; Office Director, Air Vehicles Technology Office, Defense Advanced Research Projects Agency (DARPA); Program Manager, Forward Swept Wing, X-Wing, DARPA; Assistant to the CDR for Acquisition and Costs Analysis, Andrews Air Force Base, Maryland; Chief, Joint Services Action Group JLC, Air Force Systems Command, Andrews Air Force Base; Manager of Advanced Development for Reconnaissance, HQ USAF; Technical Manager, Aeroelastic Programs, Chief of C-133 Airframe Design Review, Aeronautical Systems Division, Wright Patterson Air Force Base, Ohio. Dr. Krone joined the Aerospace Safety Advisory Panel as a member in 1987.

VOLZ, RICHARD A. (MEMBER)

Dr. Richard Volz is Department Head of the Computer Science Department at Texas A&M University. Prior to his current position, Dr. Volz was Director of the Robotics Research Laboratory and Professor of Electrical Engineering and Computer Science at the University of Michigan. He has served on three federal advisory boards in addition to the Aerospace Advisory Panel (ASAP): 1) the Air Force Scientific Advisory Board, 2) the Ada Board, and 3) the NASA Space Station Advisory Panel. He has received the Decoration for Exceptional Civilian Service from the U.S. Air Force and the NASA Special Service Award. Dr. Volz's research interests lie in languages for real-time, embedded, distributed computing manufacturing software and robotics. For the past decade, he has been a leader in the development of technology for the distributed Ada programs, having led the efforts for the development of several generations of distributed Ada systems. In the robotics and manufacturing arena, he has worked on languages for robots, manufacturing software, vision systems, grasping and manipulation, and is currently Editor-in-Chief of the *IEEE Transactions on Robotics and Automation*. Dr. Volz received his B.S., M.S., and Ph.D. degrees in Electrical Engineering from Northwestern University in 1960, 1961, and 1964 respectively, Dr. Volz joined the Aerospace Safety Advisory Panel as a member in 1986.

DONLAN, CHARLES J. (CONSULTANT)

Mr. Charles Donlan joined the research staff of the Langley Memorial Aeronautical Laboratory, then part of the National Advisory Committee for Aeronautics (NACA), the predecessor to NASA, in 1938. His career with NACA and NASA as an engineer and manager involved a broad range of aeronautical and space activities. He served as an Associate Director of Project Mercury, 1958–1961, and as the Langley Research Center's Deputy Director, 1961–1968. He was named the Deputy Associate Administrator (Technical) for Space Flight at NASA Headquarters, 1968, and served in that capacity until his retirement in 1976. During this period, he also served as the Acting Director of the Space Shuttle Program, 1970–1973. Since 1976, he has been an aerospace consultant to government and industry, notably with the Institute for Defense Analysis. Mr. Donlan became a consultant to the Aerospace Safety Advisory Panel in 1994 and joined the Panel as a member in 1983.

FITCH, DENNIS E., SR. (CONSULTANT)

Mr. Dennis Fitch is a B-757/767 Captain for United Airlines. He received a B.S. degree from Duquesne University and received his flight training from the United States Air Force. He is President of D.E. Fitch & Associates, an aviation consulting firm specializing in Cockpit Resource Management and human factors. Captain Fitch has had the unique experience of crash landing a DC-10 that lost all hydraulics and all flight controls. He and the crew hold the distinguished record of the longest time aloft without flight controls who lived to tell about it. Captain

Fitch has been commended by President George Bush and is the recipient of Senate Resolution 174, 101st Congress for his outstanding effort, poise and courage in assisting the crew in attempting a difficult emergency landing at Sioux City, Iowa. He has given numerous presentations to various corporate aviation departments and is also in demand for his inspirational and motivational program. Captain Fitch is recognized for his extensive experience as a flight instructor and check airman. He has accumulated over 15,000 hours of flight time and is an FAA check pilot designee. Captain Fitch joined the Aerospace Safety Advisory Panel as a consultant in June 1995.

KAUDERER, BERNARD M. (CONSULTANT)

Vice Admiral Bernard M. Kauderer, a consultant to industry and government, also serves as a Director of the General Physics Corporation and of Digital Systems Resources Corporation. He is the former Commander of the Submarine Forces, U.S. Atlantic Fleet and U.S. Pacific Fleet. After graduating from the U.S. Naval Academy in 1953, VADM Kauderer served on the destroyer USS The Sullivans and then as Executive Officer in the minesweeper, USS Hummingbird. VADM Kauderer served as Damage Control Assistant in the Polaris missile submarine USS Robert E. Lee, as Engineer Officer in the attack submarine USS Skipjack and then as Executive Officer in USS Ulysses S. Grant. VADM Kauderer also served as Deputy Director, Research, Development Test and Evaluation on the staff of the Chief of Naval Operations. He has commanded: Submarine Group FIVE in San Diego, the nuclear attack submarine USS BARB, the Naval Nuclear Power Training Unit in Idaho Falls, and the submarine tender USS Dixon. VADM Kauderer joined the Aerospace Safety Advisory Panel as a consultant in April 1996.

MCDONALD, JOHN F. (CONSULTANT)

Mr. John McDonald is the former Vice President Maintenance and Engineering for the Flying Tiger Line and also Vice President Technical Services for Tiger Air, a corporate jet service and modification company. Under Mr. McDonald's direction, the all-cargo airline achieved the best reliability rates in the industry from 1968 to 1979. He was elected to the Board of Directors of Flying Tiger Line in 1975 and retired in 1982. His earlier experience included fifteen years with Lockheed Aircraft Corporation principally in engineering and service support roles as Division Engineer, Service Engineering Division. Prior to joining Lockheed, McDonald served 12 years with BOAC (the predecessor of British Airways), his final position being that of Chief Technical Officer. He is a chartered engineer on the United Kingdom Register and is a Fellow of the Royal Aeronautical Society and Institute of Mechanical Engineers. He is also a Fellow of the American Institute of Aeronautics and Astronautics and the Society of Automotive Engineers. Mr. McDonald joined the Aerospace Safety Advisory Panel as a member in 1980 and continues as a consultant from 1992.

PARMET, NORMAN R. (CONSULTANT) (CHAIRMAN: 7/90–3/95)

Mr. Norman Parmet is the former Vice President, Engineering and Quality Assurance, TWA. He was responsible for the direct operation of three areas within TWA including: engineering with technical responsibility for the airline operational fleet; technical development with technical and contractual responsibility for the evaluation and construction of new aircraft types and their systems; and quality assurance with overall responsibility to assure compliance of all technical standards set by engineering and manufacturers. Mr. Parmet served on the National Research Council's Shuttle Criticality Review and Hazard Analysis Audit Panel. Mr. Parmet joined the Aerospace Safety Advisory Panel as a member in 1982.

STEWART, JOHN G. (CONSULTANT)

Dr. John Stewart is presently a partner in Stewart & Associates, a management consulting firm located in Knoxville, Tennessee. He previously served as Executive Director of the Consortium of Research Institutions in Knoxville, Tennessee. The Consortium sponsors collaborative scientific and technological endeavors among the Oak Ridge National Laboratory, the University of Tennessee the Tennessee Valley Authority (TVA) and the U.S. Department of Energy, Oak Ridge Operations. He also served as Vice President for economic and community development and Assistant General Manager (Administration) at TVA (1980–93). Prior to TVA, Dr. Stewart served as Assistant Director of the American Political Science Association (1961–62); Legislative Assistant and subsequently Executive Assistant to Senator and Vice President Hubert H Humphrey (1962–69); Director of Communications at the Democratic National Committee (1970–73); Staff Director of the Energy Subcommittee, Joint Economic Committee (1975–77), and Staff Director, Senate Subcommittee on Science,Technology and Space (1977–79). Dr. Stewart joined the Aerospace Safety Advisory Panel as a member in 1980, then became a consultant after completing his term in 1992.

GREGORY, FREDERICK D. (EX-OFFICIO)

Mr. Fred Gregory is the Associate Administrator for Safety and Mission Assurance at NASA Headquarters. He is responsible for assuring the safety, reliability, and quality of all NASA programs. He has extensive experience as an astronaut, test pilot, and manager of flight safety programs and launch support operations. He has logged over 6,500 hours in more than 50 types of aircraft, including 455 hours in space and 550 combat missions in Vietnam. He holds an FAA commercial and instrument certificate for single- and multi-engine airplanes and helicopters. Mr. Gregory joined the Aerospace Safety Advisory Panel as an ex-officio member in 1992.

STARKEY, NORMAN B. (EXECUTIVE DIRECTOR)

Mr. Norman Starkey was named the Executive Director for the Aerospace Safety Advisory Panel in August 1996. Prior to this assignment he served as the Manager, Space Shuttle Headquarters Office, Office of Space Flight, where he was the Headquarters focal point on Space Shuttle matters to other NASA offices and external interfaces. Mr. Starkey joined NASA in February 1970 as a co-op student at the Goddard Space Flight Center (GSFC). At GSFC he worked as a Structural Dynamics and Mechanical Systems Engineer on the Delta Project, and as the Mechanical Systems Manager for the OSS-1 payload that flew on STS-3. In 1980, he transferred to Headquarters, where he has worked in numerous management positions on the Space Shuttle Program. Mr. Starkey received his Bachelors Degree in Aerospace Engineering in 1972 and his Masters Degree in Aerospace Engineering in 1978, both from the University of Maryland. He later returned to the University of Maryland and earned his Masters Degree in Business Administration in 1987. He has received numerous NASA commendations, including the NASA Exceptional Service Medal and the Silver Snoopy Award.

MANNING, FRANK L. (TECHNICAL ASSISTANT)

Mr. Frank Manning, prior to his present assignment, was the Executive Director of the Aerospace Safety Advisory Panel (January 1994–August 1996). As the Technical Assitant to the Panel, he is directly responsible for managing and coordinating technical special assignments given to the Panel (including this Special Report to the White House: *Review of Issues Associated with Safe Operation and Management of the Space Shuttle Program*). Prior to his assignment to the Panel in January 1994, he served as the Manager, Safety, Reliability and Quality Assurance for U.S./Russian Programs. Mr. Manning joined NASA in 1963 at the Lewis Research Center after graduating from the University of Michigan. During his career of over 30 years with NASA, he has had a wide range of assignments including: Test Conductor on basic rocket research projects; Launch Vehicle Project Engineer for Titan/Centaur and Atlas/Centaur; Manager, Systems Engineering and Integration for Shuttle/Centaur; and Manager of the NASA Aerospace Battery Program. Mr. Manning came to NASA Headquarters in 1989.

HARMAN, PATRICIA M. (STAFF ASSISTANT)

Ms. Patricia Harman joined the Aerospace Safety Advisory Panel in August 1989, as Staff Assistant. Prior to this assignment, she served as personal secretary to the Associate Administrator for Safety, Reliability, Maintainability and Quality Assurance (in addition to lead secretary for the entire office), as well as secretary to the NASA Chief Engineer, Associate Administrator for STS Operations, NASA Executive Officer, and to various directors in the Space Shuttle and Apollo Programs. Ms. Harman has been with NASA since March 1964.

Points of Contact

In addition to the Aerospace Safety Advisory Panel staff, the Panel was assisted by the following NASA personnel who helped obtain required materials and coordinate briefings:

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William C. Hill, Office of Safety & Mission Assurance, NASA Headquarters

James A. Kelley, Safety and Mission Assurance, Kennedy Space Center

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Carl B. Shelley, Space Shuttle Program, Johnson Space Center