N72-28878

MSC-06750

NASA TECHNICAL MEMORANDUM

NASA TM X-58090
June 1972



# THE MANAGEMENT APPROACH TO THE NASA SPACE STATION DEFINITION STUDIES AT THE MANNED SPACECRAFT CENTER

Presented in Partial Fulfillment of
MSC Management Development Program
BMS-632; Human Behavior in Organizations, Fall 1971
Center for Management Studies and Analyses
College of Business Administration
University of Houston

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS 77058

NASA TM X-58090

# THE MANAGEMENT APPROACH TO THE NASA SPACE STATION DEFINITION STUDIES AT THE MANNED SPACECRAFT CENTER

Jack C. Heberlig
Manned Spacecraft Center
Houston, Texas 77058

| | | |
|---|---|---|
| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
| 4. Title and Subtitle<br>THE MANAGEMENT APPROACH TO THE NASA SPACE STATION DEFINITION STUDIES AT THE MANNED SPACECRAFT CENTER | | 5. Report Date<br>June 1972 |
| | | 6. Performing Organization Code |
| 7. Author(s)<br>Jack C. Heberlig, MSC | | 8. Performing Organization Report No.<br>TM X-58090 |
| | | 10. Work Unit No.<br>976-10-05-06-72 |
| 9. Performing Organization Name and Address<br>Manned Spacecraft Center<br>Houston, Texas 77058 | | 11. Contract or Grant No. |
| | | 13. Type of Report and Period Covered<br>Technical Memorandum |
| 12. Sponsoring Agency Name and Address<br>National Aeronautics and Space Administration<br>Washington, D.C. 20546 | | 14. Sponsoring Agency Code |

15. Supplementary Notes

16. Abstract

The overall management approach to the NASA Phase B Definition Studies for Space Stations, which were initiated in September 1969 and completed in July 1972, is reviewed with particular emphasis placed on the management approach used by the Manned Spacecraft Center. The internal working organizations of the Manned Spacecraft Center and its prime contractor, North American Rockwell, are delineated along with the interfacing techniques used for the joint Government and industry study. Working interfaces with other NASA centers, industry, and Government agencies are briefly highlighted. The controlling documentation for the study (such as guidelines and constraints, bibliography, and key personnel) is reviewed. The report addresses the historical background and content of the experiment program prepared for use in this Phase B study and proposes management concepts that may be considered for future programs.

| | |
|---|---|
| 17. Key Words (Suggested by Author(s))<br>· Space Station<br>· Study Management<br>· Program Definition | 18. Distribution Statement |

| | | | |
|---|---|---|---|
| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
| None | None | 61 | |

CONTENTS

## TABLES



## FIGURES

# THE MANAGEMENT APPROACH TO THE NASA SPACE STATION DEFINITION STUDIES AT THE MANNED SPACECRAFT CENTER

Jack C. Heberlig
Manned Spacecraft Center

## SUMMARY

The management approach used by the Manned Spacecraft Center in conducting a major NASA Phase B study was successful in combining the talents of Government and industry organizations for designing an in-depth product acceptable to both. Extensive coordination and cooperation were obtained from NASA Headquarters offices, other NASA centers, and other Government agencies. This coordination was accomplished at the Manned Spacecraft Center by focusing the study workload within a Space Station Task Group (which later became the Space Station Project Office). Assistant Study Managers within each major organization provided management assistance in support of the unique hardware and software Subsystem Managers throughout the organizational elements. The experiment program activities that were conducted prior to and concurrent with the Space Station Phase B Study, the manner in which these experiment study findings were used, and future program management considerations for this vital area are discussed.

## INTRODUCTION

This report summarizes the manner in which the NASA Manned Spacecraft Center (MSC) organized and managed the Space Station study activities. It also discusses the relationship of the Space Station study activities to NASA Headquarters, discusses the activities of industry study contractors, and provides an explanation of the mechanisms and procedures used to facilitate a smooth Government and industry team effort. With this activity, NASA initiated a comprehensive experiment and applications identification and flight planning activity.

In September 1969, NASA undertook parallel Phase B industry studies for the purpose of obtaining a Space Station Program Definition which ended with a preliminary design of a 33-foot-diameter, Saturn V launched Space Station and Phase C/D implementation plans. During the 12 months preceding contract award, the Space Station Program Definition Phase B statement of work was reviewed and coordinated throughout NASA. From the beginning, this activity represented an agency effort with direct participation from the NASA Administrator's office and from all Headquarters offices.

A Space Station Task Group, organized within MSC, was held directly responsible for the management of the in-house and Phase B contractual effort. In addition, the Task Group had to ensure that associated study results from other ongoing efforts were properly incorporated into the study effort. Later, this organization became a Space Station Project Office with expanded responsibilities for Space Station work throughout MSC.

During the course of the initial study, the Saturn V launch vehicle was terminated as an inventory item beyond the Apollo and Skylab Programs. The Space Station Program Definition studies were reoriented to use the Space Shuttle as the primary launch vehicle. This reorientation resulted in a Modular Space Station approach.

Because the experiments planning activity, although a comprehensive and broad-based program, lacked overall agency goals and objectives, undesirable study variables were introduced. The need for NASA priorities within experiment scheduling activities is still a desired objective. This report concludes by giving particular attention to the positive aspects of experiment activity and identifies shortcomings that have created some difficulties for the NASA and industry study teams. This report also provides the opportunity to postulate procedures that might be used to gain a more programmatic return in this area.

## ADMINISTRATION-WIDE PREPARATION, MANAGEMENT, AND COORDINATION

During the 12 months preceding contract award which resulted in a preliminary design of a 33-foot-diameter, Saturn V launched Space Station and Phase C/D implementation plans, direct participation was obtained from the NASA Administrator's office, the Office of Manned Space Flight (OMSF), the Office of Advanced Research and Technology (OART), the Office of Space Science and Applications (OSSA), and the Office of Tracking and Data Acquisition (OTDA).

In addition, all NASA Field Center Directors and their staffs participated in the review and contributed to the preparation of the technical and programmatic content of the statement of work. This method of operation brought together a NASA team effort early in the program definition period which provided motivation and insight for the participants throughout the Phase B activity. In this manner, the overall program philosophies were better understood and more properly reflected in the dissemination of Space Station information throughout the agency.

During the course of the study execution, the NASA Administrator held three formal quarterly reviews to assess the progress of the study. A fourth review was held on the findings of the Modular Space Station Study. Members of the NASA Steering and Review Groups attended management meetings and the quarterly review meetings that were held with the NASA Administrator, the NASA Program Office Associate Administrators, and the NASA Center Directors. These meetings, from the working level to the top NASA management level, greatly enhanced the Government and industry team effort and kept all organizations informed in a timely manner. The team effort permitted the energies of other NASA center personnel to be applied to workloads that they were best able to fulfill for NASA and permitted their results to be applied in a timely manner.

The contractor teams also conducted high-level reviews within their corporations of their study findings and on their overall progress. Although this type of management review places a burden on the major participants responsible for the study execution, it is a worthwhile activity because of the total NASA effort that is being pursued for the Space Station Program.

During the second and third quarterly reviews, the NASA Administrator invited members of the international scientific community to hear and to critique the study findings to date. International cooperation was continued and expanded in regard to these studies on configurations, systems, and experiment capability.

The Space Station Phase B study was organized and managed by an OMSF Space Station Task Force at the NASA Headquarters level. The management interfaces are shown in figure 1, the membership of the Space Station Steering Group is presented in table I, and the Review Group membership as comprised in September 1969 is reflected in table II.

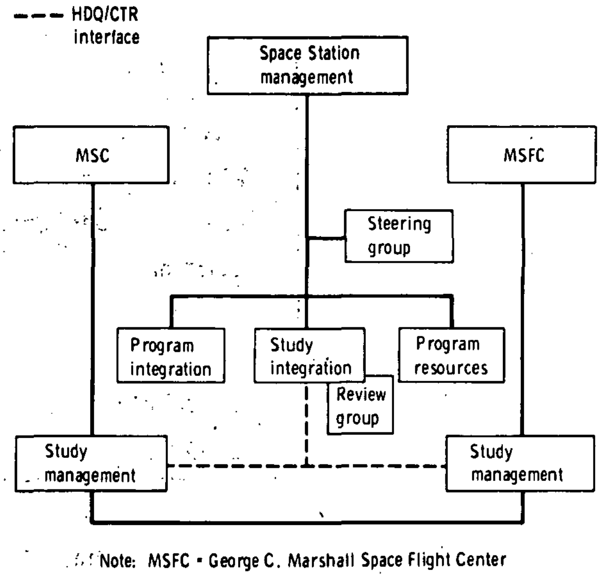



Figure 1. - Space Station Task Force.

TABLE I. - SPACE STATION STEERING GROUP

| Member | Affiliation |
|---|---|
| C. W. Mathews, Chairman | OMSF |
| D. D. Myers | OMSF |
| G. M. Truszynski | OTDA |
| J. E. Naugle | OSSA |
| O. W. Nicks | OART |
| D. D. Wyatt | Office of Program Plans and Analysis |
| W. von Braun | Office of Associate Administrator |
| W. E. Lilly | Office of Administration |
| B. Moritz | Office of Organization and Management |
| A. J. Eggers | Office of Policy |
| A. W. Frutkin | Office of International Affairs |
| D. J. Harnett | Office of Industry Affairs |
| H. M. Mark | Ames Research Center (ARC) |
| J. C. Elms | Electronics Research Center (ERC) |
| J. F. Clark | Goddard Space Flight Center (GSFC) |
| K. H. Debus | John F. Kennedy Space Center (KSC) |
| E. M. Cortright | Langley Research Center (LaRC) |
| R. R. Gilruth | MSC |
| E. F. M. Rees | MSFC |
| B. T. Lundin | Lewis Research Center (LeRC) |

TABLE II. - SPACE STATION REVIEW GROUP

(a) Group officers

| Position | Member |
|---|---|
| Chairman | F. Borman |
| Vice Chairman | F. L. Williams |
| Executive Secretary | W. C. Hayes |
| Liaison | L. E. Day |
| Liaison | W. R. Hedrick |
| Liaison | R. S. Zeigen |
| Ex Officio | D. R. Lord |
| Ex Officio | R. L. Lohman |

(b) Technical area representatives

| Technical area | Representative | Alternate |
|---|---|---|
| Mission operations | S. A. Sjoberg (MSC) | R. G. Rose (MSC) |
| Crew operations | D. K. Slayton (MSC) | T. P. Stafford (MSC) |
| Launch operations | R. C. Hock (KSC)<br>H. E. McCoy (KSC) | G. M. Preston (KSC) |
| Information management | T. Roberts (GSFC) | R. R. Carley (OMSF) |
| Space Station utilization | O. E. Reynolds (OSSA)<br>J. L. Mitchell (OSSA)<br>R. W. Johnson (OMSF) | L. B. Fong (OSSA)<br>D. P. Rogers (OSSA) |
| Design integration | P. R. Hill (LaRC) | A. Hobokan (MSC) |
| Technology readiness | R. D. Ginter (OART) | J. L. Sloop (OART) |
| Program interfaces | P. R. Swan (OART) | W. M. Gardner (LaRC) |
| Cost implications | J. F. Malaga (OOA)[a] | C. E. Koenig (OMSF) |
| Reliability and safety | H. Cohen (OMSF) | P. H. Bolger (OMSF) |
| Manufacturing and test approach | K. L. Heimburg (MSFC) | E. W. Neubert (MSFC) |
| Medicine and human factors | J. W. Humphreys (OMSF) | W. L. Jones (OART) |
| Tracking and data acquisition | H. R. Brockett (OTDA) | |

[a]Office of Administration.

A Space Station team was organized and established within MSC and the NASA George C. Marshall Space Flight Center (MSFC) for the purpose of supervising the two parallel contractual efforts. The execution of the study activities in accordance with the statement of work represented a combined NASA and contractor effort. Considerable support was provided by MSC and MSFC personnel, with inputs received from other NASA centers.

The OMSF Space Station Task Force provided top level program direction and guidelines and established and executed the necessary coordination. Initially, the Review Group functioned through a Field Director's office located at MSC that reported directly to Washington. By mid-1970, this function became part of the responsibility assigned to the OMSF Space Station Task Force.

## THE MANNED SPACECRAFT CENTER ORGANIZATION

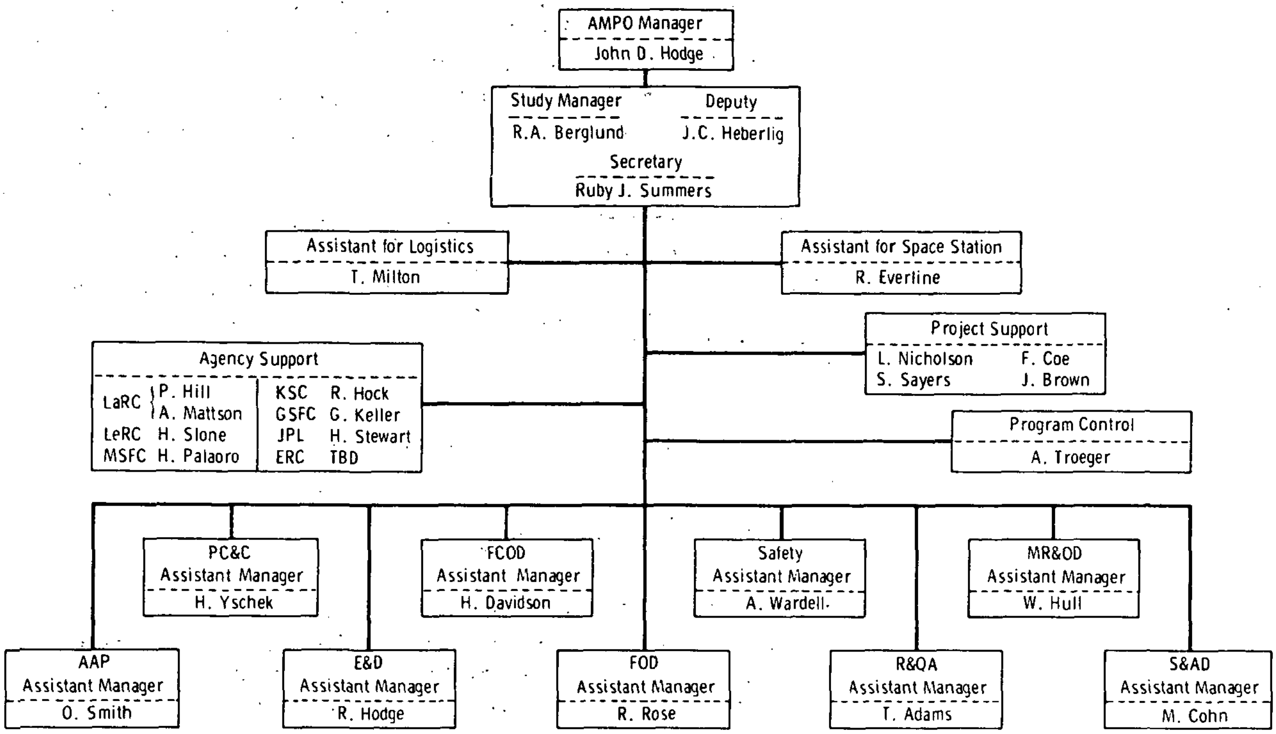
### The MSC Space Station Task Group

In response to a NASA Headquarters request, a Space Station Task Group was organized within MSC. This group was held directly responsible for the management of the in-house and Phase B contractual effort. In addition, the Task Group had to ensure that associated study results from other ongoing efforts were properly incorporated into the study effort. Later, this organization became a Space Station Project Office with expanded responsibilities for Space Station work throughout MSC. The initial organization of the Space Station Task Group is shown in figure 2. Appendix A is the MSC announcement (no. 69-67, dated May 21, 1969) authorizing the implementation of the Task Group activity.

The internal operating areas of the Task Group Office are highlighted in figure 3.

In addition to key NASA personnel assigned to the Administration-wide steering group, NASA centers had personnel assigned to follow closely the MSC in-house and contractual effort. (Some of these individuals were the same.) This arrangement provided the opportunity for broad dissemination of early study guidelines and constraints throughout the NASA organization and permitted the initiation of data transfusion from the Government to industry.

At the beginning of the Phase B study, considerable data existed within the Government files on past program experiences and the current position of the technology base. Based on a comprehensive technology review and discussions held at the NASA Langley Research Center (LaRC) in February 1969, it was believed that a Space Station Program for near-earth orbital operations could be implemented with the existing technology base and that the program did not require any high developmental risk in any technology areas. The other NASA center personnel arranged visits to many of the NASA laboratories, and many NASA personnel participated in special briefings and data exchange meetings at the contractor's plant.




Notes:

AMPO = Advanced Mission Program Office
JPL = Jet Propulsion Laboratory
PC&C = Procurement Contract and Control
FCOD = Flight Crew Operations Directorate
MR&OD = Medical Research and Operations Directorate
AAP = Apollo Applications Program
E&D = Engineering and Development
FOD = Flight Operations Directorate
R&QA = Reliability and Quality Assurance
S&AD = Science and Applications Directorate
TBD = To be determined

Figure 2. - Initial organization of MSC Space Station Task Group.

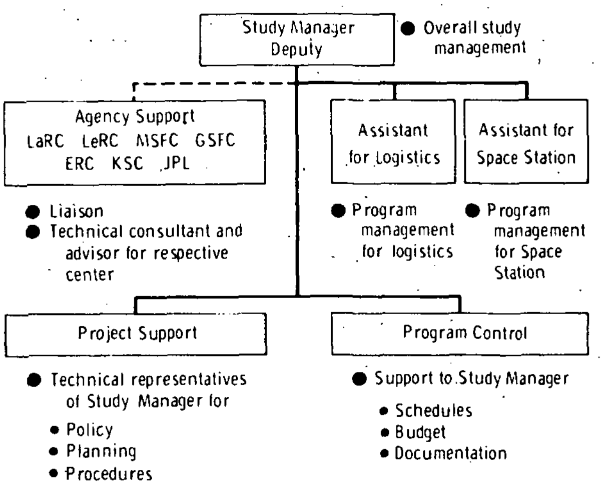



Figure 3. - Responsibilities of MSC Space Station Task Group Program Office.

## Assistant Study Managers

At MSC, the Space Station Task Group was supported directly by Assistant Study Managers, who represented the major technical organizations and other program offices within MSC. This has proved to be a most effective way of executing an effective workload conducted within the proper guidelines and constraints with the minimum of management direction and surveillance. The responsibilities of the original Assistant Study Manager are outlined in figure 4. Later, The Space Station Task Group did include a representative from the MSC Space Shuttle Program Office and a representative from the NASA John F. Kennedy Space Center (KSC) with Assistant Study Manager status responsibilities for preflight and launch operations. (See fig. 5.)

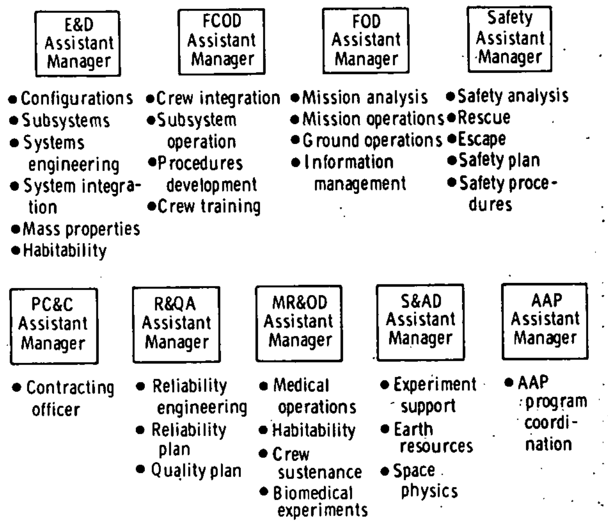



Figure 4. - Space Station Task Group Assistant Study Manager responsibilities.

The Assistant Study Managers meet each Monday afternoon for several hours to help formulate the day-to-day needs of that work week, to plan the major monthly activities, and to help formulate and support the long-range goals and objectives. The Assistant Study Managers are most effective in discussions on total program integration, systems engineering, and operational analysis. Each Study Manager is supported in depth by key personnel who represent technical disciplines or programmatic expertise. These personnel are used as required and have required only a minimum of paperwork to manage and direct.

The Assistant Study Managers are key individuals in the execution of the study activity. They are required to perform as part of two systems. One part is the total program aspect of the Phase B study, where they have to understand and support the Program Manager's position. The other part of the system is their association with their technical institutions (directorates or offices), where they enjoy a more closely knit working relationship. This association with their technical institutions permitted them the opportunity to broaden in depth the guidelines and constraints of the study which became the preliminary performance requirements on which the preliminary design was established. The development of the preliminary design was their primary product as an institution but only one aspect (the largest one) of the overall planning. The responsibilities given the Assistant Study Managers constituted a sharing of power, which they

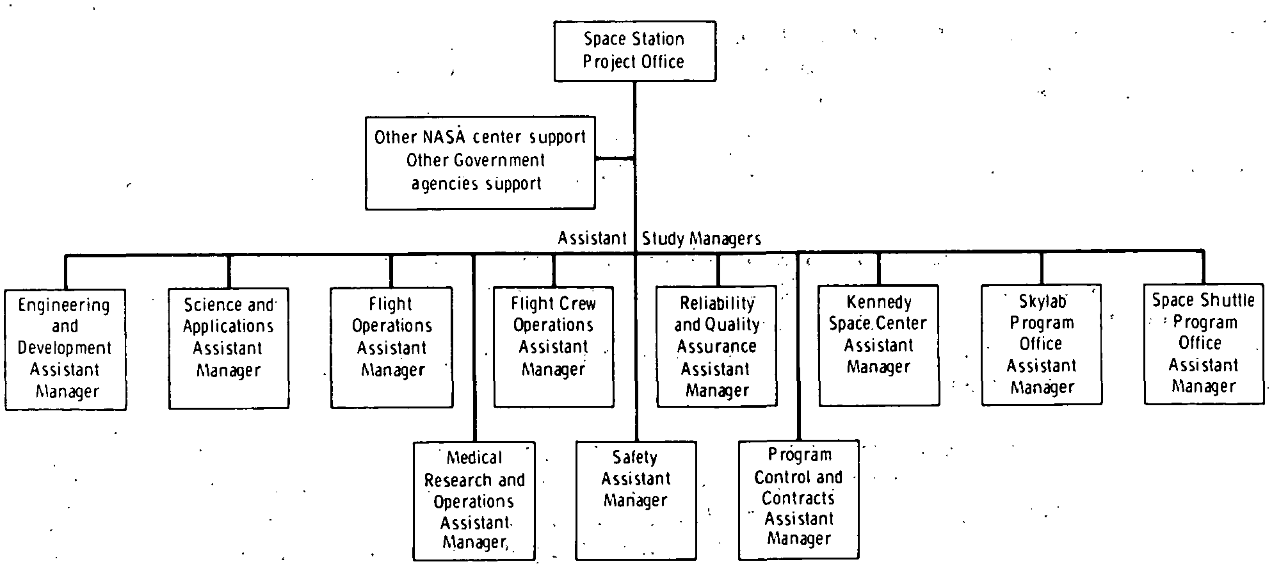



Figure 5. - Current MSC Space Station Task Group organization.

were able to use effectively in group decisionmaking and problem solving during the regularly scheduled manager meetings. Each Assistant Study Manager was able to make his individual contributions and to be recognized for them.

## Subsystem Managers (Hardware and Software)

Within MSC, major identifiable workloads have been organized into subsystem packages representing both hardware and software needs of Project Mercury, the Gemini Program, and the Apollo Program. The same management procedure is followed on the Skylab Program and is presently formulated in part for the proposed Space Shuttle Program. Over the years, this has led to the establishment of a strong Government technical data file maintained by the respective subsystems development teams. These subsystem teams have the in-depth technical responsibility for their respective subsystems for current and future programs. (See tables III and IV.)

TABLE III. - MSC SYSTEM DEVELOPMENT TEAMS

| Responsibilities | Coordination |
|---|---|
| 1. Continuity of system developments<br>2. Technical responsibility in depth for system development<br>3. Coordination with Government and industry counterparts<br>4. In-house and contractor development, testing, and evaluation programs | Technical divisions define and guide implementation of scope of work<br>1. Technical support staff involves multidivisions<br>2. Plan, use, and direct use of funds from several program offices: OMSF, OART, and OSSA<br>3. Agency system development continuity |

These teams, who work collectively with today's problems and who have personnel actively engaged in in-house development and advanced hardware development under industrial contract, are most valuable in future mission and payload studies. Their involvement in this way also makes the supporting research and advance technology activities more practical. (See fig. 6.)

The MSC subsystem manager technique is a departure from traditional business or Government organizational procedure. The technique has been working quite well and can be considered a standard way of doing business today. The subsystem manager technique began in the early days of the Apollo Program as a management approach between the Apollo Spacecraft Program Office and the Engineering and Development Directorate.

TABLE IV. - INHERENT BENEFITS OF SYSTEM DEVELOPMENT TEAMS

| |
|---|
| Current system experience includes: concepts, design criteria, specifications, system integration, development and qualification history, flight test history to date, upper and lower operating efficiencies, how to extend system useful life times, system operational shortcomings |
| Execute in-house development capability |
| Active in future mission studies |
| Assess potential system advances for next and future missions |
| Develop hardware to meet future program needs |
| Analyze logical approaches in hardware extensions or risks involved in new generation systems |
| Desire to attain commonality of long-duration hardware for meeting multiple-mission goals |
| Help develop or interface (or both) with major experiment payloads |
| Ensure information and experience transfer to new hardware and missions |

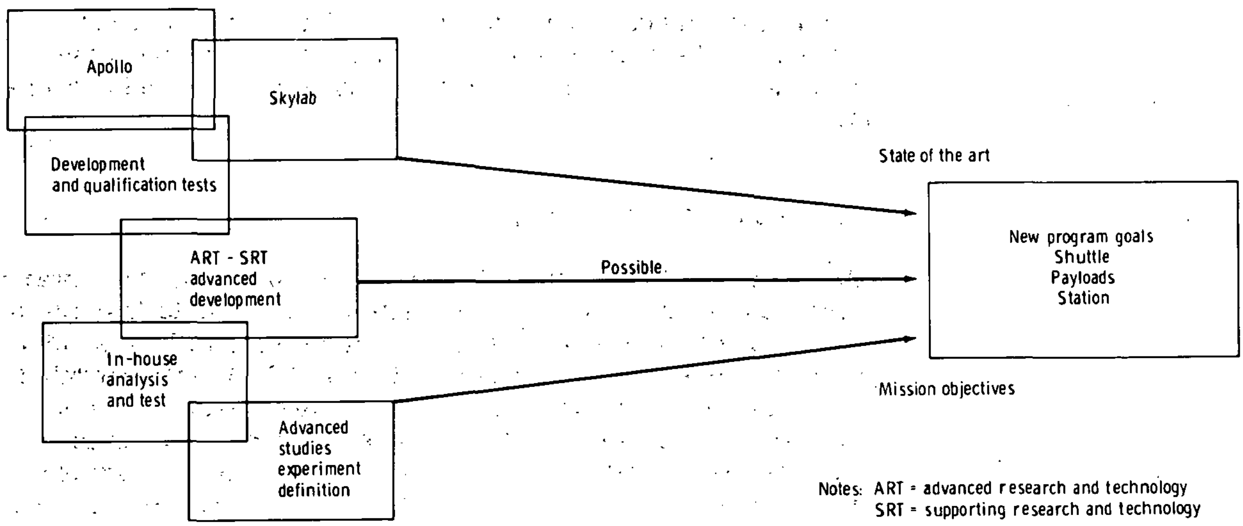



Figure 6. - Programmatic integration relationships.

In traditional organizations, a good manager never permits his men to have two bosses. This happens with the subsystem manager technique and is part of the subsystem manager relationship. The Program Manager is responsible for bringing together the necessary talent and depth of support to bring about the timely success of his program. He must use the Subsystem Manager for his special knowledge and skills in his specialty area and expects him to properly manage his own direct support and assist in following and managing the contractor effort. The Subsystem Manager has his institutional boss (directorate, division, branch, etc.). This is the line organization that he as a professional specialist is part of. It represents for MSC the pro rata share of manpower committed to support all programs and projects in this subsystem area. The technical supervisory relationship is more important here.

Many times, the subsystem teams are faced with both major programs and lesser projects competing for the same talent. Under certain management hierarchies, there may not be enough dedicated man-hours to go around. The combined and shared efforts of the subsystem teams (the Subsystem Manager plus some others working full time on the major program while others work between the program and on other tasks of developmental nature) often can succeed in meeting all the requirements.

Many individuals prefer the working environment of the system development teams. At the current time, this has the advantage of not facing termination of the workload as the Apollo flights come to an end. It provides for the longevity of the personnel and the data file. Training is faster and continually occurs. Flight problems instantly influence advanced developments. Professional relationships with Government and industry personnel last longer for the development team members. The same depth and understanding of each group are brought to bear on all programs seeking and requiring its support.

In addition, the system development teams provide the opportunity for individual accomplishment and recognition, even though they are part of a larger team effort. They permit the best of both worlds. Belonging and participating in something worthwhile and successful, and knowing and being recognized for work accomplished are important to each team member.

## Technical Data Transfer

The total Space Station management team at MSC has always maintained an awareness for the need to provide the contractor with the up-to-date technical data file available within the Government. A 3-day technical data exchange meeting was held at MSC during the second week of the Phase B study (September 8, 9, and 10, 1969). Updated Government information in the respective subsystems areas was provided to the contractor through briefings and reports. These reports and other data provided during the course of the Phase B study are recorded in a periodically published bibliography. Additional technical exchanges occurred with the contractor at other NASA centers and at the contractor's facility. These early meetings served to stimulate all participants and accelerated the ease by which data could be exchanged. On September 11, 1969, the MSFC and the MSFC Phase B contractor teams held a joint meeting with MSC for exchange of standard environmental data, experiments data, and operations information. This meeting permitted a continuity of effort between the two studies as outlined by the statement of work, and this continuity of effort followed during the course of the

Phase B effort. The MSC technical personnel from the respective subsystem development teams are able to provide the prime contractor timely data from many other contractual activities. This infusion of data maintains and balances the learning curve between the Government and industry. In many cases, the industry reports, both oral and written, are the first exposure of a broad NASA audience to the combined results.

### Coordinated Government and Industry Advanced Hardware Development

During the course of the Space Station Phase B study, MSC awarded two major contracts. These contracts were for the development of an environmental and thermal control and life support subsystem (ETC/LSS) and a solar array and battery electrical power system. To ensure compatibility of vehicle requirements and designs with the advanced development hardware being pursued, the NASA Headquarters Space Station Task Force initiated liaison and coordination among the NASA Space Station study centers, the Space Station study contractors, and the advanced hardware contractors. Formal and informal real-time discussion occurred among participants, and rapid dissemination of documentation occurred among all parties. This type of data exchange, occurring at the subsystem level by the management mechanisms established (appendixes B and C), permits a real-time programmatic and technical exchange to occur. All major participants attend preliminary design reviews, specification reviews, and so forth.

## MANNED SPACECRAFT CENTER AND NORTH AMERICAN ROCKWELL INTERFACE

North American Rockwell (NR) was assigned to MSC as the prime Space Station Phase B Program Definition contractor, and McDonnell Douglas Astronautics Company (MDAC), West was assigned to MSFC. These assignments were initiated in May 1969 by NASA Headquarters with the consent of MSC and MSFC. From the onset, the NR effort was implemented by means of a detailed study plan. This study plan was finalized and approved by the MSC study team by September 19, 1969. This study plan, which detailed all aspects for the study implementation and execution, was subservient to the contract statement of work. The study plan was well understood by all participants and has served as a most valuable management tool.

The NR organization at the implementation of the study is shown in figure 7. In addition to conducting a balanced Phase B Program Definition study, NR acted for the Government as the systems engineering and integration organization for the MSC Space Station Task Group.

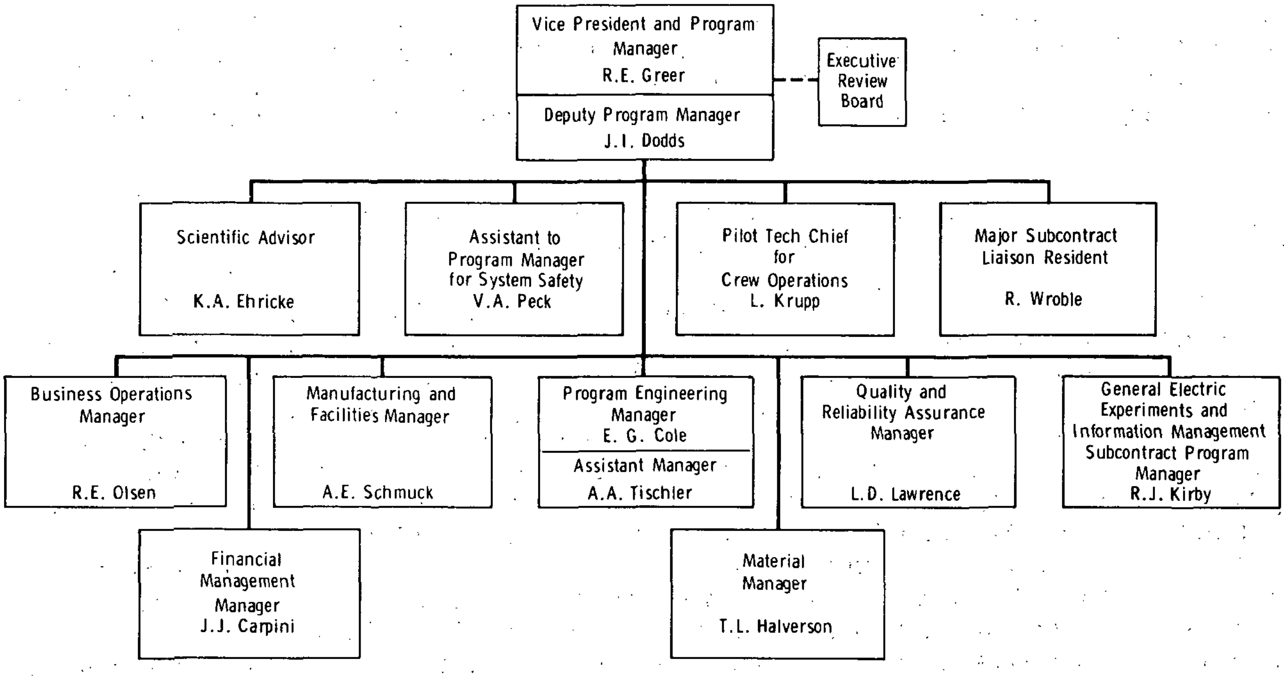



Figure 7. - Space Station Program Organization — Phase B of NR.

The organizational chart of Program Engineering at the initiation of the study is shown in figure 8. Because NASA Headquarters had designated that special emphasis be placed on certain aspects of the study, some individuals served a dual role as a project manager or engineer with responsibilities for a special emphasis area as shown by figure 8. The MSC Space Station Task Group presented the MSC Space Station study organization during an orientation meeting at the contractor facility on September 3, 1969. At this time, the management approach of using Assistant Study Managers and key technical personnel was explained along with the use of a Guidelines and Constraints Document and the relation of other NASA supporting studies to the Space Station Phase B effort.

The day-to-day working relationships with NR were then formulated, with lines of communication for NASA and NR technical interfaces (fig. 9) reflected within the study plan. During the course of the study, a day-to-day working relationship was fostered at the Subsystem Manager level, with the Assistant Study Managers providing overall direction. This has cemented the original intent of having a joint Government and industry study in which the Government supplements the industry data file with information historically possessed by the Government.

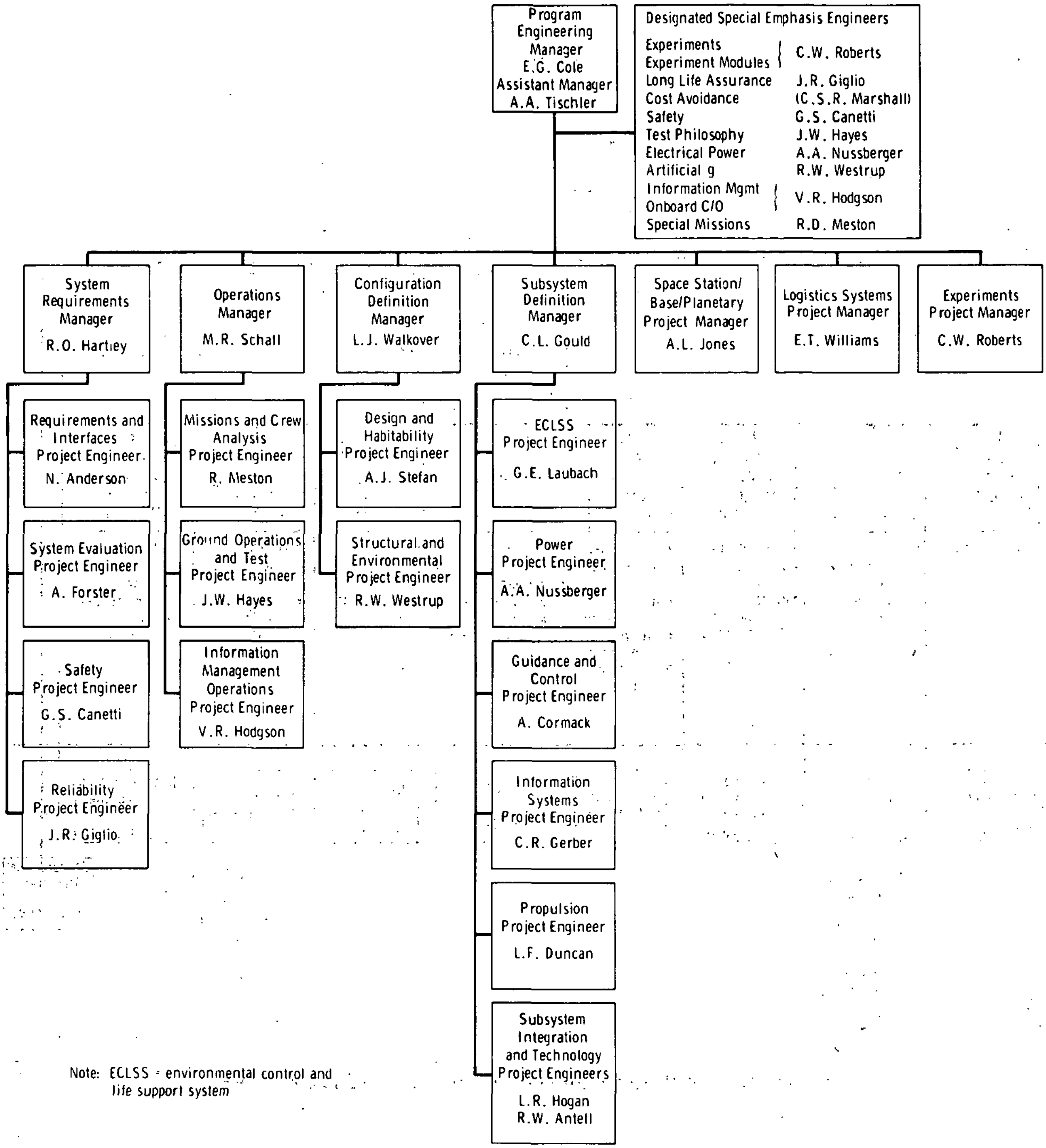



Figure 8. - Engineering organization of NR.

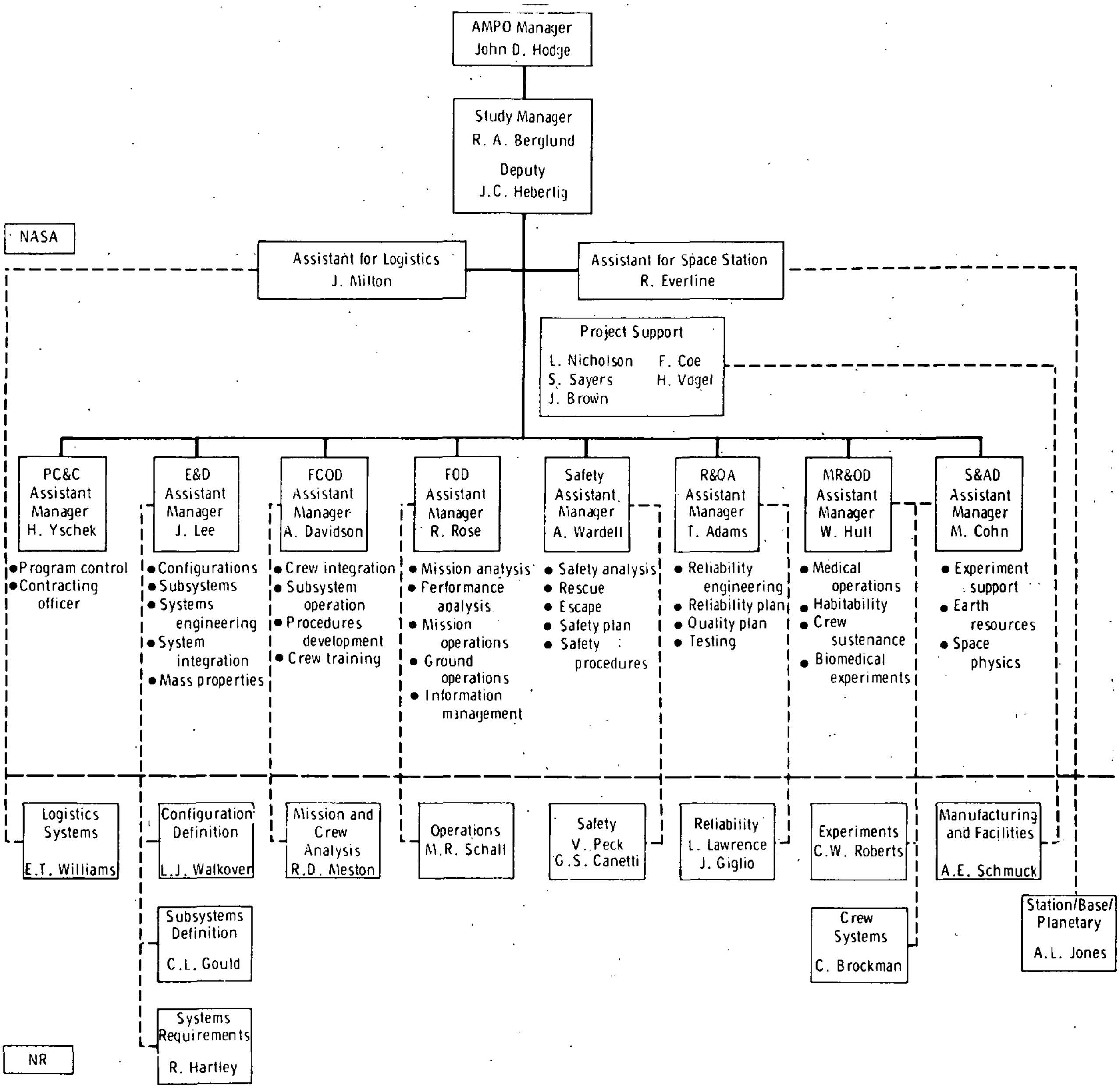



Figure 9.- Technical interface between NASA and NR.

## Government Sponsored Meetings

A primary example of the Government participation is in the area of preflight, flight, and flight crew operations. An information management subsystem coordination group was established so as to completely understand and coordinate interrelationships among operational requirements, experiments requirements, tracking networks, the Mission Control Center, and so forth. In addition, operational design meetings were organized and periodically held to fully assess and reflect aspects of flight operations, ground operations, and flight crew involvement. This procedure greatly accelerated the interchange of information and made many design concepts practical from an operations standpoint. These meetings were chaired by Government personnel who provided minutes with wide distribution.

### Final Reports

A listing of the final reports prepared by NR on the Space Station Phase B Definition Studies under contract NAS 9-9953 is provided in appendix D. These reports covering the results of the study represent the combined efforts of the Government and industry team and have had broad distribution so as to become part of the continuum. Effective organization and detailed recording of all findings of the team reflect the efforts of a prudent and conscientious contractor.

## SPACE STATION PRIME CONTRACTOR AND SUBCONTRACTOR RELATIONSHIPS

The prime contractor and subcontractor relationships for the parallel Space Station Phase B studies are shown in figure 10. Both prime contractors had major and minor subcontractors. General Electric served as a major subcontractor and associate to NR for experiments and information management work. For the MSFC and MDAC effort, Martin-Denver provided experiment support, and IBM-Huntsville provided information management subsystem effort. The prime contractor for MSC, NR, provided program and total systems engineering and integration. Many subcontractors were common to both studies. This arrangement provided the same technology base to both engineering and integration because many of these companies held technology contracts for NASA.

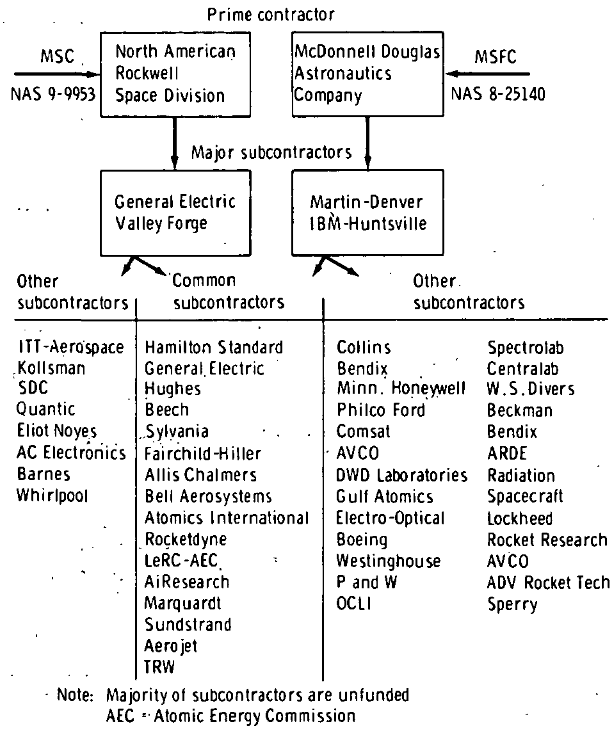



Figure 10.- Space Station Phase B studies.

## RELATIONSHIPS OF MSC AND MSFC

The MSC and MSFC personnel jointly participated in the formulation of the Phase B statement of work, and particular attention was given to the guidelines and constraints to be followed by both contractors and centers. During the course of the study, many technical exchanges between MSC and MSFC personnel occurred. Each center strongly supported the quarterly reviews. Joint meetings and visits were held with other NASA centers to maintain a complete understanding of data exchange. During the course of the study, it became desirable to organize and execute a comparable effort. The scope of this activity was to compare elements and data defined by the contractor studies. An integration panel with five subpanels was organized to accomplish this effort, which covered a time period from April to July 1970. The organization of personnel responsible for comparing elements and data defined by contractor studies is shown in figure 11. Many key personnel supported each panel. A summary volume was published along with a detailed volume for each of the five major areas outlined in figure 11. It can be concluded that both study teams met the Phase B study requirements as defined by the statement of work. Having a common set of technical and programmatic guidelines was most important for achieving comparable results and also permitted the Government personnel to more fully understand the results of other center efforts.

The MSFC Space Station Task Team Management Group organization for the September 1969 time period is shown in figure 12.

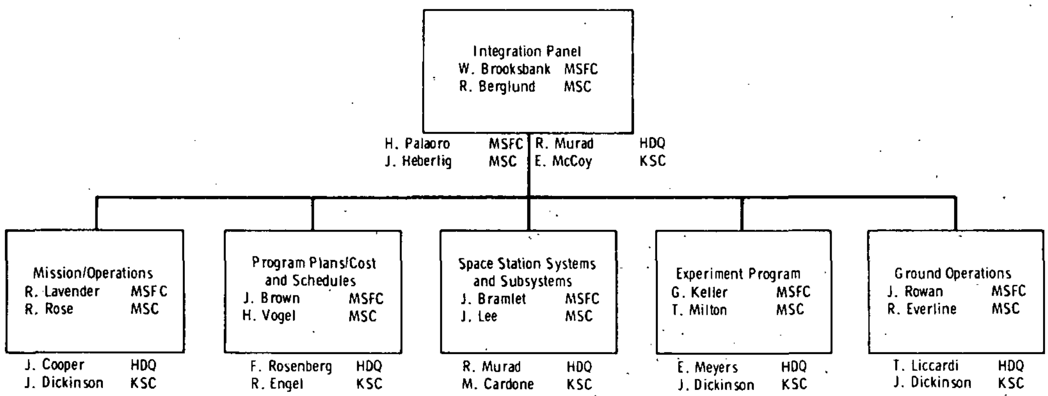



Figure 11. - Space Station comparability effort organization.

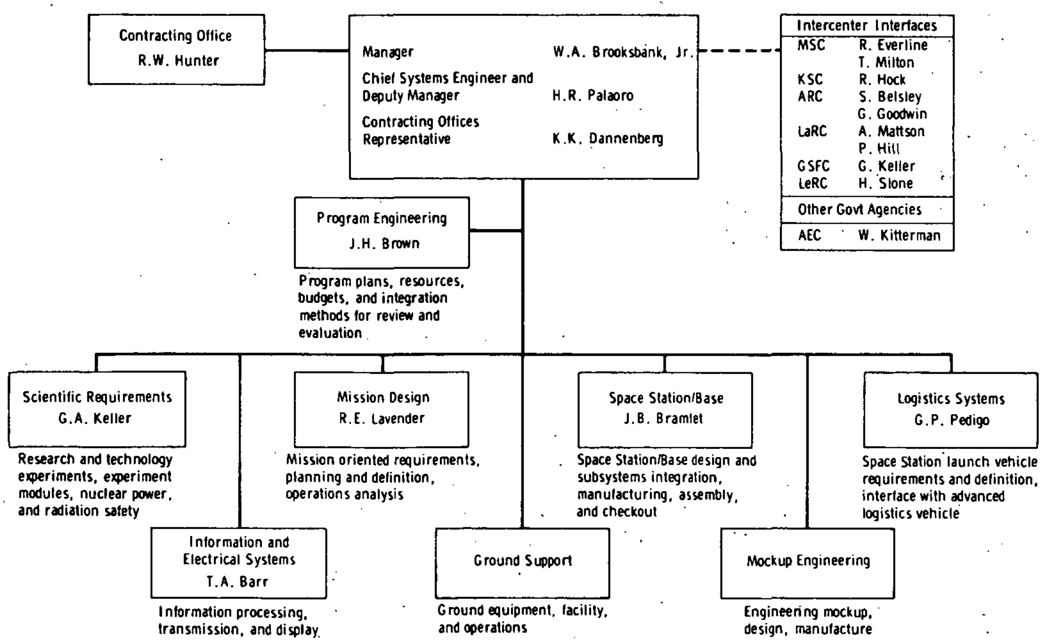



Figure 12. - Space Station Task Team Management Group of MSFC.

## DOCUMENTATION

### Guidelines and Constraints

The Phase B statement of work contained many programmatic and technical guidelines used to conduct the Phase B study. These guidelines were the result of considerable discussion during the 12 months prior to awarding the contract. Certain limitations or constraints also were contained within the statement of work to prevent divergence of the parallel effort and to eliminate certain options that were not realistic.

These data were extracted from the statement of work and were organized by MSC into a Guidelines and Constraints Document. The purpose of this document was to provide the following.

1. Single-source management control of criteria for contracted and in-house studies

2. Maximum technical and management visibility into study directions

3. A mechanism for direct input of in-house, contractor, and supporting-study results into a Phase B effort

The guidelines in the document were presented in a format that included the following program elements:

1. Program

2. Space Station

3. Space Base

4. Gemini Derivative Logistics System

5. AAP Derivative Logistics System

6. Advanced Logistics System

7. Launch Vehicles

8. Experiments and Experiment and Laboratory Modules

9. Planetary Modules

Within each major program listing of the Guidelines and Constraints Document, the following categories of guidelines and constraints were identified:

1. X. 100 — General contains the gross mission requirements and programmatic guidelines for either the total program (such as section 1. 100) or for a specific element (for example, section 2. 100).

2. X. 200 — Operations contains the operational guidelines and constraints from launch through recovery.

3. X. 300 — Configurations contains all guidelines and constraints related to internal or external arrangement of the program element and the configuration of an element at any point in the mission.

4. X. 400 — Subsystems contains guidelines related to subsystem requirements and constraints (for example, environmental control subsystems, electrical power subsystems, etc.).

Within the category listing Subsystems (X. 400), the subsections in table V were identified.

TABLE V. - DESCRIPTION OF SUBSYSTEMS CATEGORY

| Subsection | Description |
|---|---|
| X. 400XX | Subsystems - general |
| X. 401XX | Habitability |
| X. 402XX | Structures |
| X. 403XX | Electrical power |
| X. 404XX | Communications |
| X. 405XX | Instrumentation |
| X. 406XX | ECLSS |
| X. 407XX | Guidance, navigation, and control |
| X. 408XX | Explosive devices |
| X. 409XX | Propulsion |
| X. 410XX | Ground-support equipment |
| X. 411XX | Cryogenics |
| X. 412XX | Thermal control |
| X. 413XX | Materials |
| X. 414XX | Mechanical systems |
| X. 415XX | Astronaut equipment |
| X. 416XX | Biomedical behavior |
| X. 417XX | Data and information management |
| X. 418XX | Command center display and control |
| X. 419XX | Checkout (ground) |

Management and control of the Guidelines and Constraints Document were maintained by the Space Station Task Group Study Manager's office. All changes were submitted to the Study Manager for review and approval. The guidelines and constraints were classified on the following levels, which indicate the organization responsible for their content.

1. Level I - NASA Headquarters

2. Level II - Space Station Task Group

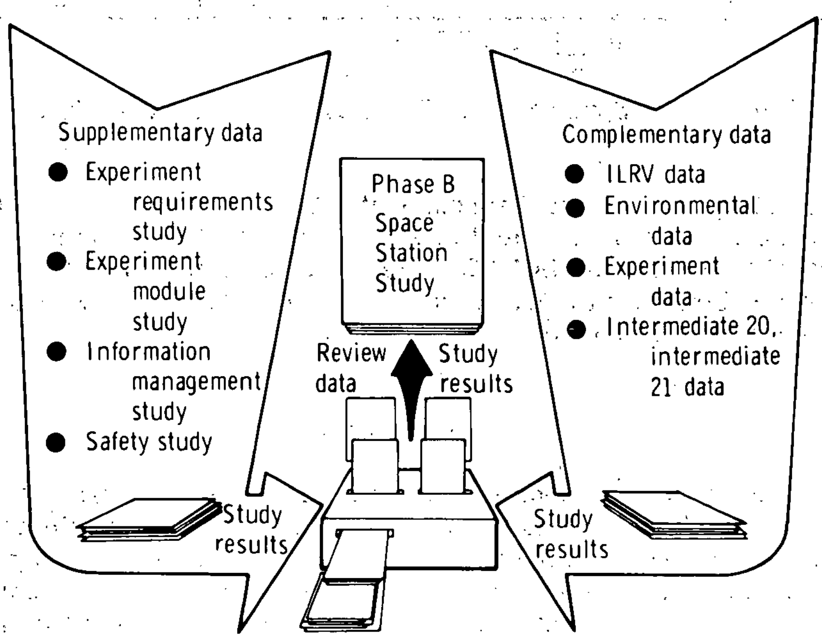
3. Level III - Assistant Study Managers

4. Level IV - Subsystem Engineer

Other supporting data were available to the Phase B Space Station Study for the Guidelines and Constraints Document from ancillary studies. Results of these various studies that were deemed applicable and that followed the program philosophy presented by the Phase B statement of work were used to obtain the Space Station preliminary design (fig. 13).

The number and types of ancillary studies underway or planned in September 1969 at the initiation of the then-planned 11-month study are shown in figure 14.

A similar Guidelines and Constraints Document was organized for the Space Shuttle-launched Modular Space Station Program requirements. This document was




Note: ILRV = integral launch and reentry vehicle

Figure 13. - Phase B supporting data.

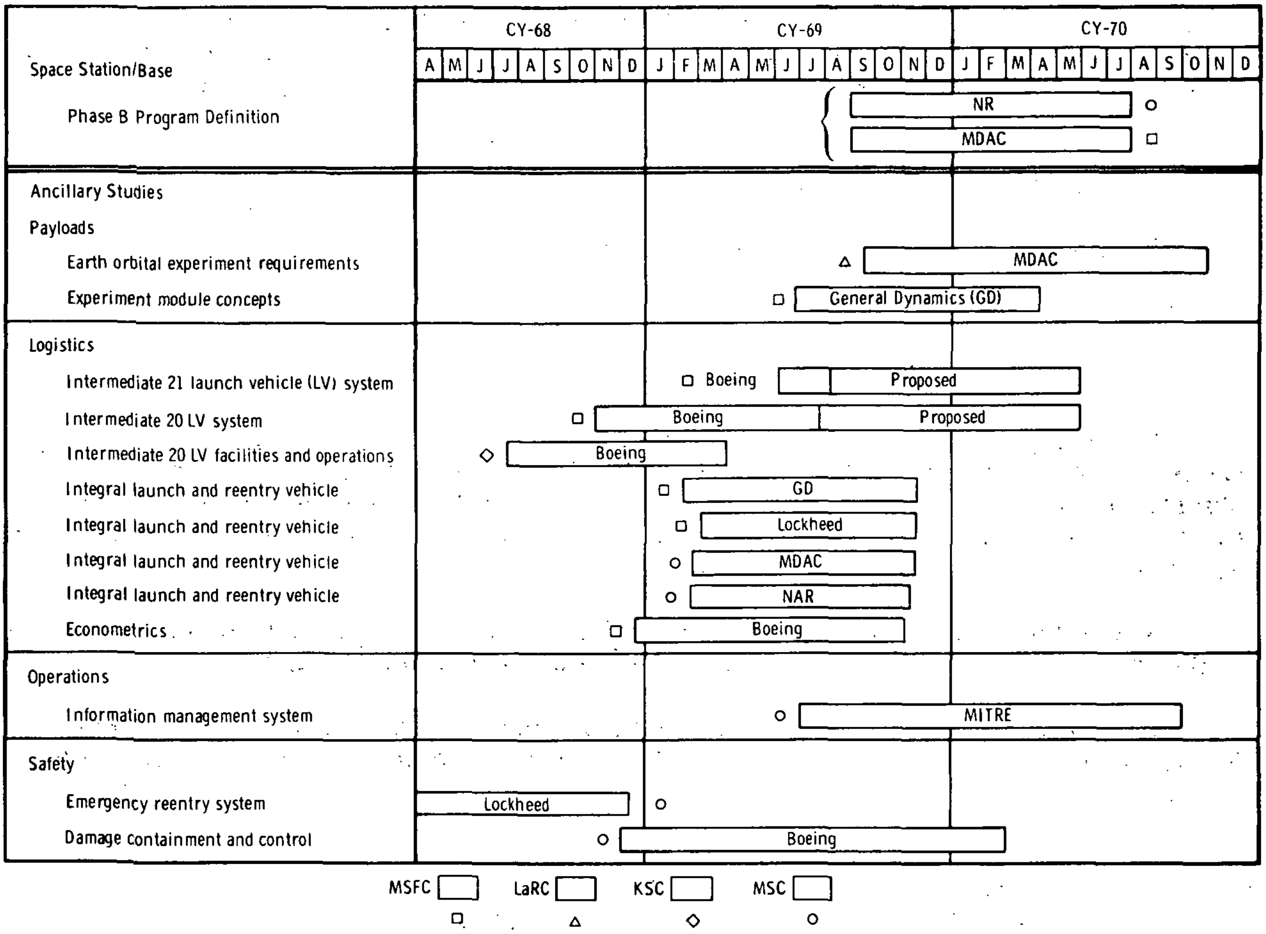



Figure 14. - Space Station Program contractual activity.

revised periodically and distributed throughout NASA and industry on a broader scale than previously done. The final Guidelines and Constraints Document for the large (33-foot diameter) Space Station is MSC-00141, Revision 0, dated June 12, 1970. The final Guidelines and Constraints Document for the Modular Space Station effort is MSC-03696, Revision 8, dated November 12, 1971.

## Bibliography

A bibliography of Government-furnished data provided by MSC to NR was prepared and published periodically. This document was useful in advising the total Space Station study personnel of the scope and source of technical data being exchanged. It also permitted other industrial firms to communicate more readily with personnel within the Government for their specific areas of interest. The final edition for the large (33-foot diameter) Space Station is MSC-01214, Revision F, dated January 29, 1971. The final bibliography for the Modular Space Station effort is MSC-04300, Revision B, dated October 15, 1971.

### Key Personnel

An MSC Key Personnel Document listing the key Government Space Station study personnel down to the subsystem manager level was assembled and published. This document was initially issued in July 1969 after the formal organization of the MSC Space Station Task Group on May 21, 1969. This document provided an immediate interplay of programmatic and technical data among all organizational elements within MSC, other NASA centers, and industry.

## INTEGRATING MECHANISMS

More than one type of integrating mechanism was in use throughout the study at all times. Formal direction was provided by the statement of work, the study plan, and the periodic issuance of the Guidelines and Constraints Document. Managerial, administrative, and technical integration occurred at the weekly Assistant Study Managers' meetings, at quarterly reviews (initially held monthly, which was too often), and at special subject meetings.

Informal integration occurred by technical specialist visits at the Government-sponsored information management subsystem and operational design meetings, by exchange of working memorandums, by visits to other NASA facilities and industry plants, and by telephone calls.

Special attention was given to knowing what work currently was in process and what work was coming up. Data from other activities were input as early as possible to maximize the benefits and capitalize on saving planned man-hours for expanded effort.

For the Modular Space Station quarterly reviews, the NASA Headquarters Space Station Task Force had MSC, NR, MSFC, and MDAC hold open meetings so that all future prime contractors, subcontractors, suppliers, and universities would be aware of current study progress.

## EXPERIMENT DEFINITION ACTIVITIES

For many years, NASA has sponsored studies to aid in formulating and identifying the most worthwhile objectives for future programs. In anticipation of major flight activity in the post-Apollo period, an increase in the Supporting Studies and Experiment Definition activity occurred in the late 1960's and continues today. The magnitude of the products generated can easily be appreciated when an attempt is made to read all the reports. This area also will need to find a low-cost "new way of doing business."

The MSC, MSFC, and contractor personnel were provided a comprehensive background briefing on the NASA experiment planning at a joint meeting at MSC on September 11, 1969. The method by which initial missions and payloads were brought together, the manner in which the worth of the experiments was studied, the need for some advanced studies in the experiments program planning area, and the overall synthesis of these accumulated data are presented in figure 15.

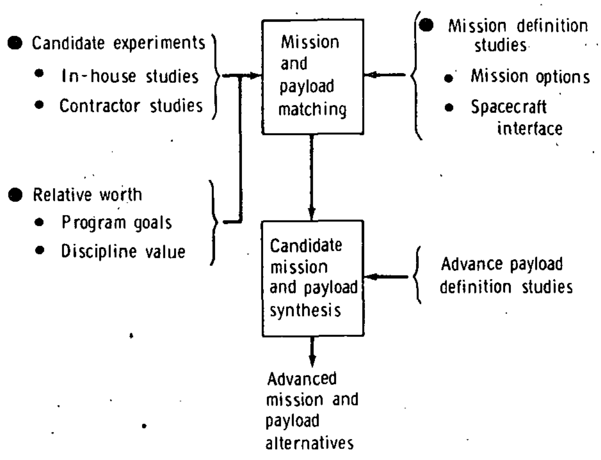



Figure 15. - Advanced experiment program planning.

The background requirements for an integrated payload planning activity (IPPA) are as follows.

1. Development of experiment cost profile over planning period

2. Evaluation and assessment of experiment program

3. Determination of mission effectiveness

4. Performance of alternate mission mode and spacecraft operation analysis

5. Support of Space Station design studies

6. Support of budget exercise: fiscal year 1970 and beyond

7. Identification of "real" experiment flight capabilities

The methodology, principal functions, and program planning and design products of the IPPA are highlighted in table VI.

TABLE VI. - INTEGRATED PAYLOAD PLANNING ACTIVITY

| Activity | Description |
| --- | --- |
| Methodology to accomplish Space Station payload planning and definition studies | -- |
| Three principal functions of IPPA | Payload analysis<br>Payload synthesis<br>Payload-mission matching |
| Provides program planning and design products | Alternate payload-mission matches<br>Payload-mission effectiveness analyses<br>Concept comparison analyses<br>Cost-schedule-resource requirements<br>Crew skills and mixes requirements |

The functional flow of the IPPA is presented in figure 16. This is an idealized case, and the total work flow could not actually occur in this manner because all data files were not compatible.

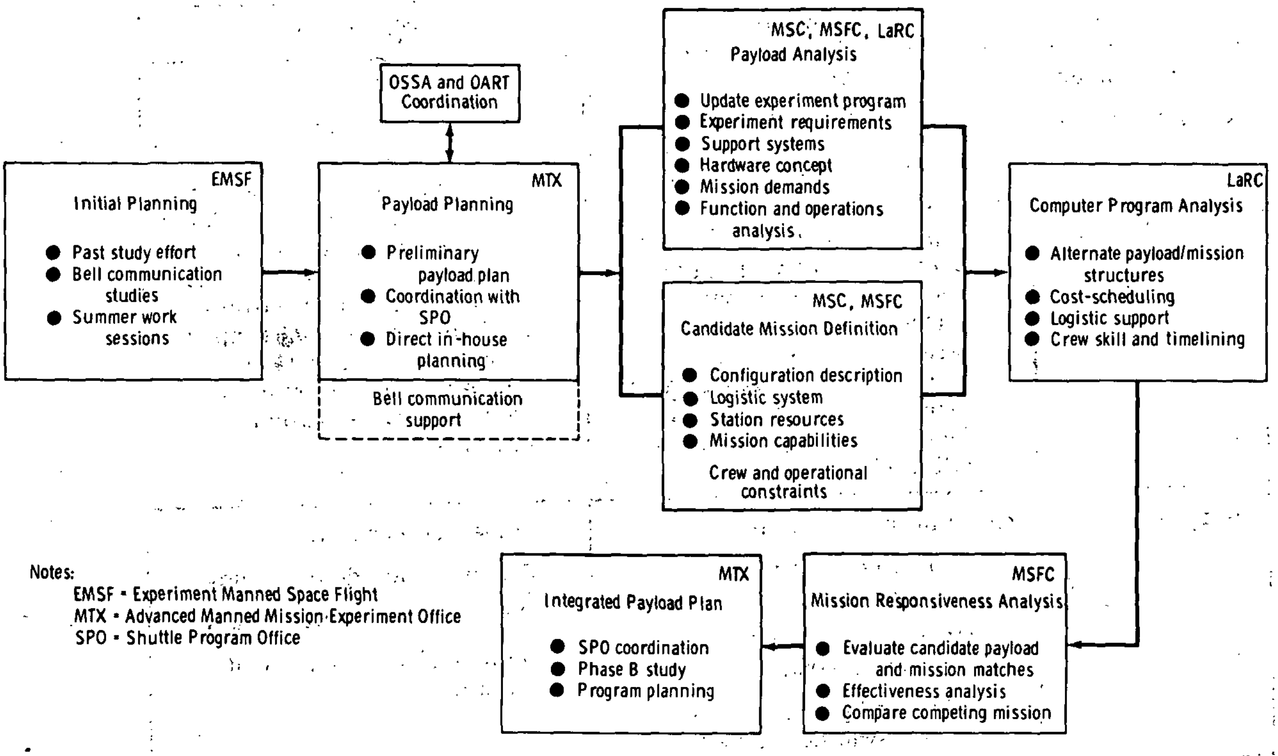



Figure 16.- Functional task areas summary of IPPA.

The relationship between the IPPA data file and the various study areas is shown in figure 17.

The content and purpose of the Yellow Book (and later the Blue Book) used as reference material by the various studies are explained in table VII.

The purpose and intent for the candidate experiment program for the Space Station definition studies are stated in table VIII.

An organizational breakdown by subject of the original eight discipline areas and 25 functional program elements (FPE's) is shown in table IX.

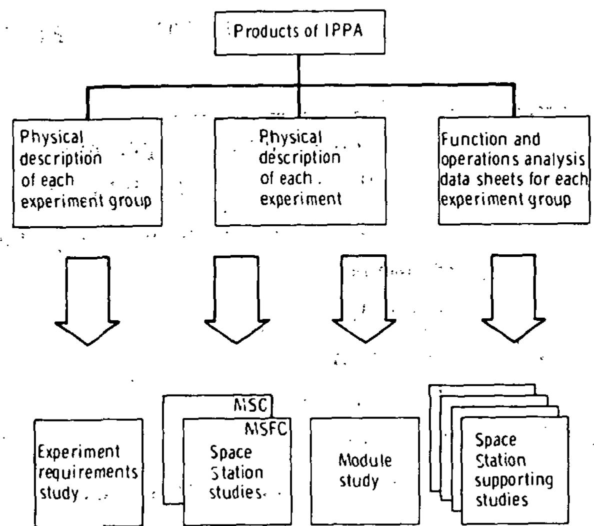



Figure 17.- The relationship between IPPA data files and various study areas.

TABLE VII. - EXPERIMENT PROGRAM SOURCE DATA

| Element | Yellow book | Blue book |
|---|---|---|
| Original issue<br>Revision no. 1 | August 14, 1968<br>September 1, 1969 | May 1, 1969<br>September 15, 1969 |
| Contents | Composite catalog of proposed and planned earth orbital experiments together with brief descriptive material regarding station/base interfaces, operational constraints and resource requirements. Experiments grouped by discipline into functional program elements (FPE's). | Representative, typical grouping of FPE's into a candidate experiment program for design studies use. Experiment descriptions, spacecraft interfaces and support requirements greatly expanded from yellow book data to provide design criteria. |
| Purpose | Provide reference for:<br>Experiment definition funding<br>Structure candidate experiment programs<br>Advanced planning programing studies | Provide reference for:<br>Space station design study<br>Experiment modules study<br>Information management study |

TABLE VIII. - CANDIDATE EXPERIMENT PROGRAM FOR SPACE STATION DEFINITION STUDIES

| | |
|---|---|
| Provide representative experiment groupings that | |
| Meet objectives and disciplinary emphasis of experiment program | |
| Provide reference for station design | |
| Disciplinary areas | |
| Biomedicine | Space physics |
| Astronomy | Engineering and operations |
| Earth applications | Space materials processing |
| Space biology | Advanced technology |
| Station will accommodate a broad but flexible experiment program | |
| Optimization of experiment program not a study goal | |
| Experiment modules concepts to be developed to define interfaces | |

TABLE IX. - CONTENTS OF CANDIDATE EXPERIMENT PROGRAM

| Discipline | FPE no. | FPE name |
|---|---|---|
| Astronomy | 5.1 | Grazing Incidence X-ray Telescope |
| | 5.2A | Advanced Stellar Astronomy Module |
| | 5.3A | Advanced Solar Astronomy Module |
| | 5.4 | Ultraviolet Stellar Survey |
| | 5.5 | High-Energy Stellar Survey |
| Space physics | 5.6 | Space Physics Airlock Experiments |
| | 5.7 | Plasma Physics and Environment Perturbations |
| | 5.8 | Cosmic Ray Physics Laboratory |
| Space biology | 5.9 | Small Vertebrates [Bio D] |
| | 5.10 | Plant Specimens [Bio E] |
| | 5.25 | Microbiology [Bio C] |
| | 5.26 | Invertebrates [Bio F] |
| Earth surveys | 5.11 | Earth Surveys |
| | 5.12 | Remote Maneuvering Subsatellite |
| Aerospace medicine | 5.13C | Centrifuge |
| | 5.13 | Biomedical and Behavioral Research |
| | 5.14 | Man and System Integration |
| | 5.15 | Life Support and Protective Systems |
| Space manufacturing | 5.16 | Materials Science and Processing |
| Advanced technology | 5.17 | Contamination Measurements |
| | 5.18 | Exposure Experiments |
| | 5.19 | Extended Space Structure Development |
| | 5.20 | Fluid Physics in Microgravity |
| | 5.22 | Component Test and Sensor Calibration |
| Engineering and operations | 5.24 | MSC Flight Operations Package |

The IPPA activity and its study relationships to other activities are reflected in figure 18.

The study logic for incorporating the IPPA product into the experiment module concepts is presented in figure 19.

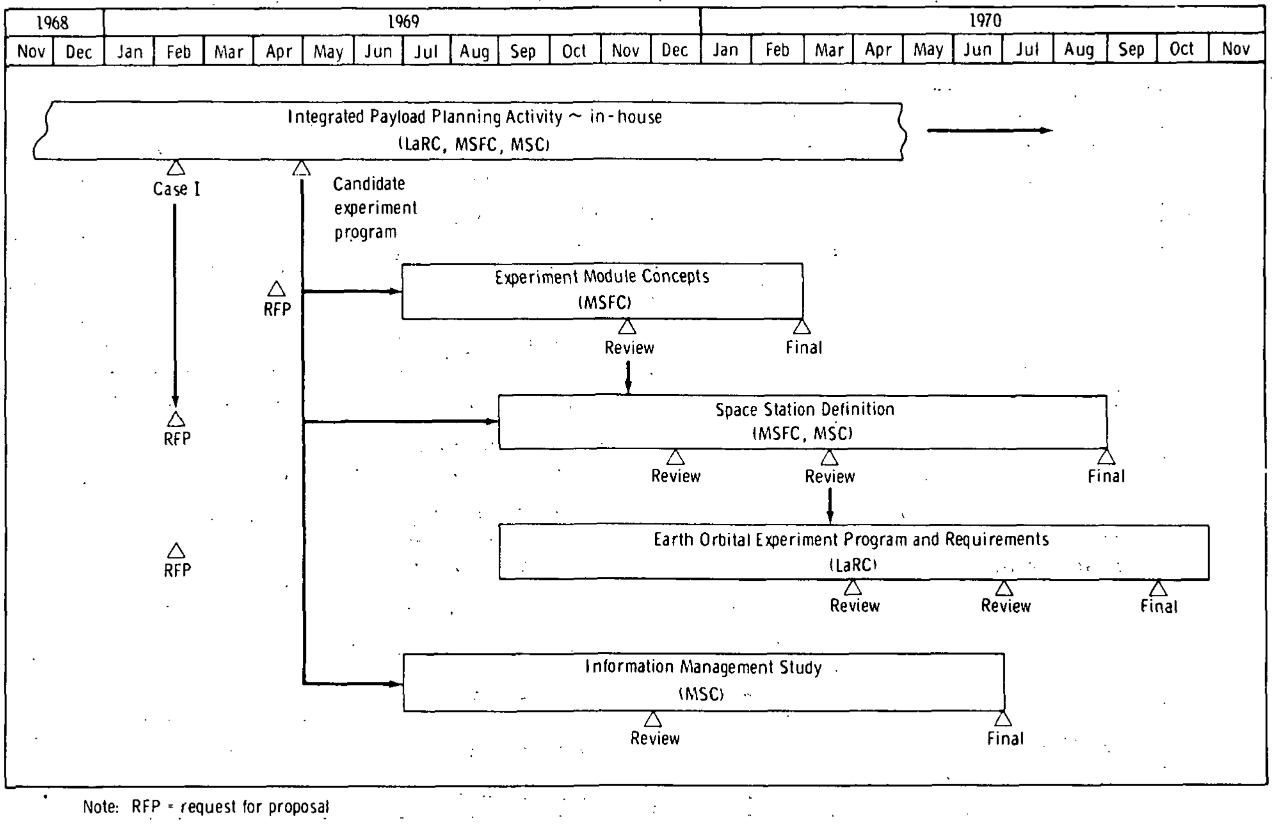



Figure 18. - Space Station experiment program study relationships.

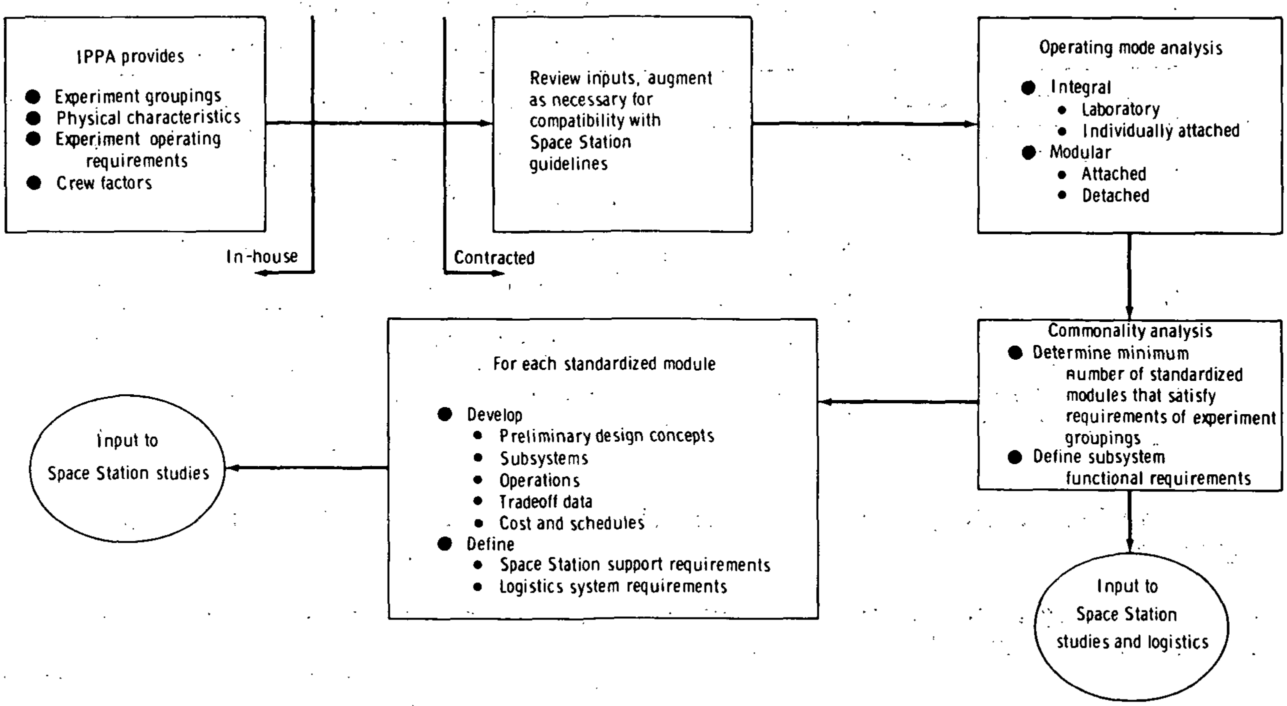



Figure 19. - Study logic for experiment module concepts.

The generation of an updated candidate experiments program (fig. 20), which was a compilation of considerable data, was a major task for the experiment module concept study.

The management relationship between the Phase B Experiment Program Steering Committee and the major users of the document is shown in figure 21.

The history and evolution of the candidate experiment program documentation is shown in figure 22.

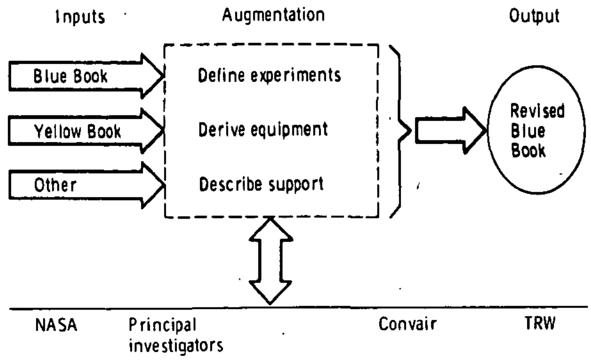



Figure 20.- Experiment module concept study.

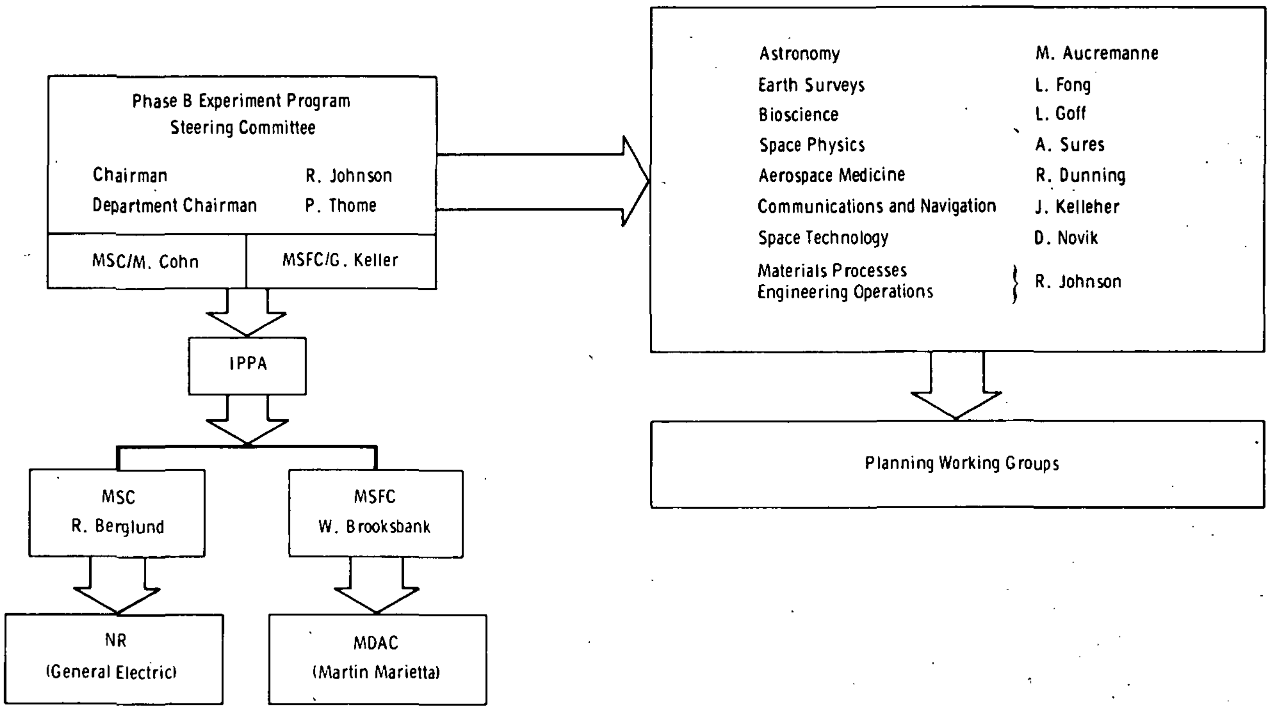



Figure 21. - Candidate experiment program management.

The NASA review group structure used to update the candidate (Blue Book) experiment program documentation is presented in figure 23.

The final organization of the Blue Book is indicated in table X. This consists of seven major discipline areas further subdivided into 25 FPE's.

- Purpose: To provide generic descriptions of possible earth orbital experiments as a design reference guide
- Form: Eight volumes
  - I Summary
  - II Astronomy
  - III Physics
  - IV Earth Observations
  - V Communications and Navigation
  - VI Materials Science and Manufacturing
  - VII Technology
  - VIII Life Sciences
- History and evolution:

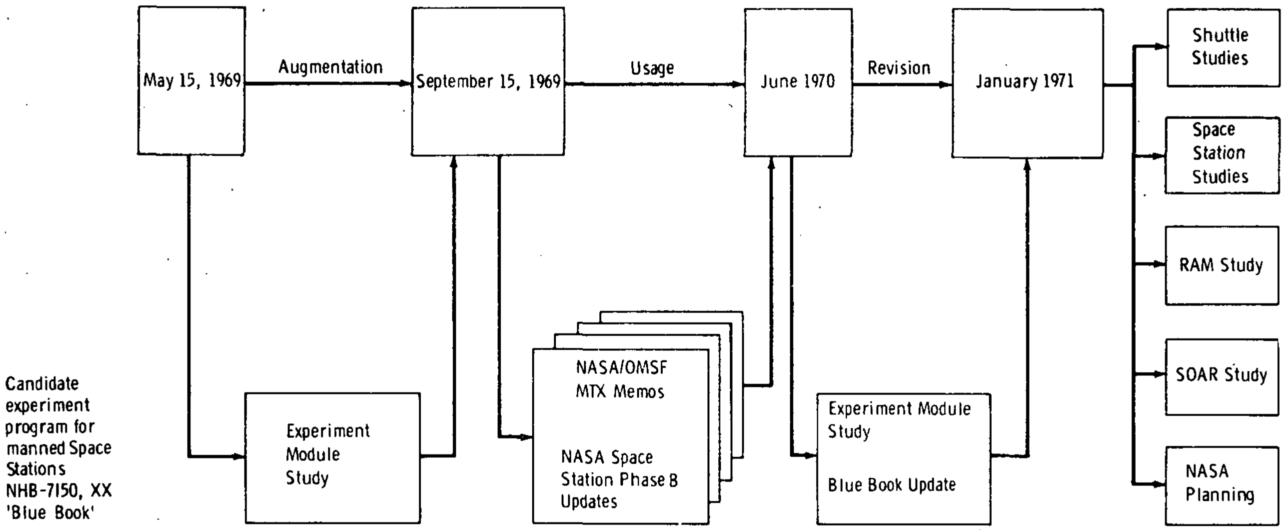



Figure 22. - Blue Book history and evolution.

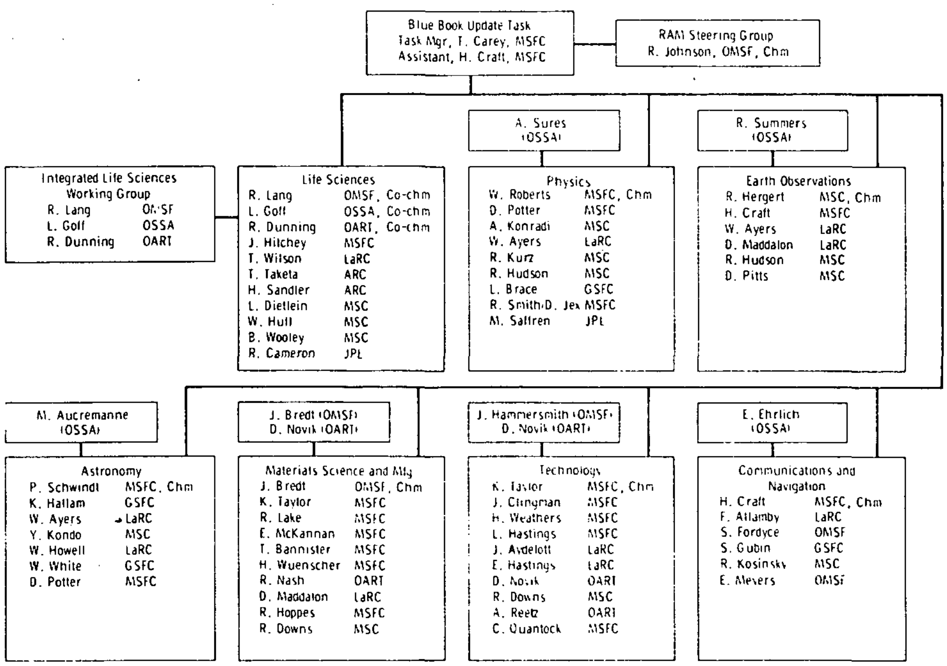



Figure 23. - Blue Book update NASA Review Group structure.

TABLE X. - BLUE BOOK DISCIPLINES AND FPE's

| | |
|---|---|
| Astronomy | Material Science and Manufacturing |
| X-Ray Astronomy | Materials Science and Manufacturing in Space |
| Advanced Stellar Astronomy | Technology |
| Advanced Solar Astronomy | Contamination Measurements |
| Intermediate Size Ultraviolet Telescopes | Fluid Management |
| High-Energy Stellar Astronomy | Extravehicular Activity (EVA) |
| Infrared Astronomy | Advanced Spacecraft Systems Tests |
| Physics | Teleoperations |
| Space Physics Research Laboratory | Life Sciences |
| Plasma Physics and Environmental Perturbation Laboratory | Medical Research Facility |
| Cosmic Ray Physics Laboratory | Vertebrate Research Facility |
| Physics and Chemistry Laboratory | Plant Research Facility |
| Earth Observations | Cells and Tissues Research Facility |
| Earth Surveys Research Laboratory | Invertebrate Research Facility |
| Communications and Navigation | Life Support and Protective Systems |
| Communications and Navigation Research Facility | Man and Systems Integration |

## Lack of Planning Goals and Priorities

The experiment planning activity encompassed all areas of NASA and had major contractual support from industry. Hindsight may show that it also was a good initial effort which may have hindered its value by the over-definition of many things. This resulted in both Space Station contractors having to overaccommodate, overschedule, and overprice. However, before the Space Station study contractors could use the candidate experiment program, the information had to be further developed into engineering and operational parameters. This meant defining much of the activity into experiment packages with backup data consisting of actual experiment hardware if not subassemblies or components. It would have been more effective to have had this data provided initially by the contractor under its task. (See fig. 20.) Both Space Station contractors, therefore, have developed independent data files, each organized for their own unique needs and not suitable for inclusion into a direct data transfer file.

If it is the policy of MSC to obtain more man-related benefits from space-flight activity at lower cost, then it will be necessary to work harder to make this happen.

The candidate experiments compiled in the NASA Blue Book are too costly to be considered as a whole, are somewhat duplicated within the support level requirements, have not been verified as the true experiment goals by the various academies, and do not consider a standard earth-like laboratory approach for many items.

For the NASA Blue Book data file to work effectively with Phase B NASA and industry studies or with future Phase C/D implementation studies, the data must be organized to lower levels that adequately support the engineering and operational data parameters. Priorities must be delineated within disciplines, and priorities must be given between disciplines after the funding for experiments and their operational support missions is determined.

The number of people involved in the management and work force must be maintained at a low level, or the experiment programs will run extremely high cost rates. Design provisions and operational support provisions must be such that the Space Shuttle transportation can be used with ease. New experiments or repetition of old experiments must occur readily during the Phase D operational mode of the Space Shuttle. Some aspects of payload planning for the future have been considered.

## Future Management Considerations

Some NASA Headquarters planning thoughts on how scientific interest could be input to result in some firm program implementation results is reflected in figure 24. The figure shows the various scientific interests inputting data through a NASA controlled activity that translates the data into a payload data bank. The payload data bank is becoming a key item and in the future must contain programmatic data as well as requirements and engineering data. The payload program definition activities would then be used in a series of activities for shuttle payload design, costing, payload requirements, and accommodations. During the past year, these products have been impacted by lack of the Space Shuttle configuration definition. The lack of interface requirements considered by the Space Shuttle design teams and the lack of payload priorities generate a situation with too big a workload for too few man-hours. A filtering system that relates this output by considering such factors as the available budget and the flight schedule to arrive at a potential payload mission assignment is shown in figure 24. This results in payload development planning implemented by the research and technology objectives and plans (RTOP) system using studies, supporting research and technology (SRT) activities, and experiment definition. This approach has not been formerly implemented; however, considerable work has been done on the preparation of the data bank, funding estimates, traffic models, and experiment definition.

Many people are involved in many different ways with various techniques and methods for inputting their products. This has resulted in considerable compilation of data, but at various levels of definition and detail. Each major study contractor has had to use these data in experiment accommodation and flight scheduling activity. To complete experiment accommodation and flight mode trade studies, each had to use a subcontractor to provide an overall data book containing requirements and engineering parameters for all proposed experiment hardware.

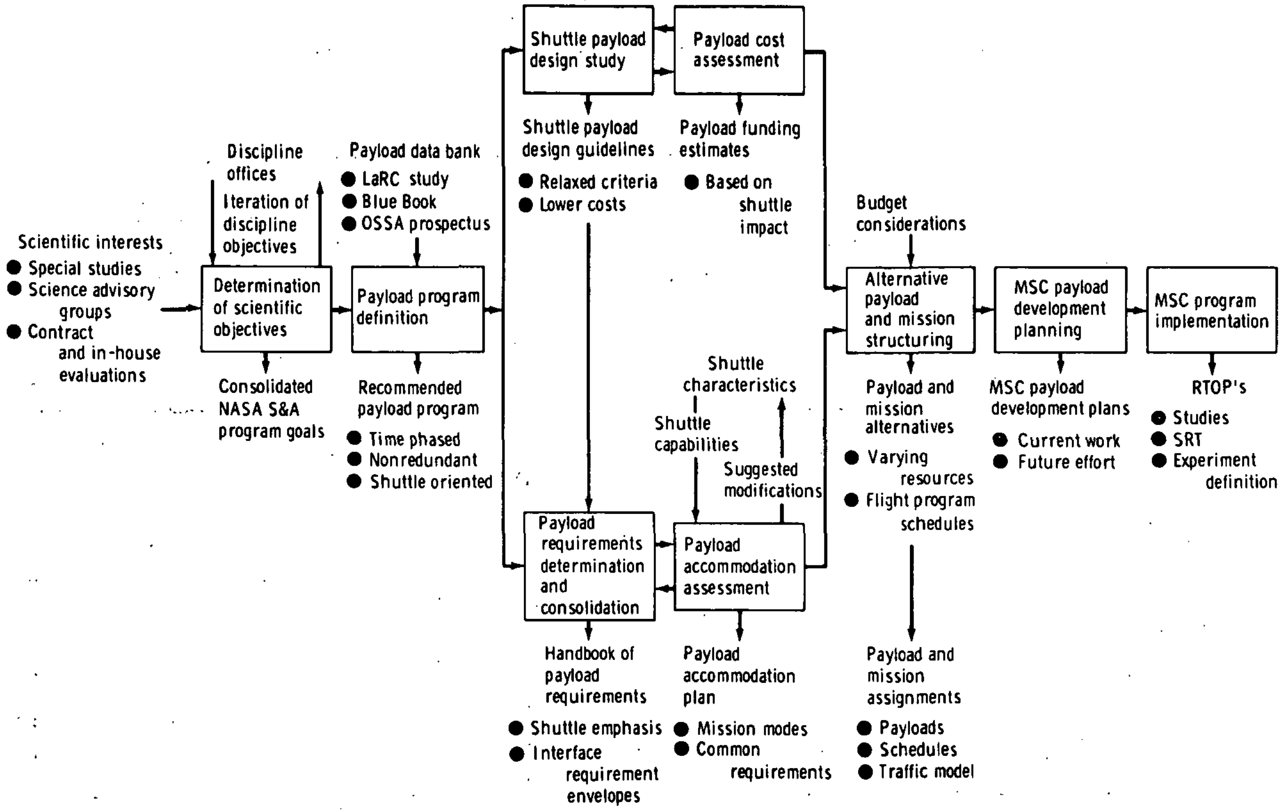



Figure 24. - Payload planning approach.

One aspect of the experiment program has been its basic organization. At one time, eight discipline areas contained all known or anticipated activities for the future. (See table VIII.) The updated Blue Book consolidated this activity into seven discipline areas as indicated by table XI. There are two ways to analyze each discipline area. The first approach looks at each area as being phenomenon-oriented — such as earth remote sensing, space remote sensing, or those experiments simulating zero gravity or the vacuum of space. This allows an opportunity to look at smaller numbers of experiment groupings, a procedure which may greatly reduce certain management interfaces. It also recognizes that multiple uses for experiments can be made on a single mission, with inherent benefits coming from cross-utilization of equipment.

The second approach is a purpose-oriented approach indicating how the seven discipline areas can be organized into applications, technology, and science. These organizational groupings and nomenclature have been discussed more often in NASA Headquarters meetings.

Either approach permits the focus of a major part of a future workload, with proper definition of program goals, objectives, and priorities, to greater reduce the implementation interface.

TABLE XI. - PAYLOAD DEFINITION APPROACHES

| Discipline | Laboratory type | | | | | |
|---|---|---|---|---|---|---|
| | Approach no. 1, phenomenon-oriented | | | Approach no. 2, purpose-oriented | | |
| | Earth remote sensing | Space remote sensing | Zero-gravity or vacuum | Application | Technology | Science |
| Astronomy | | X | | | | X |
| Physics | | X | | | | X |
| Earth observations | X | | | X | | |
| Communications and navigation | X | | | X | X | |
| Material sciences | | | X | X | | |
| Technology | X | X | X | | X | |
| Life sciences | | | X | X | | |

Desirable features:
1. Multiple missions
2. Multiple users
3. Minimum requirement for investigator-supplied equipment
4. Maximum use of "ground type" commercial equipment

The method by which three basic laboratory designs might be approached for Space Shuttle single-sortie missions is shown in figure 25. The sortie laboratory design philosophy, based on the current understanding of proposed application and experiment hardware, provides for two levels of design and equipment common to all payloads. These are the basic structure and subsystems and the standard general-purpose experimental equipment required to support activity for all laboratories. The applications and experiment hardware has a level of standardized experiment equipment for each of the three laboratories. The mission-unique flight equipment interfaces as required with the standard laboratory equipment. This interface appears to have some broad and effective advantages. It would certainly increase the effectiveness of handling more experimental equipment at a much lower cost. The equipment common to all payloads would reach a standard operating procedure early in the program, covering the complete operations aspects through the mission control management aspects.

How this approach would reduce the management interface is shown in figure 26. A basic part of NASA planning includes the concept for a NASA center to have the responsibility for maintaining the payload data bank, participating in scheduling activities to meet near-term goals, and defining future activities for meeting long-term goals. Inherent in this plan is the capability for all NASA centers to handle a particular payload as mission payload centers. This would permit the payload for a selected

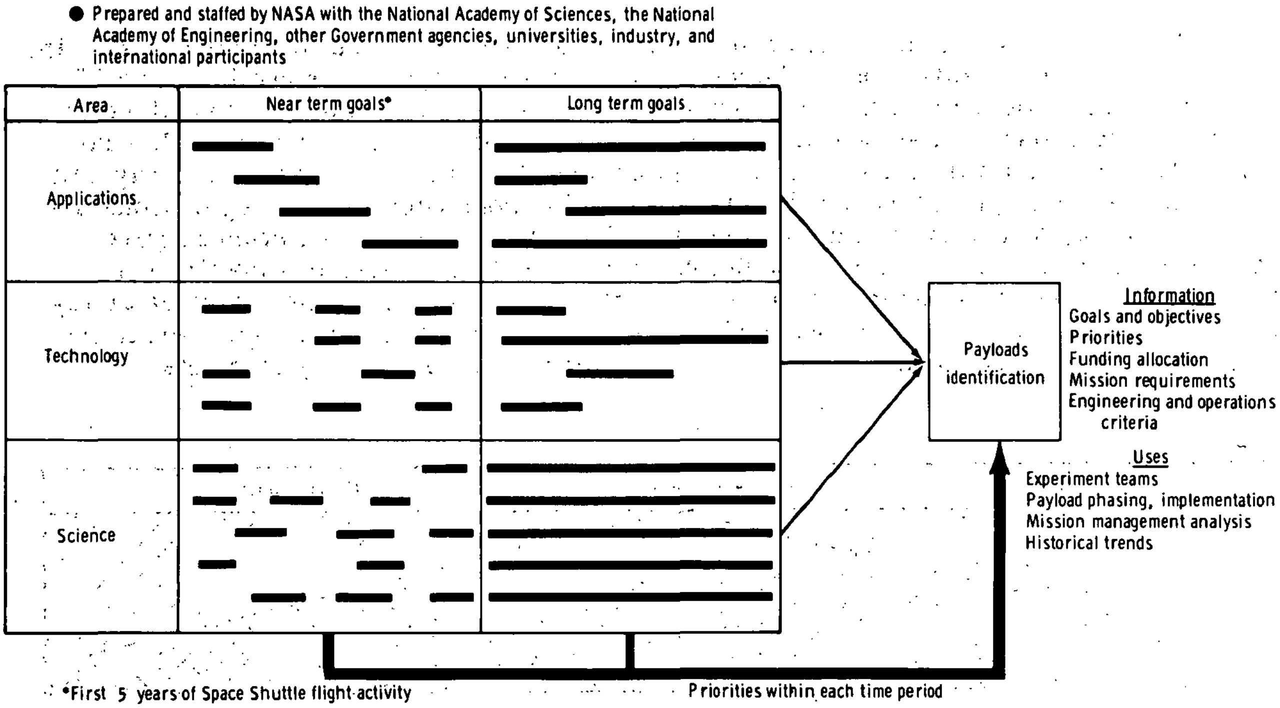



Figure 25. - Sortie laboratory design philosophy.

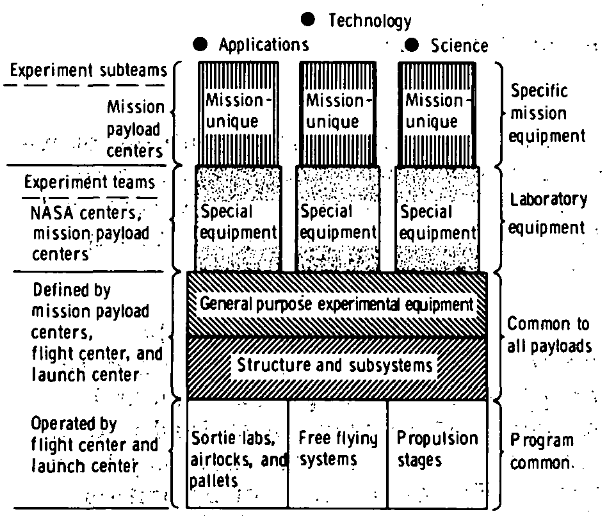



Figure 26. - Reduced management interfaces.

mission to interface with the experiment subteams or individual principal investigators (composed of NASA personnel or outside personnel). By focusing the principal investigators' attention on one mission, payload work can productively move ahead with only those involved. Before the mission-unique equipment effort is undertaken, the payload data files being worked by the various experiment teams under the overall direction of a common system or NASA center could describe adequately the laboratory standard equipment. At this time, the priorities that directly support the goals and objectives would be important in defining these requirements. If these standardized experimental laboratories are flown initially on the Space Shuttle for 4 or 5 years, the flight center and launch center could greatly simplify their mission management concepts by standardizing much of the software and operational procedures used on the ground and in flight for the general-purpose experimental equipment and the structure and subsystems common to all payloads. It is important to note that the same approach could be implemented for payloads with kick stages, free flyers, and the like.

Highlights of major activities and program elements that must be considered in the overall design and operation of a mission management concept are shown in figure 27. Mission planning for near-term operations includes the understanding of everything occurring on the ground, missions in progress, and upcoming future missions. It also includes an interface for long-term payload planning with the Space Shuttle and payload organizations. Mission control refers to more of the real-time mission operations occurring on the ground and in flight and does include the necessary logistics requirements for payloads already aloft. Each program element indicated has continuous interface with mission planning and mission control. The extent of the interface at any one time depends upon how far advanced the project is. Nevertheless, the overall management and design approach properly considers and balances all requirements.

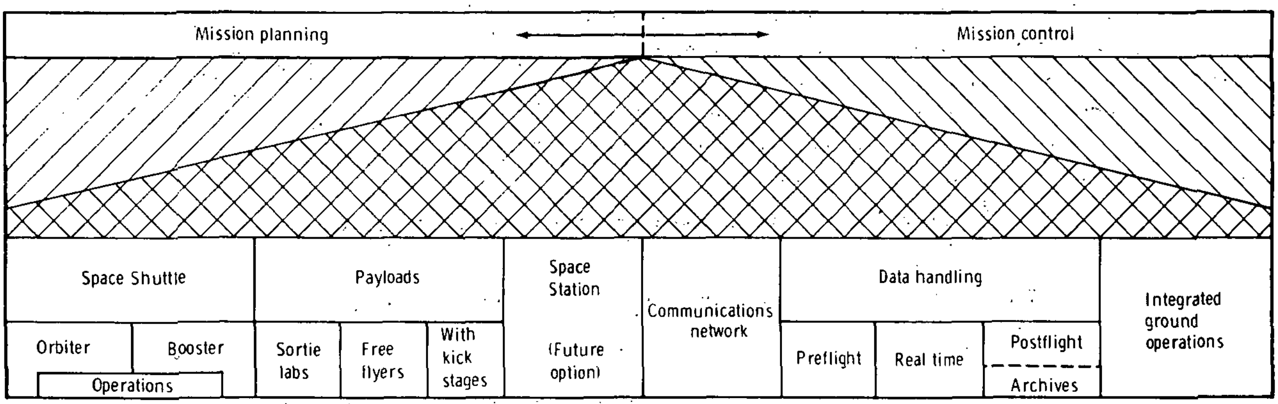



Figure 27. - Mission management concept.

Thus far, the management system has been built from the ground up with the overall consideration for protecting the workload, reducing the number and extent of management interfaces, placing more responsibility on only those teams of people required, and having a mission management concept that all teams follow to greatly reduce duplication of effort and documentation.

To effectively use the operational capability that the Space Shuttle is likely to provide, our national goals and objectives for near-term and long-term space activity need to be stimulated and made visible. The forcing function in the preparation and staffing of these policy reports must be NASA. If these reports were organized into the three areas of applications, technology, and science, definition of near- and long-term goals, based on the realities of today, could be begun. The evolvement of priorities will be most important. The results could be an updated and properly balanced NASA data bank. Visible to all would be a statement of goals and objectives, what this means in terms of mission requirements, all the background scientific and engineering parameters, the necessary priorities, and funding allocations. Funding allocations could be made at the area level for a given period of time (down to the individual experiment for one fiscal year). Proper management of the funding activity would require this flexibility and visibility. With this approach, the major workload would be enhanced greatly as shown in figure 28.

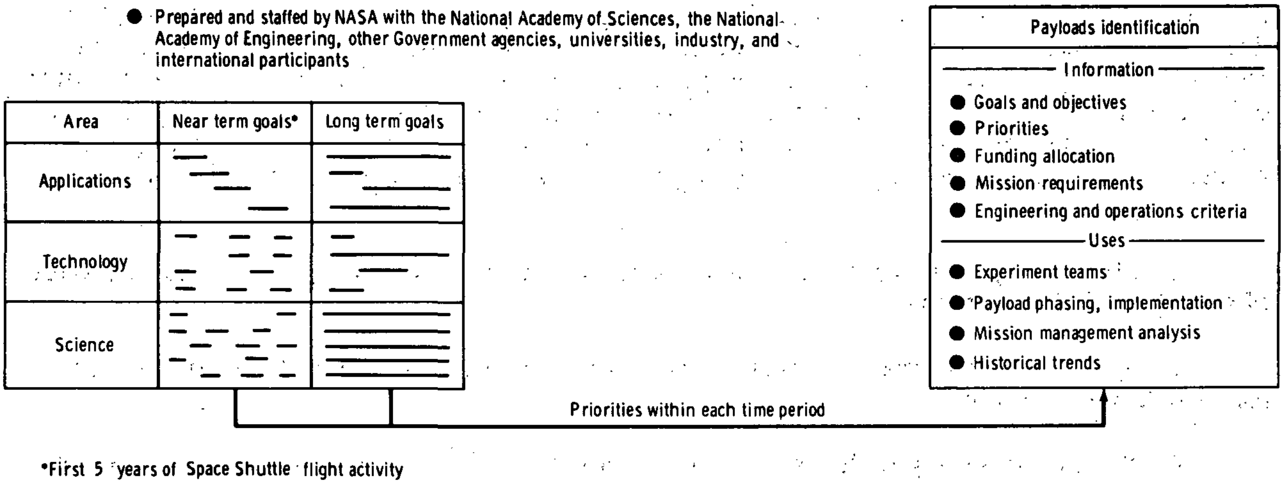



Figure 28. - National goals and objectives.

A check on this approach can be made simply by looking at table XI and figures 25 to 28. It does appear that the logic is still valid.

## CONCLUDING REMARKS

The National Aeronautics and Space Administration has had a major Space Station Definition Study underway within the agency and under contract for almost 3 years. Considerable documentation has been generated for just one contract as referenced by appendix D. A considerable amount of the study findings for the 33-foot-diameter Space Station Saturn V launch vehicle was directly applicable to the Modular Space Station Definition. In addition, considerable engineering and operational data from the Modular Space Station effort are applicable to the Space Shuttle single-sortie missions.

The following questions must now be answered: Has the learning curve advanced? Is it practical to assume that the next major program can be implemented and new methods of doing business realized at greatly reduced program costs?

The current technology position of this nation provides assurance and great expectations for accomplishments in near-earth orbit. The engineering and operational aspects appear to be far simpler than the management interface program problems. This report provides a proposed operating framework for implementing applications, technology, and science activities for smaller teams of people using more standard interface equipment and providing mission management visibility as required. The reduction of personnel is the key to lower costs. The use of standard equipment from mission to mission places more responsibility on people. It is the new and unique inventory from one flight to the next that has generated large groups of people supporting a documentation process the true value of which often was not fully understood. Future programs will be done by people, as has always been the case. These people must proceed through certain steps to gain the desired operational plateau. Shortcuts cause major problems later in the program. Rushing through any one part causes varying degrees of programmatic problems, some of which may be fatal. Regardless of the number of people involved, the learning curve must be maintained, and the most practical application of experiences must be made for meeting the goals and objectives of the new effort. The operational plateau must be reached with a minimum of funding and maintained at a low cost to permit the use of all available dollars for applications, technology, and science.

The following five items represent major points to observe in the implementation of a major agency activity.

1. Major Administration-wide study efforts should have periodic reviews with top NASA management.

2. At the beginning of the study, when the largest upsurge of manpower occurs, it is important that all participants understand the background philosophy of the study, and the reasons for the stated guidelines and constraints.

3. The prime contractor should be responsible for the total systems engineering and integration and the total documentation of results.

4. A well developed study plan at study initiation is mandatory.

5. The processes employed in programmatic systems engineering must be recognized and used.

In addition, there are many items of major importance that are noted for review and consideration.

1. Studies should last at least 1 year and be adequately funded.

2. More than one configuration can provide the functional design requirements.

3. Major parallel studies from more than one NASA center give better and more flexible planning results if goals and objectives are practical and long lasting. The same statement of work must be used for all studies.

4. The Government must support the study to a major level in several areas. These Government data must be completely prepared and disseminated in a timely manner.

5. Goals and objectives must be formulated to guide the implementation planning in all areas.

6. A limited number of guidelines and constraints should be provided to control programmatic parameters.

7. The Government should update and maintain broad distribution of the Guidelines and Constraints Document.

8. Analyses must be documented to originate, support, or counter the guidelines and constraints.

9. While a major study is in progress, planned inputs from other supporting studies are of little value.

10. Responsible support from all areas of the involved NASA center is most productive for all concerned.

11. Personnel of NASA centers must be involved in the study in an active, participating mode rather than in a passive, monitoring mode. The results must represent a combined Government and industry product.

12. Levels of responsibility must be established and individuals assigned at initiation of the effort.

13. The basic skills of center personnel at the branch level and below should be easily reached and used.

14. Management and technical direction to the contractor must have prescribed routes to follow.

15. Informal data exchanges must be encouraged. These routes of communication should be recognized and encouraged.

16. A logistics support scheme must be carefully planned and implemented to relieve paperwork burdens. Reports and minutes of meetings must be provided with ease and in a timely fashion.

17. Motivation techniques must be planned and employed.

18. Steady progress of results by individuals must be recognized.

19. Cost-related decisions will take precedence over technology and engineering factors.

20. Effective communication routes must be maintained with NASA Headquarters.

21. Results of trade studies must be used to iterate the concepts toward support of a preliminary design activity rather than support of a favorite concept based on incomplete data.

22. Contractor internal reports and data memorandums should be exchanged informally with the Government technical interface to maintain effective understanding of the work.

23. Major briefings should not be held more often than every 3 months. These briefings should be open industry meetings as established by the NASA Headquarters Space Station Task Force.

Manned Spacecraft Center
National Aeronautics and Space Administration
Houston, Texas, June 1, 1972
976-10-05-06-72

## APPENDIX A

## ESTABLISHMENT OF SPACE STATION TASK GROUP

The Space Station Task Group is hereby established to manage Manned Spacecraft Center (MSC) contracted and in-house studies associated with the Space Station Phase B Definition. Mr. Rene A. Berglund is appointed Manager of the Task Group and Jack C. Heberlig, Deputy Manager. Mr. Berglund will report to the Manager, Advanced Missions Program Office (AMPO). Mr. Robert T. Everline will serve as Assistant Manager for the Space Station, and Mr. J. Thomas Milton will serve as Assistant Manager for the Logistics Spacecraft.

Representatives from each directorate will serve on the Task Group to provide inputs from their organizations and to coordinate supplementary studies. The following personnel are appointed to these positions:

| | |
|---|---|
| Engineering and Development (E&D) Assistant Manager | - Mr. Ralph D. Hodge |
| Flight Crew Operations Directorate (FCOD) Assistant Manager | - Mr. A. Harry Davidson |
| Flight Operations Directorate (FOD) Assistant Manager | - Mr. Rodney G. Rose |
| Flight Safety Assistant Manager | - Mr. Anthony W. Wardell |
| Reliability and Quality Assurance (R&QA) Assistant Manager | - Mr. Junius B. Fox |
| Medical Research and Operations Directorate (MR&OD) Assistant Manager | - Dr. Wayland E. Hull |
| Science and Applications Directorate (S&AD) Assistant Manager | - Mr. Marvin Cohn |
| Program Control and Contracts (PC&C) Assistant Manager | - Mr. William M. Chastain |

Also, the following AMPO personnel are initially assigned to the Space Station Task Force:

Mr. Alan Troeger

Mr. Leonard S. Nicholson

Mr. Frank S. Coe

Mr. R. Stuart Sayers

Mr. Harle L. Vogel

Mrs. Ruby Summers

Additional assignments of AMPO personnel will be announced at a later date.

This organization plan for managing the in-house and contracted effort is based on two basic principles: (1) personnel involved in an in-house effort should remain in their respective line organizations to allow access to the full capabilities of that organization, and (2) in-house effort should be conceived to supplement and complement the contract effort to ensure that the best possible results are obtained.

In line with these principles, the Manager, AMPO, will have management responsibility for the definition study. However, the Director of each functional organization will have technical responsibility for his area of specialization. To ensure the exercise of this responsibility, each directorate will have a representative to AMPO who will serve as an Assistant to the Task Group Manager. These representatives will be responsible for monitoring the contractor's effort and will have access to both the philosophy and guidance of their Directors as well as the technical expertise of their directorate personnel. In the AMPO and representative relationship, AMPO will have programmatic management responsibilities for the contracted studies and will process all formal direction to the contractor affecting the scope of work or contract costs. These relationships are defined in more detail in the AMPO Space Station Program Definition Management Plan.

This approach will accomplish the following objectives:

1. Involve all levels of MSC management

2. Provide MSC directorates with direct input into study

3. Provide study managers with access to directorate philosophies

4. Provide contractors with access to directorate expertise

5. Allow directorates to conduct complementary in-house studies in support of contract effort

6. Allow development of comprehensive MSC positions and philosophies

An organization chart for the described plan is shown in figure A-1.

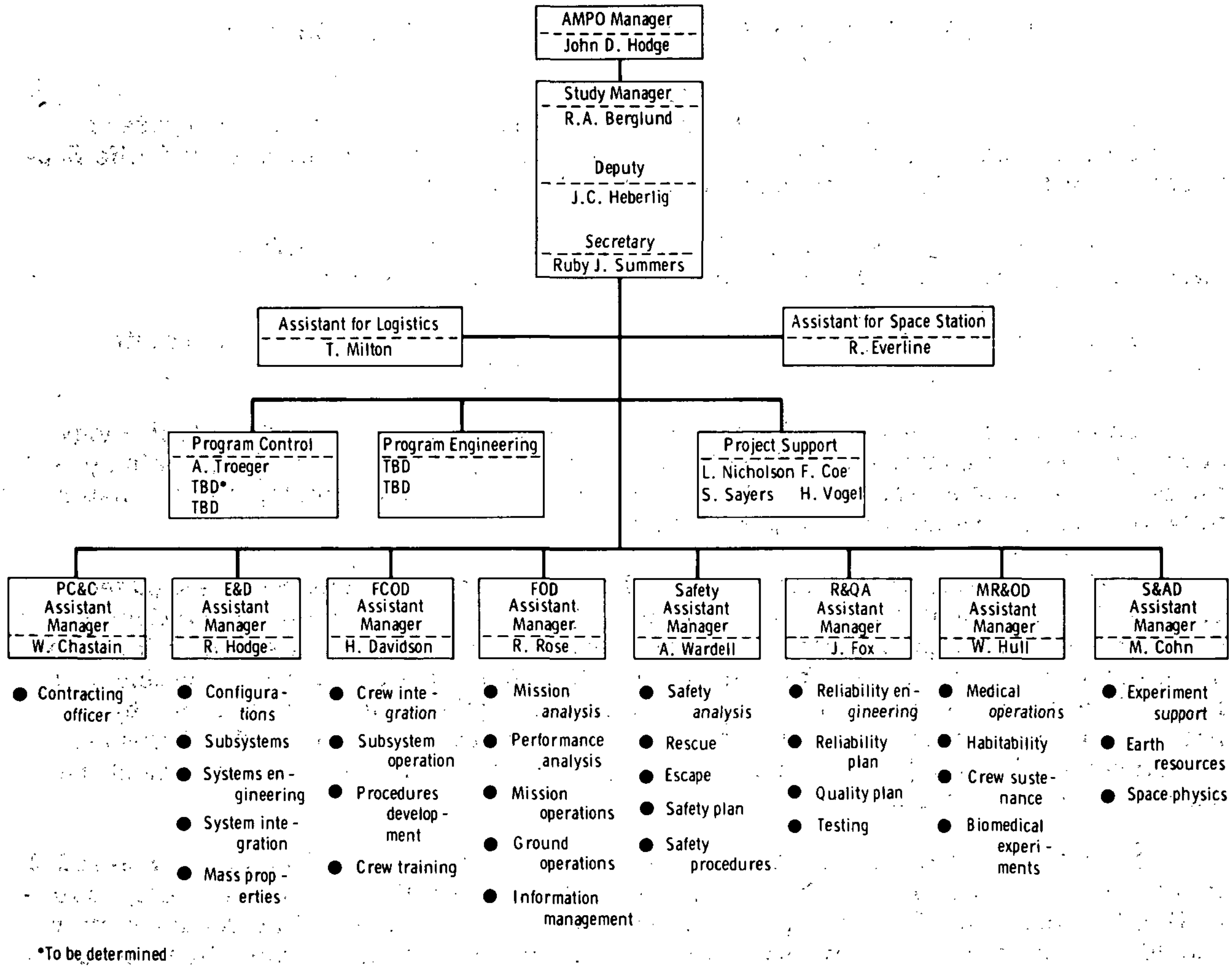



Figure A-1.- Space Station Task Group organization.

## APPENDIX B

## ENVIRONMENTAL AND THERMAL CONTROL AND LIFE SUPPORT SYSTEM COORDINATION TASK BETWEEN PHASE B SPACE STATION STUDY CONTRACTORS AND ENVIRONMENTAL AND THERMAL CONTROL AND LIFE SUPPORT SYSTEM TECHNOLOGY CONTRACTOR

The National Aeronautics and Space Administration has awarded two Phase B Space Station Study contracts and one Environmental and Thermal Control and Life Support System (ETC/LSS) Technology contract as follows:

Space Station: (1) McDonnell-Douglas Aircraft Corporation (MDAC), NAS 8-25140, and (2) North American Rockwell (NR), NAS 9-9953

ETC/LSS Technology: Hamilton Standard Division (HSD) of United Aircraft, NAS 9-10273

To ensure compatibility of vehicle requirements and designs and the technology developments being pursued, liaison to coordinate the program activities is being established. To implement this function, each participant has designated a coordinator to be the prime contact for the liaison activity.

A Manned Spacecraft Center (MSC) ETC/LSS coordinator has been designated to represent NASA. It is his responsibility to distribute appropriate documentation produced by the technology contractor, to establish the location and dates of meetings, to handle issues requiring resolution or answers by NASA, and to chair the meetings. It is the objective of the MSC coordinator to ensure compliance with this function by all parties, but on an informal basis to the maximum extent practicable. The following guidelines are established to assist in the performance of this function throughout the duration of the contracts.

1. Because of the extensive documentation associated with Contract NAS 9-10273, this documentation will be the major means to effect integration of the technology information into the Space Station contracts. Appropriate comments on this documentation should be submitted by the Space Station contractors to the MSC coordinator to ensure maximum utility of the technology activity in support of the Space Station Program.

2. In addition to document distribution and review, liaison meetings will be held in conjunction with major program review meetings or as required by review of the documentation.

3. Any of the parties (MSC, HSD, Grumman Aerospace Corporation, MDAC, or NR) can call special meetings through the MSC coordinator if required. The party calling the meeting is responsible for setting up the agenda.

4. The meetings will not be limited to discussion of prearranged agenda items.

5. Minutes of items discussed, documenting action items assigned, data exchanged, and so forth will be taken by the meeting host (in the case of meetings at MSC, by the MSC coordinator), typed, and distributed to the appropriate parties within approximately 1 week after the meeting.

6. It is the responsibility of each contractor to determine if any agreed upon task is within his contract scope. If not, Contracting Officer authorization will be obtained by the MSC coordinator prior to commencing the task.

7. The MSC coordinator may not attend all the meetings held away from MSC. Although absence of the MSC coordinator should not prevent the contractors from meeting if required, arrangements, as usual, are to be made through the MSC coordinator. Minutes will be recorded by the host, and copies of data exchanged are to be provided to the MSC coordinator.

This agreement is entered into by all parties (represented by signature) for the purpose of establishing guidelines for fulfilling the necessary liaison to coordinate the program activities. It is understood that there are no contractual implications involved and that signing represents only an understanding of the task and an agreement to fulfill the liaison in a methodical manner.

## APPENDIX C

## POWER SYSTEM COORDINATION TASK AMONG PHASE B SPACE STATION STUDY CONTRACTORS AND SOLAR ARRAY TECHNOLOGY AND BATTERY TECHNOLOGY CONTRACTORS

The National Aeronautics and Space Administration has awarded two Phase B Space Station Study contracts and Solar Array Technology and Battery Technology contracts as follows:

Space Station: (1) McDonnell-Douglas Aircraft Corporation (MDAC), NAS 8-25140, and (2) North American Rockwell (NR), NAS 9-9953

Solar Array Technology: Lockheed Missiles and Space Company (LMSC), NAS 9-11039

Battery Technology: Grumman Aerospace Corporation (GAC), NAS 9-11074

To ensure compatibility of vehicle requirements and designs and the technology developments being pursued, liaison to coordinate the program activities is being established. To implement this function, each participant has designated a coordinator to be the prime contact for the liaison activity.

The Manned Spacecraft Center (MSC) coordinator has been assigned to represent NASA. It is his responsibility to establish the location and dates of meetings, to handle issues requiring resolution or answers by NASA, and to chair the meetings. It is the objective of the MSC coordinator to ensure compliance with this function by all parties, but on an informal basis to the maximum extent practicable. The following guidelines are established to assist in the performance of this function throughout the duration of the contracts.

1. Regular liaison meetings will be held in conjunction with major program review meetings.

2. Any of the parties (MSC, LMSC, GAC, MDAC, or NR) can call special meetings through the MSC coordinator if required. The party calling the meeting is responsible for setting up the agenda.

3. The meetings will not be limited to discussion of prearranged agenda items.

4. Minutes of items discussed, documenting action items assigned, data exchanged, and so forth will be taken by the meeting host (in the case of meetings at MSC, by the MSC coordinator), typed, and distributed to the appropriate parties within approximately 1 week after the meeting.

5. It is the responsibility of each contractor to determine if any agreed upon task is within his contract scope. If not, Contracting Officer authorization will be obtained by the MSC coordinator prior to commencing the task.

6. The MSC coordinator may not attend all the meetings held away from MSC. Although absence of the MSC coordinator should not prevent the contractors from meeting if required, arrangements, as usual, are to be made through the MSC coordinator. Minutes will be recorded by the host, and copies of data exchanged are to be provided to the MSC coordinator.

This agreement is entered into by all parties (represented by signature) for the purpose of establishing guidelines for fulfilling the necessary liaison to coordinate the program activities. It is understood that there are no contractual implications involved and that signing represents only an understanding of the task and an agreement to fulfill the liaison in a methodical manner.

## APPENDIX D

## FINAL REPORTS — CONTRACT NAS 9-9953 SPACE STATION PROGRAM

## PHASE B DEFINITION

Manned Spacecraft Center (MSC) documents generated in the Space Station Program Phase B Definition are presented in the following table.

| MSC number | Title |
|---|---|
| 00700 | Space Station Program Phase B Definition Study Plan |
| 00701 | Space Station Program Executive Summary Report |
| 00702 | Space Station Program Cost and Schedule Report |
| 00703 | Space Station Program Supporting Research and Technology Plan |
| 00704 | Space Station Program Skylab Utilization Plan |
| 00705 | Space Station Program Operations Plan |
| | Part 1 - Summary |
| | Part 2 - Mission Operations |
| | Part 3 - Information Management |
| | Part 4 - Computer Program Development |
| 00706 | Space Station Program Crew Training Plan |
| 00707 | Space Station Program Design Plan |
| 00708 | Space Station Program Manufacturing Plan |
| 00709 | Space Station Program Facility Utilization Plan |
| 00710 | Space Station Program Quality Program Plan |
| 00711 | Space Station Program Test Plan |

| MSC number | Title |
|---|---|
| 00712 | Space Station Program Space Base Definition Document |
| | Vol. I - Capabilities |
| | Vol. II |
| | Part 2 - Solar Battery Configuration |
| | Part 3 - Buildup Concept |
| | Part 4 - Solar Battery and Space Station Interfaces |
| | Part 5 - Base Development Effort |
| | Vol. III |
| | Part 1 - SOSI Facilities |
| | Part 2 - Natural Environment |
| | Part 3 - Induced Environment |
| | Part 4 - Dynamic Analysis |
| | Part 5 - Conceptual Drawings |
| | Part 6 - Weight Statements |
| 00713 | Space Station Program System Safety Plan |
| 00714 | Space Station Program Management Plan |
| 00715 | Space Station Program Experiment Integration Plan |
| 00716 | Space Station Logistics Support Plan |
| 00717 | Space Station Solar Powered Program Definition Document |
| | Vol. I - Summary |
| | Vol. II - Mission Operations and Payloads |
| | Part 1 - Experiment Support Requirements |
| | Part 2 - Mission Operations |

| MSC number | Title |
|---|---|
| 00717 (continued) | Vol. III - Subsystem Definition<br>Part 1 - Environmental Control Life Support System<br>Part 2 - Electrical Power<br>Part 3 - Guidance and Control and Reaction Control System<br>Part 4 - Information System<br>Vol. IV - Configuration Analysis and Payload Accommodation<br>Vol. V - Preliminary Definition of Experiment Modules |
| 00718 | Space Station Program Crew Operations Definition Document |
| 00719 | Space Station Solar Powered Program Ground Support Equipment and Facilities Definition Document |
| 00720 | Space Station Solar Powered Program Preliminary Design Data Report<br>Vol. I<br>Part 1 - Study Summary<br>Part 2 - Space Station Core Module System<br>Vol. II<br>Part 1 - Electrical Power Subsystem<br>Part 2 - Environmental Control Life Support System<br>Vol. III<br>Part 1 - Inertial Measuring System<br>Part 2 - Guidance and Control<br>Vol. IV<br>Part 1 - Special Studies<br>Part 2 - Engineering Analysis |

| MSC number | Title |
|---|---|
| 00720 (continued) | Vol. V<br>Part 1 - Artificial Gravity Provisions System<br>Part 2 - Premission Oxygen Purge System Support<br>Part 3 - Mission Oxygen Purge System Support System<br>Vol. VI - Earth Survey Module System<br>Vol. VII - Space Station Drawings<br>Vol. VIII<br>Part 1 - Structural Analysis Calculation<br>Part 2 - Supplementary Calculations<br>Vol. IX<br>Part 1 - Failure Modes and Effects Analysis Data Analysis<br>Part 2 - Hazards Analysis |
| 00721 | Space Station Program Prelaunch Operations Plan |
| 00722 | Space Station Program Advanced Logistics Requirement Document |
| 00723 | Space Station Solar Powered Program Mass Properties Data |
| 00725 | Space Station Solar Powered Program Artificial Gravity Provisions Specification |
| 00726 | Space Station Solar Powered Program Experiments Module Specification |
| 00727 | Space Station Solar Powered Program Mission Operations Support Systems Specification |
| 00728 | Space Station Solar Powered Program Premission Operations Support Systems Specification |
| 00729 | Solar Powered Space Station Preliminary Specification Performance (with appendixes) |

| MSC number | Title |
|---|---|
| 00730 | Space Station Program Initial Logistics Systems Concepts Document |
| 00731 | Space Station Program Planetary Mission Concept Document |
| 00732 | Space Station Solar Powered Program Development Definition Document |
| | Program Element Specification |
| | Program Element Master Plan |
| 00733 | Space Station Program Phase B Definition - Monthly Progress Report - October 22, 1969 |
| 00734 | Space Station Program Phase B Definition - Quarterly Progress Report - October 1970; June 19, 1970; March 19, 1970; December 12, 1969 |
| 00735 | Space Station Phase B Definition Design Sheets |
| | Vol. I - Zero-Gravity Configuration Solar Power Space Station - May 1 |
| | Vol. II - Artificial-Gravity System for Solar Power Space Station - May 8 |
| | Vol. III - Earth Surveys Module - June 12 |
| 00736 | Space Station Phase B Definition Design Sheets |
| | Vol. I - Premission Support for the Space Station Program - June 1 |
| | Vol. II - Mission Support for the Space Station Program - June 1 |
| 00737 | Space Station Program Phase B Definition - Special Emphasis Task Summary Report |
| 00738 | Space Station Program Contract Data Requirements Document Phase C/D Contract |
| 00739 | Space Station Program Reliability Program Plan |
| 00740 | Space Base and Planetary Mission Module Cost and Schedules |

| MSC number | Title |
|---|---|
| 00741 | Nuclear-Reactor-Powered Space Station Definition and Preliminary Design<br>Vol. I - Summary<br>Vol. II - Operation<br>Vol. III - Electrical Power Subsystem<br>Vol. IV - Subsystems<br>Part 1 - Environmental Control and Life Support<br>Part 2 - Guidance and Control<br>Part 3 - Reaction Control<br>Part 4 - Information Management<br>Vol. V - Subsystems<br>Part 1 - Structure<br>Part 2 - Environmental Protection<br>Part 3 - Docking<br>Part 4 - Crew/Habitability<br>Vol. VI - Configuration - Preliminary Design<br>Vol. VII - Drawings |
| 00743 | Space Station Core Module Mockup Definition |
| 00744 | Nuclear-Reactor-Powered Space Station Cost and Schedule |
| 00745 | Nuclear-Reactor-Powered Space Station Design Sheets<br>Vol. I - Core Module System<br>Vol. II - Premission Operation Support<br>Vol. III - Mission Operation Support |

| MSC number | Title |
|---|---|
| 00746 | Radioisotope-Powered Space Station Design Sheets |
| | Vol. I - Core Module System |
| | Vol. II - Premission Operation Support |
| | Vol. III - Mission Operation Support |
| 00747 | Radioisotope-Powered Space Station Definition |
| | Vol. I - Summary |
| | Vol. II - Operations |
| | Vol. III - Subsystems |
| 00748 | Nuclear-Reactor-Powered Space Station Mass Properties |
| 00749 | Nuclear-Reactor-Powered Space Station Development Definition |
| | Vol. I - Program Element Specification |
| | Vol. II - Program Element Master Plan |
| 00759 | Cargo Module Definition |
| 02450 | Option Period Study Plan - October 5, 1970 |
| 02451 | Nuclear-Reactor-Powered Space Station Preliminary Performance Specification |
| | Vol. I - Core Module System |
| | Vol. II - Premission Operation Support |
| | Vol. III - Mission Operation Support |
| 02453 | Space Station - A Guide for Experimenters |
| 02454 | Solar-Powered Space Station Thermal Concept Formulation |
| 02455 | Space Station Mockup Brochure |
| 02456 | Option Period Executive Summary |
| 02460 | Cargo Module Design Sheets |

| MSC number | Title |
|---|---|
| 02461 | Space Station Core Module Mockup Review and Evaluations With Appendixes: Review Item Dispositions |
| 02462 | International System of Units Conversion Assessment |
| 02463 | Thirty-Three-Foot-Diameter Space Station, John F. Kennedy Space Center, Launch Site Support Definition |
| | Vol. I - Parts 1 to 10 |
| | Vol. II - Parts 11 to 19 |
| 02464 | Shuttle-Launched Space Station Concept |
| | Vol. I - Shuttle-Launched Space Station Concept Definition |
| | Vol. II - Shuttle-Launched Space Station System Definition Requirement |
| | Vol. III - Space Station 22-Foot-Diameter Core Module Comparison |
| 02465 | John F. Kennedy Space Center Launch Site Support Definition |
| 02466 | Phase B Extension Study Plan |
| 02467 | Quarterly Review Reports |
| 02468 | Contract Extension Executive Summary Report |
| 02469 | Modular Space Station Preliminary Performance Specification |
| | Vol. I - Initial Station Systems |
| | Vol. II - Project |
| 02470 | Modular Space Station Drawings |
| 02471 | Modular Space Station Preliminary Systems Design Report |
| | Vol. I - Summary |
| | Vol. II - Operations and Crew Analyses |
| | Vol. III - Experiment Analyses |
| | Vol. IV - Subsystems Analyses |

| MSC number | Title |
|---|---|
| 02471 (continued) | Vol. V - Configuration Analyses |
| | Vol. VI - Appendixes Ancillary Analyses |
| | Vol. VII - Ancillary Studies |
| 02472 | Modular Space Station Mass Properties Report |
| 02473 | Modular Space Station Mockup Review and Evaluation |
| 02474 | Modular Space Station Shuttle Interface Requirements |
| 02475 | Information Management System Advanced Development Report |
| 02476 | Modular Space Station Integrated Ground Operations Summary |
| | Vol. I - Summary |
| | Vol. II - Test |
| | Vol. III - Manufacturing |
| | Vol. IV - Ground Support Equipment |
| | Vol. V - Facilities |
| | Vol. VI - Training |
| | Vol. VII - Logistics Support |
| | Vol. VIII - Launch Site Operations |
| 02477 | Modular Space Station Program Operations Plan |
| 02478 | Modular Space Station Safety Analysis |
| 02479 | Modular Space Station Program Master Plan |
| 02480 | Modular Space Station Program Cost and Schedule Estimates |

NASA — MSC