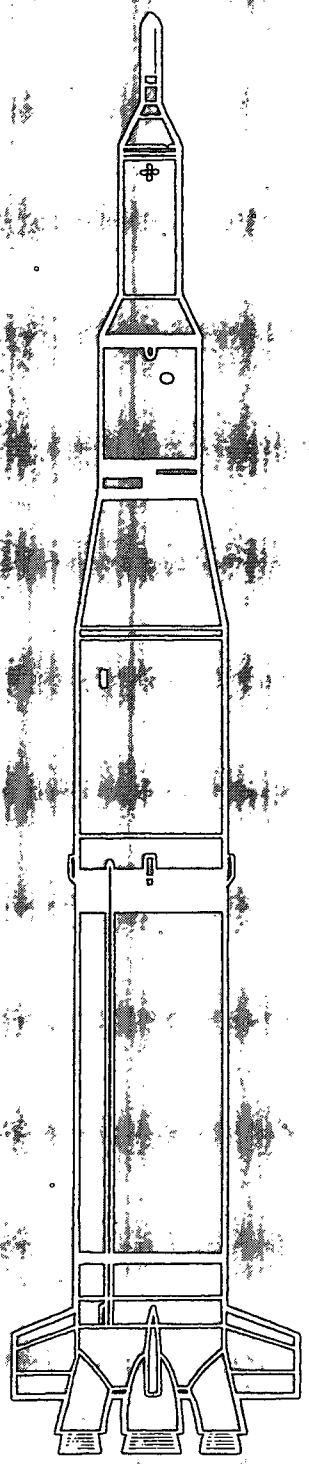
MANNED SPACE FLIGHT IN TRANSITION

FINAL REPORT

by

Eugene E. Drucker
William S. Pooler
David L. Wilemon
Bernard D. Wood

SYRACUSE/NASA PROGRAM



National Aeronautics and Space Administration

Syracuse University

MANNED SPACE FLIGHT IN TRANSITION

FINAL REPORT

by

Eugene E. Drucker
William S. Pooler
David L. Wilemon
Bernard D. Wood

NASA GRANT NO. NGR 33-022-139

SYRACUSE UNIVERSITY
Syracuse, N. Y.

March, 1973

CONTENTS

PREFACE

The reorientation of NASA in the post-Apollo period has presented to the Agency problems as serious in magnitude as those encountered in the rapid buildup of OMSF shortly after the enunciation of the Apollo Program, but of an entirely different nature. These problems are the consequence of a sharp decline in support of the Space Program, expecially where manned flight is concerned. NASA is trying to cope with the agonizing adjustments to its program plans and organizational structure made necessary by the conditions imposed on it by Congress and the Administration.

NASA has many internal resources available for providing and analyzing scientific and management information. At the same time, though, it has always recognized the value of an external view of itself by unbiased observers, as an input to and aid in the decision-making process concerning near- and long-term planning. This report is the result of an investigation by a four-man interdisciplinary team from Syracuse University during 1972. The team had acquired a knowledge base during the prior four-year period, in which a candid relationship between Syracuse University and OMSF had evolved.

The research team conducted a large number of interviews at OMSF in Washington and at the three field centers, gathering facts, opinions and suggestions concerning the current problems that OMSF faces. The practice of recording interviews did not inhibit those interviewed from being frank and spontaneous in their remarks, due to the degree of confidentiality that had been accorded similar interviews by the team in the past. Where quota-

tions appear in this report they are anonymous and are representative of prevalent attitudes encountered.

The report itself is essentially a distillation of the many opinions gathered in the field, moderated by the knowledge and judgment of the group of investigators. The ideas, recommendations and suggestions in this report have survived a very rigorous process of debate and critique among the members of the team.

The group was indeed fortunate in securing the cooperation of many intermediate and high-level management personnel, and wishes to express its sincere appreciation to those participants.

I. SUMMARY OF RECOMMENDATIONS

NASA will continue to undergo a number of important changes which will require new management approaches by OMSF. Brief statements of our recommendations in this regard are summarized below. A more detailed discussion of them can be found in the text of this report.

1. Despite all of the resistance which may be encountered, NASA should make a major effort to persuade Congress and the Executive Branch that stable, long-term funding is essential for the maximum utilization of NASA's resources and programs.

2. Based on the Apollo experience, NASA is now in a better position to evaluate the efficiency and effectiveness of various management and information systems used in programmatic undertakings. There is a consensus at the field centers that many of the Apollo management systems are too elaborate, too sophisticated, and too expensive to apply efficiently to the newer, emerging NASA projects.

3. The need for program planning by OMSF will be greater than ever before. In contrast to the early phases of the Apollo programs, projects must be clearly defined early in the development cycle. Early definition of performance specifications, cost, schedules and interface requirements minimizes ultimate project documentation. In Apollo, because of schedule pressures, a number of key decisions were delayed which resulted in large incremental costs in the development cycle. There should be a strong emphasis on freezing project designs once requirements are met. The luxury

of engineering improvements which contribute only marginally to a project should come under greater scrutiny.

4. The design philosophy within OMSF should be altered to take into account decreased reliability and redundancy requirements in unmanned programs or experimental packages and even in non-critical aspects of manned missions. The enunciation of such a change must be followed by continued review of individual design efforts to revise habits acquired in the Apollo program.

5. In some areas of OMSF a feeling of uncertainty about both NASA's future and its immediate proposed programs is evident. Three somewhat interrelated factors appear to contribute to this feeling: a) NASA's budget restrictions; b) the recent RIFs experienced by NASA; c) the lack of an identifiable long-range plan at the field centers. We believe that a multidimensional planning system can overcome some of these problems. In the past, long-range planning activities have been too far removed from the "bowels" of the OMSF organization.

6. NASA's ability to cope successfully with the future will depend largely upon NASA's long-range planning ability. We recommend that long-range planning receive the highest support and visibility within the Agency. Without primary and contingency plans it will be increasingly difficult for the various areas of NASA to be responsive. A long-range plan is seen by many as one of the major means by which Headquarters can communicate with the field centers. Two elements of NASA's planning system should be technology forecasting and socio-political forecasting.

7. What might be called a strategic organizational analysis system should be implemented whereby every work-unit within OMSF is appraised for its current and future contribution to NASA's missions and objectives. Those units which do not serve any current or strategic purpose should be eliminated or their focus changed. In the same way, NASA should reduce its holdings of cost generating assets after an audit of NASA facilities indicates that they are not likely to be of value in planned programs.

8. Headquarters should stimulate a trend for which there is increasing evidence: personnel at the operating level of the field centers are gaining a greater awareness of what the other NASA field centers are doing. We see this as a positive sign that NASA personnel are becoming increasingly alert to the importance of inter-center coordination. To a large extent this has been forced by the nature of the Shuttle Program.

9. NASA must closely examine the current organizational arrangements at the OMSF field centers and ask whether they are satisfactory for new operational modes. Many doubts have been expressed whether the current rigid departmentalization of the technical research and development areas at the field center level is conducive to efficient response to shifting priorities. NASA is in an era where fluid organizational relationships can pay high dividends.

10. NASA, largely based on the Apollo experience, presents an image to the layman that it can do almost anything -- but only at a staggeringly high cost. Yet for much of the nation it is the extravaganza which keeps NASA in the public eye. Thus, we believe that NASA will continually be

faced with the challenge of maintaining visibility as an Agency. There are a number of options open to NASA. First, the Agency can use sound marketing principles to seek from relevant constituencies support for its future activities. Second, NASA can emphasize that high R & D costs are justified by showing the social, economic and political benefits which are derived from the national investment in NASA. Third, NASA can emphasize the "spin-offs" which are developed from NASA's R & D efforts and stress their importance to society through advanced technology.

11. NASA's desire to expand the applications of its space and managerial technologies must be monitored closely in order not to stretch NASA's capabilities. In working with urban administrators, for example, NASA should be a participant but should not assume the lead role. In essence, NASA should be careful not to over-sell its problem-solving capabilities in areas too far removed from its major missions.

12. Where there is a clear pay-off to NASA and where NASA's capabilities and technologies can be effectively utilized, NASA should consider aggressively seeking new contracts from others. In dealing with other organizations, countries, and agencies, however, it will be necessary for management at all levels to be convinced that NASA can and should play a role in solving non-space technological problems. Further, it will be important for NASA management to make clear that such activities are legitimate pursuits and that they will be rewarded by the Agency.

13. OMSF management is faced with the problem of disparities among the work loads at its field centers. Relative to the two other centers,

the task assignments for MSFC in current OMSF activities are small. To remedy this circumstance, we recommend that both KSC and MSC be encouraged to utilize the technical labs at Marshall for general in-house technical support for their respective center program responsibilities.

14. MSC as lead center in Shuttle has an awesome responsibility. To assist MSC with its mission we recommend that the vast experience base for monitoring technical contracts out-of-house at Huntsville be utilized by MSC.

15. The Program Development Directorate at MSFC lacks any coherent focus. To remedy this situation and to help OMSF to better plan for the operational phase of Shuttle, we recommend that Program Development be reoriented to Shuttle User Development. It would be the responsibility of this Directorate to coordinate and support all Shuttle user-related activity both within and outside NASA.

16. The entire philosophy of protecting "manpower spaces" is detrimental. Regardless of the resistance, it is important for NASA to eliminate or reduce this barrier to organizational flexibility. Under the current system both programmatic and functional needs for flexible manpower assignments suffer. A Manpower Advisory Council should be established in OMSF, comprised of Headquarters and field center high-level personnel, to facilitate the shifting of manpower among the various Programs and Directorates as requirements change with time.

17. The lead center mode of program management should be used for a complex program with extensive interdependence of parts that requires

appreciable use of the diversity of capabilities existing in various centers. It cannot be recommended universally because of its numerous disadvantages. The lead center management concept is recommended, where suitable, primarily because it focuses management operations at an operating center with substantial technological and project management resources and thereby removes the need for large support offices at Headquarters. In addition, this management mode forces much-needed inter-center communication at the middle management levels, and it should strengthen control of complex interface problems.

18. Very careful consideration must be given to the selection of a lead center whether for the management of one large program or as an advisory center for a group of related programs. Among the dangers inherent in lead center management are: a) management by equals, which engenders certain resentments; b) concentration of resources and capabilities at one center at the expense of others; and c) loss of input for alternative designs and concepts.

19. OMSF might consider employing the advisory lead center type of office instituted for Communications at MSFC for emerging programs. This retains some of the advantages of a managerial lead center while avoiding some of the dangers. However, it contains its own set of disadvantages.

20. In delegating responsibility for technical integration of a large contract to the prime contractor, OMSF must retain for itself full managerial control of integration.

21. In the long run, it should be advantageous to maintain as clear a distinction as possible among OMSF centers in their roles and areas of competence for reasons of economy and to strengthen rather than diffuse expertise.

22. It is possible that the designation of field centers as belonging to OMSF or any other NASA office could be discontinued to increase flexibility in resource utilization and to broaden financial support for the individual centers. It is recommended that contingency plans be formulated which recognize this possibility.

23. There has been no unified thrust in OMSF in the area of new program development. While NASA R & D for new programs should definitely remain at the field centers, we see the need for a stronger integration and coordination role by Headquarters in new program development. Headquarters should also be a catalyst.

24. NASA should exert greater control over its contractors to accelerate their conversion from production to R & D modes. The procurement of relatively large numbers of items of a given design is not appropriate to current and future programs.

25. NASA, and particularly OMSF, must strongly avoid fiscal dependence on the Department of Defense budget. Its civilian posture and its general autonomy must not be compromised.

26. NASA should take steps now to correct the misleading publicity concerning the cost and capability of the Space Shuttle Program. For

reasons beyond the control of NASA or OMSF, budget curtailments have revised expectations for Shuttle, particularly in the cost to put a pound in orbit. Failure to correct the public record now may damage NASA's credibility for the future.

II. THE NEAR-TERM NASA SCENARIO

The plans and actions of any organization depend not only upon its own perception of internal factors, but upon external conditions -- that is to say, upon the total scene or setting of the organization in the broadest sense. NASA will continue to undergo a number of transitions in management and operations which will be directly influenced by NASA's own desires, and by the uncertainty and turbulence in NASA's environment.

This section briefly summarizes the various factors which will affect NASA in the near future, in the judgment of the Syracuse Study Group.

A. CHANGE IN FOCUS

-- NASA is at a point where the intensity of public support has significantly changed. The Shuttle Program has not engendered the public support and excitement that Apollo did.

-- In the near future there is not likely to be a program which will have a high, clearly-defined national priority, like Apollo.

-- There will be an abandonment of NASA's "single focus" image. NASA is entering an era where it will be necessary to deal with varied constituents making diverse demands.

-- Manned space flight is no longer the predominant activity in NASA. The OMSF development centers will become increasingly involved with OAST, OSS, OTDA, and OA. Thus

the distinctions between manned and unmanned activities will be much less clear than they traditionally have been.

-- In project control, priorities will change from the "performance, schedule, cost" order of the Apollo era to a "performance, cost, schedule" ranking in the more austere post-Apollo years. Even design objectives will sometimes be sacrificed for cost reductions. Concurrently, NASA design philosophy will tend toward the acceptance of higher failure probabilities in order to optimize the total costs in non-man rated hardware.

-- A larger number of smaller projects will be undertaken concurrently by OMSF than in the past decade. This requires more technical support from the centers despite fewer personnel and reduced funds.

B. BUDGET RESTRICTIONS

-- For the immediate future NASA will continue to be faced with the dilemma of operating within a minimal budget. There will be demands for increased Congressional budget appropriations from all areas of the government. NASA will continue to feel the intense competition for appropriations during this decade. Barring unforeseen circumstances, NASA's funding levels during the 1970's

will most likely remain close to current absolute funding levels. This implies a considerable reduction of buying power and slippage in NASA's priority as measured by a reduced percentage of the Gross National Product.

-- Although NASA is a civilian agency primarily, it also has a secondary role of contributing where possible to the national defense. As long as NASA had specifically publicized goals such as a manned lunar landing, the Agency remained primarily identified with non-military activities. Currently, however, NASA could benefit from DOD support, but might then have difficulty maintaining its civilian orientation.

C. PLANNING

-- NASA is entering an operational era where cost/benefit justification of various progrms will be mandatory. This is true because of restricted budgets and the tendency, therefore, to carefully scrutinize budget items. NASA will have to recognize the need to match its programs to broader societal priorities.

-- Planning cycles of 10-15 years will replace the shorter, crash-type Apollo program planning activity.

-- With the prospects of an extended period of peace and a more stable economy, effective and reliable long-range

planning can be anticipated for NASA. NASA can benefit from these trends in that it may be easier for the Executive Branch and Congress to "order" national priorities.

-- NASA's future programs will be defined, implemented and controlled more in line with the traditional industrial R & D methods. In effect, more classical, phased development will take place with a careful evaluation of program alternatives in terms of mission objectives and hardware. Conformance to a constant spending pattern will be necessary even at the expense of increased operational costs.

-- NASA may find its credibility seriously damaged by circumstances beyond its control. The initial estimates of only $100 per pound to put Shuttle payload in orbit went far in obtaining public and Congressional support for the program. The figure was apparently based on a reuseable system with many flights per unit and a relatively high frequency of launch. Unfortunately, budget considerations required drastic revisions in design in order to reduce initial development costs. As a consequence, the cost per launch has now been projected at a higher level. Furthermore, with the reduced operating budgets now envisioned, the projected frequency of launch needed for the anticipated economics will not

be possible. These two conditions imposed on NASA from outside mean that the cost per pound in orbit will be much larger than initially advertised. When it becomes obvious through Congressional hearings and other channels that the cost projection will not be achieved, NASA will be held accountable. To prevent a possible loss of confidence, NASA and particularly OMSF should gradually inform the public about the real costs of experiments in space and the reasons for the change. Some adverse reaction now may protect the Agency's future.

D. ORGANIZATION AND MANAGEMENT

-- It is expected that future programs, and especially Shuttle, should benefit from the Apollo experience. There is considerable evidence that NASA has learned much from both the successes and the mistakes made in the management of Apollo. It is incumbent upon OMSF to demonstrate the effective use of managerial and technical systems laboriously evolved during Apollo.

-- The organizational center of power at each OMSF field center should now be more nearly equidistant from the program management and the engineering sides of the house. This trend should promote a better working relationship between program/project management and the technical areas of NASA.

-- NASA's OMSF management is faced with the problem of a disparity between the work loads at the field centers. While the roles of MSC and KSC are rather clear for the next few years, the role of MSFC is not. The eventual role of MSFC will largely depend upon three variables: 1) the ability of MSFC to be innovative and responsive to both OMSF and unmanned opportunities; 2) the degree of participation of MSFC in the Shuttle program; and 3) the development of a payload management capability by MSFC or other long-range roles yet to be defined.

E. REVISED ROLE

-- Because of the demands of new programs, NASA will be increasingly required to deal effectively with a number of complex interfaces within and external to the Agency. NASA will thus be required to be more adept at program integration. The increasing complexity of physical (technical) interfacing will demand more effective managerial interfacing and integration.

-- The Soyuz Project will be important to NASA in terms of national and international public relations and visibility, but it is not likely that this is the beginning of a major trend toward international cooperation in space.

-- NASA will have an opportunity to assist the United States in its current balance of payments problem, as recently noted by Dr. James Fletcher. The potential exists for NASA's capabilities to be focused on international as well as national needs in the areas of global sensing and surveillance, earth resources, measurements and instrumentation. NASA can continue to be a major source, catalyst and disseminator of new technology which can be applied to new products and processes.

III. ORGANIZATION

A. FIELD CENTERS

1. The Lead Center Concept

a. Background. The most significant recent management policy decision in OMSF has been the establishment of a lead center role in program management. The lead center concept is not new in NASA, but for OMSF it represents a radical departure from the management mode of the Apollo program under which most current OMSF personnel have operated for more than a decade. The shift, therefore, has not gone unnoticed at any level in the Manned Space Flight centers, drawing comments of satisfaction and great expectation from some quarters but skepticism, if not foreboding, in others.

In our interviews through the Summer of 1972, this broad spectrum of reaction to questions about lead center operation depended somewhat on which center we were visiting, but it resulted also in part from the fact that "lead center" implied different things to different people. Of course, at that time, its full implication for the Space Shuttle Program could not be foreseen. It is still too early to expect that all fears of the unknown have been removed.

We believe that, despite the usefulness of this management mode, there are legitimate objections to the lead center role and that these must be balanced against the immediate and long-range advantages. MSC's announced position as a lead center for the Space Shuttle Program is the most clear-cut lead center role in OMSF, but there are and have been other examples worth examining.

b. Center Insulation in the Apollo Program. Direction of the Apollo program was concentrated in Washington. Of course, at the highest levels of center management there was extensive interaction among the three centers through the Management Council and the Level II review boards. But this management level dealt primarily with broad policy decisions. There was a surprising degree of insulation at the project manager level and below. In essence, the three major Manned Space Flight Centers operated as lead centers (though the term was not used) in the clearly distinguishable aspects of the program. MSFC was assigned lead role for booster hardware, MSC for the spacecraft and for astronaut training, and KSC for launch operations. Headquarters, with the aid of intercenter panels and control boards, exercised overall program control and coordination. This mode required the buildup of a sizeable HQ management and technical staff to monitor and direct Apollo activities at the centers.

c. Quasi-Lead Center Role in Skylab. Towards the end of the Apollo program, attention turned to the organizational demands of new programs. As the Skylab program developed, overlapping the operational phase of the Apollo program, a large percentage of Skylab's development work was assigned to the Marshall Space Flight Center whose development work for Apollo was well past its peak. Program control authority was still exercised in the Skylab office at Headquarters, however, and MSFC's role was not that of lead center although many thought of it in those terms. Certainly there is some justification in thinking of one center as "lead center" when its responsibilities are clearly greatest and its design decisions shape the

program. Perhaps this "quasi-lead center" role could be characterized as "technical lead center".

Some managers at the Manned Spacecraft Center were concerned about the strong influence MSFC was having on what they felt was very largely an astronaut-oriented undertaking with all the training and life-support aspects that this implied and in which they felt themselves to be most competent, but they were much too busy with their part of the Apollo program at that time to raise a serious objection. Nevertheless, resentments were voiced.

d. Managerial Lead Center Role in Shuttle. With the establishment of a full-fledged Space Shuttle Program, the management mode definitely shifted to the lead center concept. MSC was eventually given major, although not ultimate, management responsibility for the program, even for those components of research and development work to be done or contracted for by MSFC. The Shuttle program was clearly going to be a long-range effort. Both MSFC and MSC had been thinking for some time of the technical problems involved. By the time the decision was made that a lead center would be selected for Shuttle, the Apollo program was in its last phases and was well past any major demands on the research and development capabilities of those two centers. Both were in a position to compete strongly for the role of lead center, and both saw the attainment or loss of that role as the determinant to their own future in manned space activities as well as in the whole Agency. Indications are that the intercenter competition was fierce and the resentments and even antagonisms engendered may

last a long time. That is not to say that the competition itself was not fruitful, but the negative aspects cannot be ignored.

It is important to avoid a simplistic view of the extent to which the lead center role of MSC has decentralized management of the Shuttle program. There is still a Space Shuttle Program Office within OMSF at Headquarters. Its Director and the Associate Administrator for OMSF undoubtedly can be reached for a review of any major decision. Nevertheless, the strong belief is that MSC as the lead center for this large program can exercise broad authority over any other center associated with the program. For the first time in OMSF, one center (MSFC) had been placed in a subordinate position to another (MSC) in the management hierarchy.

e. Advantages of Lead Center Management. In the following discussion of advantages and the later discussion of disadvantages in the establishment of a lead center for a program or group of programs, the prime concern is with the managerial lead center role of MSC in the Space Shuttle program.

-- Reduction in Headquarters Personnel. Certainly one of the clear motives in a shift to management through lead centers is to avoid the build-up of personnel at Headquarters. Based on the Apollo experience, it seems adviseable that Headquarters now should truly be composed of top-level decision makers, men with ultimate authority and responsibility, with staffs lean enough to allow rapid and reliable communication without excessive duplication of roles and efforts.

-- Closing the Gap Between Top Management and the Operating Centers. While ultimate program authority will remain at Headquarters in Washington

in present lead center schemes, the management level immediately below will be located at the lead center. That center functions as an operating center where detailed program control, component design, test evaluation, and daily management are accomplished. This will keep second-level management in direct and continuous communication with all elements of the program. We believe this will provide a more flexible response capability for problem solving. Operational interfaces with the prime contractors occur through field centers and management decisions regarding established contracts should be made at that level. It would seem appropriate to have all Control Boards below Level 0 meeting at the lead center so that while broad policy decisions are made at Headquarters, all detailed program decisions are made at the lead center.

-- Retain Staff Support Technical Experts Close to Their Base of Competence. A technical man removed from the day-to-day environment of his colleagues who are deeply involved in research and development quickly loses his high level of proficiency. To keep abreast of developments to the extent that he himself can be a reliable critic and advisor while in the Washington program office, he must gather around him additional support personnel. They, in turn, are then removed from the continuous growth evident in an operating center. To the extent that they can keep themselves thoroughly immersed in developments, they must inevitably be duplicating efforts of others.

Program managers need the most competent technical support continuously at hand. In the Apollo program, there was an attempt to maintain various

offices of expertise in Washington. This was understandable when the development of management methods was going on in parallel with the development of the essential technology. Much has been learned since then. Headquarters program offices should now be able to function with fewer technical advisors in their own offices and reply on the competence of field center program managers who have ready access to in-depth technical support.

-- Preservation of the Special Competence of Individual Centers. If Headquarters carefully assigns lead center roles in accordance with the established and demonstrated capabilities of the centers, then it will be possible for each center to strengthen its existing resources in one or another specialty. This requires that lead center assignments be rotated so that no center that is important to NASA's long-range objectives loses its technical and managerial capabilities. Certainly there are many other considerations, especially current work loads at the various centers. But the frantic buildup days of a decade ago are not likely to return. Programs will be developed and authorized at a slower pace, and key management decisions such as lead role selection can be made with the deliberation they deserve.

-- Elimination of Duplication of Effort and Competence. Rather than try to surpass all other centers in all ways, a lead center must be prepared to utilize the resources of the others to the greatest extent possible. Whether or not this will really occur depends on the skill with which top NASA and OMSF management handles the designation of lead center roles and

remains prepared to support each center in its area of acknowledged expertise.

For fully effective operation, NASA must not be a collection of unrelated, redundant centers. With the recognition that various areas are adequately supported in other centers and that whichever center might be designated as lead center another can be delegated the responsibility for the parts of the program it is capable of handling, each center should be willing to acknowledge another as having primary competence in certain fields.

-- Improved Center-to-Center Communication. As the lead center is forced to deal with other centers working on the same program, communications between centers must increase in frequency and scope. This research team was surprised in its study of the Apollo program to discover how uninformed managers and engineers at all levels in the Manned Space Flight centers were concerning the activities within other centers. This ignorance was particularly evident in matters of management. It may have been less serious in the dissemination of strictly technical information since avenues existed for this purpose, but in the utilization of administrative and managerial knowledge there was very little interchange.

Perhaps Apollo had sufficiently few real interfaces to allow this situation to persist with no excessive loss in efficiency. Certainly that is not so in the Space Shuttle program, and it is not likely to be so in others. Furthermore, only a minimum of duplication in effort is likely to be tolerable in the future. As well as avoiding excessive trial-and-error

duplication on the way to the discovery of effective courses of action, this forced intercourse should also engender a greater sense of respect and trust among individuals performing similar tasks at different centers. In fact, the extreme insularity of the two centers has already been broken. Our interviews in 1972 disclosed, in limited instances, a growing awareness in both MSC and MSFC of each other's strengths and a certain amount of grudging respect that had developed during the early negotiations between the two centers in connection with the Space Shuttle program.

-- Strengthened Control of Complex Interfaces. When a program such as Shuttle contains complex interfaces such that any slight variation in one element impacts the design parameters of another being developed elsewhere, the coordination of activities and decisions through a lead center with its in-depth capabilities plus program authority becomes more and more desirable. Where the interfaces among the component parts of a program are minimal or simple, the lead center role is not so important. Each center, taking responsibility for its own part of the program, can report to and take direction from Headquarters as in the Apollo program. No one can delineate exactly what degree of interface complexity warrants or demands lead center management, but this is certainly a major consideration.

-- Operating Center Contractor Control. Through the Apollo program the various centers became adept at negotiating contract changes with contractors. At this stage in NASA's maturity, it is perhaps unnecessarily cumbersome to bring Headquarters into so many NASA/contractor relationships.

With the location of higher level management and the supporting technical resources at the lead center, it should be in a better position than Headquarters itself to evaluate change proposals and change requests. The man in day-to-day contact with contractors on detail should be best able to work with the contractors in evaluating progress and deficiencies. This degree of detailed knowledge can never be moved to Headquarters.

f. Disadvantages in Lead Center Management. The following disadvantages relate especially to the role of MSC in the Space Shuttle program:

-- Management by Equals. Resentments are always engendered when authority and control over one part of an organization are exercised by another part that is at an equal level in conventional organizational hierarchy. Lead center management sets up just such a situation. The fact that a higher level program office exists at Headquarters does not make this any less distasteful when in fact one center must take direction from, must accept whatever limited responsibility is assigned by, and must be continuously accountable to a sister center. Regardless of how carefully the lead center is selected, the others will not perceive or acknowledge it to be superior either technologically or in management capability.

Parts of NASA that have operated in one version or another of lead center management in the past may be quite accustomed to reporting to other centers. This is not so in the two Manned Space Flight centers, MSC and MSFC, which throughout the Apollo program were very largely independent of each other. Each was in effect autonomous, reporting upwards but seldom horizontally. Each developed a justifiable pride in its own

abilities but at the same time some degree of suspicion and mistrust of the other, born of past rivalries and regrettable ignorance.

-- Domination of NASA by One Center. The reason that the selection of one or another center as lead center for the Shuttle program assumed such importance in the eyes of all personnel at both MSC and MSFC was that this was the only big, long-range program for OMSF in the foreseeable future. The lead center for the one well-funded manned program could become the center that dominates the whole Agency.

Failure to be selected as lead center for Shuttle became a demoralizing blow for MSFC. The significance of morale throughout NASA can never be ignored. The high morale of the 1960's played a tremendous part in the outstanding success of the Apollo program. It is doubtful whether NASA's programs, with such technological complexity and risk, can ever operate with the acceptable lower level of commitment evident in other government agencies where failure, though perhaps more serious to the nation, is less dramatic.

-- Atrophy of Other Centers. The domination of NASA by one center endangers the continuation of the others. Each center must be maintained above some critical level of financial support and activity or it can quickly lose its competence. As experienced men leave they will not be replaced by the needed dynamic younger men. Without continuous experience in contract management, any center would soon become incapable of assuming the direction of large contracts in the future. Without challenging research and development work, the engineering capabilities would soon

degenerate.

If there were to be a large number of relatively small programs phasing in and out at a fairly steady rate so that each major center could be given the lead role frequently, no one center would come to be regarded as the key NASA center. But this is not the case. In short, should one center be the only real lead center for some years, the others would be neglected and their usefulness irretrievably lost.

-- Loss of Alternative Proposals. It has been an advantage to NASA in general and OMSF in particular to have alternative proposals for major or minor aspects of a program flowing to Headquarters from more than one center for evaluation. In fact, the existence of more than one center and the rivalry among them has stimulated individuals and centers to sponsor alternative schemes.

With the management and evaluation of a program or a number of programs in one area by a lead center, Headquarters may be deprived of the opportunity to criticize adequately. This will not necessarily be so. It depends on the open-mindedness with which the lead center itself encourages and evaluates inputs from elsewhere, and it depends on the strength and decisiveness of Headquarters itself insisting on a free flow of information, adequate financing of other centers, and its own prerogatives.

-- Favoritism in Task Assignments. The fear that a lead center for a program or for a class of programs may show favoritism in the assignment of roles to others, and indeed, may keep a disproportionate amount of R & D work or contract supervision to itself, has been expressed repeatedly by

some NASA managers we have interviewed. However, if Headquarters were to insist on certain equitable task assignments beyond giving broad guidelines, this intrusion on lead center authority could be rightfully resented and could negate some of the advantages inherent in decentralization. To say that these are groundless fears and that there are sufficient external controls over lead center decisions to avoid abuse of prerogatives does not satisfy. Perceived threats are demoralizing whether they are real or not. If top OMSF and NASA management provides the right environment, time can overcome many of these difficulties.

g. Uniformity in Program Management. NASA has had and will continue to have a wide variety of programs. It would be a mistake to insist that the management structure for all programs should be identical since each program raises its own unique problems of communication, funding, time scale, contract control, and so on. Furthermore, management techniques should be no more static than technology, and to find the best mode of operation may require experimentation, selection, and rejection of whole schemes or particular details. Consequently, one cannot say that all programs should be controlled through a lead center with certain prescribed authority, or that all centers should be involved equally in every undertaking, or that each program should have a program office at Headquarters. Each project must be objectively judged for its adaptability to one management mode or another.

Nevertheless, there is merit in uniformity. Any new type of operation inherently includes risk. Within one government agency, individuals

and suborganizations are more comfortable with a large degree of predictability. They learn to respond to an accepted mode of operation and in so doing they respond with less confusion and greater efficiency. The proliferation of management roles that are in fact quite different, but are all referred to as "lead center," will inevitably aggravate the suspicions with which each new management directive is viewed and lengthen the adjustment time required before productive work can begin.

h. Comments on Advisory Lead Center in Communications. The lead center function to be performed by the Communications Program Office located at MSFC avoids actual "management by equals" since this office will not directly control program funds. It is true that an office at one center will sit in judgment over the efforts of a sister center or other offices at the same center, but still its function is essentially advisory. Final decisions are to be made at Headquarters and all directives are to flow through the usual channels. Headquarters, in this case the Communications Office in Applications, may accept or reject or modify whatever advice it receives. As long as that higher office is always accessible for appeals and counter arguments, no center or group need fear that a sister organization rejected its proposal or hobbled its operations. The "lead center" office must scrupulously avoid favoritism and prejudice, but there is no reason to believe that cannot be accomplished.

In its role of evaluation and advising, this office has convenient access to the total technical and managerial resources of MSFC. The functional directorates, particularly Science and Engineering, already

contain experts in the wide range of disciplines necessary for deep technical scrutiny of any program or task, and these individuals need not be attached to the Communications Office except on an ad hoc basis. Of course, the Office of Applications lacks an "institutional base". That is to say, no NASA center is specifically designated as "belonging" to it. By contrast, three major centers, MSFC, MSC and KSC, are organizationally within OMSF. One might, therefore, argue that there is no need for OMSF to have a key staff function located outside Headquarters since it can draw directly on all three centers. But OMSF cannot then adequately evaluate conflicting claims or proposals without maintaining a staff thought by many to be unnecessarily large and a duplication of talent existing elsewhere.

The most serious objection to the advisory lead center role is that the office lacks clout. Without direct control of funds or any line authority, the advisory group may be continuously frustrated.

It is of interest to note that the group at MSFC which was asked to propose an organization and method of operation for the Communications Program Office was reportedly warned to propose a scheme with which they themselves could live if some other center were given this lead center role. This reportedly became an overriding consideration in all details of the proposal, and there is reason to believe that it played a large part in making their proposed organization acceptable to the Office of Applications.

2. OMSF Field Centers

Given the character of the Shuttle program and the level at which it

is funded, certain continuities and discontinuities are apparent when surveying the OMSF field centers.

Houston, almost since its inception, has had a strong program orientation, and in general, the technical directorates have been subordinate to program considerations. This was partly due to the varied tasks assigned to Houston, the new "state-of-the-arts" technology and design problems associated with the assigned tasks, and a historical succession of quite strong program managers. Generally, with the exception of developing mechanisms to manage its lead center responsibility, Houston will not have any major readjustments to make to accommodate the demands of the Shuttle program.

Kennedy does have major readjustments to make to accommodate Shuttle. The trend toward combining manned and unmanned launches will be actualized in this program and the disparate philosophies of these two heretofore separate groups will have to be reconciled. The different vehicle capabilities and configurations will necessitate reworking launch sites and test and check-out procedures. Kennedy, although it views its major responsibility in NASA as a launch service facility, also views its test and check-out procedures as the ultimate verification of design and development. This second function might precipitate conflict if Houston, as lead center, desires to assume greater test and check-out responsibility.

The planned frequency of Shuttle launches and projected quick turnaround times will impose a heavy burden on Kennedy and will necessitate an overhaul of the organizational strategies and operational procedures

worked out for Apollo and Skylab. Although the launch group already dominates this center, this will be even more so for Shuttle.

One of the major problems the Shuttle program will face will be that each field center will need visibility into other parts of the program. If a viable configuration and integration mechanism can be established, then during the operational phase of Shuttle this proven procedure can be slightly modified to coordinate the "cargo" configuration and launch activities specific to each Shuttle flight. While it is true that Houston as lead center has the overall decision-making responsibility for design and development of Shuttle, this does not necessarily mean that all of the program control activity has to be performed at the center itself.

Houston and Kennedy are alike in that the projected work load at each center is comparable to that of Apollo and Skylab. This is not so for Huntsville, where the work load in Shuttle is significantly reduced when compared to Apollo. The major readjustments at this center involve accepting a clearly subordinate role in Shuttle development and creating a new work load to utilize the size of its work force and physical plant. The lack of work is a serious dilemma but it can be alleviated by two somewhat different strategies. First, both Houston and Kennedy should have greater access to the laboratories at Huntsville and be persuaded to use them as technical support for the management tasks they have been assigned and, as well, to tap the vast technical contract monitoring experience that exists in the labs. Houston, for example, will face a monumental task in

relating to and monitoring the activities of the prime contractor on Shuttle, particularly since the prime also has overall technical integration responsibility. Huntsville can make an invaluable contribution in this area. Second, rather than encourage Huntsville to develop new programs, either Shuttle-related or not, the whole problem of maximizing the use of Shuttle should be made a prime responsibility of this center. Shuttle was sold to Congress, the President, and the American people as an all-purpose vehicle which could accomplish numerous ends from surveying earth resources to providing a research base for significant and needed scientific developments. As well, it is expected to contribute to our military capability. But, there is no one single place in all of NASA where a group is working on all of the potential uses for Shuttle, working out procedures to encourage its use, or establishing guidelines and techniques to marry varied user requirements with NASA procedures and the constraints of the Shuttle vehicle itself. This is a large task and one that Huntsville could quite adequately handle.

With appropriate Headquarters action one can foresee, in the future operational phase of Shuttle, a relatively clean and co-equal breakout of responsibilities among the three centers. Kennedy would be the launch service facility, Houston would control the missions and Huntsville would manage the payloads and experiments and develop routine and innovative patterns of use for Shuttle.

3. The Role of the Center Director

Center Directors in OMSF are called on to play a variety of roles

internal to a center and relating the center to the larger OMSF organization and other units of the Agency. In the current period with reduced resources and the greater inter-center activity and/or program mix, the role of the center director has become even more complex.

The program organization format utilized in OMSF demanded that the center director trade off program, functional, and institutional considerations in the course of carrying out his role. With the lead center concept, greater complexities are introduced, particularly in defining the hierarchical relationships between center directors and program managers, at the center and headquarters levels. Before Shuttle, although there were inherent ambiguities, the center director's position vis-a-vis program managers at the center, the Headquarters program manager, and the head of OMSF, was understood. Depending upon the situation, at times the center director played an institutional role, sitting on the Management Council, for example, and evaluating the progress of Apollo program activity. At other times he played a program role, relating to the Apollo Program Manager at Headquarters and "supporting" the program manager at his center. While ambiguities were present, the existence of a clearly defined Headquarters program office, attached to the Associate Administrator's Office of Manned Space Flight, with clear overall program authority, provided a necessary starting point for working out authority relations in the organization.

On Shuttle, the lead center concept has blurred the Headquarters-center distinction and has created an ambiguity overload in terms of authority and responsibility in the overall program organization. It

appears that it is necessary to make a clear distinction between technical responsibility and policy responsibility for running Shuttle. Further, it is necessary to locate the responsibility for over-all policy at Headquarters. Without this distinction, each center director will have difficulty in carrying out his center's program responsibility. At Houston, the center director might be inclined to take on broad responsibilities similar to those of the head of OMSF in Apollo. This would be much too great a responsibility when coupled with his center roles. At the other two centers, the autonomy and hierarchical balance which the center director provides would be upset. If the distinction between technical authority and overall program responsibility is not clarified the center directors of Kennedy and Huntsville would be primarily taking direction from Houston and become subordinate to that center rather than acting as co-equals whereby all three centers relate in essentially the same way to a clearly superordinate office at Headquarters.

Regardless of how one assesses the center director's role, it is obvious that a center director to be successful in OMSF must have certain qualities. He must, first of all, be technically competent. Each of the centers is involved in work of great technical complexity and to oversee this work the center director himself must have a strong technical background. Second, a center director must be an organizationally aware and sensitive person who can divide the labor in such a way as to optimize productivity and keep all elements of the center satisfied. Also, he must anticipate environmental changes and alter his center organization to

anticipate or accommodate them. Third, the center director must be strong enough to keep all of the diverse elements integrated, to protect the autonomy of his center (particularly in the light of the numerous new inter-program office and inter-center relationships emerging in NASA), and to protect the base of technical expertise in his center. Fourth, it helps if the center director is an "insider" who knows the center, is trusted by center personnel, and has the respect of those within and outside his center.

The decreasing distinction between manned and unmanned flight and the resultant greater interpenetration of other programs into OMSF centers will be a major problem for the center director. To be responsive to all of the varying demands and yet maintain center autonomy and integrity will be a great challenge for the center director.

B. PROGRAMS

1. Program Organization

Programs are defined by schedule, performance and cost parameters. On the Apollo program, schedule and performance considerations predominated. Shuttle, by contrast, is being managed with cost as the major factor. Performance, in terms of more narrowly designed objectives and schedules, has been continually modified to meet the unyielding cost constraint. The manner in which Manned Space Flight in NASA operates, particularly the field centers, is changing considerably because of the differences between Apollo and Shuttle. This section will suggest some of the organizational

alternatives open to OMSF in the light of present and predictable near-term future circumstances with which this office will have to cope.

Essentially OMSF can move toward one of two opposite extremes. First, it can continue to grow and maintain its strong program orientation as was the case with Apollo. It was hoped that Shuttle would provide the means for large and sustained program activity, but changing national priorities and emergent socio-political factors dictated otherwise. If NASA is to retain its strong programmatic emphasis, either the Shuttle program will have to be enlarged in concept and resource allocations, or some large-scale complementary program will have to be started. Neither alternative seems likely.

The second extreme OMSF can move toward is a revised but larger version of the old NACA organization. That is, OMSF can become a bureau-type office concentrating on its national space resource responsibility. This development pattern would be quite traumatic for the overall Agency in that it would require further reductions in manpower and a wholesale reorganization with laboratory and technical considerations dominant.

It is probable that the form of OMSF's future organization will be somewhere between these two extremes. The near-term future of the Agency, particularly after Shuttle, appears to entail a period of relative quiescence and therefore organizational changes toward the bureau-type agency. When the present responsibilities in OMSF are matched against its capabilities, OMSF is in an untenable position. The cost of maintaining the present organization and associated physical plant cannot be justified

given the tasks OMSF has been assigned and its future prospects. NASA, and in particular OMSF, has already demonstrated that it can grow in size and capability very quickly if the occasion arises. It would appear that a practical strategy for OMSF would involve adopting a modified bureau-type posture and attempting to conserve as much of its technical capability as possible.

In view of known and probable tasks that will be the responsibility of OMSF, the three field centers are experiencing quite disparate problems. Houston, with the lead center designation for Shuttle, is not facing any major readjustment. It will continue to be organized around a major, large-scale program effort. What adjustment problems the center will face involve issues of establishing its lead center presence in OMSF, gaining greater visibility into other centers of OMSF and establishing and maintaining all of the coordinative groups and activities necessary to perform its major technical management responsibility. If the decision is made to stress in-house technical and management support activities, the task of managing the development of a significant portion of the Shuttle program coupled with the overall lead center responsibility for Shuttle will mean that MSC will not have to undergo any major reorganization.

In many respects, the situation at Kennedy is similar to that of Houston. The Shuttle program places a significant burden on this center in terms of developing new launch facilities and capabilities. The projected increased frequency of launches and the required short turnaround times involve KSC in both large-scale developmental and operational

activities. While Shuttle is certainly different from Apollo, from the perspective of quantity of work, Kennedy will be kept as active if not more so with Shuttle. At this center the major readjustment will involve integrating unmanned and manned launch-related activities. The planned launch site on the West Coast will impact activities at Kennedy only minimally.

Huntsville, of the three centers, has been the most greatly affected by the phaseout of Apollo and the emergence of Shuttle as the major follow-on manned space flight activity. It continues to have a great technical capacity distinct from the other OMSF field centers. Given the lack of significant Shuttle responsibility, the high degree of uncertainly surrounding programs after Shuttle, and its superb technical capability, it is our suggestion that Huntsville should adopt a technical service orientation, and temporarily, at least, de-emphasize its large program management function. This could be done by using the Huntsville labs as the major technical support for development activities being managed at Kennedy and Houston. As well, a conscious decision should be made to funnel research activities and frontier state-of-the-arts technology development work to this center. And finally, a more significant role in Shuttle should be defined for Huntsville involving payloads and experiments for Shuttle, coupled with developing methods to enhance the "user" demand for Shuttle.

This new direction for Huntsville will entail a major readjustment whereby the center no longer will be organized around major program activity, but rather, technical capability. Further, if the "user" facilitation

role is delegated to Huntsville, the Program Development directorate can be transformed into a User Development directorate and a better focus for the activities and planning in that section of the Huntsville organization can be established. All of this will require better integration and responsiveness on the part of the center, and therefore stronger center management.

2. Project Management

In our judgment, NASA's project management system is sound. But it is essential that the project management system capitalize on the strengths of the functional and institutional organizational elements of NASA while overcoming some of the barriers of the large, functionally-oriented organization. Specifically, NASA could further improve its project management mode by continuing to emphasize these areas:

a. OMSF should continually emphasize the importance of the project management system to the success of NASA's developing projects. This can be accomplished, in part, by disseminating the project manager's authorities, responsibilities, and charter to all the "working levels" of the organization — not only within a center but also among interfacing field centers. Such a step can minimize to some extent the conflict situations and ambiguities which almost always develop when a new program is being established. As smaller, less visible projects are undertaken by NASA, this will become even more important. This is clearly a NASA top management responsibility.

b. NASA must continue the development of inter-center matrix management techniques. If NASA is viewed as a national R & D resource for astronautics and aeronautics, more management attention must be devoted to identifying and integrating the vast managerial and technical expertise within the total NASA organization. Emphasis by NASA's top management on the necessity of more effective inter-center integration can have the important advantage of more fully utilizing NASA's in-house competence. One of the most positive benefits would be in eliminating redundant manpower resources.

c. One of the principal factors which makes NASA's approach to project management truly unique is the strong in-house technical capability. This technical back-up must be preserved.

d. In the future NASA should give more attention to "cross-skill" training for project managers and selected technical personnel. In the past we have observed that long-term project management assignments often do affect an individual's technical capabilities. In some cases, project managers have openly admitted to us that they have indeed lost their technical competence. This causes employee mobility problems when project assignments are completed. Too often the result is to overburden the managerial ranks with people who have no real role to fulfill.

e. Our field interviews indicate that in the future a concentrated effort should be made (and encouraged by OMSF) to keep the various program offices as lean as feasible. Many managers in the field centers have expressed the notion that in Apollo the program offices were allowed to

become too large, thus affecting efficiency and response capability. For future programs we recommend that the various program offices rely more heavily on existing functional and staff offices. Such an approach, when feasible, leaves the expert in his normal functional organization. The Shuttle Program Office at MSC, for example, has made some important strides in this direction in the areas of flight computer programming, range safety and flight operations.

3. Subsystem Management

A positive step has been taken to improve the effectiveness of the subsystem manager concept. At MSFC, in the Apollo program, the subsystem manager was located in the Project Management Directorate (PM). A key role of the subsystem manager was to interface with various laboratories in S & E to elicit subsystem support. While this approach proved workable, there was the inevitable conflict over subsystem objectives. That is, various forms of conflict occurred between the project management organization and the various functional technical directorates. The subsystem manager is now co-located in the functional directorate. This new subsystem management mode is essentially the approach employed at MSC in the Apollo program.

For future projects it appears that a positive step is being made by increasing the subsystem manager's authority for his identifiable work package. Under this approach the subsystem manager will be given a more responsible job and will have visibility as the single point-of-commitment for a work package. This should help the subsystem managers to interface more successfully and give them better access to technical skill centers

in the laboratories and technical areas. Rather than being attached solely to a project manager, the new subsystem manager will be part of the laboratory organization. For this approach to function effectively, the subsystem manager will have to be carefully selected and his appointment agreeable to the major interfaces.

The subsystem manager will be an "integrator" of both technical and managerial information as it affects his entire work package. For this approach to work there must be a clear definition of the subsystem manager's role with all the key interfaces. It must be understood that the new subsystem manager is the single point-of-commitment. As noted in our field interviews, several key questions must be asked in delineating the subsystem manager's role:

-- Is there agreement within the various work units of the center as to what the subsystem manager's job actually entails?

-- Is it clear to everyone whom he is ultimately responsible to?

-- Who reviews the work of the subsystem manager?

-- How will conflicts be resolved? What appeal channels are available?

-- Who defines the subsystem manager's work package? How are agreements met among key interfaces on the assigned work package?

-- How will subsystem integration be accomplished?

-- How are key interfaces established?

In summary, we feel this new approach to the role of the subsystem manager will be an important step in increasing the effectiveness of NASA's project management system.

IV. PLANNING ACTIVITIES

A. LONG-RANGE PLANNING

An area of concern to NASA is the viability of the Agency's long-range planning efforts. While this study group is concerned with the total NASA planning process, our remarks are particularly addressed to the planning function within OMSF. NASA and OMSF have had a number of long-range planning operations but their effective utilization appears to have been sporadic. Some of the traumas experienced by NASA in the Apollo phase-down and the reorientation of NASA to a multi-project mode might have been avoided if NASA's planning efforts had been 1) more substantial, and 2) given greater organizational support and commitment at all levels.

1. Problem Areas

The following areas are problematic for the Agency and should be addressed in NASA's long-range planning efforts:

a. Perspective on Shuttle. Some personnel at the field centers question how and where NASA is focusing its future efforts. Many field center personnel do not see the evidence of a NASA long-range plan. In particular, there is some doubt about the eventual role of the Space Shuttle as it affects their own field center activities. Many functional areas, for example, within the OMSF Field Center do not appear to understand how they will integrate with Shuttle or what Shuttle will mean to the long-term objectives of NASA. Further, Shuttle is often perceived as being synonomous with NASA's long-range planning activities. We believe this is detrimental to NASA and that Shuttle must be put in a more appropriate perspective.

b. Visibility of NASA Plans at Center Level. Due to the lack of a visible planning system which NASA personnel can readily identify with, NASA often does not operate as an integrated, goal-oriented organization. While there is ample evidence that field centers are responsive to current NASA plans and programs where their role is clearly identified, there is some ambiguity at the field center level regarding the role NASA Headquarters wants a field center to perform when NASA plans do not significantly impact the center. This causes confusion and ambiguity on the part of field center management and personnel have developed a "field center" orientation rather than a "NASA-wide" orientation.

c. Integration of Manned and Unmanned Program Plans. The distinctions between manned and unmanned activities are gradually eroding. NASA thus needs to derive a long-range planning system which can be a catalytic agent in the integration of manned and unmanned activities at all field centers. As one NASA manager remarked, "we need a long-range plan on which we can base our operational plans."

d. Anticipation of National Priorities. It seems clear that an increasingly important activity for NASA during the latter part of this decade and beyond will involve closer working arrangements with other organizations outside the NASA/aerospace context. A planning system should be devised that can anticipate shifting national priorities and thereby assist NASA in its integrative efforts with state and federal agencies.

e. Marketing NASA's Capabilities. NASA by its charter has a mandate

to "market" its scientific and engineering capabilities. To date, however, their general utilization in the public and private sectors has been minor. By the establishment of an effective planning system NASA can: 1) assist in identifying and assessing the potential markets for its technology; 2) facilitate the building of a demand for its technology; and 3) monitor the success of the technology utilization process. As a national R & D resource NASA must identify the technologies which can benefit various sectors of society. Only by an intensive planning system can these technologies be effectively identified, assessed, and eventually transferred to potential users.

2. Dimensions of a Total Planning System

NASA's planning system should incorporate two fundamental dimensions:

a. Operational Planning System. NASA has been almost exclusively concerned with an operational planning system. This planning system is primarily based on current and projected programs and associated activities, budgeting, and the forecast of human and physical resource requirements.

b. Strategic Planning. The second planning dimension that is essential for NASA is strategic planning, which is concerned with long-range forecasting, scenario development, and the possible impact of environmental influences on NASA. Effective strategic planning can reduce the uncertainties of the future by forecasting conditions which are likely to change or alter the nature and mission of NASA. Strategic planning is an important

tool in identifying opportunities and threats early enough so that action plans can be initiated and implemented.

There are two important components of a strategic planning system:

Technology Forecasting: The role of the technology forecasting activities would be to identify and assess emerging technological developments which could impact NASA so that these can be factored into NASA's long-range planning efforts. Technology forecasting also would include the forecasting of NASA-generated technology.

Socio-political Forecasting: This involves developing alternative scenarios of events which could occur in the social/political environment and which could affect NASA's future whether they are threats or opportunities. Some examples are:

-- Attitudinal changes of various sectors of society toward national and international space-related activities.

-- Changes in the political climate affecting funding of NASA activities.

-- Changes in attitudes toward means to solve chronic national public sector and world problems; i.e., the desire to use technological and/or ideological solutions to such problems as nutrition, war, international conflict resolution, earth resources utilization, etc.

-- Changes in national life styles, values, importance of national and international social and political problems.

It is important to emphasize that neither technology forecasting nor social forecasting alone is sufficient for anticipating NASA's emerging environments. It will take both approaches to develop alternative future roles for NASA. NASA cannot effectively operate in its larger "host" environment unless clear, meaningful goals are articulated and approved by society. (The SST is a good case in point.)

The probabilities are fairly low for the emergence of a clear-cut Presidential or Congressional action-oriented mandate for NASA to follow. As a consequence, NASA must largely take the initiative for developing innovative programs and marketing them to the public, Congress, and the Executive Branch. Thus, in the future, it will be important for NASA to build a broad-based constituency and strengthen its links with those who make and influence decisions which can impact NASA's future. Such activities would be an integral component of NASA's strategic planning activities.

Both operational planning and strategic planning must be integrated since they are interactive components of a total planning system. Strategic planning will become critical for NASA's future. Our recommendations for the establishment of a strategic planning system within NASA does not imply that NASA has not followed such a course in the past. NASA by the nature of its programs has had to do strategic planning, technology forecasting, and some socio-political forecasting. Our report, however, advocates a continuous, concentrated NASA planning effort.

B. STRATEGIC ORGANIZATIONAL ANALYSIS

Strategic organizational analysis is closely related to long-range planning and must be integrated with it to be effective. While we realize that some form of organizational analysis is being done, we are advocating an increased emphasis on this important dimension of organizational planning.

1. Organizational Audit

We advocate that a rigorous and continuing organizational audit should be made for the entire NASA organization commencing with OMSF. Strategic organizational analysis involves the evaluation of every identifiable organizational unit and assesses each unit's current and probable future contribution to NASA's missions and objectives. To make NASA a lean and flexible organization, there are a number of organizational areas which should be identified which may not serve any current or strategic NASA purpose. In effect, we advocate that the functional and staff areas within each of the field centers and at Headquarters be viewed in terms of contribution. Only by following some form of strategic organizational analysis can NASA meet the flexibility requirements that a multi-project organization demands. Flexibility will be critical for NASA in view of the more uncertain nature of its future programs. In short, an effective response capability will become increasingly important for NASA. If various organizational units are audited for their present and potential contribution to NASA's long-

range comprehensive plan, each work unit can then be classified as "strategic," "core operating base," "marginal," or "expendable".

2. Classifications

a. Strategic. A strategic classification denotes that the contribution of a particular organization unit is critical to NASA's long-term future. It is an area which should receive priority in terms of top management attention, resources, and manpower.

b. Core Operating Base. A classification of core operating base would denote a necessary, enduring part of the organization, such as necessary institutional areas and functional skill centers. For example, an R & D laboratory or work-unit within the laboratory might have multiple contributions to make to NASA's objectives, whereas an engineering unit whose capabilities can be easily duplicated may not be necessary. Core operating areas would be those areas which are necessary to support the various strategic functions and programs of NASA. Unless the audit carefully examines the entire NASA organization, it is highly likely that various units will be thought of as core operating areas but, in reality, deserve a lower classification rating. Classifying those institutional/functional areas at Headquarters and at the field centers which are clearly not strategic or core operating base will be one of the most difficult activities in the auditing process.

c. Marginal. A marginal classification might reflect that a particular work unit should be supported if the Agency can afford it.

d. Expendable. The expendable category denotes that an area is not necessary for current or forecasted NASA objectives. The area, for example, might have outlived its original charter. Over time, however, the particular unit was not dismantled and has existed due to "benign neglect," oversight, or unjustified entrenchment.

A careful audit is bound to reveal that certain areas of a particular unit are indeed important, while others have limited or no contribution to make if a strategic plan exists. We are aware of the many constraints on NASA, such as the Civil Service System. We feel, however, that NASA is now in a good position to begin working towards a concrete plan. It will become more difficult to do so as time passes and the organization becomes increasingly bureaucratic.

This type of organizational analysis should be a continuing function with high-level NASA management support. The recent decision to restructure Program Management at MSFC is a fairly valid example of the results which a continuing strategic organizational analysis audit could make with top management support.

3. Manpower Advisory Council

An important value of strategic organizational analysis will be its contribution to RIF planning and implementation. While some procedures already exist for RIF planning, we feel that a concentrated effort also must be made whereby priorities are established on the basis of total organizational needs. It is suggested that priorities be established with the

management of the specific work unit and a NASA-wide Manpower Advisory Council. It would be necessary for such an Advisory Council to be closely integrated with NASA's long-range planning function and the recommended strategic organizational analysis function. Within many work units it is obvious that some skills are more expendable than others. Where possible, those skills which do not enhance NASA's technical response capability should be subject to the earliest RIFs.

C. FIELD CENTER FUTURE PROGRAM PLANNING

In terms of long-range or advanced program planning, one area which has concerned us is the activities of the Program Development Organization at MSFC and the Future Program Office at MSC. Both groups are actively involved in attempts to evaluate new program alternatives for their respective field centers and for NASA. The important question, however, is the degree to which these activities are congruent with NASA's over-all, long-range plans and objectives. If they are congruent, the activities are logical. We generally agree with such a method of new program development at the field centers, where in-depth technical capability exists. On the other hand, if program development activities at MSC and MSFC are not integrated and coordinated by a long-range master plan, we feel that such efforts may well be inefficient because the efforts of each center will not be coordinated with what NASA should and could be doing.

Our interviews have indicated that there is some confusion over the roles of future program development groups at the field centers as they

relate to over-all NASA planning. We believe that it is important for Headquarters to decide whether field center program development activities should be coordinated with NASA's long-range plans, whether they should be decentralized operations to help the field centers market their capabilities to the rest of the NASA operation, or whether program development activities should be some combination of these roles. Whatever the decision, it is important to disseminate to the field center personnel Headquarters' view of these activities.

D. NASA ASSET UTILIZATION

NASA has accrued a number of physical assets which cannot be easily replaced if allowed to deteriorate. A problem currently facing NASA is how to determine whether an asset should be retained or discarded, and how to minimize the maintenance expense of those assets which are potentially useful to NASA. While some of these resources contribute directly to NASA's national R & D capability, others may be expendable and should be disposed of in some way. The problem of asset evaluation is related directly to the development of a viable long-range plan. We feel that one of the most important steps NASA can take in the transition from a dominant, large program to the concurrent management of several smaller programs is to employ those assets which are useful and eliminate or dispose of those not useful to NASA's future. At MSFC, for example, the total "value" of assets (MSFC and contractors) reportedly is approximately

two billion dollars. While some of these assets have essentially a zero disposal value, it has been estimated that their replacement cost would be almost double their original cost. The effect of an inventory of NASA's assets will probably be greatest at MSFC since it has more industrial assets than the other OMSF field centers. In particular, an audit should be made of the following:

-- Michou

-- Mississipi Test Facility

-- NASA Special Tooling/Soft-ware/Computers

-- Space Experiments which have not been used

-- Plant and manufacturing equipment at the contractor's plant and at NASA field centers

A realistic evaluation of NASA's assets can only be made in the light of a long-range plan. A simplified scheme of the NASA asset inventory and evaluation process is shown in Figure 1.

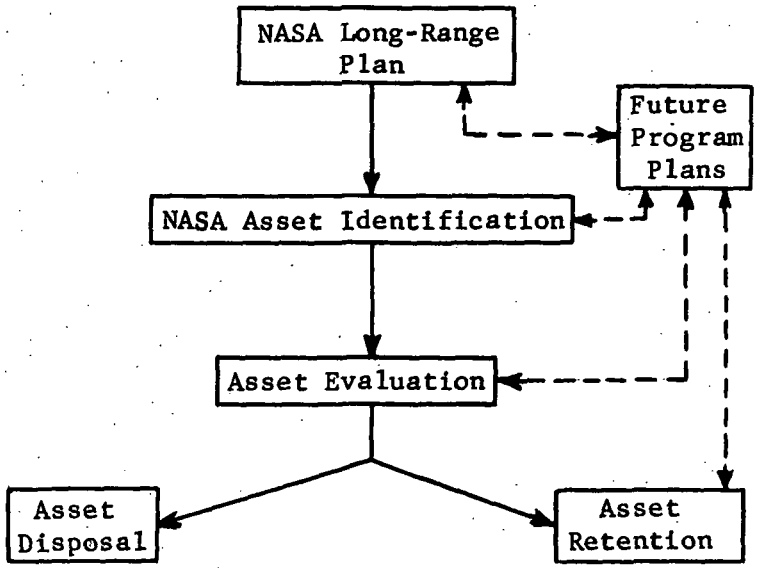


Figure 1. NASA Asset Inventory Process

V. OPERATIONAL ACTIVITIES

In this section of the report five factors are discussed which deal directly with operational activities of programs and centers within OMSF. Changes which have taken place are viewed through a comparison with operational activities noted in the recent past, and some attempt is made to assess the effects of these changes on OMSF programs and resources. This is not intended to be an exhaustive review of transitional factors, but is simply comment on various details which seem to this research team worth evaluating as program plans and organizational structure are reviewed by OMSF.

A. CONVERGENCE OF MSC AND MSFC ACTIVITIES

In the past few years the technical expertise and the specific activities of the two major OMSF development centers, MSC and MSFC, have converged significantly and tend to overlap. This had not been so to the same extent through the earlier phases of the Apollo program where the tasks of the two centers could be quite clearly distinguished and each center was very fully occupied with its own contribution to that large program. MSFC, building upon a core of personnel already experienced in booster technology, developed a large, highly competent R & D organization concerning itself primarily with the design, production and testing of various kinds of spacecraft boosters. While many contractor organizations also have developed skill in booster engineering, their efforts tend to rise and fall with the magnitude of each contract they are awarded. It is fair to say that MSFC,

because of its stability and continuity through many projects, became and still is the most important repository of booster knowledge and experience in the country.

MSC developed more rapidly. Although it originally lacked a nucleus with extensive astronautic experience, MSC's mission caused it to evolve into the national focal point of expertise in spacecraft design, flight crew training, and operations, particularly mission control.

KSC, of course, concentrated on the checkout and launching of manned and unmanned spacecraft. In cooperation with the other two centers, it developed meticulous checkout procedures which contributed in a major way to the success of KSC launches.

As the end of the Apollo program approached, and with the future of NASA only vaguely defined, the development centers at Huntsville and Houston started to broaden the scope of their expertise to enable them to compete more effectively for post-Apollo programs. MSFC, already somewhat involved in the training of astronauts by virtue of its neutral buoyancy tank, involved itself to a greater extent in the planning and preliminary design of projects like HEAO and Skylab. The development tasks involved spacecraft, crew operations, and mission operations. The boosters for these projects were essentially fully developed items.

At the same time, MSC extended its work into the booster area, particularly for the Space Shuttle program. The booster and spacecraft are much more closely integrated with each other than they were with Apollo, and so the preliminary design of Shuttle necessarily required in-depth

knowledge of booster engines as well as spacecraft and crew operations.

Taken by itself, the broadening or rounding out of a center's expertise seems to be a desirable objective. However, OMSF is operating with much more limited resources than it did a few years ago. It cannot afford to have two centers which duplicate each other, nor would the Congress or Administration permit such a situation to exist for long. It is their unique, in-depth expertise that has brought distinction to these development centers. The expanded scope of activities at either center can now come only at the expense of diluting some of the areas of established excellence with regard to both in-house technical talent and the finely honed ability to monitor contractors in highly specialized fields.

KSC has avoided direct competition with MSC and MSFC for projects because its mission has been distinct and its responsibilities have kept it fully occupied. The advantages to NASA and the nation that have accrued by virtue of KSC's relative independence are generally recognized in OMSF. This independence has guaranteed a level of checkout control and design verification through test that might otherwise not be possible. Therefore, the possibilities of reassigning some of the checkout authority to MSC or MSFC should be evaluated very carefully. Because of the larger degree of interdependence between the subsystems of Shuttle, there may well be a tendency for MSC as lead center, or for the Shuttle integration contractor, to insist on control of the flight hardware much beyond that exerted in the Apollo missions. This would constitute not only a further dilution of a development center, but a weakening of the key strength of

KSC in its own quality control function.

The advantage of maintaining separate and distinct field centers goes beyond the value of unduplicated technical expertise. It allows each center to develop its own management scheme suitable to the peculiarities of the center's mission. Innovative developments in management should be transmitted from one center to another exactly as new technology must be to avoid parallel, overlapping experiments.

B. CONTRAST BETWEEN APOLLO AND MULTI-PROGRAM OPERATION

Many of the current difficulties in managerial and operational activities in NASA as a whole and in OMSF in particular stem from the transition from a concentrated preoccupation with the huge Apollo program to a more balanced concern for a number of ongoing programs and long-range planning for the future. It is very instructive to compare operational activities and organization during Apollo with those of the present and foreseeable future.

1. Defined Goals

The clearly stated primary goal of Apollo, to land a man on the moon before 1970, made planning and priority assignment unambiguous. To have a definite objective and a definite time limit is a program controller's dream. Neither of these has been specifically enunciated for Shuttle or any other post-Apollo program. Shifting priorities coupled with open-ended goals and variable funding will aggravate all future programs.

2. Real-Time vs. Phased Design and Development

In the Apollo program, although the objective was clearly defined, the time constraint was responsible for many costly changes as the whole Agency learned from ongoing experience. For Shuttle and other programs, there can be a more deliberate phased development with careful evaluation of alternatives, optimizing R & D versus operational costs. While some design flexibility must always exist in a complicated program, design requirements can be frozen early and costly changes minimized.

3. Resource Utilization

In Apollo, all centers were fully utilized, and although some duplication of effort and wasteful activities were unavoidable, manpower and facilities were not idle. Not all components of the OMSF centers are now fully utilized and they have become very competitive for work assignments and authority. This demands a strong control by Headquarters at a time when Headquarters staff must be reduced. The entire Agency is suffering contraction pains. It is always easier to cope with growth, and organizational shrinkage is always traumatic. The inevitable lag in adjustment to reduced funding complicates the underlying problem of transferring operations from Apollo to current programs.

4. Program Offices

When there was a step-function rise in the number and magnitude of contracts managed by MSFC early in Apollo, there was a need for the

coordination and program visibility afforded by the Industrial Operations (later Program Management) Directorate. With reduced resources, that center could not afford this additional management structure. But what is more important, without a management directorate, all programs, large and small, now have direct line access to the center director. At both MSFC and MSC, the center director should be the key administrator in ensuring access of programs to functional resources. He is in the best position to effect the necessary trade-offs and to assure program offices at Headquarters that priorities are being adequately considered.

5. The Mixture of Manned and Unmanned Missions

The three OMSF centers were overwhelmingly concerned with manned flight programs during the Apollo period. Now each center has significant unmanned space activities and there is more interaction with other NASA offices. One effect of this will be a reduction in the influence the astronauts as individuals and as a group have had on many design considerations. Mission Operations, for instance, must still consider their needs but must take a more balanced view of mission objectives. As MSFC, MSC, and KSC react more and more with other parts of NASA and manned and unmanned experiments are further mixed, perhaps for their long-range viability these centers should no longer be designated as OMSF centers.

6. Distinction Between Center Roles

In Apollo, MSFC was primarily booster oriented and MSC primarily concerned with the manned spacecraft. As noted elsewhere, there has since

been a blurring in the distinction between the activities of the two centers. It is useful to think of one as outstanding in large hardware development and another as extremely competent in mission control, to name only two separate areas. A lack of distinct role identification weakens both centers.

7. Design Reliability

It has been noted elsewhere in this report that in post-Apollo programs the shift in priorities from performance/schedule/cost towards performance/cost/schedule and even to cost/performance/schedule has begun to take place. This demands a complete reevaluation of design philosophy as each program is initiated. Not only do post-Apollo programs have a more relaxed schedule restraint, but also designers can achieve economy and weight reduction through broader uncertainty limits and decreased redundancy. This is obviously true in unmanned missions, but is also possible in man-rated hardware where experience has developed confidence in various systems. Policy in this regard can be changed more easily than individual activities.

8. Complexity of Interfaces

Complicated as Apollo was, the interfaces between the Saturn booster and the spacecraft were minimal. By comparison, the engine and spacecraft interfaces in the Space Shuttle program are much more numerous and complex. This demands increased communication between centers at the lower levels of project management.

C. NASA AS A CONTRACTOR

There are two reasons why various parts of NASA will find themselves acting increasingly as a contractor rather than as the manager of contracts. First, other government agencies and private industry are finding NASA's capabilities of use to them and will seek to use both its facilities and its expertise in an expanding range of technical problems. Second, with the adoption of the lead center management mode, OMSF has created a more formal manager/contractor relationship between the lead center and any other part of the Agency assigned a task in the lead center's program. This will be an extension of the program office/functional directorate relationships familiar in past programs, but with a significant difference.

1. External Contractor

NASA in general and OMSF in particular have acquired vast experience in managing major federal contracts. The Agency has been rightfully praised for its ability to work with private corporations on a tremendous range of development contracts, and this represents a unique area of expertise within NASA.

The Agency has already performed essentially as a contractor in such areas as the launching of various earth satellites for others including the Department of Defense, foreign governments, and the communications industry. Also, basic development work and testing have been done for

the aircraft industry. But much of this has been secondary to NASA's principle concern and has not involved OMSF to any significant extent.

Now it will be very advantageous for the Agency not only to agree to perform certain tasks for others, but aggressively to seek out contracts from others. This can mean both a much expanded source of funding and an opportunity to display its value to the nation as a technological resource and as an imaginative and creative problem solver. NASA recognizes these opportunities but might not appreciate the inversion of its contractual relationship.

The immediate opportunities for NASA are in the area of earth resources. The Agency's services are being sought by the federal Departments of Interior, Agriculture, Transportation, and Housing and Urban Development; and will be sought further by Coast and Geodetic Survey, the Army Corps of Engineers, Fish and Wildlife Service, and the Environmental Protection Agency. Certainly private corporations in communications will expand demands for satellite launch, possibly to include maintenance and repair, and many manufacturing companies could benefit from NASA's R & D.

Strong Headquarters leadership is essential in establishing this new role. A real transformation of attitudes is required for managers, scientists, and engineers throughout NASA if these expanding possibilities are to be exploited. All must realize that the life of the Agency depends on performance in these areas, and they must do more than simply respond to requests; they must create demands for their services. No one outside of

NASA can appreciate the potential of the technology and management capability in the Agency. Very few can imagine where NASA might be of service. It is not enough to say, "we are willing and able." NASA must invest time and energy in identifying which of its capabilities might benefit others and what problems in both the private and public domains might be amenable to solution through NASA expertise. Furthermore, NASA personnel must realize that these are respectable pursuits and that accomplishments in non-space applications of technology will be appreciated and rewarded.

2. Internal Contractor

The lead center management mode creates a different kind of contractor relationship. In the Apollo program, each OMSF center responded to the directives of the Headquarters program office, and line authority was unambiguous. Horizontal relationships between program management and functional directorates operated principally within one center or another. With MSC now lead center in the Space Shuttle program, another center such as MSFC when working on that program is operating essentially as a contractor to MSC's Shuttle Program Office. Each center working on some part of Shuttle will have a Shuttle Program Office through which entree to its functional directorates is controlled or monitored. Whether that office actually has authority through control of funds or is simply a liaison office, whether it acts as manager or resident clearing house will depend on the control Headquarters exerts on its lead center and on the personal style of each manager. New stresses will undoubtedly be generated. This

contractor relationship with another center may in fact be a great advantage in the control of the program, but it introduces new institutional relationships within OMSF and requires some revision in the attitudes of both management and technical personnel. The whole question of lead center role is dealt with in Section III of this report.

D. OMSF MANPOWER UTILIZATION

We believe that the field centers have become less flexible and responsive to organizational and programmatic needs for two reasons. The first is the proliferation of middle-management positions. The second is the protection by some managers of the number of manpower spaces allocated to their work units. Therefore, we strongly recommend that a manpower advisory council composed of top field center personnel be established to facilitate the shifting of manpower resources when and where needed. This is, of course, congruent with our recommendation for strategic organizational analysis. We are aware of the Civil Service problems entailed in such a recommendation, but we are hopeful that NASA and the Civil Service Commission can cooperate to make the system more flexible and responsive.

1. Management Positions

The proliferation of management positions often results when an individual in a technical job can be rewarded further only if he is given a supervisory position. As a consequence, he may be given a grade for supervision by having sometimes as few as three people reporting to him.

The establishment of these small departments and "shops" often leads to an increasing fragmentation and rigidity within a field center. To have a small work unit the "supervisor" needs his own secretary, his own mail symbol, his own cost code, etc. All this makes the shift of human resources more difficult, impeding organizational flexibility and adaptability. The administrative expense of maintaining these fragmented work units often cannot be justified. Unfortunately, there is the natural tendency to protect and maintain the work unit even after it has outlived its usefulness.

2. Manpower Spaces

The second impediment to organizational flexibility is the high value placed on "manpower spaces." The individual work unit's "wealth" at any level in the organization is too often measured by the number of manpower spaces allocated to it, regardless of expertise, need, or priority. As one NASA manager remarked, "Manpower spaces are like a peasant owning chickens: if you own more than the next guy you are better off." Efforts to promote flexibility, rotation of personnel, and integration of work units are sometimes defeated because supervisors are reluctant to relinquish these spaces. Often the spaces themselves appear to be more important than the individuals occupying them. This problem is most serious when a man who is not being fully utilized or who is unhappy with his role within his assigned work unit cannot get a release, even when another unit or office desperately needs his services.

E. CONTRACT INTEGRATION FOR SHUTTLE

One aspect of the recent contract awards in the Space Shuttle program has bothered this research team and that is that the prime contractor for the program has been awarded also the contract for technical integration of all efforts. We hasten to note that no one interviewed by us has expressed the same misgivings even in response to direct questions about the matter. Still, the potential for inherent conflict of interest must be noted.

The arguments are strong in favor of having the large prime contractor responsible for tracking progress of its own efforts and those of its subcontractors. In the Space Shuttle program this will be a tremendous task. The manpower required for this alone will be beyond the civil service manpower either desired by NASA or allowable at this time. An alternative to making the prime contractor the technical integration contractor would have been to bring in another company whose sole responsibility would be technical integration. This would undoubtedly be wasteful, introducing much duplication of effort. (It might be similar to the Boeing TIE contract in Apollo which was not altogether successful.)

A strong cautionary note must be sounded at this time: There must be a clear distinction between technical integration and managerial control integration. While it is reasonable that the prime contractor should assume wide responsibility as technical integrator, NASA itself, presumably through its lead center for the program, must maintain full and in-depth control of

all aspects of the program through its own management and control resources.

NASA's Apollo experience has made it fully capable of such management control, and experience has shown that only limited responsibility should be delegated outside the Agency. If MSC's current manpower is not great enough to perform this function adequately, then its management offices must be augmented by transfers from other parts of OMSF whose in-house capability is surely adequate to the task. NASA's technical capability is generally acknowledged. Its management expertise is not always appreciated.