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Title UTILIZING LATERAL ORGANIZATIONAL PATTERNS IN A RESEARCH AND DEVELOPMENT FUNCTION: MISSION PLANNING FOR MANNED SPACEFLIGHT

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UTILIZING LATERAL ORGANIZATIONAL PATTERNS IN A RESEARCH AND DEVELOPMENT FUNCTION: MISSION PLANNING FOR MANNED SPACEFLIGHT

BY
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THESIS

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ABSTRACT OF THESIS

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Leslie James Sullivan, M.A.
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Innovative management techniques developed for the Apollo Program may constitute as significant a contribution to our country's capabilities as the technical achievements--this concept is advanced by certain authorities, including James E. Webb, former NASA Administrator. This study focuses on a key organizational structure within the Apollo Program--spaceflight mission planning, an organizational structure exhibiting singular lateral patterns of organization.

Three working hypotheses comprise the thesis of this study. First, the mission planning structure is a representative example of Likert's multiple, overlapping group concept. Second, line supervisors are the major factor integrating the activities of the cross-functional groups into overall organization. Third, the use of multiple, overlapping groups is an extremely valuable tool in achieving coordination. Three techniques are utilized in collecting data necessary for determining whether or not twelve evaluation criteria are met: (1) a survey of organizational literature is made to identify relevant concepts, (2) an analysis of the mission planning structure is made based on agency sources, and (3) information is utilized from a questionnaire submitted to members of the cross-function groups.

The survey reveals that lateral coordination is treated in the literature, until recently, only in a most limited manner. Authorities through the 1930's are concerned primarily with hierarchical relationships. Traditional authorities develop concepts of specialization, departmentalization, and vertical coordination; for them, lateral coordination indicates deficiencies in organizational design. M. P. Follett's concept of lateral coordination, however, is the exception; for her, effective coordination is necessarily early, direct, self-adjusting, and continuous. Commencing with C. I. Barnard and H. A. Simon, and as further developed by contributions from the newer disciplines, concepts of lateral coordination take on increasing importance. By the 1960's authorities such as McGregor, Likert, Burns and Stalker, and Pelz and Andrews advance concepts involving definite patterns of lateral coordination. Further, many of these authorities concur with Likert's concept of multiple, overlapping groups as a basic building block for developing these lateral organizational patterns.

The Apollo mission planning structure is composed of six line organizations which are coordinated in their mission planning activities by an overlay of twelve boards, panels, and working groups. Analysis shows that of the 121 members of these cross-function working groups, 53 percent are supervisors from the six line organizations; the remainder are non-supervisory members from the same organizations. Further, eleven of twelve chairmen are supervisors; the majority being from one hierarchical level higher than the remaining members. Respondents to the questionnaire state: (1) Apollo mission planning

could not have been accomplished without this cross-function group structure, (2) utilization of this structure increases the overall quality of mission planning by 50-100 percent, and (3) membership by line supervisors is the most important factor contributing to effective cross-function group utilization. Respondents further state: (1) their time is more effectively utilized in these cross-functional activities than in line organization activities, and (2) these cross-functional groups contribute substantially to creative results.

In summary, it is concluded that the three hypotheses are verified. It is also suggested that the concept of cross-functional groups utilized in this structure may have an important implication for effective committee usage. It is recommended that managers systematically consider lateral coordination patterns in designing and updating their organizations; the Linear Responsibility Chart is suggested as one tool that can be productively utilized in lateral organizational analysis.

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INTRODUCTION

The success of Apollo 11, man's first lunar landing mission, has been acknowledged worldwide to be a managerial, as well as technological accomplishment of the highest order.[1] The organizational structure which was developed at the Manned Spacecraft Center, National Aeronautics and Space Administration (NASA), Houston, Texas, to plan the Apollo spaceflight missions performed a central, major function in the realization of this national objective. The purpose of this study is to describe, to analyze, and to evaluate the effectiveness of the Apollo mission planning organizational structure, especially its unusual pattern of lateral coordination. In addition, dependent on the findings made and the conclusions reached, recommendations are made, both for practical use of the concepts developed as well as for suggested areas requiring further study.

The methodology employed is essentially descriptive research, utilizing both primary and secondary data sources. A comparative analysis of the mission planning organizational structure is made in terms of relevant organizational concepts, based on a survey of the literature. Furthermore, as preliminary data suggests especial relevance to Rensis Likert's concept of multiple, overlapping groups,[2] a major thrust of the comparative analysis is in terms of Dr. Likert's model.

The study is divided into nine parts or chapters. Chapters I through III delineate the scope of the study. Specifically, Chapter I

establishes the significance of the study. Chapter II develops the working hypotheses, sets forth the assumptions made, and defines the boundaries of the study. Chapter III describes the research design, specifying the ways by which the hypotheses are tested and methods are used to accomplish the design.

Chapters IV through VII develop the data in accordance with the research design. Chapter IV surveys the literature, outlining the major relevant concepts utilized in evaluating the Apollo mission planning organizational structure. Chapter V highlights the environment of the Apollo mission planning structure to aid in the interpretation of the findings of the study. Chapter VI presents an analysis of the mission planning structure based on historical data sources. Chapter VII sets forth and interprets the results of the questionnaire concerning the lateral coordination mechanism submitted to personnel who participated in this aspect of the Apollo mission planning structure.

Chapter VIII summarizes the findings of the study and presents the conclusions reached.

Chapter IX concludes the study by making recommendations, both for practical application in ongoing organizations as well as others which indicate areas of potential research.

FOOTNOTES

1. Representative comments are:
(a) in an Editorial, Administrative Management, September, 1969, p. 19.

> The giant leap by mankind which put human footprints on the moon was also a giant expression of the management process.

(b) in an Editorial, Time, August 1, 1969, p. 24.

> . . . many scientists are convinced that the fresh technical ideas that helped send man to the moon will ultimately make his material life far better on earth. Perhaps the most exciting promise, they say, is not in the technical achievements themselves, but in the mastery and management of the multiple skills that produced them. Teams of specialists had to harness their disparate talents in order to make so vast an enterprise as the Apollo program succeed. A similar cooperative effort, they contend, could be equally effective in tackling more earthy problems . . . .

2. Rensis Likert, The Human Organization (New York: McGraw-Hill Book Company, 1967), pp. 156-188.

CHAPTER I

SIGNIFICANCE OF STUDY

The Manned Spacecraft Center (MSC)[1] has been responsible for the design of all manned spacecraft and for the associated mission planning for all spaceflights flown by the United States In the short span of eleven years, MSC,[2] a new organization, has successfully accomplished three major manned spaceflight programs--Mercury, Gemini, and Apollo. During the majority of this period, two or more of these programs were managed concurrently, in addition to other manned spaceflight programs currently in the planning or early developmental phases. Significant factors indicate it is warranted that attention should be focused on the MSC Apollo mission planning structure--a major organizational element, contributing materially to these program successes. The aim of this chapter is to treat comprehensively the justifications for selecting this area for study and to indicate possible study implications.

Basically, three factors, two primary and one secondary, shape the direction of the study. First, as indicated briefly in the Introduction, the MSC Apollo mission planning organization performed a key technical and managerial role in an endeavor which successfully achieved a national goal and which, as President Kennedy predicted, would ". . . serve to organize and measure the best of our energies and skills . . ."[3] Many of the management practices and

concepts employed in this functional area are representative of techniques utilized, to a varying degree, throughout NASA in co-ordinating the activities of the various organizations engaged nation-wide in support of the Apollo Program. As such it merits special study and consideration.

Consider for instance, the comment of Tom Alexander, an Associate Editor of Fortune magazine, a few weeks before the lunar landing mission in an article entitled "The Unexpected Payoff of Project Apollo."

> The really significant fallout from the strains, traumas, and endless experimentation of Project Apollo has been of a sociological rather than a technological nature: techniques for directing the massed endeavors of scores of thousands of minds in a close-knit, mutually enhancive combination of government, university, and private industry.[4]

Or consider the statement of Sir Charles P. Snow, noted British scientist and manager, who suggested that one of the principal benefits of Apollo 11 was the new hope that the ". . . technological and organizational skills of the whole NASA team . . ."[5] were indicative of the managerial resources available to the world for solving many of man's age-old problems.

These statements embody much of what James E. Webb, former Administrator of NASA has emphasized in recent years. For example, in September, 1968, in an address at Harvard University he stated:

> There is, as suggested earlier, the matter of <u>how</u> as well as <u>what</u>. The <u>way</u> in which we have built up . . . and what we have learned in the process . . . and how well we adapt . . . may constitute as important a contribution to our Nation--to its ability to move forward into the future--as the space capabilities themselves.

and, further in the same speech,

> The essence of the job NASA has done is not that a new body of knowledge and technology was already at hand. The essence of our job has been that of organizing and managing the use of available knowledge and technology in a purposeful and effective way. This, fundamentally, has been a job of organizing and managing people and simulataneously making sure citizen and their legislative representatives were in a position to understand, to accept, and to sup ort what was being done and the purposes for which it was being done.
>
> Here, I believe, also lies the essence of the other great undertakings that our society will have to face up to.[6]

Another primary factor in selecting the MSC Apollo mission planning structure for study is the interest in the singular lateral organizational pattern that has been developed to ensure effective coordination in the extremely complex mission planning process. This second factor may prove to be even more important from a fundamental research standpoint. The following paragraphs briefly outline the mission planning process and the associated lateral organizational pattern that has been developed.

The function, mission planning, is concerned with the trajectory,and flight planning associated with the various spaceflights. However, the functional area encompassed is very broad. In the early design phases of a spaceflight program, mission planning designs strongly influence the configuration of the proposed spacecraft; in the latter developmental and operational phases of the program it is concerned with optimizing spacecraft performance and achieving specific mission objectives. Its considerations range from the place-

ment of tracking stations around the world to the specification of specific actions that an astronaut will take at specific times in a mission. It is concerned not only with normal operations but also with planning for contingency events. It is characterized by a highly iterative work process essential to achieving the comprehensive integration of the extremely numerous and interdependent elements of the final operations plans.

In accomplishing the Apollo mission planning effort, a hierarchical system of boards, panels and working groups, official and semi-official in nature, has been developed to achieve the close lateral coordination required among the organizations having mission planning responsibilities.[7] What evolved, in effect, is an organizational matrix; an overlay of program-oriented organizational elements superimposed on the functional organization. Key members of the functional organization are given additional duties--on panels, committees, or boards with responsibility for effecting lateral coordination. These panels, boards and committees are arranged in a hierarchical system with member representation from corresponding levels of the functional hierarchy.

The implications associated with the development of this lateral organizational structure in the Apollo mission planning area can be very significant. The organizational pattern that has developed is apparently different from that which most organizations employ and may incorporate new concepts, or at least new techniques in its structure. Preliminary analysis indicates that it may have relevance to Dr. Likert's concept of multiple, overlapping groups,

especially as he has suggested that his concept would be of particular use in achieving coordination in large research and development organizations.[8] If it should be proven that the MSC Apollo mission planning structure is representative of Dr. Likert's model it would constitute an important finding. For while Dr. Likert has indicated that "There are scattered examples indicating that the general approach . . . is now being used at least partially . . . ,"[9] he has also stated that:

> Large governmental agencies as well as business enterprises are suffering from the failure of current efforts to solve the complex problems of coordination caused by extensive functionalization. This failure is preventing government, as well as industry, from making full use of the new knowledge created by the extenssive research which it is supporting. As a consequence, large Federal agencies are not realizing a full return on their substantial research expenditures in the physical and biological sciences and cannot do so until they can solve this organizational problem.[10]

A third factor, while possibly of secondary importance, is that the structure of MSC Apollo mission planning boards, panels and work groups also needs further study for reasons internal to MSC in order to claify its structure, interrelationships and effectiveness. This aspect of the study may also have other, more important considerations, as clarifications and improvements developed for internal MSC purpose may have broader implications in the overall study.

In summary, each of the three factors discussed in this chapter demonstrate a need for a study of the MSC Apollo mission planning structure. For here is a key organizational unit at a focal point of one of the largest, most successful, technical endeavors of all time, an organizational unit that exhibits unusual lateral co-

ordination patterns and which shows characteristics of being representative of a conceptual model that a leading researcher proposes for organizations of the future, and an organizational unit whose structure and effectiveness has not as yet been adequately assessed. Taken together, these factors are compelling reasons for emphasizing that this area is a highly significant field for inquiry. The next chapter moves into the purpose, scope, and limitations of the study.

FOOTNOTES

1. For approximately its first two years (Oct., 1958 to Jan., 1961) Manned Spacecraft Center was designated as the Space Task Group.

2. Manned Spacecraft Center hereafter is referred to as MSC.

3. President John F. Kennedy in an address at Rice University, Houston, Texas, September 12, 1962, as cited in The Apollo Spacecraft: A Chronology, Vol. I, by Ivan D. Ertel and Mary Louise Morse, The NASA Historical Series (Washington, D.C.: Government Printing Office, 1969), p. 188.

4. Tom Alexander, "The Unexpected Payoff of Project Apollo," Fortune, July, 1969, pp. 114-156.

5. Sir Charles P. Snow, "The Moon Landing," Look, August 26, 1969, p. 72. (Phrase underlined for emphasis by study author.)

6. Address by James E. Webb, then Administrator, NASA, at the John Diebold Lecture on Technological Change and Management, Harvard University School of Business Administration, Boston, Mass., September 30, 1968.

7. At the request of the Apollo Spacecraft Program Manager, MSC, a study of MSC mission planning was conducted. The result is NASA General Working Paper No. 10,080 entitled Mission Planning at the Manned Spacecraft Center, by Earle B. Young, William A. Larson and Wesley R. Westmeyer, (Houston: Manned Spacecraft Center, April 4, 1969). This study has been a very useful source in providing data concerning the responsibilities and composition of the various mission planning boards, panels, and working groups.

8. Ibid., p. 187.

9. Ibid., p. 183.

10. Ibid., p. 157.

CHAPTER II

THE THESIS

The basic purpose of this study is to describe, to analyze, and to evaluate the effectiveness of the MSC Apollo mission planning organizational structure. The chapter objectives are (1) to develop the principal ideas or hypotheses which, at least tentatively, provide a conceptual basis for viewing and assessing the subject organizational structure; (2) to establish definite boundaries of the study by both defining study exclusions, as well as by describing study content; and to (3) identify certain basic assumptions which have been made in conducting the study.

Working Hypotheses

Preliminary data strongly suggest that the structure of boards, panels, and working groups which overlays the basic functional structure is a key element in the overall MSC Apollo mission planning structure. It is also this structure of boards, panels, and working groups, developed as a strong coordinating mechanism, which evidences a lateral organizational pattern not found, or at least not formally identified in most organizations. Finally, it is this structure which in its relations with the functional organization that exhibits characteristics suggesting Dr. Likert's concept of multiple, overlapping groups.[1] Therefore, in view of these distinguishing traits

which the structure exhibits, the following working hypothesis is postulated.

Working Hypothesis I. The organizational structure developed to perform MSC Apollo mission planning is a highly representative example of the multiple, overlapping group structure proposed by Rensis Likert for large R & D organizations.

As one views the overlay of MSC board, panel, and working group structure superimposed on the functional line organization, a number of questions are raised. First, what is the potential for conflict between elements of the line organization and the board structure? Second, how is potential for conflict minimized? Third, what is the principal factor which ensures that board structure activities are effectively integrated into the overall mission planning function?

In regard to the first question, the potential for conflict is obviously very dependent both on the membership within the board structure as compared with membership in the functional organization and is also dependent on the working relationships that have been established to coordinate the activities of these organizational entities. Pertaining to the second question, the potential for conflict can be effectively minimized by having dual membership; that is, having all members of the board structure also be members of the related functional organization. As to the third question, a very effective method of integrating board activities into the overall mission planning function is to have the same personnel who perform

the integrating function in the functional organization also perform the same function in the board structure. In other words, the integrating function should be performed by the line supervisors who also participate as members in the board structure at levels commensurate with their positions in the line hierarchy. This concept is consistent with statements of Dr. Likert who has emphasized that supervisory participation is essential in the multiple, overlapping group structure and that each multiple, overlapping group should have "a superior from the next higher level . . . included in each subordinate, cross-function work group."[2] As a consequence, the following hypothesis is postulated.

Hypothesis II. The major factor integrating the activities of cross-function groups into the overall organization is participation within these groups by line supervisors.

Hypotheses I and II are concerned principally with the structure of the MSC Apollo mission planning structure. However, in addition to determining the organizational structure, it is also essential for purposes of this study that the effectiveness of the mission planning board structure be determined. Hypothesis III is formulated with the objective of making that determination.

Hypothesis III. The use of the multiple overlapping group structure is an extremely valuable tool in achieving highly successful coordination in a complex organizational environment.

Boundaries of Study

The boundaries of the study as described herewith involve two reference levels--organizational and conceptual.[3]

First, organizationally, the study treats only those six major organizations that are significantly involved in Apollo mission planning; it does not encompass the entire MSC organization. Second, this study basically treats these six organizations only in terms of their participation in the Apollo mission planning function. To the extent that these organizations perform other Apollo functions or similar mission planning activities in support of other programs, these aspects are not treated, except as they are directly relevant to this study. Third, the entire Apollo mission planning function is not included within the study; only those mission planning functions which accomplished by the MSC organizational elements are included. However, as these MSC Apollo organizations perform the substantial portion of the Apollo mission planning functions, it is not necessary to consider the mission planning functions performed by other NASA organizations and contractors. In addition, the MSC Apollo mission planning structure of boards, panels, and working groups was constantly evolving as it adjusted to program phase changes. For purposes of this study, however, only the organizational structure as it existed in the period (July, 1968 through July, 1969) immediately preceding the first lunar landing mission is analyzed.

The development of the board, panel, and working group structure into a strong lateral coordinating mechanism is evidently

the most significant aspect of the MSC mission planning organization. Consequently, the primary thrust of the study is toward analytical concepts which can be utilized to explain and interpret the significance of this lateral organizational pattern. In that respect, concepts developed in such fields as classical and modern organizational theory, group theory, information theory, cybernetics, decision theory, motivational theory, etc., are utilized, as applicable, to analyze the subject structure. However, as the scope of the study is limited to concepts which are sufficiently broad to explain both organizational structure developments as well as theoretical concepts, many of the concepts in these fields of the literature will not be immediately applicable.

Accordingly, although Dr. Likert has formulated a broad systems theory of organization, it is not within the scope of this study to analyze the MSC mission planning structure in terms of his overall theory. For example, while many of his concepts such as the principle of supportive relationships,[4] group methods of supervision,[5] and even his basic concept of a consistent systems approach to organization[6] are probably relevant,[7] they are treated only incidentally in the study.

Furthermore, although the structure of boards, panels, and working groups naturally involves extensive use of meetings, the subject of effective methods and techniques of conducting committee meetings, etc., is not included as such within the main thrust of the study. Rather, as indicated by Hypothesis II above, the concern is with broader organizational methods used for effectively inte-

grating committee activities into the overall mission planning function.

Assumptions

Two fundamental assumptions are implicitly made in the fundamental approach to this study. The first assumption is that the style of management and operations within the MSC Apollo mission planning organization is basically in accord with characteristics of organizations at the borderline between Style 3 (consultative) and Style 4 (participative) in Dr. Likert's continuum of management systems.[8] This assumption is based on two earlier studies conducted independently at MSC. The first study was relatively limited and involved only the managers in one of the six organizations concerned with mission planning.[9] Measuring six factors which Dr. Likert uses to determine management style, the study showed that the managerial personnel at the various levels of the organization perceived the organization style to be in the high consultative range for three factors (leadership, motivation and communication) and in the medium consultative range for the other three factors (decisions, goals, and control). The second, more recent study involved non-managerial professionals in five of the six organizations involved in mission planning.[10] The results of this study indicated the majority of the mission planning organizations were operating in the high consultative range, with the one organization that had been surveyed earlier moving into the participative range.

The second assumption made concerning the MSC Apollo mission planning organization is that it is composed of highly successful and effective R & D organizations led by highly skilled technical managers and that therefore its methods of operation merit special study. This assumption is based on three factors. First, it performed a central role in what has been acknowledged worldwide as an outstanding technical and managerial accomplishment--the Apollo Program. Second, the majority of organizations performing the mission planning function have received special recognition both by national professional organizations and top NASA management for their team performance, not only for their work on Apollo but also previously, for work associated with Projects Mercury and Gemini. Third, leaders at the various levels of the mission planning organization have, during the years, received many special awards from national professional organizations, other national groups, as well as recognition from the NASA organization for outstanding technical and leadership accomplishments. As an example, in considering only one type of award, members of the MSC Apollo mission planning structure have been selected in the last nine years on five different occasions for the Arthur Flemming Award as one of ten outstanding men in government.

In concluding this chapter, the following summary statements are made. First, basic assumptions are (a) that the organizational elements of the MSC Apollo mission planning structure are highly successful organizations led by personnel recognized nationally as outstanding technical managers and (b) that these organizations are

managed in a style that is characterized as a consultative-participative systems approach. Second, that although the study could be broadened both organizationally as well as conceptually, the main thrust of the study is limited to an analysis and evaluation of the lateral coordinating mechanism of the MSC Apollo mission planning structure. Third, and finally, the basic thesis is that the MSC Apollo mission planning structure, utilizing Rensis Likert's concept of a multiple, overlapping group structure, has developed as an extremely valuable tool for achieving highly successful coordination. The next chapter develops the research design by which the validity of the working hypotheses are tested.

FOOTNOTES

1. Likert, The Human Organization, pp. 158-188.

2. Ibid., p. 176.

3. The entire subject of the MSC organizational environment is treated extensively in Chapter V, "MSC Environment," of this study. The subject of organizational concepts is treated further in Chapter IV, "Survey of the Literature," of this study.

4. Likert, The Human Organization, p. 47.

5. Ibid., pp. 49-51.

6. Ibid., p. 123.

7. See the next section, "Assumptions," in the current chapter for an expansion on this idea.

8. Likert, The Human Organization, pp. 14-24.

9. Frederik P. Williams, A Study of Organizational Behavior and Management of the Flight Operations Directorate NASA - MSC (Unpublished study, Manned Space raft Center, dated July, 1968).

10. Richard A. Hamilton, A Comparative Analysis of the Professional's Occupational Environment at the Manned Spacecraft Center (Houston: NASA Manned Spacecraft Center, January, 1969).

CHAPTER III

THE RESEARCH DESIGN[1]

The objectives of this chapter are (1) to specify the major criteria which are used to test the validity of the hypotheses, and (2) to set forth the research techniques used, as well as the sequence in which they are accomplished.

Criteria for Validating Hypotheses

In this section criteria are presented for validating each of the three hypotheses developed in the previous chapter. In addition, there is also shown the source of research data which, in subsequent chapters, is compared with the criteria to substantiate or reject the respective hypothesis. That is, for each criteria it is specified as to whether the evaluation is conducted with secondary research data (MSC organizational analysis data) or primary research data (questionnaire results). If primary research data are used, the specific question(s) from which the data are obtained is so indicated. A copy of the questionnaire with its associated cover letter is in Appendix A. The questionnaire itself is discussed in detail in the next section of this chapter.

Hypothesis I Validation Criteria

Hypothesis I. The organizational structure developed to perform MSC Apollo mission planning is a highly representative example of

multiple, overlapping group structure proposed by Rensis Likert for large R & D organizations.

Validation Criteria

1. The organizational structure exhibits a lateral pattern of communication and interaction at ". . . every hierarchical level . . ."[2] as "a legitimate part of the formal system . . ."[3] (Figure 1 on the next page shows three structural cross-function groups in a hierarchical structure.)

   Validation Data Sources: a) Analysis based on organizational data

   b) Questions 4, 14, 15

2. Cross-function groups are "linked to the rest of the organization by means of persons who are members of more than one group."[4] These persons who hold overlapping group membership are termed linking pins.

   Validation Data Source: Analysis based on organizational data

3. "Each cross-function group has as its superior a . . . person from the hierarchical level directly above that of the other members of the group."[5]

   Validation Data Source: Analysis based on organizational data

4. Group decision-making processes are heavily relied on within the cross-function groups.[6]

   Validation Data Source: Question 9

5. Although participation in the cross-function group structure requires that direction be taken from more than one supervisor, such dual direction does not give rise to difficulties to the

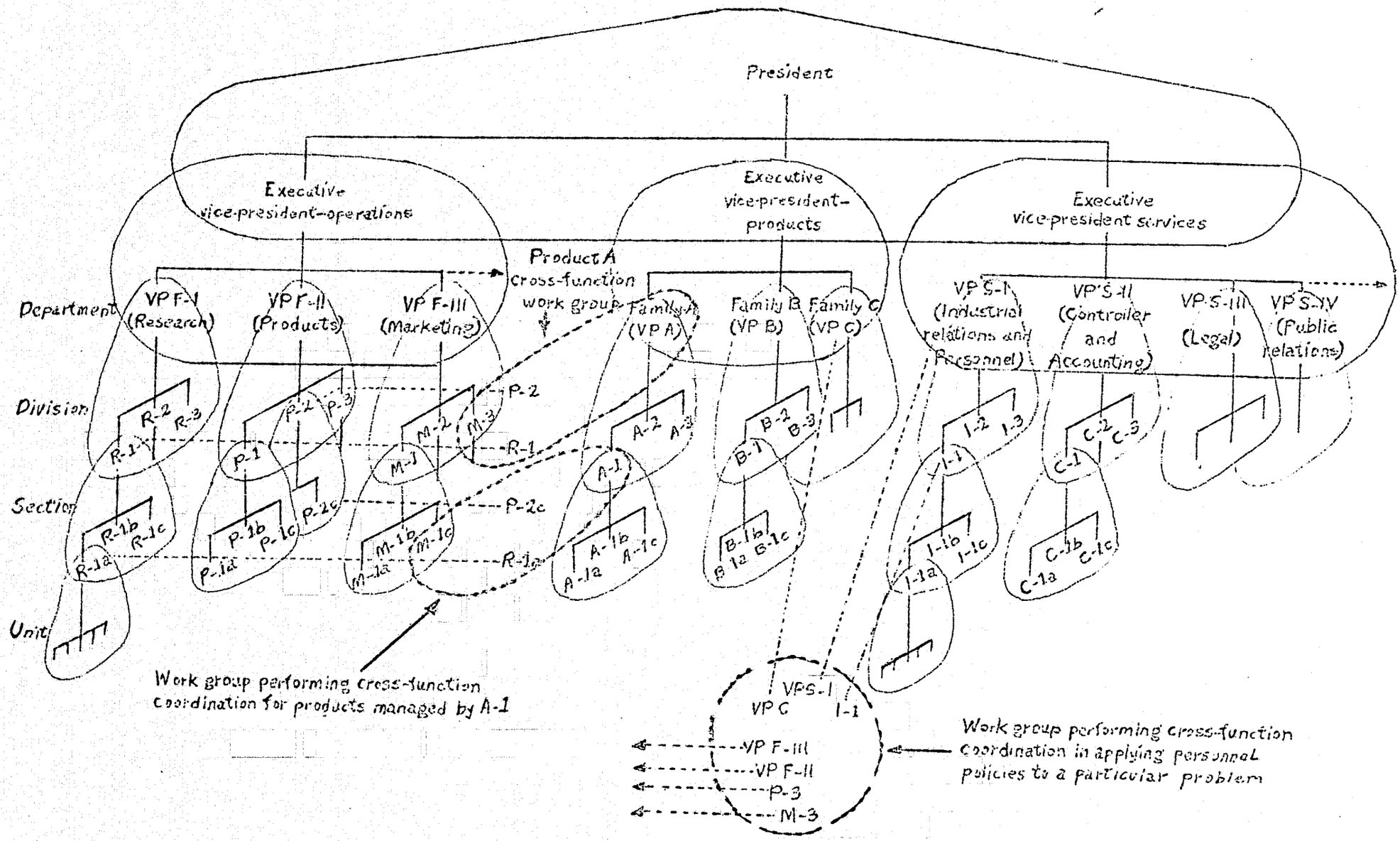


Figure 1. Multiple, Overlapping Group Structure

From Rensis Likert: The Human Organization

employee involved.

Validation Data Source: Questions 10, 11

Hypothesis II Validation Criteria

Hypothesis II. The major factor integrating the activities of cross-function groups into the overall organization is participation within these groups by line supervisors.

Validation Criteria

1. Analysis of organizational structure shows significant participation by line supervisors as linking pins between the cross-function groups and the rest of the organization.

   Validation Data Source: Analysis based on organizational data

2. An increase of line supervisory participation in cross-function groups increases performance capabilities of the groups.

   Validation Data Source: Question 13

3. Participants in cross-function groups recognize participation by line supervisors as a major factor in the integrating cross-function activities with the rest of the organization.

   Validation Data Source: Question 16

Hypothesis III Validation Criteria

Hypothesis III. The use of the multiple overlapping group structure is an extremely valuable tool in achieving highly successful co-ordination in a complex organization environment.

Validation Criteria

1. The cross-function group structure is very effective in ensuring that proper personnel are involved in the decision-making process.

Validation Data Sources: a) Question 12

b) Analysis based on organizational data

2. The cross-function group structure significantly aids in the effective performance of the overall function.

   Validation Data Source: Questions 17, 18

3. The cross-function group structure is very effective in providing lateral coordination.

   Validation Data Source: Question 5

4. As the cross-function structure is an effective tool the participants recognize that their time and efforts are well utilized in the performance of this function.

   Validation Data Source: Questions 6, 7, 8

Research Techniques

The aim of this section is to describe the research techniques used and the objectives they are designed to achieve in the study plan. A discussion of these techniques follows in order of the subsequent presentation in study.

Survey of the Literature

The goal of this survey is to provide an overall perspective of concepts in the literature which are useful for analyzing the MSC Apollo mission planning structure. While the main thesis of the study is that Dr. Likert's theory provides a sound conceptual interpretation for the subject organizational pattern, the added insights from these other concepts identified in the survey provide an opportunity for

more comprehensive productive analysis.

The survey is divided into four major phases chronologically--the Scientific Management Period (1885-1925), the Administrative Management Theory Period (1925-1938), the Multi-Disciplinary Period (1938-1960), and the Modern Organizational Theory Period (1960-Present). The survey of the literature covering the first two periods is limited to the writings of acknowledged major contributors to the field of organizational theory from business and public administration. For the third and fourth period, the survey is broadened to include concepts as may be relevant from the fields of communications theory, cybernetics, information theory, group theory, and decision-making theory. However, much of the work in these areas is not directly relevant as many of the concepts and theories posited do not adequately consider the organizational structure except by implication, therefore only generalized trends will be indicated. The results of the survey of the literature are treated in Chapter IV.

MSC Environment

The purpose of this portion of the research study is to provide adequate background material concerning the environment of the MSC Apollo mission planning structure in order to provide a proper perspective and thereby enhance the capability to analyze and interpret the study findings. The basic data sources for this phase of the study are NASA historical records (secondary research data).

MSC Apollo Mission Planning Structure

The purpose of this phase of the study is to comprehensively describe, analyze and interpret the MSC Apollo mission planning structure. Consideration is given first to the normal, vertical hierarchical structure, then to the board, panel, and working group structure which forms the lateral organization pattern and finally to the inter-relationships between these two elements of formal system. Special studies conducted include analyses of board, panel, and working group membership (a) in order to compare board membership with membership in the rest of the organization, (b) to determine extent of line supervisor participation, (c) to determine if multi-level hierarchical participation exists in each cross-function group, and (d) to determine extent members participate in more than one cross-function group. Primary data sources for this phase of the study are MSC secondary sources plus additional MSC primary source data needed to update information on board structure composition. Data obtained in analyses are used substantially to test Hypothesis I, and, in addition, to provide supporting data to test Hypotheses II and III.

The Questionnaire

The Questionnaire (see Appendix A) was formulated with the primary purpose to provide data not otherwise available, but required for testing Hypotheses II and III. In addition, it provides information relative to the use of the board, panel, working group structure in other, previous MSC programs (Mercury and Gemini) as well as to

determine the feasibility of using a similar organizational arrangement in future programs.

The mailed questionnaire is essentially in closed form style, with twenty-one of the twenty-two questions providing for a multiple choice type of answer. The last question is in free form designed to enable the answeree to comment on any aspect of the MSC Apollo mission planning structure, relative to its make-up, effectiveness, or future application in other functions.

Developed in accordance with the requirements for data outlined in the preceding paragraph, a preliminary version of the questionnaire was submitted to two members of the MSC technical staff for pre-testing. Based on their comments minor changes were made in three of the questions. Analysis of the board, panel, working group structure shows that total participation in the various board, panel, and working group meetings averaged about 128 members. Because of the relatively small size of the population it was determined to submit the questionnaire to all persons who substantially participated in any of the groups. This standard of "substantial participation" is used as many of the questions require insight and familiarity with the cross-function activities that can only be gained after such participation. Thus, the term "substantial" is defined to include group members who participated in at least five meetings of their respective group during the year under study, or in those cases where the group met less than five times during the year, all members of the group were included. Based on a review of attendance records and the above criteria, questionnaires were submitted on March 6,

1970 to ninety-one members of the cross-function groups with a request that they be completed and returned by March 13th.

Appendix A of this study includes the cover letter (self-explanatory) which was submitted with each questionnaire.

The questionnaire responses are presented and analyzed in Chapter VII.

Conclusions and Recommendations

Chapter VIII, "Conclusions," correlates the evidence developed in Chapters IV through VII and arrives at an overall conclusion as to the proof or disproof of the working hypothesis. In addition, relevant concepts drawn from the survey are included to provide added scope of this study.

The remaining chapters of the study implement this research design. The next chapter discusses the survey of the literature.

FOOTNOTES

1. The research design approach and methodological terminology used in this paper is essentially that suggested in Jessamon Dawe's Writing Business and Economics Papers (Totowa, N.J.: Littlefield, Adams & Co., 1965). This book was extremely useful in developing this research design.

   Other works consulted in this phase of the study, especially in regard to the questionnaire, include:

   Wilson Gee, Social Science Research Methods (New York: Appleton-Century-Crofts, Inc., 1950), pp. 300-318.

   Pauline V. Young, Scientific Social Surveys and Research (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1956), pp. 115-136, 176-203.

   Carter V. Good and Douglas E. Scates, Methods of Research (New York: Appleton-Century-Crofts, Inc., 1954), pp. 277-316, 604-634.

   J. Francis Rummel and Wesley C. Ballaire, Research Methodology in Business (New York: Harper and Row, Publishers, 1963), pp. 107-146.

2. Likert, The Human Organization, p. 173.

3. Ibid., p. 170.

4. Ibid., p. 50.

5. Ibid., p. 165.

6. Ibid., pp. 49-51.

CHAPTER IV

SURVEY OF THE LITERATURE

The purpose of this chapter is to present an abstract of concepts advanced and techniques utilized in performing the lateral coordination function in organizations. Certain concepts and techniques in the abstract are identified and selected for later use in the study to aid in the interpretation of findings involving the MSC Apollo mission planning structure. The survey includes both a review of current concepts in the fields of organizational theory, communications theory, cybernetics, group theory, and decision-making theory, as well as a brief review of the writings of major contributions from earlier periods.

The survey as presented below is divided into four major phases chronologically--the Scientific Management Period (1885-1925), the Administrative Management Theory Period (1925-1938), the Multi-Disciplinary Period (1938-1960), and the Modern Organizational Theory Period (1960-Present). These periods are so titled to indicate the main thrust of the organizational thought during the period.

Scientific Management Period (1885-1925)

This section considers the contributions of three authorities, Frederick W. Taylor, Henri Fayol and Mary Parker Follett, to the concept of lateral coordination.

Frederick W. Taylor

Conventionally, the term "scientific management" is equated with "Taylorism" and with time and motion studies. As a matter of fact, to a large extent, the major emphasis in the literature of this period is on techniques for improving production.[1] However, Frecerick W. Taylor stresses that he advocates ". . . a complete mental revolution . . ." on the part of workingmen and managers.[2] His concept of scientific management has four basic elements: "(1) science, not rule of thumb; (2) harmony, not discord; (3) cooperation, not individualism; (4) maximum output, not restricted output."[3] In addition, he elevates the status of management by assigning it new, specialized functions of planning and organizing.[4] He also developes the "functional" supervisor concept. That is, any number of staff specialists can directly control a worker with respect to his work in their field of specialization.[5]

However, although his new concept of management and his functional supervisor concept both require a significant increase in the number of staff specialists, Taylor advances no concept by which these staff specialist organizations coordinate their activities. Rather the emphasis in his works is placed almost exclusively on the idea of identifying, isolating, and assigning to specialists the various tasks or functions that must be performed in an organization. The concept of coordination, which is a necessary coordinate element of specialization, is treated within his works only to the extent that ". . . supervisors would smooth out difficulties which arise

between different . . ."[6] specialists. Thus Taylor leaves the task of handling the coordination function to others.

Henri Fayol

While Taylor developed his concepts with a perspective initiated from the shop floor, Henri Fayol's perspective is essentially that of an executive director of a large coal and steel combine.[7] Fayol is recognized as having formulated one of the first general administrative management theories. He also is the ". . . earliest known proponent of a theoretical analysis of managerial activities; an analysis which has withstood almost a half-century of critical discussion."[8] He identifies five universal management activities: planning, organizing, commanding, coordinating and controlling.[9] He also lists fourteen principles or rules of thumb which are to be generally utilized and are ". . . flexible and capable of adaptation to every need."[10] For purposes of this study, one of the management activities, coordination, and one of his principles, unity of command and the scalar chain are especially important.

For Fayol, coordination is:

> . . . to harmonize all the activities of a concern so as to facilitate its working, and its success. It is to bear in mind in any activity whatsoever . . . , the obligations and consequences such action involves for all the functions of the business.[11]

Fayol lists three signs that indicate lack of coordination in an organization. First, departments which operate as if they were ends in themselves. Second, water-tight compartments exist within the departments. Third, the general interest is not con-

sidered and initiative and loyalty are non-existent.[12] He proposes two methods for coordination, weekly conferences of department heads and liaison officers. Liaison officers are used to the extent that department meetings cannot be held. However, the conference of department heads is essential to the success of an organization. It has for its aim:

> . . . to inform management about the running of the concern, to make clear co-operation to be expected as between various departments, to utilize the presence of departmental managers for solving various problems of common interest. In such conferences it is not a case of drawing up the plan of action of the business, but of facilitating the carrying out of this plan in the light of current events. The scope of each conference extends over a short period only, normally a week, during which the harmonizing of activity and focusing of effort are to be ensured. . . . all departmental heads meet once a week, on a given day, under the chairmanship of the general manager.
>
> . . . . . .
>
> In a relatively short time--about an hour--the general manager is informed as to the general run of things, and can make decisions touching various departments simultaneously, and can be explicit as to how different departments are to help one another. Each departmental head goes away knowing exactly what he has to do and in the knowledge that he is to return in a week's time to give an account of what he has done. Such cohesion could not be obtained without conference even if ten times more time and effort were to be expended.
>
> . . . . . .
>
> . . . observation has convinced me that a weekly meeting is just as suitable for businesses of any kind having a labour force of similar magnitude . . . . I think that the

> weekly meeting of departmental heads is indispensable for purposes of coordination in the case of very large units, ministries, and the government proper, and I myself would make it a binding obligation for all concerns.
>
> . . . . . .
>
> The co-ordinating conference is to co-ordination what the plan of action is to foresight, what summarized charts of personnel are to the human organization; it is a characteristic sign and essential instrument. If the sign is missing there is a good chance that the function is badly carried out but the presence of such a sign is no absolute guarantee of smooth working and in addition the manager must know how to use the instrument properly, and the art of manipulating these various instruments is one of the qualities required of the manager.[13]

In addition to the above coordinating mechanism which accomplishes coordination for supervisors under one superior, Fayol also proposes another method of coordination involving communication between employees in different organizational units. He terms his method the gang plank approach.[14] Normally, his principles of unity of command and the scalar chain indicate that communications should go up the scalar chain of supervisors to a common supervisor and then back down another chain of supervisors to appropriate organizational units. He points out, however, that there are many activities that require speedy execution for which the scalar chain cannot be used. Figure 2 (below) shows the gang plank (F to G) in an organization whose scalar chain is represented by G to A to Q.

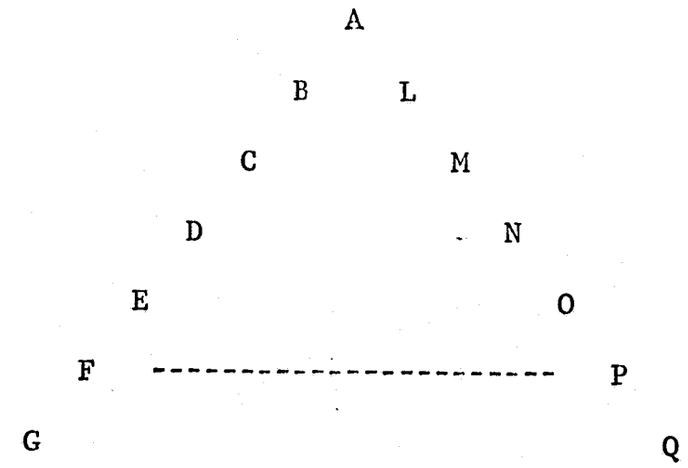


Figure 2--The Gang Plank. (From Henri Fayol: General and Industrial Management)

Fayol comments on the merits and use of the gang plank approach as follows:

> So long as F and P remain in agreement, and so long as their actions are approved by their immediate superiors, direct contact may be maintained, but from the instant that agreement ceases or there is no approval from the superiors direct contact comes to an end, and the scalar chain is straightway resumed. Such is the actual procedure to be observed in the great majority of businesses. It provides for the usual exercise of some measure of initiative at all levels of authority.
>
> The use of the "gang plank" is simple, swift, sure. It allows the two employees F and P to deal at one sitting, and in a few hours, with some question or other which via the scalar chain would pass through twenty transmissions, inconvenience many people, involve masses of paper, lose weeks or months to get to a conclusion less satisfactory generally than the one which could have been obtained via direct contact as between F and P.
>
> . . . . . .
>
> It is an error to depart needlessly from the line of authority, but it is an even greater

> one to keep to it when detriment to the business ensues.[15]

Mary Parker Follett

Mary Parker Follett became prominent in the early 1920's as a result of her work in adult education as well as for her political writings, including The New State (1920) and Creative Experience (1924). Subsequently because she considered that business leaders were generally more active than public administrators in trying to solve management problems, she shifted the emphasis of her studies to business management.[16] Thus many of her ideas later developed in the field of business management draw upon her earlier work in political science. In placing a strong emphasis on the sociological character of organization she pioneered in what has become a major field of emphasis in organizational theory.[17]

To Follett, coordination is the basis of sound organization and administration[18] and she, accordingly, treats the subject of coordination in an outstanding manner in her studies. A summarized evaluation of coordination in her own words follows:

> The imperative need of the moment is a search for the best methods of co-ordination, of adjustment. But the process of adjusting is not one which can be imposed from outside--it is essentially, basically, by its very nature, a process of auto-controlled activity.[19]
>
> . . . the chief weaknesses of those businesses which I have studied was lack of co-ordination. Yet there is much talk of co-ordination. Why, then, do we not get it? First, because its advantage, its necessity, is not yet seen with sufficient clearness. Secondly, the system of organization in a plant is often so hierarchical, so ascending and descending, that it is almost

impossible to provide for cross-relations; the notion of horizontal authority has not yet taken the place of that of vertical authority. We cannot, however, succeed in modern business by always running up and down a ladder of authority. In the third place, cross functioning seems often to be conceived of as useful only when difficulties arise, or when it is obvious that joint consultation on some specific problems would be desirable. But as such consultation is necessary all the time, some machinery which will operate continuously should be provided.[20]

Four fundamental principles of organization are:

1. Co-ordination by direct contact of the responsible people concerned.

2. Co-ordination in the early stages.

3. Co-ordination as the reciprocal relating of all the factors in a situation.

4. Co-ordination as a continuing process.

In regard to the first principle, co-ordination by direct contact of the responsible people concerned, we find in some industries that control is coming more and more to be effected through cross-relations between heads of departments instead of up and down the line through the chief executive.[21]

My second principle was co-ordination in the early stages. This means that the direct contact must begin in the earliest stages of the process.[22]

I do not believe there will ever be any geuine, any effective, uniting except that begun in 'the very early stages.' In government this will mean in the smallest units, whether these be geographical or vocational; in industry, in joint sub-committees.

That expression, 'the very early stages,' expresses the essence of my whole philosophy of organization, in business or in government. . . . it is not sufficiently recognized that co-ordination is a process which should have its beginnings very far back in

the organization of the plant. You cannot always bring together the results of departmental activities and expect to co-ordinate them. You have to have an organization which will permit an interweaving all along the line. Strand should weave with strand, and then we shall not have the clumsy task of trying to patch together finished webs.[23]

The third principle, co-ordination as the reciprocal relating of all the factors in a situation, shows us just what this process of co-ordination actually is . . . . reciprocal relating, this interpenetration of every part of every other part, and again by every other part as it has been permeated by all, should be the goal of all attempts at co-ordination, a goal, of course, never wholly reached.

. . . . . .

If then the process of co-ordination is one of interpenetration, it is obvious that it cannot be enforced by an outside body. That is why I have very grave doubts whether 'central' planning, as at present conceived by many, will bring us any appreciable degree of co-ordination.

. . . . . .

Co-ordination means change in the parts co-ordinated. Co-ordination in its stricter meaning does not imply change in the parts, but co-ordination is now being used, somewhat inaccurately perhaps, as synonymous with correlation. Correlations is probably the better word because correlation implies interpenetration of the parts while co-ordination implies only an harmonious ordering of parts.[24]

We can never reconcile planning and individualism until we understand not as an apartness from the whole, but as a contribution to the whole. In some of the businesses I have studied, I have been told that the head of a department should subordinate the good of his department to the good of the whole undertaking. But of course he should do no such thing. His departmental point of view is

needed in the whole. It must indeed be reconciled with all the other points of view in the business, but it must not be abandoned.[25]

. . . the plan proceeds horizontally throughout the whole organization involving ultimately all the related departments. Thus planning remains an integral part of the management of the self-governing units.

. . . planning as a horizontal process between the units of a company and planning as a horizontal process between the departments of a single unit. This is what we should aim at . . . .[26]

My fourth principle was co-ordination as a continuing process.

I am claiming that a Planning Board if rightly conceived can make for the great freedom of individual men or individual industries. One reason for this is that the machinery for co-ordination would be continuous, not set up for special occasions. If a board is set up to consider a special problem the tendency is naturally to think only of the question under discussion; the incentive to discuss the principles which can serve as guides for future similar cases is not so great. But if we had a permanent Planning Board, and it should make some classification of problems, then when a fresh problem arose it would be able to see the points in which that resembled a certain class of problems . . . .

Now continuous machinery for working out the principles of relation, whether it be in factory or nation or internationally, is of the very essence of freedom. For it tends toward freedom when the rest of our world is following certain principles; we are bound when someone's action toward us may be of one kind to-day and another tomorrow . . . . Collectively to discover and follow certain principles of action makes for individual freedom. Continuous machinery for this purpose is an essential factor . . . .

> Another advantage of a permanent Planning Board is that then the circle, or spiral, is not broken in the transition from planning to activity and from activity to further planning. A mistake we often tend to make is that the world stands still while we are going through the process of a given adjustment. And it doesn't. Facts change, we must keep up with the facts; keeping up with the facts changes the facts. In other words, the process of adjustment changes the things to be adjusted.[27]

Summary

Although these authorities were writing in approximately the same time period it is apparent, and as brought out later in this chapter, that their various views on lateral coordination approximate the range of views current in the field of management today. Taylor, concerned with specialization and departmentalization, minimizes coordination and relegates it to problem areas to be solved by supervisors. Fayol, assigning it a major role, makes it one of his five management activities. He also recognizes that lack of adequate coordination can be a major organizational problem. His concept of the weekly conference of department heads is an instrument for positive coordination within a hierarchical group. In many respects, it anticipates aspects of Likert's group pattern of hierarchical organization.[28] He also recognizes that there are occasions when problems require direct coordination and communication outside the immediate organization and in these instances his gang plank approach is to be used.

Mary Parker Follett goes a step further than Fayol and assigns to coordination the principal role for achieving

organizational goals. She also charges that lack of coordination was the chief weakness of businesses which she studied. Her four principles of coordination provide an even more positive basis for coordination. Coordination may be early, direct, self-adjusting and continuous. In addition, she adds that coordination must not just involve a harmonious ordering of the parts, but that there must also be an internal reciprocal adjusting of the parts.

In addition to the hypotheses criteria developed in Chapter III, five factors from this section are used in later chapters to aid in evaluating the MSC Apollo mission planning structure. The five factors are Fayol's concept of weekly conferences of department heads and Follett's concepts of early, direct, self-adjusting and continuous coordination.

Administrative Management Theory (1925-1938)

This section briefly considers the contributions of Leonard D. White, W. F. Willoughby, James D. Mooney and Alan C. Reiley, John M. Gaus, Luther Gulick, L. Urwick, Elton May and F. G. Roethlesberger.

Leonard D. White and W. F. Willoughby

Leonard D. White's Introduction to the Study of Public Administration in 1926, followed closely thereafter by W. F. Willoughby's Principles of Public Administration in 1927 were the first systematic treatments of American public administration from an administrative management point of view. Reflecting the environ-

ment of the time, major emphases of their work include civil service reform and the Federal personnel system, separation of administration from policy, economy and efficiency, a concern for the integration and grouping of governmental activities, and in Willoughby's work a substantial coverage of budgetary and fiscal matters of government.[29]

In regard to the matter of coordination both White and Willoughby consider it only in the broadest terms, and only in an indirect way, based on a mechanistic organizing of functions. Their concern is with consolidating the position of the chief executive and integrating the activities of the administrative organizations into "a single integrated piece of administrative mechanism"[30] under the direction of the chief executive. Thus, Willoughby devotes an entire chapter, Chapter V, "Organization of the Administrative Branch as a Whole," to a discussion of the relative merits of independent versus integrated or departmental organizations.[31] White, in a later work,[32] in his discussion of the "new management," continues this main emphasis on the role of the chief executive, his staff, and the coordination of activities into departments under the chief executive. It is only in the third edition (1949) of his work, Introduction to the Study of Public Administration,[33] in a new part, "The Dynamics of Management," that White, in Chapter XV, "Coordination and Communication," discusses coordination in terms of the on-going organization. Even here, while stressing the necessity of effective coordination, illustrations are limited to the inter-departmental and chief executive levels.

James D. Mooney and Alan C. Reiley

In 1931 Mooney and Reiley, in their classic work Onward Industry,[34] developed a set of principles based on a structural approach to organization. While recognizing that people were involved in the day-to-day coordination it is their thesis that ". . . sound co-ordination of these jobs, considered simply as jobs, must be the first and necessary condition in the effective co-ordination of the human factor."[35] Their primary concern then is with the depersonalized organizing process rather than with the subsequent personalized administration of organization.[36] For them all the organizations are scalar (hierarchical) and it is scalar chain by which coordination, the first, or basic principle of organization ". . . becomes effective throughout the organization."[37] A summary of their position on coordination is as follows:

> Coordination . . . is the orderly arrangement of group effort, to provide unity of action in the pursuit of a common purpose.[38]
>
> True co-ordination in the formal sense can only be effectuated through functional definition, and such co-ordination must begin at the top. Without it there will be friction, even at the top, and in these circumstances it is futile to look for co-ordinated harmony at any other point down the line.
>
> . . . . . .
>
> Co-ordination, as we have noted, is the determining principle of organization, the form which contains all other principles, the beginning and the end of all organized effort. We must find the actual process, however, through which co-ordination becomes effective throughout an organization. Here I would distinguish between two forms

> of co-ordination, the perpendicular and the horizontal.
>
> The principle of perpendicular co-ordination is expressed in the single word authority.[39]

It is through authority and the process of delegation that the coordination of functions is achieved.[40]

> So much for perpendicular co-ordination, operating through leadership and the delegation of authority, without which no organization can function. Another factor of equal importance is that of indoctrination in the common purpose, which is obviously essential to the true intelligence of concerted effort. Here enters the other great principle, that of horizontal co-ordination, which operates not through authority and the function of command but through the universal service of knowledge. This difference between the perpendicular and the horizontal forms of co-ordination brings us to the final distinction in functionalism, that between the line and the staff.
>
> . . . . . .
>
> Authority, with its process of delegation, is of course essential in every organization, but experience proves that the service of knowledge is an equal necessity, and, furthermore, that such service is impossible through the contacts of command alone. Staff services, whether formally organized or not, are bound to grow up in every organization. There formal organization, however, is demanded if we are to achieve the most efficient forms of concerted human effort.
>
> . . . . . .
>
> In all forms of organization, what I have called horizontal co-ordination is the principle that indoctrinates every member of the group in the common purpose, and thus insures the highest collective efficiency and intelligence in the pursuit of the objective.[41]

John M. Gaus

John M. Gaus, distinguished political scientist and authority in public administration, suggested in 1936 a theory of organization which emphasized the human element.[42] Concerned that the term organization was being used in such a way as to give it ". . . a mechanical, non-human quality . . .",[43] he states that organization is "a relating of individuals so that their efforts may be more effective in the accomplishment of some purpose."[44] The essence of administration is education,[45] and the role of leadership is to ensure that each individual in the organization ". . . knows his function . . . so that there will be no uncertainty and hesitation in the integration of his actions with those of the other members of the organization."[46] In addition, the administrator must endure that he "wins the active consent and support"[47] of the members of the organization. It is through the realization of these two goals that the function of coordination is accomplished. For coordination is:

> . . . the task of obtaining this active consent of these persons in their day-to-day activity through the careful allocation of functions, the co-operative evolving of working policy, the securing and making available of relevant knowledge, the determination of priorities in processes and activities, the delimitation and focusing of efforts and resources, and the recruiting and canalizing of the ideas and energies of the persons in the organization.[48]

Thus, Gaus sees the coordination function as being accomplished by the line supervisor through a process of education. Recognizing difficulty in a large organization for an administrator to know

all that is required, Gaus sees an auxiliary technical staff which facilitate the work of these administrators through service and advice.[49]

Luther Gulick

As a member of President Roosevelt's Committee on Administrative Management, Luther Gulick, integrating and further elaborating on concepts of Fayol and Mooney and Reiley, developed a structural theory of organization which "became widely accepted in American textbooks dealing with public administration."[50] Especially famous is his acronym, POSDCORB, which is designed to direct attention to the functions of a chief executive: planning, organizing, staffing, directing, coordinating, reporting and budgeting.

His theory,[51] as set forth in Papers on the Science of Administration, states that the division of work ". . . is inescapable," and therefore "co-ordination becomes mandatory."[52] Coordination must be achieved in two coordinate ways: (1) by organization, and (2) by the dominance of a central idea of purpose which is necessary for ". . . action and self-coordination in the daily operation of all parts of the enterprise."[53]

Coordination is achieved in organizations by a system of hierarchical authority from the top administrator to "the ultimate work subdivisions."[54] There are four basic organizational patterns which can be utilized by purpose, by process, by persons or things, and by place.[55] The determination of which pattern of organization to use is dependent on which is the most effective way to coordinate

the organizations activities, for instance, by process or by purpose.[57]

Organizationally, the basic means of coordination is hierarchical, but there are other coordinating mechanisms which:

> . . . must be regarded as part of the organization as such. Among these must be included planning boards and committees, interdepartmental committees, co-ordinators, and officially arranged regional meetings, etc. These are all organizational devices for bringing about the co-ordination of the work of government. Co-ordination of this type is essential. It greatly lessens the military stiffness and red tape of the strictly hierarchical structure. It greatly increases the consultative process in administration. It must be recognized, however, that it is to be used only to deal with abnormal situations and where matters of policy are involved, as in planning. The organization itself should be set up so that it can dispose of the routine work without such devices, because these devices are too dilatory, irresponsible and time-co suming for normal administration. Wherever an organization needs continual resort to special co-ordinating devices in the discharge of its regular work, this is proof that the organization is bad. These special agencies of co-ordination draw their sanction from the hierarchical structure and should receive the particular attention of the executive authority. They should not be set up and forgotten, ignored, or permitted to assume an independent status.[58]

As indicated above, in addition to coordination by organization, there is a second essential method of coordination and that is by ideas. In this respect, Gulick's concept closely follows Mooney and Reiley and will not be discussed here.

L. Urwick

Colonel Urwick's theory of organization also involves concepts similar to those of Fayol, Mooney and Reiley, and Gulick.

Therefore, for purposes of this study, a review of Urwick's thinking is limited essentially to his concept of staff.[59] Basically, it is his position that in large organizations coordination can most effectively be achieved by utilization of the staff concept.[60] Urwick's concept of staff does not involve authority to command[61] nor specialized functions such as personnel or similar activities, but rather consists only of personnel who are generalists and whose function is coordination. The role of the staff generalist is to facilitate the work of their immediate superior by (a) collection and dissemination of information for him, (b) transmission of his orders and instructions and (c) anticipation and resolution of difficulties in carrying out his plans. These staff generalists are located at each of the various hierarchical levels as may be required by workload demands.

There are two consequences which result because of inadequate staff support. First, there is an excessive use of committees and second, superiors, rather than performing their planning and leadership functions, are bogged down in paperwork and other similar details.[62]

Some relevant comments by Urwick on committees are:

> Committees are a subject in themselves. A committee is a group of persons to whom certain functions have been assigned on condition that they discharge those functions conjointly and in a corporate capacity. A unit of organization in this form is always an alternative to employing an individual to perform the same functions. Experience suggests that it is a form with distinct limitations.
>
> . . . . . .

> Committees have certain structural peculiarities. They are discontinuous: they cease to exist as a unit each time that the committee rises. The chairman must either lead a committee or some other member will.
>
> . . . . . .
>
> Committees are also prone to a number of psychological weaknesses. Mr. E. C. Lindeman has listed fourteen of the most common, ranging from 'tendency to indulge in irrelevant discussion,' through 'members try to impress superior' and 'Chairman obtrudes opinions' to 'tendency to jump to conclusions.'
>
> . . . . . .
>
> But even if the activities assigned to it are correctly chosen and care and intelligence are used in its composition, a unit in committee form will only work really successfully if certain basic conditions are fulfilled. Its members must understand that the purpose of a committee is not to win support for this or that individual opinion, but to develop a collective judgment which is something more than the sum of the individual views represented--a resultant having an entity of its own and developing out of the conjoint thinking of the committee.[63]

Elton May and F. J. Roethlisberger

As a result of certain of investigations conducted during the period from 1927 to 1932 at the Hawthorne plant of Western Electric, the concept of organization was significantly broadened. The works[64,65,66, 67] of two of the key investigators, Elton May and F. J. Roethlisberger, have provided a comprehensive description, analysis and interpretation of the data obtained. Briefly stated, their findings were that, in addition to the formal organization,

there exists in organizations a much broader social organization. This social organization consists of the ". . . actual patterns of interactions existing within or between employee groups, supervisory groups and management groups . . ."[68] Further, that like the:

> . . . family, the social organization of any group is felt as a real thing, indeed as something far more real than the technical organization of a factory; and spontaneously formed human relations are felt to have a meaning and a value that are lacking in purely hierarchical relations or in those relations that are involved in merely working together in time and place, according to an arbitrarily determined plan.[69]

In addition the findings showed that there was a wide difference in the effectiveness in which the two principal functions of the organization were being performed.[70] The economic function, the functioning of the firm from a profit and loss standpoint was well understood and was constantly being improved upon. However, the second function, the internal function which involves the maintenance of an effective social organization and ultimately the effectiveness of the total organization was not significantly being improved upon. As a result there was a failure to adequately develop:

> . ... skills and techniques for securing co-operation, that is, for getting individuals working together effectively and with satisfaction to themselves. The slight advances which have been made in this area have been overshadowed by the new and powerful technological developments of modern industry.[71]

Other relevant findings are:

> Some parts of the system can change more rapidly than others. The technical organization can change more rapidly than the social organization; the formal organization can change more rapidly than the informal; the systems of beliefs and ideas can change more rapidly than the patterns of interaction and associated sentiments, of which these beliefs and ideas are an expression. In the disparity in the rates of change possible there exists a precondition for unbalance which may manifest itself in many forms.
>
> . . . . . .
>
> . . . the limits of human collaboration are determined far more by the informal than by the formal organization of the plant. Collaboration is not wholly a matter of logical organization. It presupposes social codes, conventions, traditions, and routine or customary ways of responding to situations. Without such basic codes or conventions, effective work relations are not possible.[72]
>
> If human collaboration is based on social codes which regulate the behavior and attitudes of individuals to each other, no logical contrivances by themselves can substitute for them. Technological advance must presuppose and make use of such codes. Any plan to promote collaboration among the workers, therefore, has to be thought of in relation to its effect on the actual social organization of the workers and not merely from a logical viewpoint alone. Successful management of any human enterprise depends largely on the ability to introduce more efficient methods without disrupting in the process the social foundations on which collaboration is based.[73]

Summary

The basic organizational concern of White and Willoughby was with increasing the capability of the chief executive to manage the activities of the administrative organization. Proposed methods for providing this capability are threefold: first, giving the chief executive control over all administrative organizations; second, providing him with adequate staff support; and third, integrating scattered organizational units into cohesive departments. However, organizations today are not generally faced with this basic type of coordination problem; in this study at least, the above methods are not immediately relevant and, therefore, will not be considered further.

The approaches of Mooney and Reiley, Gulick, and Urwick to the matter of coordination are basically the same, emphasizing its structural aspects. All four authorities consider coordination as basic internal goal of organization, with the hierarchical or scalar chain serving as the primary coordinating mechanism. Mooney and Reiley emphasize that coordination must be considered first from a structural viewpoint, that organization is the most important element in coordination. Urwick, with Mooney, Reiley and Gulick agreeing, stresses that in large organizations a line-staff structure is required to ensure effective coordination. When speaking here of staff, Urwick limits it to generalists who serve as assistants to line supervisors at appropriate hierarchical levels and who facilitate his work by serving as information-gatherers and by relieving him of work detail. All four authorities indicate that the staff function

involves horizontal coordination whose purpose is knowledge and service. In addition, Gulick identifies four types of organizational patterns--by purpose, by process, by person or thing and by place--and indicates that the basis for choice among the four types depends on which pattern provides the most effective coordination for the particular situation under consideration. While Gulick and Urwick both see the necessity for committees, both consider that their use should be very limited. Gulick states that wherever there is continual use of committees that is a sign that the organization is bad; Urwick more specifically states that it indicates a lack of staff generalists, who could more effectively and efficiently perform the task.

Gaus approaches coordination from the viewpoint of the individual; that it is the individual who must do the coordinating and be coordinated. It is the purpose of leadership through education, to provide the basis for coordination. The leader must ensure, first, that each employee knows his function and its interrelationship with the remainder of the organization and, second, that the employee is willing to participate.

Mayo and Roethlisberger approach the problem of coordination as a group phenomenon, pointing out the limitations placed on coordination by social norms. They indicate that relatively little thought is given to social group considerations when formal organizational changes are made. They also identify three factors that should be considered in making changes in organization. First, social group relations within organization which, in many instances, have more meaning and value to individuals than do strictly formal

relations. Second, it is easier to make changes in the formal organization than it is in the social organization. Third, social norms regulate or restrict cooperation.

In addition to the hypothesis criteria developed in Chapter III, three factors drawn from this section are used in later chapters as an aid to evaluating the MSC Apollo mission planning structure. The three factors are (1) organizational structure, including concepts of hierarchical coordination, staff generalists, and Gulick's four organizational patterns, (2) the individual aspect, including Gaus' educational hypothesis, and (3) the social group as a limiting factor in coordination.

Multi-Disciplinary Period (1938-1960)

The knowledge that one can gain about organizations from the literature up to this period can be compared with the knowledge that can be acquired about an elephant by examining only its skeleton. However, during the period under discussion, the field of study was broadened tremendously. As many social science disciplines began to focus their efforts on organizations, new perspectives were added. Extensive empirical investigations were conducted concerning the individual as well as concerning small group dynamics in organization; studies of the relationships of various organizations to their environment were conducted. Theories of organizations as decision-making systems or as communications networks were also developed. The management science/systems analysis approach was also introduced.

These many pokings and probings began to yield bits and pieces of information about the different aspects of this elephantine phenomenon called organization. Thus, during the latter part of the period it became increasingly apparent that a much broader concept of organization must be developed to effectively relate all of these diverse views and concepts of organization which these authorities were postulating as a result of their findings. It is to this goal then, to the development of a general integrated theory of organization, that modern organizational theory is striving.

A consideration of all investigations and concepts developed or initiated in the many disciplines during this period is beyond the limited scope of this study. Only a few of the authorities such as Chester Barnard, Max Weber and Herbert Simon, whose works stand out as beacons early in this period, will be focused upon for relevant concepts. Further, pertinent findings from other authorities and disciplines will also be briefly described. However, consideration of certain authorities such as Karl Deutsch, Douglas McGregor and Rensis Likert, will be deferred to consideration in the next section. While they made a significant impact on the field during the 1950's, their major works, wherein they comprehensively describe their theories, were not published until the 1960's.

Chester I. Barnard

In 1938, Chester I. Barnard published his classic work, The Functions of the Executive. In it, he postulates a theory of organization which encompasses many of the concepts that are developed

further by others later in this period. It is Barnard's basic premise that human beings, ". . . do not function except in conjunction with other human organisms,"[74] and that the reason for these interactions are to achieve some purpose or purposes that could not be achieved individually, without cooperation. That all such cooperation by two or more persons for a definite end involves a cooperative system which is ". . . a complex of physical, biological, personal, and social components which are in specific relationship . . ." The formal organization, or ". . . system of consciously coordinated personal activities or forces,"[75] is but one of the components of a large system, called a cooperative system.[76] "Moreover, most formal organizations are partial systems included within larger organization systems. The most comprehensive formal organizations are included in an informal, nebulous, and undirected system usually named 'society.'"[77]

In cooperative systems there is also the informal organization, that is "the aggregate of personal contacts and interactions . . ."[78] which are ". . . not a part of or governed by any formal organization."[79] Informal processes, which are unconscious when compared with the conscious formal processes, have two types of effect: "(a) they establish certain attitudes, understandings, customs, habits, institutions; and (b) they create a condition under which formal organizations may arise."[80]

With the foregoing perspectives in mind, a summary of Barnard's comments which have implications for this study follows:

> Systems of cooperation are never stable, because of changes in the environment and the evaluation of new purposes. . . . adjustment of cooperative systems to changing conditions or new purposes implies special management processes . . . .[81]

> The techniques of communication are an important part of any organization and are the pre-eminent problems of many. In an exhaustive theory of organization, communication would occupy a central place, because the structure, extensiveness, and scope of organization are almost entirely determined by communication techniques.[82]

> It may, therefore, be said that all large formal organizations are constituted of numbers of small organizations. It is impossible to create a large organization except by combining small organizations.

> The basic organization, if measured by the number of persons simultaneously contributing to it, is usually quite small--from two to fifteen or twenty persons, and probably not having an average of more than ten.

> The clue to the structural requirements of large complex organizations lies in the reason for the limitations of the size of simple organizations. The limitations are inherent in the necessities of intercommunication. . . . we discussed communication between persons as an essential element of cooperative systems; it is also the limiting factor in the size structure of complex organizations.

> . . . . . .

> The size of the unit, therefore, usually is determined by the limitations of effective leadership. These limitations depend upon (a) the complexity of purpose and technological conditions; (b) the difficulty of the communication process; (c) the extent to which communication is necessary; (d) the complexity of the

> personal relationships involved, that is, of the social conditions.[83]
>
> The fact that these large organizations are built up of small unit organizations is neglected in the spectacular size that ensues, and we often pass from the whole or major divisions to 'men.' The resulting dismissal fromthe mind of the inescapable practice of unit organization often leads to utterly unrealistic attitudes regarding organization problems.[84]
>
> The coordination of efforts essential to a system of cooperation requires, as we have seen, an organization system of communication. Such a system of communication implies centers or points of interconnection and can only operate as these centers are occupied by persons who are called executives.[85]
>
> Accordingly, persons specializing in the executive functions in most cases are 'members' of, or contributors to, two units of organization in one complex organization--first, the so-called 'working' unit, and second, the executive unit.[86]

Max Weber

Although Max Weber, German sociologist, had completed his work by 1920, it wasn't until 1946 that H. H. Gerth's and C. Wright Mill's translation entitled From Max Weber: Essays in Sociology[87] and in 1947 that Talcott Parsons' and A. M. Henderson's translation of The Theory of Social and Economic Organization[88] made his theories of bureaucracy generally known in the United States. For that reason, his work is discussed at this point. Weber's theory of organization is based on the manner in which the authority in organization is legitimized. The ideal-type for him is the

bureaucratic or rational-legal organization which he sees as ". . . the dominant institution of modern society."[89] This rational-legal authority consists of two basic parts: (1) a commitment to expertise and (2) acceptance of hierarchical authority.[90]

As a result, his bureaucratic structure is a closed hierarchical system, operating machine-like as a neutral instrument, not with individuals, but only roles being filled. Thus, from an entirely different base, Weber posits a normative theory of organization very similar to that advanced earlier by the administrative management school. However, as shown by Peter Blau in his studies of bureaucratic organizations, individual needs for security, power and status do influence the workings of the bureaucracy.[91] Further, P ilip Selznick in his study of TVA shows that bureaucracies need not be a closed hierarchical system but can react intimately at all levels with their environment, both internal and external.[92]

Herbert A. Simon

The contributions of Herbert Simon, summarized in three of his works[93, 94, 95] span almost the entire period under discussion. In 1947, in Administrative Behavior, he advanced his basic thesis that:

> . . . organization behavior is a complex network of decisional processes, all pointed toward their influence upon the behaviors of the operatives--those who do the actual 'physical' work of the organization. The anatomy of the organization is to be found in the distribution and allocation of decision-making functions. The physiology of the organization is to be found in the processes whereby the organization influences the

decisions of each of its members--supplying these decisions with their premises.[96]

In this study we shall be primarily con-concerned with 'vertical' specialization--the division of decision-making duties between operative and supervisory personnel.

There would seem to be at least three reasons for vertical specialization in organization. First, if there is any horizontal specialization, vertical specialization is absolutely essential to achieve coordination among the operative employees. Second, just as horizontal specialization permits greater skill and expertise to be developed by the operative group in the performance of their tasks, so vertical specialization permits greater expertise in the making of decisions. Third, vertical specialization permits the operative personnel to be held accountable for their decisions . . .[97]

'Who <u>really</u> makes the decisions?' Such a question is meaningless--a complex decision is like a great river, drawing from its many tributaries the innumerable component premises of which it is constituted. Many individuals and organization units contribute to every large decision, and the problem of centralization and decentralization is a problem of arranging this complex system into an effective scheme.[98]

Communication may be formally defined as any process whereby decisional premises are transmitted from one member of any organization to another.

Communication in organizations is a two-way process: it comprehends both the transmittal <u>to</u> a decisional center (i.e., an individual vested with the responsibility for making particular decisions) of orders, information, and advice; and the transmittal of the decisions reached <u>from</u> this center to other parts of the organization. Moreover, it is a process that takes place upward, downward, and laterally throughout the organization.

> The information and orders that flow downward through the formal channels of authority and the information that flows upward through these same channels are only a small part of the total network of communications in any actual organization.[99]

From the foregoing we see that other than recognizing the need for some type of hierarchical decision-making structure, Simon does not propose any specific form of organizational structure. The ultimate form that should be developed is one that ensures that the "proper" premises or information is given to the "proper" decision-maker who then has "proper" mechanisms for distributing his decision to others as a premise for their decisions.

In 1950, Simon, in conjunction with Donald Smithburg and Victor Thompson, presented the first systematic treatment of public administration from a behavioral viewpoint. As much of this work incorporates thinking expressed by Barnard and by Simon in his earlier work it is not discussed here. However, excerpts from one section dealing with the use of conferences and committees follow:

> Where decisions are complex, requiring the reconciliation of a wide range of points of view, effective communication often requires that all the persons involved in the decision be brought together for face-to-face discussion in a conference or series of conferences. Where it is desired to formalize the conference procedure, and where the same group of persons is involved in a series of conferences, a definite committee can be established.
>
> An important advantage of the conference and the committee over step-by-step clearance as a means of reaching a joint decision is that each participant is exposed directly and simultaneously to the views of all the others. There is a maximum of opportunity

for the free interchange of information and ideas.

. . . . . .

There were a number of reasons for the success of the committee process in this case. . . . the committee served to formalize an informal communication system that was already largely in existence.

Second, the problems involved . . . cut completely across departmental lines. Almost every major aspect of the plan was of considerable interest to at least a half dozen departments. Where each problem confronting a committee is of interest to only a few of the participants, the committee is likely to be much less successful.

Apart from their effectiveness in securing a free interchange of views, and hence in securing sounder decisions, conferences and committees serve other important communication functions. First, they communicate a thorough understanding to the participants of the decisions reached. Moreover, by providing a feeling of participation in the decision-making process and a feeling of responsibility for the decisions reached, they greatly improve the motivations of the participants in later carrying out the decisions. There is a considerable and growing body of evidence that group participation in decision-making is an important means for securing acceptance for new programs and organization changes.

. . . . . .

It should not be concluded that committees are an unmitigated blessing.

. . . committees can prove an extremely costly and time-wasting device if they are brought together without a real reason for their existence, if they suffer from ineffective chairmanship or inadequate preliminary spade work by a properly staffed

> secretariat, or if they continue in existence (as they often do) after their work has been completed. Frequently they are used for inappropriate tasks. For example, a committee can review a document that has been drafted previously, but almost no group of more than two or three persons can efficiently do the work of drafting. Likewise, committees are often bogged down in debate about questions of fact that could be more accurately and quickly decided by a little research outside the committee chambers.[100]

In their work, Organizations, 1958, March and Simon make a number of pertinent points concerning coordination:

> One peculiar characteristic of the assignment problem, and of all the formalizations of the departmentalization problem in classical organization theory, is that, if taken literally, problems of coordination are eliminated. Since the whole set of activities to be performed is specified in advance, once these are allocated to organization units and individuals the organization problem posed by these formal theories is solved.
>
> Of course, writers on organization theory are aware that coordination is a highly significant problem. Our point is simply that this problem is absent from the formal models, and hence that the formal models depart widely from what is asserted in a common-sense way about organizations. As is often the case, common sense appears to be more relevant to the real-world phenomena than do the models. . .[101]
>
> The type of coordination used in the organization is a function of the extent to which the situation is standardized. To the extent that contingencies arise, not anticipated in the schedule, coordination requires communication to give notice of deviations from planned or predicted conditions, or to give instructions for changes in activity to adjust to these deviations. We may lable coordination based on pre-established schedules coordination by plan, and coordin-

> ation that involves transmission of new information coordination by feedback. The more stable and predictable the situation, the greater the reliance on coordination by plan; the more variable and unpredictable the situation, the greater the reliance on coordination by feedback.[102]
>
> The capacity of an organization to maintain a complex, highly interdependent pattern of activity is limited in part by its capacity to handle the communication required for coordination. The greater the efficiency of communication within the organization, the greater the tolerance for interdependence.[103]

Other Contributors

A review of the literature involving the traditional or operational school of organization for the period indicates no significant change in the position adopted earlier by Fayol, Gulick, and Urwick. George Terry, in his work, has chapters both on coordination and on communications, but these essentially elaborate on ideas expressed earlier.[104] Ralph C. Davis devotes over one hundred pages to staff organization, but once again, it is only a further elaboration and detailing of ideas expressed in earlier work.[105] Harold Koontz and Cyril O'Donnel, as with Terry and Davis, discuss the nature of, reasons for, misuse of, and disadvantages of committees.[106] Koontz's eight reasons for use of committees are: (1) need for group deliberation and judgment, (2) fear of placing authority in one person, (3) representation of interested groups, (4) coordination of plans and policies, (5) transmission of information, (6) consolidation of authority,

(7) motivation through participation, and (8) avoidance of action. The six reasons he lists as disadvantages of committees are: (1) high cost in time and energy, (2) tendency to compromise to least common denominator, (3) indecision and domination, (4) having yes-men or warring camps, (5) splitting of responsibility, and (6) minority tyranny.[107]

During the 1950's increased attention was devoted to the study of communication networks in small groups. The principal focus was on determination of the most efficient communication linkage patterns among members of small groups. A series of experiments were conducted by Bavelas (1950), Leavitt (1951), Heise and Miller (1951) and Guetzkow and Dill (1957) utilizing different linkage patterns.[108] Basic patterns considered were a serial linkage or chain, a radical linkage or wheel, and a circular or all channel linkage. While a review of the findings of these studies is beyond the scope of this paper, it is significant that Robert Dubin has formulated a theory of organizational linkage as a result of these and other similar studies.[109] Dubin reaches the following conclusions:

> The big result of the Guetzkow-Dill experiments for our purposes is this. Where a group of individuals is originally constrained to interact in interpersonal linkage-systems requiring more than the minimum numbers of links, they will, if given the opportunity, reduce the linkage system to the minimum. We would additionally infer from their data that the greater the departure from the minimum number of links, the greater is the self-generated pressure to reorganize the

closed group into a minimum linkage system.[110]

> The argument may be summarized briefly. A unit is part of an organization if it has at least one link with a member unit of the organization. Links among units are the mainstreams of organization: channels of information, authority, work-flow, and personnel mobility. Systematic ways of connecting units vary in the number of linkages required. If stability of the organization is is a desirable goal, then choices may be made among unit linkage-systems according to the criterion of minimizing the number of links. There are theoretical reasons and empirical evidence to support this criterion.[111]

> Indeed, I would be presumptuous enough to suggest that the satirical Parkinson's Law --'Work expands so as to fill the time available for its completion'--(Parkinson, 1957) is itself grounded in the Law of Linkage for Parkinsonian administrators, viz.: Maximize the number of linkages among organization units and work will have to expand to maintain them![112]

However, Dubin's conclusion that minimum linkage patterns are best is subject to serious question. For example a study of communication nets with Air Force bomber crews by Robert Ziller in 1958 found ". . . that the more flexible groups and the more confident groups were generally found to be those with the more open communication systems . . ."[113]

Or, as William G. Scott reports:

> Indeed, it has been found that the circular (committee or participation) pattern contributes far more to human satisfaction on the job and it increases productivity.
>
> . . . . . .
>
> Some circumstances may require a committee-participative form of decision or joint

> consultation on problems. These conditions include highly involved technical problems or the co-ordination of complex organizations. Participation is also useful when it can be shown to improve both morale and efficiency. However, group decision making or participation is not defensible as a pure 'morale booster.'[114]

As suggested earlier, by the middle of the 1950's it became apparent that modern organizational theory would have to take on a broad ". . . conceptional-analytical base" and ". . . above all, a synthesizing, integrating nature."[115] This conceptual basis was also proposed by Kenneth Boulding in 1956.[116] He suggests first that developing a hierarchical model of systems is a more systematic way of approaching general systems theory. He proposes a hierarchy of nine levels, in ascending order: (1) framework, (2) clockworks, (3) thermostat, (4) open system, or self-maintaining structure (cell), (5) genetic-societal level (a plant, for example), (6) animal, (7) human, (8) social organizations, and (9) transcendental.

He further indicates that this model suggests where there are gaps in our knowledge as we can only construct adequate theoretical models up to about the fourth level, but not much beyond.[117] As his subtitle "The Skeleton of Science" suggests, we have a long way to go to construct an adequate theory of human organization.[118]

Summary

One of the most striking features evident in this section is the extent to which the organizational theory advanced in the earliest work, The Functions of the Executive meets the criteria

of a systems approach. Another striking fact is the similarity of Barnard's concept of organization with that of Rensis Likert whose theory is discussed in the next section. Both take the view that the basic building block of organization is what Barnard calls the unit organization. Barnard also points out that there is a failure to take into account these basic units which is utterly unrealistic and which leads to serious organizational problems. Another similarity between Barnard's concept and Likert's lies in what Barnard terms the centers or points of interconnection between unit organizations. Barnard suggests that these interconnections must be performed by competent persons called executives, Likert uses the term linking pins. Both emphasize that this linking pin function is performed by a person who is in effect a member of both groups.

Weber's theory, which is extremely mechanistic, implicitly emphasizes that the coordination function is accomplished only by the proper organizing of parts. Nevertheless, its use as a sounding board by others, such as Selznick and Blau, has served to show that organizations are social institutions that must be viewed both in terms of their various environments as well as the fact that organizations' internal workings and goals are markedly influenced by the feelings, sentiments and values of their members.

Herbert Simon, with his view of organization as a decision making process, stresses the basic need to organize effectively to ensure that premises or information is most efficiently provided

decision centers. He proposes no explicit organizational structure other than a hierarchical decision scheme. He does present some pertinent comments on committees. First, the committees are most useful where problems are complex and speed in decision-making is important. Second, in some instances, committees may be just a formal recognition of an informal communication system. An important concept which Simon advanced is the differentiation between co-ordination by plan and coordination by feedback and their application in stable and predictable situations versus variable and unpredictable situations. Another idea he posits is the need for a highly efficient communication system to achieve coordination in a complex, interdependent pattern of activity.

Concepts associated with communication networks and the relative efficiency of various linkage patterns add another dimension to the study of lateral coordination. Robert Dubin suggests that minimum linkage is best. Other studies indicate that in complex, unstable situations, patterns within increased linkage are more productive. In any event, while the findings to date may be inconclusive, they do indicate there is a tradeoff point between costs and benefits associated with the number of linkages established. However, using Kenneth Boulding's hierarchical scheme as frame of reference, it is suggested that the linkage or coordination mechanism must be as sophisticated as the problem or situation in which it is operating.

In addition to the hypotheses criteria developed in Chapter III, four factors from this section are considered in subsequent

chapters in evaluating the MSC Apollo mission planning structure. First, the lateral coordinating structure is considered as to its effectiveness as a mechanism for transfer of premise information as suggested by Simon's decision theory. Second, the MSC Apollo mission planning structure is considered in terms of Simon's concept of coordination by feedback. Third, it is considered in terms of communication network linkage theory. Finally, in terms of Kenneth Boulding's suggestion, it will be evaluated in terms of its sophistication when compared with the problem with which it must be concerned.

Modern Organizational Theory Period (1960-Present)

There are a number of basic underlying themes which set apart the literature of this period from that preceding it. First, there is an acknowledgment that the world in which we live consists, to an unprecedented extent, of organizations.[119, 120] Second, the world in which we live is one of explosive change, and organizations must have new capabilities with which to adapt to changes.[121, 122] Third, in considering their various aspects, organizations and associated management systems cannot be viewed as being of one type but rather as existing in different forms along continuum in different forms.[123, 124, 125, 126] Fourth, there are ". . . three broad streams . . . democracy, collaboration, and science . . . moving steadily toward a confluence in the twentieth century."[127] Collaboration, or cooperation is the most recent of these ideas

and is a twentieth century addition to our value system.[128, 129] While collaboration normally is thought of in terms of individuals or groups within an organization, Peter Drucker suggests that a new theory must be formulated, a theory:

> . . . of the society of organizations is needed to explain organizational interdependence.
>
> . . . . . .
>
> But the new interdepencence among organizations is not primarily physical. Increasingly, major organizations farm out to each other the very performance of their own functions. Increasingly each organization is using the others as agents for the accomplishment of its own tasks. There is an intertwining of functions such as we have never known before. The roles are subject to rapid change; what one organization is expected to do today, another one may take on tomorrow.[130]

Given these considerations, this section aims to briefly review the relevant aspects of the works of such authorities as Douglas McGregor, Rensis Likert, Tom Burns and G. M. Stalker, Karl Deutch, Warren G. Bennis, and Donald C. Pelz and Frank M. Andrews. Furthermore, as their study is focused directly on management of large research and development projects, concepts of David I. Cleland and William R. King as formulated in Systems Analysis and Project Management are examined.

Douglas McGregor

Douglas McGregor states that the traditional conception of organizational theory is based on certain assumptions about human behavior. First, man has an inherent dislike for work and he will

avoid it, if at all possible. Second, man has to be directed, coerced and threatened with punishment to ensure he performs adequately on the job. Third, the average person avoids responsibility, wants direction, has little ambition and desires security above all. This concept of human motivation McGregor styles as Theory X.[131]

McGregor indicates there is ". . . a growing body of research findings . . ."[132] which indicates that Theory X is weak and inadequate. He then proposes a new theory, Theory Y, based in part on Maslow's hierarchical scheme of human needs. Theory Y is based on the following assumptions: (1) work is as natural as play or rest; (2) man will exercise self-discipline in trying to achieve objectives to which he is committed; (3) there are rewards other than economic which can be utilized to motivate man; (4) given the right environment man can learn to seek responsibility; (5) many more people than actually do can contribute effectively to creative solutions; and (6) the capabilities of the average person is not fully utilized.[133]

The effect on coordination, especially lateral coordination, as stated by McGregor is as follows:

> The line manager who seeks to operate within the context of Theory Y will establish relationships with his subordinates, his superiors, and his colleagues which are much like those of the professional vis-a-vis his clients. He will become more like a professional staff member (although in general rather than specialized ways) and less like a traditional line manager.
>
> All managers, whether line or staff, have responsibilities for collaborating with other members of the organization in achieving organizational objectives. Each is concerned with (1) making his own resources of knowledge, skill,

and experience available to others; (2) obtaining help from others in fulfilling his own responsibilities; and (3) controlling his own job. Each has both line and staff responsibilities.

One consequence of this approach is the greater significance which the managerial team acquires at each level of organization. Much of the manager's work--be he line or staff--requires his collaboration with other managers in a relationship where personal authority and power must be subordinated to the requirements of the task if the organizational objectives are to be achieved.

. . . . . .

Many activities simply cannot be carried on and many problems cannot be solved on an individual basis or in two-person relationships. In addition, there are severe negative consequences when we ignore the necessity for group action and attempt to solve certain problems in terms of pair relationships.

In general we are remarkably inept in accomplishing objectives through group effort. This is not inevitable. It is a result of inadequate understanding and skill with respect to the unique aspects of group operation.

. . . . . .

If, however, the superior recognizes the existence of the intricate interdependence characteristic of modern industry, and if he is less interested in personal power than in creating conditions such that the human resources available to him will be utilized to achieve organizational purposes, he will seek to build a strong group. He will recognize that the highest commitment to organizational objectives, and the most successful collaboration in achieving them, require unique kinds of interaction which can only occur in a highly effective group

> setting. He will in fact discourage discussion or decision making on many matters which affect his organization except in the group setting. He will give the idea of 'the team' full expression, with all the connotations it carries on the football field.
>
> . . . . . .
>
> The modern industrial organization is a vast complex of interdependent relationships, up, down, across, and even 'diagonally.' In fact, the interdependence is so great that only collaborative team efforts can make the system work effectively. It is probable that one day we shall begin to draw organization charts as a series of linked groups rather than as a hierarchical structure of individual 'reporting' relationships.[134]

Rensis Likert

Dr. Rensis Likert, Director, Institute for Social Research, University of Michigan, has been head of ". . . one of the major institutions conducting research into human behavior in organizations."[135] His work, New Patterns of Management, based upon the empirical findings of his group over the previous twelve years, was published in 1961. In it he proposes a new theory of management, based upon his conclusions as to the methods currently being used by managers who exhibited the best performance records in American business and government. In essence, he concludes that the traditional theories of management are inadequate because they (1) assume that people work only or primarily for economic reasons and (2) they ignore small group methods of supervision. He found that the high-producing supervisor generally uses broader motivational forces and

is more skillful in supervising his subordinates as a group, in fact, ". . . the higher his skill in using group methods of supervision, the greater are the productivity and job satisfaction of his subordinates."[136] As a result of his findings, Dr. Likert:

> . . . presents an interesting new theory of organization which integrates the numerous findings of small group and organizational efficiency studies. His theory is of particular interest since it is one of the few modern organization theories that deals with both organizational behavior and organizational structure.[137]

In the broad perspective, Dr. Likert suggests that his new management system lies at one end of a continuum of ". . . various systems of management and control that has evolved in the course of time . . ."[138] While indicating that organizations may exist anywhere on the continuum, with many intermediate patterns, he identifies four basic types of management style. They are Exploitive Authoritative, Benevolent Authoritative, Consultative and Participative management styles. The three named first are management systems that he considers traditional; the fourth is his science-based system. He subsequently changed the nomenclature to Systems 1 through 4, respectively, to avoid possible prejudging by respondents when completing questionnaires. Figure 3 depicts the various systems on the continuum, utilizing both nomenclatures.

His concept is based on the fact that he found ". . . a remarkably consistent set of interrelationships"[139] between leadership styles and nine organizational characteristics: motivation,

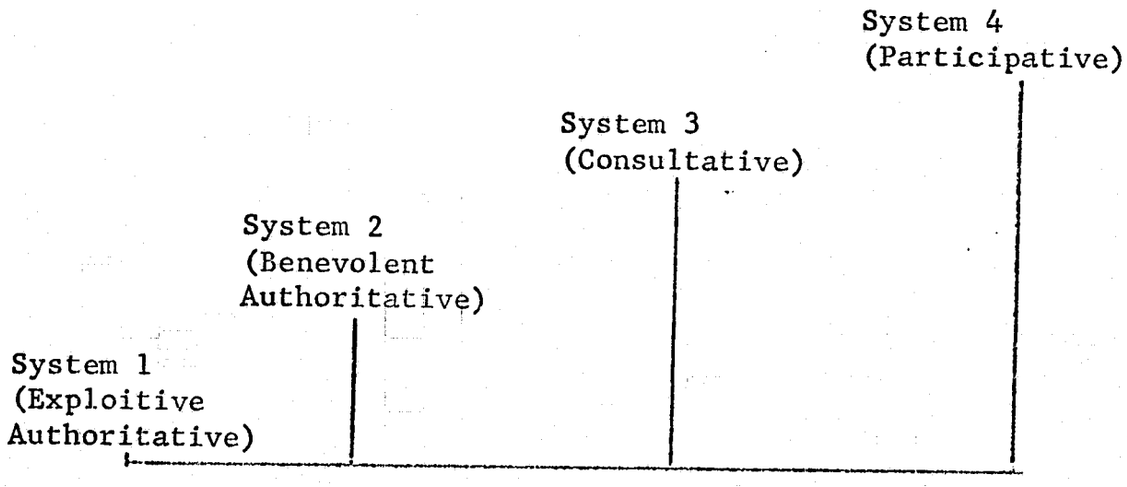


Figure 3. Likert's Management Continuum.

communication, interaction, decision-making, goal-setting, control, and performance. A complete listing of the organizational and performance characteristics of the four different systems may be found on pages 14 through 24, The Human Organization.

There are three concepts which form the foundation for Likert's System 4; they are (1) the principle of supportive relationships, (2) the setting of high performance goals, and (3) the use of group methods of supervising, including group decision-making.

The principle of supportive relationships states that:

> The leadership and other processes of the organization must be such as to ensure a maximum probability that in all interactions and in all relationships within the organization, each member, in the light of his background, values, desires, and expectations, will view the experience as supportive and one which builds and maintains his sense of personal worth and importance.[140]

In other words, supervisors are to be employee-centered. They focus their attention on the human aspects of their subordinates' problems. They regard their jobs as dealing with human beings as well as with the work. They see their role as facilitating the work of their subordinates; they exercise general rather than detailed supervision.

However, it is not enough that the supervisor be employee-centered. He must also have high performance goals and every member of his group:

> . . . should have high performance aspirations as well. Since these high performance goals should not be imposed on employees, there must be a mechanism through which employees can help set the high-level goals which the satisfaction of their own needs require.[141]

The third concept, and the one with which this study is principally concerned, is the use of group methods of supervision. There are two aspects of group supervision. First, the relations or interactions within each group; second,the relations or interactions between groups. Within the group the supervisor relies heavily on group processes rather than on man-to-man interaction. While, naturally, man-to-man interaction occurs, there is also a positive effort to ensure that at:

> . . . each hierarchical level . . . all subordinates in a work group who are affected by the outcome of a decision are involved in it. (A work group is defined as a superior and all subordinates who report to him.)

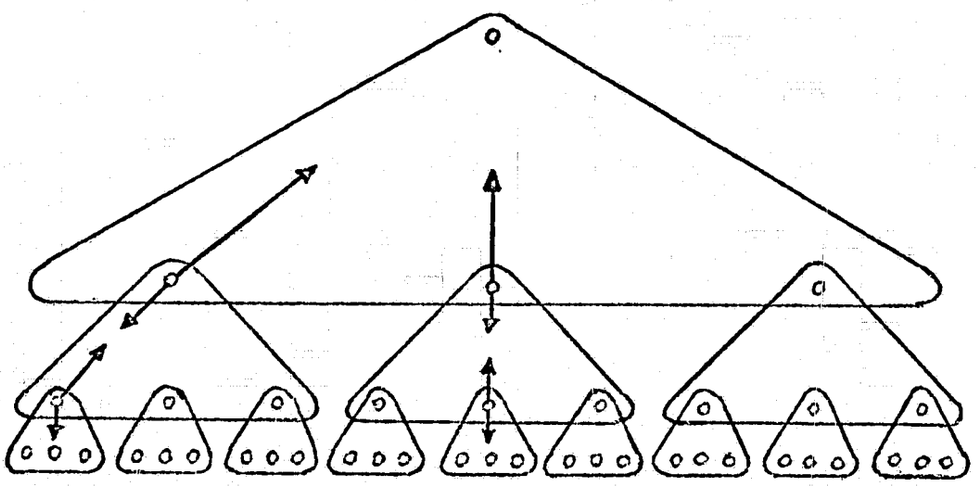
> When the group process of decision making and supervision is used properly, discussion is focused on the decisions to be made. There is a minimum of idle talk. Communication is clear and adequately understood. Important issues are recognized and dealt with. The atmosphere is one of 'no nonsense' with emphasis on high productivity, high quality, and low costs. Decisions are reached promptly, clear-cut responsibilities are established, and tasks are performed rapidly and productively. Confidence and trust pervade all aspects of the relationship. The group's capacity for effective problem solving is maintained by examining and dealing with group processes when necessary. It is essential that the group method of decision making and supervision not be confused with committees which never reach decisions or with 'wishy-washy,' 'common-denominator' sort of committee about which the superior can say, 'Well, the group made this decision, and I couldn't do a thing about it.' Quite the contrary! The group method of supervision holds the superior fully responsible for building his subordinates into a group which makes the best decisions and carries them out well. The superior is accountable for all decisions, for their execution, and for the results.[142]

The focus of this study is directed at the second aspect of group supervision, the interactions between groups. Building up this basic organizational building block Dr. Likert goes on to state that:

> . . . organizations will function best, when its personnel function not as individuals but as members of highly effective work groups . . . consequently, management should deliberately endeavor to build these effective groups, linking them into an over-all organization by means of people who hold overlapping group membership . . .[143]

Those individuals who hold overlapping group memberships are called "linking pins (Figure 4). In a standard hierarchical organization:

> The superior in one group is a subordinate in the next group, and so on through the organization. If the work groups at each hierarchical level are well knit and effective, the linking process will be accomplished well.[144]



(The arrows indicate the linking-pin function.)

Figure 4. The linking pin. (From Rensis Likert. New Patterns of Management.)

In this earlier work, New Patterns of Management, in addition to formulating this hierarchical system of overlapping groups, he further suggests there should be lateral linkages across the organization, that these additional linkages should ". . . act as the sinews binding the organization together and making it stronger and more effective."[145] However, it is only in a later work, The Human Organization, that he fully develops this concept of multiple, overlapping groups.[146] The overlapping groups and linking pins as shown in Figure 4 indicate only vertical or hierarchical relation-

ships, not recognizing horizontal or lateral communication channels. In that respect, Likert's basic model is similar to the typical organizational chart. He subsequently substantially modified this basic model to show horizontal overlapping groups, whose function is to provide lateral coordination. Each cross-function group has as its leader a person from the hierarchical level directly above that from other members of the group. This provides for vertical integration as well as lateral coordination. Figure 1, page 22, shows three such overlapping groups performing cross-functional coordination. We thus see that a central concept in Dr. Likert's theory is:

> . . . organizations are not sets of relationships among people, as depicted in the typical organization chart, but rather are relationships among sets of interlocking and interdependent groups. It is the linking pins who occupy key roles in organizations in terms of serving as the channel of communication and influence from one group to another.[147]

> . . . the network structure of an organization using a science-based theory like System 4 is appreciably more complex than is the usual vertical structure . . . and requires greater learning and skills to operate it well. It is not a line, nor a line-staff, form of organization but is a complex grid system with an elaborate, interlaced, organizational structure. It provides powerful resources for horizontal as well as vertical coordination. This complex network, through its alternate linkages, provides, as we have seen, better communication, greater capacity to deal with differences by group decision making, and better coordination. . . . It yields a more flexible organization and motivates individuals throughout the company to exercise more initiative in bringing about

> improvement and change, as well as giving them the means for doing so.[148]

In thus formally recognizing these horizontal overlapping groups, Dr. Likert has suggested a new conceptual tool for effecting coordination in large, complex organizations.

Dr. Likert considers that the problem of how to achieve coordination in a highly functionalized company one of the most serious facing the manager today. He states that the System 4 theory of organization must be adopted if the increasingly complex organizational problems which face managers are to be satisfactorily solved.

> Virtually every large company faces, in more or less serious form, the problem of whether to organize on a functional basis or on a product or geographical basis or to try some compromise solution. The requirements of both specialization and low unit costs achieved by large-scale operations (economy of scale) press for a functional form of organization. But it is not easy for a large, highly functionalized organization to achieve effective coordination. New products emerging from research, for example, do not move from research to development to manufacturing to marketing with the speed and coordination required to capitalize on the large demand for a new and useful product.
>
> Unfortunately, major trends are aggravating this already serious problem of how to achieve coordination in a highly functionalized company. New knowledge and methodologies are being created at a rapidly accelerating rate as the national expenditures for research and development increase. Because of the limits of human capacity, more, not less, functionalization is required to take effective use of these new resources. Increases in functionalization, in turn, make effective coordination both

more necessary and even more difficult.[149]

In a recent issue paper he states that:

> System 4 with its multiple overlapping group structure and group problem solving, in addition to its capacity to enable an individual to have two or more bosses, provides unique resources for achieving effective lateral, as well as vertical, coordination. Since the successful use of R & D usually requires effective lateral coordination, a shift to System 4 can increase appreciably the benefits an organization derives from its R & D expenditures.[150]

Tom Burns and G. M. Stalker

During the 1950's, Tom Burns and G. M. Stalker conducted a series of studies involving the management of traditional Scottish firms which were trying to introduce electronics development work into their operations. A majority of these firms failed in the attempt. Burns and Stalker were able to discover significant differences between those firms that were able to make the change-over and those that failed. As a result of their findings, Burns and Stalker suggested there is a continuum of management systems. The two polar cases they identify as the mechanistic and the organic.[151]

The mechanistic system is adapted to relatively stable situations. There is a strict departmentalism of functions and tasks, which are precisely defined. There is an emphasis on a vertical hierarchy of control, authority and communications. Each person and organizational unit tends to operate as a distinct

separate entity.[152] This system compares with the Weberian rational-legal bureaucracy.

The organic system is flexible and can accomodate change. It has a facility for handling non-routine decisions and in fact, handles this type of decision as a normal function. Given the unstable nature of conditions with which this type of organization must deal, there is a continual readjustment of tasks and jobs. Individuals and organizational units perform their assignments in light of overall knowledge of the organization's goals, interacting closely with others participating in the action.

> Interaction runs laterally as much as vertically. Communication between people of different ranks tends to resemble lateral consultation rather than vertical command. Omniscience can no longer be imputed to the head of the concern.
>
> . . . . . .
>
> The shift from mechanistic to organic . . . makes considerable demands on individual members of an organization. In general terms, they are required to . . . regard it as something kept in being by the sustained creative activity of themselves and other members, to cease being 'nine-to-fivers' and turn 'professionals.'[153]

Karl Deutsch

Karl Deutsch has approached the problem of organization, particularly political organization, as a matter of communication and control. He states that communication theory, control theory and cybernetics can produce important insights for all organi-

zations.[154] He also notes that the words cybernetics and government come from the same ". . . Greek root that refers to the art of the steersman."[155] He suggests that government or organizations should be viewed less as a matter of power and more as a problem of steering and that steering is essentially a matter of communication, feedback and control.

It is not intended here to go into any detail concerning his total theoretical construct, but only to briefly present two aspects which may have immediate bearing on this study. While Deutsch uses examples from the political science they are also applicable to all large organizations:

> The first mistake consists in overestimating the importance of impersonal media of communication, such as radio broadcasts and newspapers, and underestimating the incomparably greater significance of face-to-face contacts. These face-to-face contacts determine to a large degree what in fact will be transmitted most effectively and who will be the 'insiders' in the organization, that is, those persons who receive both information and attention on highly preferred terms.[156]
>
> The strategic 'middle level' can perhaps be defined somewhat more closely. It is that level of communication and command that is 'vertically' close enough to the large mass of consumers, citizens, or common soldiers to forestall any continuing and effective direct communication between them and the 'highest echelons'; and it must be far enough above the level of the large numbers of the rank and file to permit effective 'horizontal' communication and organization among a sufficiently large portion of the men or units on its own level.
>
> . . . . . .

> It should be noted that the persons on this strategic 'upper-middle-level' usually receive very little publicity. They are the 'men behind the scenes' in the sense that they are the 'men who do the work' of making, permitting, and executing the largest number of strategic decisions.[157]

Warren G. Bennis

It is Warren Bennis' position that the Weberian rational-legal type of bureaucracy is not adequate to cope with the many problems that beset organizations today.[158] Instead he suggests that future organizations will have special characteristics:

> The key word will be 'temporary'; there will be adaptive, rapidly changing temporary systems. These will be organized around problems-to-be-solved. The problems will be solved by groups of relative strangers who represent a set of diverse professional skills. The groups will be conducted on organic rather than mechanical models; they will evolve in response to the problem rather than programmed role expectations. The function of the 'executive' thus becomes coordinator, or 'linking pin' between various project groups. He must be a man who can speak the diverse languages of research and who can relay information and mediate among the groups. People will be differentiated not vertically according to rank and role but flexibly according to skill and professional training.[159]

He asserts that organizations, in order to cope with the rate of change they are experiencing, will increasingly make use of planned-change programs to move toward: ". . . less bureaucratic and more participative 'open-system,' and adaptive structures."[160] He further states that the adequate performance of

the horizontal linking pin function is a key requisite to effect this change.[161]

Donald C. Pelz and Frank M. Andrews

During the period 1958-1960 Donald Pelz and Frank Andrews conducted a series of investigations which examined the relationship between ". . . a scientist's performance and the organization of his laboratory."[162] There were eleven organizations in the study, including five industrial laboratories, five government laboratories, and seven departments in one university. Since the Pelz and Andrews investigations explored the affect of communication and coordination on scientists and engineers in R & D organizations similar to the organization being examined in this study, certain results of their investigations are directly applicable. They can be summarized as follows.

First, an increase in horizontal contacts (contacts with colleagues) correlates directly with higher performance.[163]

> We did not design the research to test a systematic organizational theory. As it turned out, though, the foregoing results tied in well with some of Rensis Likert's ideas, formulated mainly from data on non-scientific organizations. Likert's concept of management by overlapping groups is consistent with our results.[164]

Second, Pelz and Andrews found that there are correlations between how tightly coordinated an organization is, the type of scientists (Ph.D or non-Ph.D engineer) and the amount of autonomy required for good performance.

In general, we found that (A) the looser the situation, the more strongly high levels of motivation (both internal and external in source) accompanied high performance. But (B) the individual's autonomy and influence were most effective in situations of only moderate looseness. Part (C) gives some clue as to why; there were numerous hints that maximum autonomy in a very loose setting may isolate the individual from stimulation.[165]

One explanation for these results may be that in loose or extremely loose settings the most autonomous scientists tended to withdraw from outer stimulation (or to reduce inner motivation), that is, to weaken stimuli which might have enhanced their performance. In very tightly coordinated situations, at the other extreme, autonomous individuals were both motivated and stimulated; but the rigidities of the setting apparently prevented these factors from enhancing creativity. Thus only in the middle-range situations were two essential conditions present: (a) high autonomy was accompanied by a number of strong motivations and stimulations, and (b) the setting was flexible enough to allow these factors to improve performance.

In the loosest settings, full autonomy may encourage complacency rather than zest, narrow specialization rather than breadth. In the strongholds of research, the isolated rooms in the ivory tower may not be the best habitat for achievement.

It suggests, we think, that you emphasize different techniques when dealing with different segments of your research organization. For the sake of discussion we'll stretch a point and assume that all five levels of coordination are represented in different parts of your organization. Consider first the research engineers in your development laboratories: moderately autonomous non-Ph.D's, developing new products or processes. Let's assume they

> correspond to level III. For these men, the kind of philosophy represented in Rensis Likert's New Patterns of Management should be highly effective. These men should rise to the challenge of more participation in decision-making. Stimulate them with a wide variety of problems. Make sure each man has three or four specialized skills, and a fair degree of leeway to follow up his own ideas.[166]

David I. Cleland and William R. King

Systems Analysis and Project Management, by David Cleland and William King, is one of the best balanced and comprehensive treatments of project management available in the literature. It divides project management into two phases, planning and execution; the title of the work reflects this division. System analysis, covered in the first part of the book, concerns itself with the planning phase of new programs and analysis of alternatives using the systems approach a la McNamara-Hitch. The second part of the book discusses the execution phase of the program--project management. Specific subject areas covered in the latter half of the work include: the project environment, concepts of project management, charting lateral organizational relationships, and project control techniques.[167]

In discussing the theoretical basis for project management the authors review the concepts of the traditional school as well as the administrative management school. In summarizing these theories, they state that it must be remembered that ". . . these ideas were developed for organizations that were smaller and environ-

ments that were simpler than those of today."[168] Citing the works of Ralph C. Davis, George R. Terry and Harold Koontz, it is implied that Cleland and King's basic theoretical orientation is of the operational school. They also indicate that ". . . the concepts of traditional and project management compliment each other; they are not two distinct approaches to the execution function."[169] However, they indicate that to the extent the traditional school operates on a Theory X basis which ". . . limits human collaboration in the organization,"[170] it is inadequate and they therefore suggest Theory Y as a method of operation and motivation.

Project management is concerned with:

> . . . the task of integrating functional and extraorganizational efforts directed toward the development and acquisition of a specific project. The project manager (or systems manager) is confronted with a unique set of circumstances and forces with each project, and these circumstances and forces channel his thought and behavior into somewhat singular patterns of response.
>
> The project manager's position is based on the realization that modern organizations are so complex as to preclude effective management using traditional organizational structures and relationships. Traditional philosophy is based on a vertical flow of authority and responsibility relationships and emphasizes only parts and segments of the organization. It does not place sufficient importance on the interrelationships and integration of activities involved in the total array.[171]

Cleland and King suggest four criteria to be used in deciding whether or not a project office should be established. They are: magnitude of effort, unfamiliarity, interrelatedness, and organi-

zational reputation.[172] In other words, it is a relatively large undertaking, it is different from the normal routine, there is a high degree of interdependence among the tasks, and the organization's stake in the undertaking may be crucial.

There are two basic types of project organizations, the pure project organization and the matrix organization.[173] In the pure project organization the manager is given authority to run the project as if it were a one-product company. The matrix organization is composed of both a project and a functional structure. It can take a large variety of forms depending on the project-functional combinations. In a matrix organization:

> . . . a functional organization exists in which the project manager reports to the chief executive in a line capacity. The staff of the project manager's office may vary in number from only the manager himself to several hundred people, depending upon the degree to which the project activities are centralized. As the project manager's responsibilities increase and more facets of the project are centralized under his control, the company may establish an organizational entity (a division) to manage the project independently. In this type of matrix organization, the project manager has authority over the functional managers regarding the 'what' and 'when' of the activities; the functional manager determines <u>how</u> the support will be given. The functional managers are responsible to both their functional supervisors and the project manager for support of the project. This situation, in which a line functional manager (such as a production manager) is placed in a position of providing advice, counsel, and specialized support to a project manager, who is concerned with unifying project activities across the company, represents a change in the authority relationships. This is a radical departure from the line-staff organizational dichotomy

that has been the mainstay of management theory for decades. Also it seems to be a violation of the scalar principle described by Henri Fayol.

Authority patterns in the organization . . . flow both vertically and horizontally throughout the company. In addition, there is flow to outside participating organizations. Project organization frequently disregards levels and functions and superimposes the project structure on the existing organization. The structure depends, to a large degree, on the location of the project contributor, regardless of where that contributor is located. Thus, at times it is difficult, if not impossible, to chart the relationships . . .

Some form of matrix organization is established almost universally in companies engaged in developing, testing, and delivering large projects. In this dual management process, deliberate or purposeful conflict is recognized as a mechanism for achieving good trade-offs. Even though the organization is aligned in such a way that the conflict is required (and recognized), the chief executives expect the managers to work out their conflicts. In other words, the project manager and the functional managers must resolve the recurring conflicts that arise during the course of the project's life. Only truly significant disagreements should be brought up to a common superior for resolution; management by exception is the rule! Both project and functional managers have the right of appeal, but before any such right is exercised, two criteria should be met: (1) the issue is clearly drawn, with alternatives and costs described, and (2) it is a salient project-functional issue. The resolution of salient conflicts may determine the organizational placement of a project.

Creating a matrix organization results in major organizational changes in a company. In general, these changes emphasize decentralization of authority and responsibility.[174]

The matrix, or mixed, organization has many advantages:

1. The project is emphasized by designating one individual as the focal point for all matters pertaining to it.

2. Utilization of manpower can be flexible because a reservoir of specialists is maintained in functional organizations.

3. Specialized knowledge is available to all programs on an equal basis; knowledge and experience can be transferred from one project to another.

4. Project people have a functional home when they are no longer needed on a given project.

5. Responsiveness to project needs and customer desires is generally faster because lines of communication are established and decision points are centralized.

6. Management consistency between projects can be maintained through the deliberate conflict operating in the project-functional environment.

7. A better balance between time, cost, and performance can be obtained through the built-in checks and balances (the deliberate conflict) and the continuous negotiations carried on between the project and the functional organizations.

There are some disadvantages to a mixed organization. The balance of power between the functional and the project organizations must be watched so that neither one erodes the other. The balance between time, cost, and performance must also be continually monitored so that neither group favors cost or time over technical performance.[175]

Although naturally Cleland and King recognize that horizontal relationships are the essence of project management, there is little discussion in their work of concepts or techniques for lateral coordination. There is some discussion on communication networks, but

little more than stating that there are formal and informal networks of communication.[176] In this respect, the work reflects the traditional management approach.

There is in their work, however, a very extensive discussion of methods for analyzing and charting horizontal relationships.[177] Recognizing that the traditional organization chart has proven to be a useful tool for depicting hierarchical relationships of the traditional school, Cleland and King explore the possibility of developing a method for depicting horizontal relationships. The method which they suggest is use of the linear responsibility chart (LRC) or a modified version of it which they call systems charting. Figure 9, on page 190 shows a simplified linear responsibility chart.

> Typically, the LRC shows these characteristics:
>
> 1. Core information from conventional charts and associated manuals displayed in a matrix format.
> 2. A series of position titles listed along the top of the table (columns).
> 3. A listing of responsibilities, authorities, activities, functions, and projects down the side of the chart (lines).
> 4. An array of symbols indicating degree or extent of authority and explaining the relationship between the columns and the lines.
>
> Such an arrangement shows in one horizontal line all persons involved in a function and the extent and nature of their involvement. Furthermore, the one vertical line shows all functions that a person is responsible for and the nature of his responsibility. A vertical line represents an individual's

> job description; a horizontal line shows the breakout of a function or task by job position.
>
> There are two primary advantages to this mode of presentation. First, position descriptions and position guides are better at laying down responsibilities and authority patterns than at portraying relationships. Second, this type of charting depicts the work of top management as an integrated system rather than as a series of individual positions. The chart makes it easy to compare the responsibilities of related executives; in the coordination of budgets, for example, six individuals share the responsibility, ranging from 'must be consulted' to 'may be consulted' and 'must be notified.' The filled-in chart provides a quick picture of all the positions involved in the performance of a particular function.[178]

Other Contributors

Although they cannot be examined here extensively, there are a number of other authorities who should be identified as having contributed ideas to the subject of lateral coordination. Victor A. Thompson, for example, has discussed extensively the basic conflict between hierarchical authority and professional authority.[179] Similarly, Robert Golembiewski has pointed out that the old concept of line-staff relations, or the Neutral and Inferior Instrument (NII) concept, is no longer applicable, and that the new concept must be a Colleague model.[180] Furthermore, Wesley L. Hjornevik, former Associate Director, NASA Manned Spacecraft Center, has identified six different organizational patterns which MSC utilizes to facilitate lateral coordination:

1. A multidisciplined effort achieved by assigning the required professionals to a project office for the duration of the project

2. A multidisciplined effort achieved by creating a small, coordinating project office but leaving the professionals in their respective organizations.

3. A multidisciplined effort achieved through informal working groups and panels without any organizational change

4. A multidisciplined effort achieved by physical colocation of personnel without any formal or informal organization changes

5. A multidisciplined effort achieved by assigning specific missions to an organization or individual

6. A multidisciplined effort achieved through a flexible personnel classification system that permits a diversified staff within any given functional organization.[181]

Summary

Two basic patterns emerge as one summarizes the ideas and concepts of the authorities discussed in this section. First, they all recognize that modern organizations, in varying degrees, are faced with a very unstable environment. Second, that the individuals with these organizations must take a more active and broader role in ensuring accomplishment of organizations objectives. This broader role involves substantially more lateral coordination with colleagues in other organizational units. Likert, supported by McGregor, Bennis, Pelz and Andrews, suggests that interlinkage by

linking pins is an essential element in this lateral coordination process.

In addition to the hypotheses criteria developed in Chapter III, four factors from this section are used in later chapters as an aid in evaluating the MSC Apollo mission planning structure. First, Deutsch's concept of the strategic "middle level" as a key lateral linking mechanism is considered. Second, in respect to Pelz and Andrews findings, the impact of lateral coordination on individual performance is considered. Third, the MSC Apollo mission planning structure is considered in terms of Pelz and Andrews' concept of coordination and autonomy. Fourth, the MSC Apollo mission planning structure is evaluated in terms of Cleland and King's concept of matrix organizations.

Evaluation Factors

Sixteen factors have been identified in this chapter as potential aids for evaluating the MSC Apollo mission planning structure. The basic purpose of identifying these factors is to ensure that a broad perspective is taken in analyzing the subject structure. Sufficient data is not available to evaluate the structure in terms of each of these factors. However, to the extent that this data is not available, limitations of the study are thereby identified. The sixteen factors are:

1. Fayol's concept of weekly conferences of department heads

2-5. Follett's concepts of early, direct, self-adjusting and continuous coordination

6. Traditional concepts of hierarchical coordination, including Gulick's four organizational patterns

7. Coordination from the aspect of the individual, including Gaus' educational concept

8. The social group as a limiting factor in coordination

9. Coordination as a mechanism for transmitting premise information a la Simon

10. Coordination by feedback

11. Coordination in terms of communication network linkage patterns

12. Boulding's concept of tool sophistication versus problem difficulty

13. Deutsch's concept of "strategic middle level"

14. Pelz and Andrews' concept of the relation of coordination and autonomy

15. Pelz and Andrews' concept of increased horizontal contacts and increased performance

16. Cleland and King's matrix organization.

FOOTNOTES

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CHAPTER V

MSC ENVIRONMENT

On May 25, 1961, only twenty days after Alan Shepard's first fifteen minute suborbital flight and nine months before John Glenn's first U. S. orbital space flight, President John F. Kennedy urged that the United States establish as a National goal a manned lunar landing before the end of the decade.[1] The Nation accepted the challenge and, assigning this goal top priority, during the next nine years provided resources in excess of twenty-three billion dollars and a peak work effort of over 400,000 personnel from gov government, industry and universities to achieve this objective.[2] The purpose of this chapter is to provide a perspective of the organizational environment in which the MSC Apollo mission planning structure operated, thereby to aid in analyzing and interpreting study findings. Briefly described are the complex of organizations, the roles performed, interrelationships, and the policies and procedures in which the MSC Apollo mission planning function performed.

Overview

At the time of President Kennedy's decision, NASA was two and one-half years old and, in the area of manned spaceflight, was engaged in only one program, Project Mercury. Project Mercury was under the direction of the Space Task Group (STG), the nucleus

of the yet to be formed Manned Spacecraft Center, which was located at the NASA Langley Research Center, Virginia. Of the four NASA Centers that would become substantially involved in manned space flight activities, two had just been formed and two were yet to be organized. The Marshall Space Flight Center had been formed from the nucleus of the Wernher von Braun team and personnel of the Redstone Army Arsenal, Huntsville, Alabama. The Goddard Space Flight Center, recently formed, was engaged in developing the worldwide tracking network for Project Mercury, as well as conducting unmanned space projects. During the next six months the Manned Spacecraft Center was formed with a nucleus of personnel from the 700 man Space Task Group. The Kennedy Space Center was formed later from a nucleus of Marshall Space Flight Center and Manned Spacecraft Center personnel located at Cape Kennedy.

In the next five and one-half years, during the period of the design and development of the Apollo spacecraft, launch vehicle and associated launch and other ground support facilities, a total of fourteen U.S. manned space flights, including four Mercury and ten Gemini missions, were flown. Gemini, approved after Apollo, was an interim program, designed to provide the U.S. with additional operational experience prior to flying Apollo. Subsequently, after a delay of one year because of the fatal fire at the launch pad, the manned Apollo missions were flown, culminating nine months later in the successful lunar landing mission of July 16, 1969.

Organizations

There are eight elements or groups which comprise the basic organizational environment as pertains to the MSC Apollo mission planning structure. The keystone, naturally, is NASA Headquarters; the other seven elements are NASA-MSC, NASA Marshall Space Flight Center (MSFC), NASA Kennedy Space Center (KSC), NASA Goddard Space Flight Center (GSFC), Department of Defense manned spaceflight support group, the Apollo spacecraft prime contractors,[3] and the MSC support contractors.[4] The NASA organizations are shown on the chart on the next page in Figure 5.

Manned Spacecraft Center[5]

The Manned Spacecraft Center was established on November 1, 1961, approximately seven months after President Kennedy proposed the Apollo Program.[6] Its predecessor, the Space Task Group (STG), had been formed three years earlier to accomplish Project Mercury. Within the next four months, this small group[7] not only realized its initial primary goal of putting the first U.S. astronaut, John Glenn, into earth orbit, but had also determined the basic configuration of the Apollo spacecraft command and service module and had awarded the contract for its design and manufacture.[8] Furthermore, Gemini was announced as an interim program,[9] and relocation of MSC personnel to Houston, the selected location of MSC, was begun.[10]

During the next seven years, the following events occurred at MSC. It grew in size from 770 civil personnel to approximately 4600 personnel, approximately 57 per cent of whom are technical,

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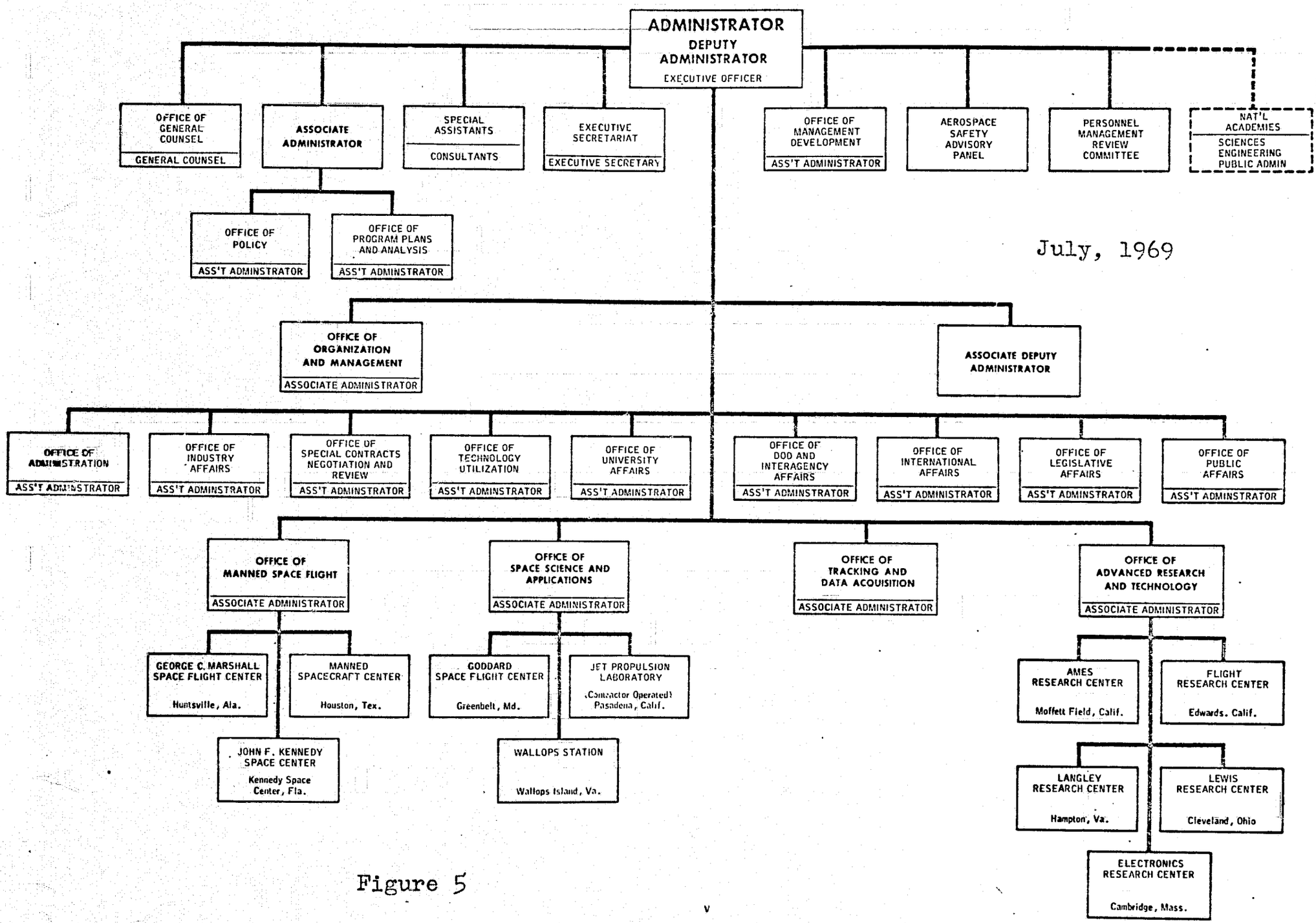

Figure 5

scientific or technical professionals.[11] From ranchlands just south of Houston, Texas, a Center was developed encompassing facilities and associated equipment valued in excess of $600,000,000.[12] Major facilities built include the Mission Control Center, Lunar Receiving Laboratory, Space Environment Simulation Laboratory, Mission Simulation and Training Facilities, Flight Acceleration Facility, Vibration and Acoustic Test Facility and Systems Evaluation Laboratory.

Concurrent with these developments, MSC guided Projects Mercury and Gemini to successful conclusion, thereby making the United States pre-eminent in manned spaceflight. Top MSC management personnel who are responsible for these signal successes have worked together for over eight years. For example, of the top eleven technical MSC managers, eight also performed similar key roles in Gemini and Mercury programs. Further, a large majority of the next level of supervisors (division chiefs) also played important parts in the previous programs. As a result, their close teamwork is very evident in the performance of their functions.

The Manned Spacecraft Center has three basic responsibilities. First, it is responsible for manned spacecraft design and development, including performing studies for advancement of manned spacecraft technology. Second, it is responsible for conducting manned space flight missions, including development of mission plans and training of flight crews and flight controllers. Third, it is responsible for performing lunar and earth science investigations

as well as earth resources survey and applications programs. The basic framework in which these functions are principally accomplished are through major spaceflight programs such as Mercury, Gemini, and Apollo. Other programs currently in developmental or planning phases are the Apollo Applications Program, designed to test concepts, techniques, and technology for long duration space flights; the space shuttle; the space station; and spacecraft designed for planetary missions.[13]

The organizational structure of MSC (Figure 6, next page) through which the MSC Director manages his operations, reflects the functional and program aspects outlined in the preceeding paragraph. There are three program offices--the Apollo Spacecraft Program Office, the Apollo Applications Program Office, and the Advanced Mission Program Office. Briefly, the responsibilities of the program offices can be summarized as follows: (1) they are responsible for integrating the activities of the line organizations concerning their respective program, (2) they coordinate and integrate associated activities in other centers and agencies, and (3) they technically direct the spacecraft developmental and manufacturing contractors. There are five major line organizations: the Engineering and Development Directorate, Science and Applications Directorate, Medical Research and Operations Directorate, Flight Crew Operations Directorate, and Flight Operations Directorate. These organizations have a dual function; first, to support the program offices and, second, to advance manned spaceflight technology in their respective functional areas. The functions and

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HOUSTON, TEXAS

July, 1969

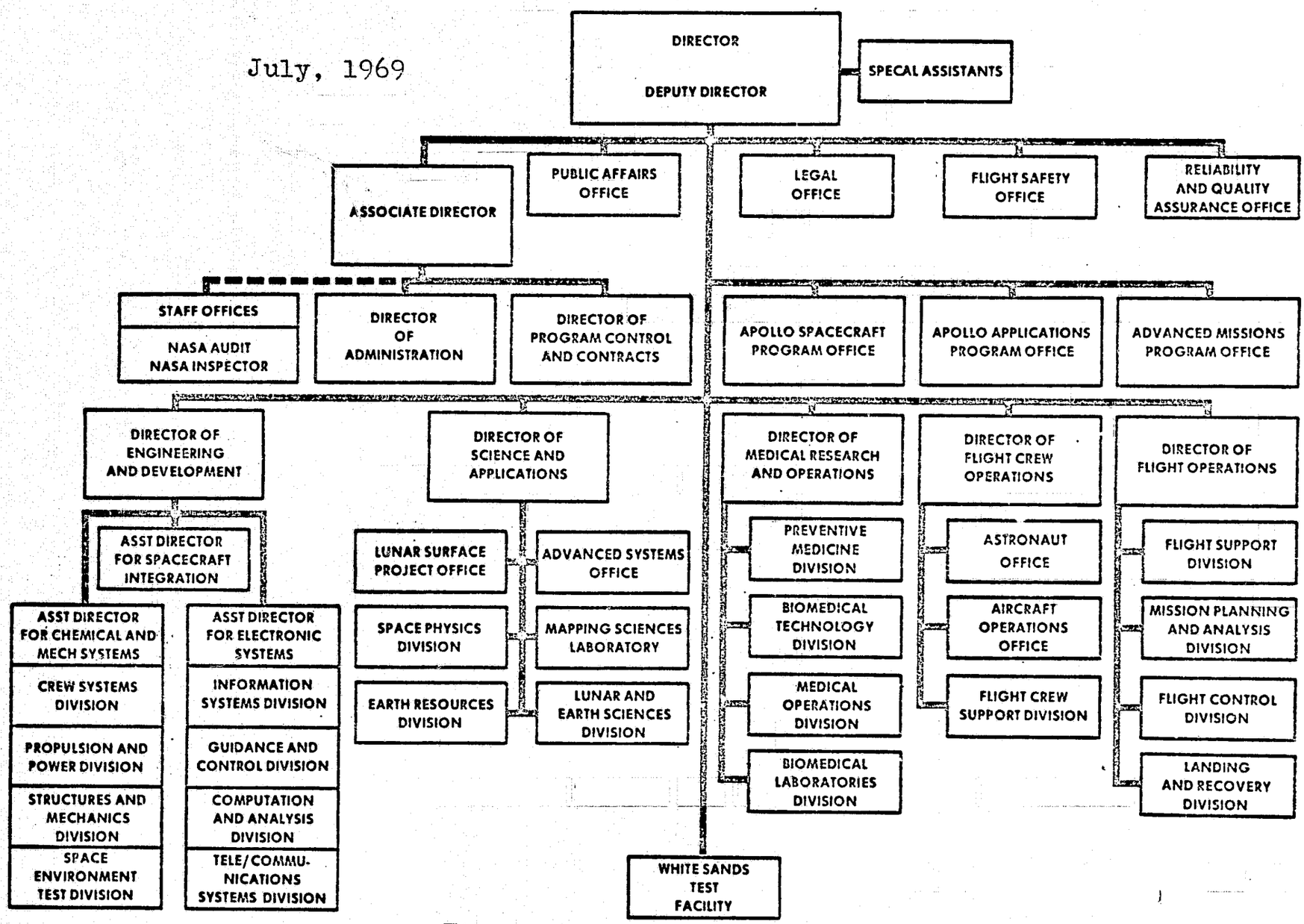

Figure 6

organization of these five line organizations and the Apollo Spacecraft Program Office will be treated more extensively in the next chapter as they comprise the MSC Apollo mission planning structure.

There are also two staff organizations, technical in function, which aid the MSC Director in ensuring that there is (1) a high level of safety in test programs as well as (2) high reliability and quality in flight vehicle components. The remainder of MSC organization consists of management and administrative support elements. A small field test organization is located at White Sands, New Mexico.

MSC Contractors

In accordance with NASA policy,[14] contractors perform essentially all manufacturing and directly associated developmental work for the major manned spacecraft programs. Further, contractors also provide substantial support in the form of services at the manned space flight centers. The first group are normally termed spacecraft or prime contractors; the latter are normally termed support contractors, whether they provide services, or equipment and associated operation and maintenance sup ort at the respective center.

For the Apollo spacecraft program, there are a total of thirty-six contractors[15] who had contracts of over $5,000,000; four of these contractors are prime contractors and the remaining thirty-two are subcontractors. The largest contract, which is with North American Rockwell Corporation, is in excess of six

billion dollars. The other three prime contractors are Grumman Aircraft Engineering Corporation for the lunar landing module, and A. C. Spark Plug of General Motors Corporation and Instrumentation Laboratory of Massachusetts Institute of Technology which, together, had responsibility for design, development, and manufacture of spacecraft guidance and navigation systems.

In the 1968-69 time period there also were approximately 9,000 support contractor personnel located on-site or in the near vicinity of MSC who were responsible for laboratory operations or mission support.[16] The mission support contractors were primarily responsible for maintenance, operation and reconfiguration of the Mission Control Center, while others performed certain mission planning activities. With a reduction in the Apollo workload the number of support contractors is currently being substantially reduced.

Other Organizations

Within NASA Headquarters, the Associate Administrator for Manned Space Flight is responsible for managing all NASA efforts directly associated with manned spaceflight. Through the Office of Manned Space Flight (OMSF) he directs:

> . . . the development of the large launch vehicles and spacecraft, and the launch, operational, logistic, life support, and related systems required for man to perform missions in space.[17]

The Associate Administrator (OMSF) also provides overall management direction to three NASA field centers--MSFC, KSC, and MSC.

Day-to-day management of Apollo Program activities at the Headquarters level are under the direction of the Apollo Program Manager.

The Marshall Space Flight Center (MSFC) at Huntsville, Alabama, is responsible for designing, developing and test support of launch vehicles required for the Apollo Program. A family of three different launch vehicles--the Saturn I, the Saturn IB and the mammoth thirty-six story Saturn V--were developed in the phased-growth program. The Kennedy Space Center, Cape Kennedy, Florida, is responsible for the test, checkout, and integration of launch vehicle and spacecraft components as well as launch operations. Another NASA Center, Goddard Space Flight Center, performed a major role in support of the Apollo Program. Although because of its other responsibilities, it did not report to the Associate Administrator for Manned Space Flight, it was responsible for implementation and operation of the worldwide system of tracking stations, instrumentation ships, instrumentation aircraft, and communications satellites utilized for Apollo space flights. The Department of Defense (DOD) also provides a broad range of support to the Apollo Program. Through the DOD Representation for Manned Space Flight Support who coordinates elements of Air Force, Navy and Army in the support they provide in such varied activities as specialized spacecraft systems testing, medical research, and launch and recovery operations.

Interrelationships

The interrelationships of NASA Headquarters, NASA centers, other government agencies, and the Apollo contractors in accomplishing

the Apollo Program are exceedingly complex; the aim of this subsection is to merely highlight certain basic aspects of those interrelationships.

First, the unifying element in forcing or necessitating the interrelationships is the ultimate mission--the lunar landing. Each organizational element has certain responsibilities for developing either elements of the spacecraft, the launch vehicle, ground support facilities, the mission plans, and the ground and flight crews necessary to perform the mission. But all of these must perform as one on launch day and this can only be accomplished by the closest of team work, integrating requirements and making trade-offs on capabilities and limitations of the various systems.

Basically, all major components utilized in the mission go through the same technical developmental process. The steps are design start, requirements definition, design development, manufacturing, test and checkout, delivery, integration and combined test of mission components, and, finally launch.[18] At the completion of each of these steps there is a major technical review to assess progress, evaluate problem areas and determine the feasibility of proceeding on to the next phase. As there are a number of different missions to be supported there are mission components progressing through various phases of the technical process at the same time.

A basic mechanism for ensuring integration of requirements and the associated design and development of the mission components is the Apollo Program Configuration Management System.[19] By

restricting various types of configuration changes to certain organizational levels it ensures that changes cannot be effected in one area without assessing the impact in related areas. The top configuration control board is chaired by the Apollo Program Manager, NASA Headquarters and includes representatives from the three centers which are responsible for ensuring all mission components are integrated on launch day.

In addition to this basic coordinating and control mechanism there is another coordinating mechanism for integrating the activities of NASA Headquarters and the three manned space flight centers. This is a hierarchical system of twenty-four subpanels, eight panels and a Panel Review Board which involves the activities of 340 personnel parttime at the peak of the Apollo Program activities.[20] The purposes of panels and subpanels, consisting primarily of technical personnel from the three centers, are to establish requirements, resolve interface problems, identify action items and otherwise serve to ensure the integrated design and development of mission components. The Panel Review Board's purpose is to resolve technical issues referred up to it from the panels.

The highest ranking integrating mechanism is the OMSF Management Council which consists of the Associate Administrator for Manned Space Flight, the Center Directors from the three manned space flight field centers, as well as certain other OMSF representatives. This group meets for two to three days each month in this capacity to completely assess all current management and technical areas.

The Apollo related activities of the Goddard Space Flight Center and of DOD are integrated into the above-mentioned co-ordinating system by MSC who has primary responsibility in the broad areas supported by these government organizations.

Management Policies

Presented here are some representative comments, expressing NASA management views on organization and operating policy.

Comments of James E. Webb
Former Administrator, NASA

> At the time I took . . . office on February 14, 1961, I stated . . . that my purpose would be to work toward creating an environment within which NASA could be as innovative in the management of its programs as it was in aeronautics and space science.[21]

> If the organizational framework in which executives are fitted is rigid, the executives can hardly be flexible. Since the endeavor itself must be able to maneuver in a turbulent atmosphere. . . , the elements that make up the endeavor must in their turn be responsive to quite flexible controls.[22]

> Yet as a system of management, the traditional doctrine constructed by Taylor, Weber, Fayol, and others, is not suited to the very large, complex undertaking. The fundamental shortcoming is the assumption of a highly rigid and inflexible structure. These concepts apply quite well to routine, repetitive, and stable operations. But they are self-defeating for the highly complex endeavor . . . , where rapid change and adjustment are the essence.[23]

> We decided as a matter of deliberate policy to place principal reliance on the American industrial establishment and the

American university system as a whole. We decided to focus our governmental efforts principally on developing the needed in-house competence to make responsible decisions and on organizing and managing. A measure of what we had in mind is the fact that ninety percent of every dollar that has come to NASA has moved outside the Agency. Our purpose was to spread the difficult problems over the largest number of able minds in the belief that this would produce the best answers. We recognized that to be effective in this approach NASA had to have very strong scientific and technical in-house capabilities.[24]

Comments of Wesley L. Hjornevik
Former Associate Director MSC

The concept of the matrix organization--the overlay of programs across functions--is one of the basic management principles of MSC. Program management is necessary so we can coordinate and manage the spacecraft programs. Functional management is necessary to provide the skilled functional specialists (professionals) who furnish technical inputs in managing the programs and to provide the reservoir of talent necessary to conceive and design new programs.[25]

The second basic principle of MSC's management of its diverse staff is the concept of decentralized responsibility. For all practical purposes, once a key leader was selected in any given functional area, he was essentially given a free hand to recruit and create the type of organization he felt was necessary to do his job.[26]

The third significant management principle practiced at MSC is the concept of supporting the laboratory environment. . . . this is an extension of the early basic decisions in the formation of NASA that NASA would manage its contractors from a laboratory environment in which the staff could maintain its technical competence.[27]

Summary

We thus see that the environment of the MSC Apollo mission planning system is extremely complex and dynamic. Structurally, the environment consists of technical government and contractor organizations dedicated to a common goal--the manned lunar landing mission. Because of complex interrelationships, hierarchies of boards, panels, and sub-panels have been developed to integrate the activities of these organizations at all working levels. Finally, management policies place a strong emphasis on innovative management practices, on being flexible, and a strong concern for both the individual as well as program goals.

FOOTNOTES

1. U. S., Congress, Senate, Committee on Aeronautical and Space Sciences, Documents on International Aspects of the Exploration and Use of Outer Space, 1954-1962, Staff Report, 88th Congress, 1st Session, 1963, pp. 202-203.

2. U. S. Congress, House, Committee on Science and Astronautics, Apollo Program Management, Staff Study for the Subcommittee on NASA Oversight, 91st Congress, 1st Session, 1969, p. 1.

3. The term prime contractor is used here to designate those contractors who have responsibility to development and manufacture of major spacecraft hardware. Prime contrac tors for the Apollo spacecraft include North America Rockwell Corporation, Grumman Aircraft Engineering Corporation, Massachusetts Institute of Technology (MIT) Instrumentation Laboratory and A. C. Spark Plug Division of General Motors Corporation.

4. The term support contractor is used here to designate those contractors who provide technical or administrative support either on or immediately adjacent to the MSC facility. It does not include spacecraft contractor personnel.

5. As the researcher has been an employee of MSC for over 8 years much of the information presented herein is based on personal knowledge acquired over the period of these years. To the extent that certain information is not documented herein it can be assumed that the information is available at MSC but that the researcher is drawing on his own knowledge.

6. National Aeronautics and Space Administration, The Apollo Spacecraft: A Chronology, Vol. 1, by Ivan D. Ertel and Mary Louise Morse, The NASA Historical Series (Washington, D. C.: Government Printing Office, 1969), p. 118, (Hereinafter referred to as Apollo Chronology).

7. In July, 1961, STG had approximately 770 civil service personnel; by July, 1962, it had grown to 1620 personnel.

8. Apollo Chronology, p. 128.

9. Ibid., p. 132.

10. Ibid., p. 143.

11. National Aeronautics and Space Administration MSC/Apollo Program Management, prepared by Management Analysis Branch (Houston: Manned Spacecraft Center, November 26, 1967), p. I-3. It was informally confirmed that the percentage for later years is approximately the same.

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13. U. S., Space Task Group Report to the President, The Post-Apollo Space Program: Directions for the Future, MSC 1839-69 (Houston: Manned Spacecraft Center, September, 1969), pp. 1-25, passim.

14. James E. Webb, Reflections on Government Service (Houston: Manned Spacecraft Center, not dated), Part II, p. 18. This is a compilation of three lectures presented in the McKinsey Foundation Lecture Series, Graduate School of Business, Columbia University, on May 2, 9, and 16, 1968.

15. NASA, MSC/Apollo Program Management, Figure I-4, no page number.

16. NASA, MSC/Apollo Program Management, p. I-5.

17. U. S., General Services Administration, National Archives and Records Service, United States Government Organization Manual 1969-70 (Washington, D.C.: Government Printing Office, 1969), p. 464.

18. U. S., Congress, House, Apollo Program Management, p. 230.

19. NASA, MSC/Apollo Program Management, pp. D-1, D-2.

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21. U. S., National Aeronautics and Space Administration, An Administrative History of NASA, 1958-1963, by Robert L. Roshalt, NASA SP-4104 (Washington, D.C.: Government Printing Office, 1966), p. iv.

22. Webb, Reflections on Government, Part III, p. 16.

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25. Wesley L. Hjornevik, Chapter IV "Guiding Work Relationships Among Scientific, Engineering, and Administrative Professionals" in Issues in Public Science Policy and Administration: A Symposium, prepared under the auspices of the Program for

Advanced Study in Public Science Policy and Administration, The University of New Mexico, 1969.

26. Ibid., p. 20.

27. Ibid., p. 21.

CHAPTER VI

MSC APOLLO MISSION PLANNING STRUCTURE

Apollo XIII was fifty-six hours into the mission, 202,000 nautical miles from earth, when the explosion occurred in the Odyssey. Critical oxygen, power and water supplies in the service module were most; shortly, primary navigation equipment also became inoperable. It was only by utilizing Aquarius, the lunar module, and employing all types of contingency plans and backup procedures that the astronauts averted almost certain death. Yet, three and one-half days later, after another 421,000 nautical miles of spaceflight, the Odyssey command module made a perfect splashdown in the South Pacific, only four miles from the recovery carrier. After the mission, the astronauts attributed their safe return to the ". . . initiative and ingenuity . . ." of the ground controllers in making extensive use of contingency mission plans.[1] The purpose of this chapter is to describe, analyze and, to a limited extent, evaluate the effectiveness of the MSC Apollo mission planning structure--the organizational mechanism through which Apollo nominal and contingency spaceflight planning is accomplished.

As was indicated in Chapter I, where the mission planning function is described more extensively, a spaceflight mission must be designed in much the same manner as the spacecraft. In fact,

there is an iterative feedback between space vehicle and mission requirements and constraints throughout the design and development of both components. In addition to the mission planning which must be performed for each of the different missions in the program, extensive mission analysis studies are made ". . . to anticipate all the possibilities that could affect the flight. . ."[2] and to develop contingency procedures to circumvent problem situations that might occur.

There are a number of facts to which attention should be drawn prior to beginning the description of this MSC Apollo mission planning structure. First, a similar board, panel, working group structure was not utilized to any significant extent for mission planning on Mercury and Gemini, the two previous manned spaceflight programs. The complexity of the mission planning required for flights in these programs was less by orders of magnitude and consequently the mission planning activities were substantially less, not requiring formal intra-center lateral coordinating mechanisms. Second, boards, panels, and working groups are also used in Apollo coordinating hardware design and development. Furthermore, such panels and working groups were used in Mercury and Gemini to coordinate overall program activities among the different organizations. For example, Paul Purser lists a total of seven such interface working groups in the Mercury program. Their purpose, as he states it:

> These groups do not necessarily make decisions or recommendations but they do assure the

> rapid interchange of technical information and a correspondingly early uncovering of potential mutual problems. The presence of technical personnel from all the potentially interested areas greatly reduces the possibility of problems remaining unrecognized.[3]

Overview

The Director and Deputy Director are responsible for the implementation of all functions and programs assigned MSC. For the Apollo Program, the Director has assigned responsibility for the planning and execution of missions to each of his five functional line organizations in accordance with their respective ongoing duties and responsibilities. He has also assigned responsibility to an MSC Apollo Spacecraft Program manager to: (a) technically manage Apollo spacecraft contracts, (b) coordinate MSC Apollo matters with both the Headquarters Apollo Program Manager as well as overall Apollo interfaces with other NASA Centers, and (c) coordinate and integrate the activities of the five MSC functional organizations into the Apollo program. Thus, what has been established is a matrix organization.

The Program Manager and the five managers of the functional organizations have coordinal responsibility; their relation is that of colleagues. The Program Manager tends to operate in terms of the "when and what" of activities, while the functional managers are more concerned with how activities will be accomplished. Problems which arise are not settled by formal authority, but rather by the law of the situation. In such instances the Diretor

and Deputy Director are advised of the situation, not to seek authority for resolution of a dispute, but rather for consultation as senior technical colleagues.

This study focuses the organizational area immediately below the level of Director and his Deputy; it is concerned with interrelationships among the Program Manager and the five functional managers as well as among their subordinates.

Line Organizations

The six principal organizational elements (Figure 6) which comprise the MSC Apollo mission planning structure are: the Apollo Spacecraft Program Office, the Flight Operations Directorate, the Flight Crew Operations Directorate, the Engineering and Development Directorate, the Medical Research and Operations Directorate, and the Science and Applications Directorate. The approximate number of professional man-years that each organization devoted to Apollo mission planning from July, 1968 to July 1970 (FY70), the period under consideration, and the relative percentage of this manpower to the total of their respective professional personnel is as follows:[4]

Organizational Unit	FY70 Man-years Apollo Mission Planning	Percent of Unit's Total Work Force
Apollo Spacecraft Program Office	65	20%
Flight Operations Directorate	600	75%
Flight Crew Operations Directorate	240	75%
Engineering & Development Directorate	230	20%
Medical Research & Operations Directorate	20	20%
Science & Applications Directorate	45	20%
	1200	

The total of 1200 man-years represents approximately fifty percent of the total MSC technical professional man-years. It should be noted that in addition to performing Apollo mission planning function, a significant number of these personnel also support mission operations during actual space flights.

The MSC Apollo mission planning functions, described in skeletal form, for each of these six organizations are listed below.

Apollo Spacecraft Program Office[5]

The Program Office, focal point for MSC Apollo Program activities, consists of approximately 320 personnel, of which 100 are located at contractor facilities. Its primary mission planning activities include: (a) developing overall program plan, including integration of hardware development plans and mission program plans; (b) coordinating and developing the test program, the mission directive documents, the determination of instrumentation and measurement lists and requirements, the determination of engineering data acquisition and reduction requirements, and the establishment of detailed mission schedules; and (c) reporting detailed test results of each mission.

Flight Operations Directorate

The Director of Flight Operations, with a staff of 800 personnel, is the senior MSC representative for mission operations. He is responsible for mission planning, determining requirements

for flight control operations and facilities, and for operation of the Mission Control Center. Furthermore, the directorate develops recovery planning and coordinates implementation with DOD. Its primary mission planning activities include: (a) developing mission trajectories, both for nominal and contingency situations; (b) developing flight mission rules which specify systems performance evaluation criteria as well as action to be taken in the event of specific systems or equipment failure; (c) integrating all MSC flight support requirements and coordinating with other responsible NASA organizations or with DOD; and (d) providing flight controllers for mission operations.

Flight Crew Operations Directorate

The Flight Crew Operations Directorate, consisting of approximately 380 personnel, is responsible for training the astronauts. Its primary mission planning activities include: (a) preparing the mission flight plan used for onboard spacecraft activities; (b) providing flight crew inputs to development of mission operations procedures; and (c) instructing flight crew on conduct of experiment.

Engineering and Development Directorate

The Engineering Directorate, with a staff of 1090 personnel, is responsible for technical direction of assigned system and subsystem work of program contractors, as well as for extensive in-house test and evaluation programs. Its mission planning activities include: (a) analyzing spacecraft-to-ground communications and

tracking systems capability and performance; (b) analyzing guidance, navigation and control systems; and (c) developing, testing, and evaluating life support systems, both spacecraft and spacesuit.

Medical Research and Operations Directorate

The Medical Research and Operations Directorate, with ninety-eight personnel, is responsible for: (a) ensuring that medical instrumentation requirements for evaluation of astronaut physical status are incorporated into mission planning; and (b) ensuring that mission plans incorporate limitations imposed by physical and medical considerations.

Science and Applications Directorate

The Science and Applications Directorate, with 248 personnel, is responsible for mission experiments related to space and earth science. Its mission planning responsibilities include: (a) providing space environmental data required to support spacecraft and mission design; (b) developing flight experiment test objectives and requirements; and (c) planning for and providing operational support during mission.

Board, Panel, Working Group Structure

There are a total of twelve boards, panels, and working groups which have been organized to coordinate laterally the Apollo mission planning activities of these six major MSC organizational elements.[6] All but the first named, have as their primary function mission-related activities. The Apollo Spacecraft Configuration

Control Board, the senior board in the Apollo spacecraft structure, however, is also the principal spacecraft hardware control board and, thus, serves to integrate overall spacecraft hardware development and mission design and operations activities.

The twelve lateral coordination mechanisms are:

1. Apollo Spacecraft Configuration Control Board
2. Apollo Spacecraft Software Configuration Control Board
3. Crew Procedures Control Board
4. Data Priority Coordination Working Group (Mission techniques Document Coordination)
5. Data and Requirements Control Panel
6. Flight Operations Plan Meetings
7. Radiation Constraints Panel
8. Lunar Surface Operations Panel
9. Extravehicular Activity Task Force
10. Apollo Abort Working Group
11. Consumables Subsystem Working Group
12. Mission Change Review Group

The principal focus of this study and analysis is on the interrelationships of these boards, panels, and working groups both among themselves and with the six line organizations.

Apollo Spacecraft Configuration Control Board

The Apollo Spacecraft Configuration Control Board is the senior MSC Apollo board. It or the other MSC Apollo boards, panels, and working groups, all of which are subordinate to it, can act on all MSC Apollo matters except in those instances where proposed

changes affect the launch vehicle or other Center/agency responsibilities. In such cases, changes are referred to the NASA Headquarters Apollo Configuration Control Board.

While the MSC Apollo Spacecraft Configuration Control Board has both hardware-oriented boards, panels, and working groups, for purposes of this study the hardware-oriented groups are not concerned.

This board normally meets on a weekly basis from one to six hours to consider major hardware or mission changes as well as program status. The composition of the board is:

1. Manager, Apollo Spacecraft Program Office--CHAIRMAN
2. Director, Engineering and Development Directorate
3. Director, Flight Operations
4. Director, Flight Crew Operations
5. Director, Medical Research and Operations
6. Director, Science and Applications
7. Assistant ASPO Manager for Flight Safety
8. Command and Service Module Program Manager
9. Lunar Module Program Manager

Apollo Spacecraft Software Configuration Control Board

The function of this board is to ensure the orderly and timely development of the command module and lunar module computer programs. These computer programs reflect mission planning decisions, especially in the areas of guidance, navigation and control. The

board meets on a weekly to biweekly basis for approximately five hours. The board's composition is:

1. Director, Flight Operations--CHAIRMAN

Representatives of:

2. Flight Crew Operations Directorate
3. Apollo Spacecraft Program Office
4. Engineering and Development Directorate

Crew Procedures Control Board

The primary function of the Crew Procedures Control Board is to maintain control over decisions concerning flight crew procedures. The board meets approximately every two weeks for three to four hours. The composition of the board is:

1. Director, Flight Crew Operations--CHAIRMAN

Representatives of:

2. Flight Crew Operations Directorate
3. Flight Operations Directorate
4. Apollo Spacecraft Program Office
5. Engineering and Development Directorate

Data Priority Coordination Working Group (Mission Techniques Document Coordination)

The purpose of this group is to describe exactly how the various mission techniques, especially from a guidance, navigation and control aspects, are to be accomplished. It actually functions as eleven panels associated with specific mission phases such as lunar descent, midcourse correction phase, etc., developing documen-

tation of both ground and onboard techniques. The various groups meet weekly to biweekly depending on the particular mission phase emphasis. The composition of the working group is as follows:

1. Chief, Data Priorities Coordination, Apollo Spacecraft Office--CHAIRMAN

Representatives of:

2. Apollo Spacecraft Program Office
3. Flight Operations Directorate
4. Engineering and Development Directorate

Data and Requirements Control Panel

The function of this group was to serve as a configuration control panel for the modification of the Mission Requirements Document from which requirements the mission plan is developed. It has been disbanded, with the Flight Operations Plan Meeting now accomplishing these responsibilities. The panel met monthly for three or four hours. The board's composition was:

1. Chief, Systems Engineering Division, Apollo spacecraft Program Office--CHAIRMAN

Representatives of:

2. Flight Operations Directorate
3. Medical Research and Operations Directorate
4. Engineering and Development Directorate
5. Flight Crew Operations Directorate

Flight Operations Plan Meetings

The Flight Operations Plan Meetings are the basic mechanism for coordinating mission design and planning at MSC. All elements of the Center involved in Apollo mission planning participate in these meetings. The meetings serve as the primary control panel for proposed changes to mission constraints, mission rules and various trajectory modifications. Approximately six mouths before a mission, the Flight Director for the respective mission assumes responsibility for these activities and conducts Flight Director meetings. The Flight Operations Plan Meetings are conducted approximately every three to four weeks, being approximately seven to eight hours in duration. The composition of the board is:

1. Technical Assistant for Apollo, Flight Operations Directorate--CHAIRMAN

Representatives of:

2. Apollo Spacecraft Program Office
3. Engineering and Development Directorate
4. Flight Crew Operations Directorate
5. Medical Research and Operations Directorate
6. Science and Applications Directorate

Radiation Constraints Panel

The purpose of this panel, which is a subgroup of the Flight Operations Plan Meetings, is to coordinate the activities of MSC personnel working on various aspects of the radiation hazards of Apollo flights. The panel meets approximately every month, with the meetings lasting from three to four hours. The panel composition is as follows:

1. Technical Assistant for Apollo, Flight Operations Directorate--CHAIRMAN

Representatives of:

2. Flight Operations Directorate
3. Flight Crew Operations Directorate
4. Medical Research and Operations Directorate
5. Science and Applications Directorate
6. Apollo Spacecraft Program Office

Lunar Surface Operations Panel

The purpose of this panel, which is a subgroup of the Flight Operations Plan Meetings, is to develop flight crew procedures during lunar surface exploration. This panel meets at least once a month, with each meeting lasting from four to eight hours. The composition of the board is:

1. Head, Lunar Surface Operations Office, Flight Crew Operations Directorate--CHAIRMAN

Representatives of:

2. Flight Operations Directorate
3. Engineering and Development Directorate
4. Medical Research and Operations Directorate
5. Science and Applications Directorate
6. Apollo Spacecraft Program Office

Extravehicular Activity Task Force

This group was established to provide a medium for coordination of Apollo extravehicular activity (except lunar surface operations). The Extravehicular Activity Task Force, while still

chartered, no longer meets, as the last scheduled extravehicular activity took place on Apollo IX. The composition of the task force is:

1. Systems Engineer, Apollo Spacecraft Program Office--CHAIRMAN

Representatives of:

2. Flight Operations Directorate
3. Engineering and Development Directorate
4. Flight Crew Operations Directorate

Apollo Abort Working Group

The purpose of this group was to identify abort situations, capabilities and procedures for all mission phases. It met approximately six times in FY1969 prior to being incorporated into the Data Priority panel system. The composition of the working group prior to its cessation was:

1. Assistant Chief, Mission planning and Analysis Division, Flight Operations Directorate--CHAIRMAN

Representatives of:

2. Flight Crew Operations Directorate
3. Apollo Spacecraft Program Office
4. Flight Operations Directorate

Consumables Subsystem Working Group

The purpose of this group is to coordinate and maintain consumable budgets for propellants, oxygen, water, hydrogen, electrical systems, portable life support systems, helium, and reaction control system propellants. The group meets approximately once a

month, for three to four hours. The composition of the group is:

1. Head, Consumables Analysis Section, Flight Operations Directorate--CHAIRMAN

Representatives of:

2. Engineering and Development Directorate
3. Flight Crew Operations Directorate
4. Flight Operations Directorate

Mission Change Review Group

This group was set up to ensure full coordination and implementation of any changes in mission design related to trajectory planning. Only three meetings of this group were held; the function is now performed by a trajectory change sheet sign-off procedure. The composition of the group was:

1. Assistant Chief for Mission Design, Flight Operations Directorate--CHAIRMAN

Representatives of:

2. Apollo Spacecraft Program Office
3. Flight Crew Operations Directorate
4. Engineering and Development Directorate

Analysis of Interrelationships

In this section, information is presented showing the relationship of membership in the board, panel, working group structure in comparison with membership in the six line organizations. In addition an analysis is made of the results and comparisons are made to determine the extent to which they prove or disprove certain of the hypotheses criteria.

Figure 7 on the next page shows the MSC Apollo mission planning matrix. Listed down the left-hand column are the twelve board, panel, working groups; across the top of the page are the six line organizations. Figures within each block, from left to right, show: first, the total number of personnel from the respective line organizations who normally participate in the meetings; second, the number of these participants who are line supervisors; and third, the chairman of the respective board, panel, or working group.

A summary of the results are as follows. The total member participation for the twelve groups average at 128 personnel, of whom sixty-four persons or fifty-three percent are supervisors. The variance in supervisor participation in the groups ranges from the Apollo Spacecraft Configuration board which is composed ninety percent of supervisors (100 percent, if the secretary of the board is excluded) to the Extravehicular Activity Task Force which has no supervisors on it. The chairmen of the twelve groups come from only three line organizations; six are from the Flight Operations Directorate, three (one of whom is on temporary assignment from Flight Operations) are from the Apollo Spacecraft Program Office, and one is from the Flight Crew Operations Directorate. Except for the Extravehicular Activity Task Force, which isn't actively functioning, chairmanship of the respective groups is assigned to the organization that has principal line responsibility; thus the group serves as added resource for the respective line manager to accomplish his duties and responsibilities. It also is a formal mechanism for

MSC APOLLO MISSION PLANNING
SYSTEM MATRIX SHOWING MEMBER REPRESENTATION (a)

Apollo Boards, Panels, Working Groups	Apollo Spacecraft Program Office	Flight Operations Directorate	Flight Crew Operations Directorate	Engineering & Development Directorate	Medical Research & Operations Directorate	Science & Application Directorate	Total
Spacecraft Configuration Control (b)	5 (4) (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	10(9)(1)
Spacecraft Software Configuration Control	2	5 (5) (1)	2 (1)	1 (1)			10(7)(1)
Crew Procedures Control	1	1 (1)	6 (5) (1)	2 (1)			10(7)(1)
Data & Requirements Control	6 (4) (1)	3 (2)	2 (1)	2 (1)	1 (1)		14(9)(1)
Flight Operations Plan	2 (1)	15 (8)(1)	3	3	1	1	25(9)(1)
Radiation Constraints	1	3 (1) (1)	1		2 (2)	1 (1)	8(4)(1)
Lunar Surface Operations	1	1	1 (1) (1)	1 (1)	1	2	7(2)(1)
Extravehicular Activity Task Force	1 (0) (1)	1	2	2			6(0)(1)
Consummables Subsystem		4 (1) (1)	1	3			8(1)(1)
Mission Change Review	1 (1)	4 (2) (1)	2 (1)	(1)			8(5)(1)
Data Priority (Mission Techniques)	1 (1) (1)	3 (3)	2 (1)	1 (1)			7(6)(1)
Abort Working Group	1 (1)	5 (4) (1)	2				8(5)(1)
Total	22(12)(4)	46(28)(6)	25(11)(2)	17(7)(0)	6(4)(0)	5(2)(0)	121(64)(12)

(a) Based on analysis of information in NASA General Working Paper No.10,080, Mission Planning at The NASA Manned Spacecraft Center (April, 1969), as modified based on updated information developed in March, 1970.

(b) First number is total membership, first parenthesis indicates members who are supervisors in formal organization, second parenthesis indicates Head of Respective Board, Panel, or Working Group.

Figure 7

the other line organizations to provide their inputs into the planning.

In the figure on the following page, Figure 8, the composition of the various boards, panels, and working groups is shown according to the relative hierarchical position of the participants in their line organizations. The category title "Non-Supervisory" may be somewhat misleading as it includes not only those personnel from within the lowest organizational units, but also includes another twenty-five percent who serve on staffs at higher levels of the line hierarchy.

As is quickly brought out in the future, the chairmen of ten of the twelve groups are at a higher level in the line hierarchy than the majority of the remaining members of the group. Also in the case of one exception, the chairman of the Apollo Spacecraft Configuration Control Board is the Apollo Spacecraft Program Manager, who previously had moved to this critical position from his former position as Deputy Director of MSC; it can be assumed that he still exerts much of the senior colleague influence of his former position.

Furthermore, Figure 8 also shows the percentage participation of supervisors in board, panel, and working groups compared to the total number of supervisors in the MSC Apollo mission planning structure. The estimated total number of superiors in the overall mission planning structure was arrived at by totaling only those superiors in the six line organizations who are in subunits that significantly participate in mission planning activities. At the

LINE SUPERVISORS' PARTICIPATION IN
MISSION PLANNING BOARDS, PANELS, AND WORKING GROUPS

Apollo Boards, Panels, Working Groups	Managers	Div. Chiefs	Branch Chiefs	Section Heads	Non-Supv.
Spacecraft Configuration Control	(a) 8 (1)	1	0	0	1
Spacecraft Software Configuration Control	1 (1)	4	2	0	3
Crew Procedures Control	1 (1)	4	2	0	3
Data & Requirements Control		5 (1)	4	0	5
Flight Operations Plan		3 (1)	3	3	16
Radiation Constraints		1 (1)	2	1	4
Lunar Surface Operations				2 (1)	5
Extravehicular Activity Task Force					6 (1)
Consumables Subsystem				1 (1)	7
Mission Change Review		2 (1)	2	1	3
Data Priority (Mission Techniques)		1 (1)	3	2	1
Abort Working Group		2 (1)	2	1	3
Total in Groups	10 (3)	23 (6)	20	11 (2)	57 (1)
Estimated total in Mission Planning Structure(b)	8	25	50	88	1030
% of Group to Estimated Total	(c) 125%	92%	40%	13%	6%

(a) Number in parenthesis indicates chairman supervisors

(b) and (c) Explained in text

Figure 8

lower and intermediate hierarchical levels, the estimate of total superiors involved may be in error up to seven to ten percent; such an error is not significant in the overall study findings. Because some superiors participate in more than one board, panel, or working group, the percentage participation shown is somewhat higher than the actual number of individual supervisors who participate in the groups. At the top level, two managers serve on two boards. They each serve on one board as a member, and as a chairman on other separate boards--consequently the 125 percentage participation shown for managers. At the division of chief level there is one supervisor who serves on three groups and five more who serve on two groups. There are four at the branch chief level, one at the section chief level and eight at the non-supervisory level who serve on more than one committee. Thus a total of twenty-one personnel have dual group membership beside their line organization membership. As a result, the integration of board, panel, working group activities should be enhanced. An evaluation of the above facts in light of relevant hypotheses criteria elicits the following preliminary findings:

1. In relation to Criteria 1, Hypothesis I, analysis of Figures 7 and 8 shows that the MSC Apollo board, panel, working group structure does exhibit characteristics of a lateral pattern of coordination at every hierarchical level and that this lateral pattern is legitimate part of the formal system.
2. In relation to Criteria 2, Hypothesis I, analysis of Figure 7 shows that these cross function groups are linked to the line

organization by means of persons who are members of more than one group.

3. In relation to Criteria 3, Hypothesis I, analysis of Figure 8 shows that the cross-function groups have in at least ninety percent of the cases, a superior from the hierarchical level directly above that of the other members of the group.
4. In relation to Criteria 1, Hypothesis II, analysis of Figures 7 and 8 shows that supervisors participate to a significant extent (fifty-eight percent of membership) in cross-function groups.
5. In relation to Criteria 1, Hypothesis III, analysis of the functional responsibilities of the line organization in comparison with membership on boards, panels, and working groups show a high correlation, thus indicating proper personnel are involved in the decision making processes.

Other Significant Factors

At this point, having in the briefest way reviewed the functions and structure of the MSC Apollo mission planning structure and having determined that it does exhibit certain characteristics common to Likert's concept of multiple overlapping groups, a better understanding of the structure might be obtained if it is also briefly examined as a functioning system, in terms of inputs, processing and outputs.

First, what are the outputs? Prior to launch and the successful conclusion of a mission all that can be seen is much activity and

a steady output of documents. Generally these documents have one of two words in their title, either "requirements" or "plans"; also, depending on the time period involved, these two words are qualified by such adjectives as "preliminary," "general," "interim," "revision II," "specific," "final," "updated," etc. These documents represent certain milestones accomplished in the mission planning process.

The essence, then, of the mission planning process is to develop plans to conduct spaceflight missions. However, as the majority of the personnel engaged in mission planning also support mission operations (either as flight crew or flight controllers) a closely interrelated objective is to develop knowledge within these individuals so that they may most effectively perform their operational responsibilities. Another output, to a lesser extent, of the mission planning process is in the form of specifications for, and analysis of, space vehicle hardware development.

The basic inputs to the process are twofold. First, a set of requirements stating what the basic objectives of the program are and, second, as the program develops, complex sets of changing constraints and performance capabilities for all of the various flight and ground support systems.

It is thus the function of each of the six organizations within their area of responsibility to take the basic objective, for instance "to go to the moon," and through an iterative process of ever more detailed and comprehensive analyses to develop the mission plans. But there is one compelling factor which dictates the manner

in which this must be accomplished. That is, each of the organizations must depend on a constant stream of information being produced by the other five organizations in order to proceed stepwise with its own planning responsibilities.

This knowledge then, is the basic output of the mission planning process and to be used effectively it must be disseminated early, directly, and continuously--words used earlier by Mary Parker Follett to describe the planning process. In fact, her concepts of an ". . . interpenetration of every part by every other part . . ."[7] and a constant interweaving of strand upon strand, are essential ingredients of successful spaceflight planning.

In trying to compare the MSC Apollo mission planning structure to organizational concepts of the traditional school or to administrative management ideas, their concepts of organizations, after acknowledging that there is a basic hierarchical arrangement in the MSC Apollo mission planning structure, fail to describe the system. Gulick's four concepts of organization by process, product, place or clientele certainly don't apply to the MSC Apollo mission planning structure. The matrix organization as described by Cleland and King is a more effective concept overall; however, it too is inadequate in that it fails to describe the interworkings among the various subunits of matrix organizations.

Herbert Simon's concept of the lateral coordination as a mechanism for transmitting premise information is certainly relevant in this case, but it only explains the necessity for extensive lateral contacts without aiding in explaining the co-

ordinating mechanism itself. This is also true of his concept of coordination by feedback. He explains that situations which are unpredictable and unstable require coordination by plan, but this concept also does not explain the mechanism. What is lacking in his concept, is a description of a mechanism for planned lateral feedback.

Summary

The MSC Apollo mission planning structure has been described and analyzed. It is found to consist of six major line organizations, coordinated laterally by a system of twelve boards, panels, and working groups. An analysis of member participation of the lateral groups shows that the average total membership is about 121, approximately fifty-eight percent of whom are supervisors from all levels of the line organizations. It is these supervisors who also provide the leadership to these groups: eleven of the twelve groups are chaired by supervisors. In comparing the foregoing facts with certain of the hypotheses criteria, preliminary findings indicate that the MSC Apollo mission planning structure exhibits characteristics common to Likert's concept of multiple, overlapping groups.

Also, in evaluating the MSC Apollo mission planning structure, features brought out in this chapter are compared with certain of the concepts or factors enumerated in the survey of literature and the following determinations made: (a) the traditional or administrative management concepts of organization do not provide an adequate conceptual basis for explaining the structure;

(b) that the Cleland-King matrix, while adequate to explain the overall organization, is not adequate to describe the lateral co-ordinating mechanism; (c) that Simon's concepts adequately describe the necessity for the extensive lateral coordination but do not explain the lateral mechanism; and (d) that Mary Parker Follett's concepts of early, direct, self-adjusting and continuous co-ordination are immediately applicable to describing the concepts underlying the MSC Apollo board, panel, working group structure.

The focus of this chapter has been limited essentially to the basic skeleton of the lateral coordinating mechanism. In the next chapter, results of a questionnaire are presented, thereby developing a much more rounded picture of the structure.

FOOTNOTES

1. Remarks by Astronauts James E. Lovell, Fred W. Haise and John L. Swigert in a nationally televised news conference conducted at Houston, Texas, April 21, 1970.

2. John P. Mayer, "Mission Analysis" in Manned Spacecraft: Engineering Design and Operation, edited by Paul E. Purser, Maxime A. Faget, and Norman F. Smith (New York: Fairfield Publications, Inc., 1964), p. 23.

3. Paul E. Purser, "Summary of Management and Operational Philosophy" in Manned Spacecraft: Engineering Design and Operation, pp. 492-493.

4. The number of Apollo mission planning man-years given for each organization is a rough estimate provided only as an insight into the extent of each organization's involvement in Apollo mission planning activities. It is probably accurate within ten percent.

5. The brief functional statements for the six MSC Apollo mission planning organizations are adaptations of larger functional statements listed in Mission Operations Plan (Houston: NASA Manned Spacecraft Center,January, 1968), pp. 21-27.

6. This listing of boards, panels, and working groups is based on NASA General Working Paper No. 10,080, Mission Planning at the NASA Manned Spacecraft Center. One board, the Apollo Navigation Working Group, listed in Working Paper 10,080 has been omitted. This group is an inter-center rather than an intra-center working group.

7. Dynamic Administration: The Collected Papers of Mary Parker Follett, edited by Henry C. Metcalf and L. Urwick (New York: Harper and Brothers, 1941), p. 159.

CHAPTER VII

QUESTIONNAIRE RESULTS

The purpose of this chapter is to describe, analyze and interpret the results of the questionnaire submitted to the members of the MSC Apollo boards, panels, and working groups. A copy of the questionnaire and the associated cover letter are in Appendix A.

In accordance with the research design criteria developed in the subsection "The Questionnaire," Chapter III of this study, the questionnaire was submitted to 97 individuals of whom 71 furnished responses. An analysis of the returns shows that there is a representative number of responses in terms of: (1) the boards, panels, and working groups, (2) the six line organizations, and (3) supervisors and non-supervisors. The analysis also shows there is no significant difference in the responses based on these same considerations.

Except for Question 4, there is no evidence that difficulty was experienced in answering the questions. The problems experienced with analyzing the responses to Question 4 are discussed later. Twenty-three of the 71 respondents, besides completing the 21 multiple choice questions, also provided comments in response to Question 22, which calls for free-form response.

For each of the questions, the question itself, the response by the participants and the analysis are presented below. For

facilitating the interpretation of data, the responses of the participants are shown in percentages. The sequence in which the questions are listed is not the same sequence in which they are listed on the questionnaire, rather the questions are rearranged in accord nce with the hypotheses criteria to which they apply as developed in Chapter III, "The Research Design."

Introductory Data

1. In what capacity did you serve on the board, panel, or working group?

   7% Head 89% Member 4% Both

This question was included to provide a basis for determining whether in later questions there were differences in responses from these three groups. As indicated above, however, there were no significant difference.

2. What percentage of your time was devoted to the Apollo mission planning function?

   41% 75-100% 17% 50-75% 23% 25-50% 19% 0-25%

3. What percentage of your time spent in Apollo mission planning was directly tied to work on board, panel, or working group (e.g., preparing for, attendance at, follow up)?

   7% 75-100% 10% 50-75% 20% 25-50% 63% 0-25%

Questions 2 and 3 were included to provide background information as well as to determine whether there is a relation to the amount of time devoted to Apollo mission planning and the time devoted to board work. An analysis of the individual responses shows that, as total mission planning activities increase so does the time on board activities increase, at least to a slight extent. Responses

to Question 2 support statements made earlier in the study that the Apollo mission planning function is accomplished by personnel who have other responsibilities; 42 percent indicate that less than 50 percent of their time is spent on this function. Question 3 brings out the fact that 63 percent of the respondents spend less than 25 percent of their time engaged in activities directly related to the board. The significance of this answer is brought out later.

19. Was there a similar group, formally organized, performing the same functions for Mercury or for Gemini?

20. To what extent did a similar hierarchy of semi-formal boards, panels, working groups exist under previous programs

It was assumed that the structure of boards, panels, and working groups which had developed for Apollo mission planning was significantly different than that developed for Mercury and Gemini. This difference was posited by the increased complexity of the Apollo mission planning function and the consequent necessity for a much larger and more formal coordinating mechanism.

In regard to the Mercury Program, 70 percent of the respondents, in answering Question 19, confirmed this assumption. Another 29 percent indicated they didn't know as they were not associated with the Mercury Program. One person did state there was a similar formalized board in his area. In respect to Question 20, no respondents indicate that there was a similar semi-formal structure for Mercury; 7 percent indicate there was one to a slightly lesser extent; and 70 percent indicate there was one to a much lesser extent. Twenty-five percent indicate that they didn't know.

In regard to the Gemini Program, 9 percent indicate that there was a similar group organized to perform the same function as their group; 60 percent indicate there was not a similar group; and 29 percent indicate they didn't know. In response to Question 20, no respondents state that there was a similar semi-formal structure for Gemini; 37 percent indicate that there was one to a slightly less degree; 47 percent indicate there was one to a much less extent; and 16 percent indicate they didn't know.

It thus appears that for Mercury the very limited mission planning effort did not elicite a similar structure. However, to a limited extent, a similar structure of less scope and formality was utilized for the Gemini Program. The MSC Apollo mission planning structure, therefore, representa a mature development of a concept rather than a completely new idea. Other factors to be discussed later also indicate that the MSC Apollo mission planning structure was not developed as the result of a single management planning effort, but developed piecemeal.

Hypothesis I Data

4. To what extent were the following, principal functions of the board, panel, or working group?

This is the question with which the respondents encountered problems in answering. It is now obvious that the multiple choice response (shown in Appendix A) was poorly designed. However, an analysis of the data provides a basis for determining the relative importance of the five functions listed. The percentage of respondents and the function they indicate as a top board function

are: 35 percent, horizontal coordination; 25 percent, making decisions; 19 percent, providing solutions; 12 percent, identifying problems; and 9 percent, vertical coordination. The problem with the design of the multiple choice response, of course, is that these functions are not mutually exclusive. Further, the respondents recognize that horizontal (or lateral) coordination is the principle function of the group and, to that extent, their answers provide limited evidence in support of validation criteria 1, Hypothesis I; that is, the groups are structured primarily for lateral communication and coordination.

Moreover, independent of the above problems, the respondents (in same groups) also showed a great divergence in the relative importance in which they place the three functions of identifying problems, making decisions, providing solutions. It appears that board members should be more aware of the purposes of their respective groups.

14. To what extent does the "system" of boards, panels, and working groups that finally evolved constitute a hierarchical arrangement similar to the formal organization?

19% very much 47% moderately 27% slightly 7% not at all

15. To what extent do you consider the complex of boards, panels, working groups to be an integrated system?

46% very much 43% moderately 11% slightly

Responses to these questions also tend to corroborate validation criteria 1, Hypothesis I, that there exists a lateral coordinating mechanism that is a legitimate part of the formal system. In Question 15, 89 percent of the respondents indicate

they consider these boards, panels, and working groups to be an integrated system, either moderately or very much. Moreover, in Question 14, 66 percent of the respondents indicate that they consider these boards, panels, and working groups to be similar to a formal organization, either moderately or very much.

9. To what extent were decisions arrived at by group participation rather than by one individual making the decision at the board, panel, or working group meetings?

53% very much 44% moderately 3% not very much

Evaluation criteria 4, Hypothesis I, states that group decision processes are heavily relied on in cross-function groups. Ninety-seven percent of the respondents indicate that group decision making processes are used very much-to-moderately, thus furnishing strong evidence that this criteria has been met.

10. To what extent did the board, panel, working group structure result in the members working, in effect, for two or more supervisors?

10% very much 44% moderately 36% little 10% not at all

11. To the extent that the board, panel, working group structure did involve a person working for two supervisors, what difficulties were encountered?

-- many 6% moderate 63% little 31% none

Evaluation criteris 5, Hypothesis I, states that although participation in cross-function groups requires direction be taken from more than one supervisor, such dual direction should not give rise to difficulties for the employees involved. In answering Question 10, 54 percent of the respondents indicate that board membership involves working very much-to moderately for two super-

iors. However, in Question 11, 94 percent indicate that this causes little or no difficulties. Thus these responses furnish strong evidence that this criterion is met.

Hypothesis II Data

13. It is assumed that in the period from November, 1966 through March, 1967 (e.g., emphasis having shifted from Gemini to Apollo, etc.) there was a significant increase in the number of line supervisors who became members of various Apollo boards, panels, and working groups. Does such an increase in membership increase the capabilities of the boards, panels, and working groups?

44% very much 37% moderately 19% slightly

Validation criteria 2, Hypothesis II, states that an increase in line supervisory participation in cross-function groups increases performance capabilities of the group. As 87 percent of the respondents indicate a very much-to-moderate increase in capability in the above case, this criteria is considered to have been effectively met.

16. To the extent that the complex of boards, panels, working groups was a system, what was the principal integrating factor? Check appropriate blockfor each item.

	Very much	Moderate	Slight
Formal procedures	31%	42%	27%
Members who were non-supervisors in their respective organizations	14%	35%	51%
Members who were supervisors in their respective organization	55%	30%	15%
Heads who were non-supervisors in their respective organization	8%	40%	52%
Heads who were non-supervisors in their respective organizations	61%	22%	17%

Validation criteria 3, Hypothesis II, states that participants in cross-function groups recognize that participation by line supervisors in these groups is a major factor integrating these cross-function activities with line organization activities. The above ranking of factors shows that chairmen who are also supervisors in line organizations are the highest ranked factor at 61 percent; members of boards, etc., who are supervisors in line organization is the second highest ranked factor at 55 percent. The remaining factors are ranked substantially lower, consequently it is considered that validation criteria 3, Hypothesis II, is met.

Hypothesis III Data

12. To what extent did the board, panel, working group structure ensure that the proper personnel were involved in making mission planning decisions?

80% very much 19% moderately 1% slightly

Validation criteria 1, Hypothesis III, states that the cross-function group is very effective in ensuring that proper personnel are involved in the decision-making process. Eighty percent of the respondents indicate that this is very true of the mission planning structure, thus this is considered as strong evidence that this criteria has been met.

17. What was the significance of the board, panel, working group structure in the Apollo mission planning process?

64% Extremely important, mission planning could not have been accomplished without it

36% Important, but functions it performed could have been accomplished by informal groups or other methods.

Not too important, functions it performed were
-0- peripheral to mainstream mission planning effort

18. To what extent did the board, panel, working group structure increase the overall quality of mission planning?

39% 75-100% 35% 50-75% 23% 25-50% 3% 0-25%

Validation criteria 2, Hypothesis III, states that cross-function group structure significantly aids in the effective performance of the overall function. In Question 17, 64 percent of the respondents state that the mission planning function could not have been accomplished without it. In Question 18, 74 percent of the respondents said that cross-function group structure increased the overall quality of mission by over 50 percent. This is considered to be conclusive evidence that criteria 2 is met.

It is significant that 74 percent of the participants said that the quality of mission planning improved by over 50 percent although in a previous question 63 percent indicated that they spent less than 25 percent of their time in board activities.

5. How effective was the board, panel, working group in performing the following functions?

	Excellent	Good	Fair	Poor
Horizontal coordination	60%	34%	4%	2%
Vertical coordination	27%	51%	12%	10%
Identifying problems	37%	35%	21%	7%
Providing solutions	36%	36%	18%	10%
Making decisions	43%	38%	11%	8%

Validation criteria 3, Hypothesis III, states that the cross-function group is very effective in providing lateral coordination.

Sixty percent of the respondents indicate that effectiveness of the board was excellent; 94 percent indicate that its effectiveness in lateral coordination was excellent to good. This is considered ample evidence that validation criteria 3 is met.

6. How effective was utilization of time in board, panel, working group meetings compared to utilization of time within your functional organization?

   10% much better 35% better 45% about the same

   8% not quite as good 2% poor

7. What was the caliber of the individuals on the board, panel, working group compared to the caliber of the rest of the mission planning organization personnel of comparable grade level?

   7% much better 48% better 44% about the same

   -- not quite as good 1% poor

8. To what extent did the board, panel, working group structure contribute to creative results?

   39% very much 43% moderately 18% not very much

Validation criteria 4, Hypothesis III, states that as the cross-function structure is an effective tool, participants will recognize that their time is well utilized in the performance of this function. The responses to these questions in addition to providing more than sufficient evidence to meet the validation 4 requirements, presents other significant data.

It is quite customary to see derogative comments in the literature about committees. The respondents here disagree that committee action is necessarily ineffective. In fact, in an organization that uses committees extensively, 45 percent indicate that their time is better spent in committee activities than in

line activities. Fifty-five percent consider that the caliber of the individuals is better on the committees than in the normal line organizations. Eighty-two percent indicate that the boards', etc., contribution to creative results is in the moderate to very much range.

The probable reasons for these answers are threefold. First, line supervisors from the next hierarchical level generally serve as chairmen of the boards, panels, and working groups. These chairmen exercise the same skills in leading these groups as they do in their own organizations. Second, because of the interrelated aspects of the mission planning function, each participant requires information from the other participants to effectively perform his own function. Third, as the Pelz and Andrews studies indicate there is a strong correlation between an increase in horizontal contacts and an increase in higher performance. As a result, under the guidance of line supervisors, the other two factors provide a dynamic and stimulating work environment.

21. To what extent should a mechanism similar to the board, panel, working group structure be used in the future for other large, complex operations?

    79% probably in most instances

    21% moderately, depends on the circumstances

    -0- little, this is probably an isolated instance where it could be effective

It is significant that no respondent considers the effective use of a cross-function structure in this case as an isolated instance. As is brought out in their comments in the next section,

the respondents have identified some important advantages to utilizing this type of structure.

Respondents' Comments

22. Comments (Concerning MSC Apollo mission planning "system" of boards, panels and working groups or concerning its use as a management technique in the future; e.g., in looking back now would you improve the Apollo system of boards, panels, and working groups?)

As indicated earlier, 21 of the 71 respondents submitted comments in addition to completing the multiple choice answers. Their comments fall into two classes--problem areas, and advantages and recommendations; they are summarized below.

Problem Areas

The type of problems which the respondents identify are all associated with improving the effectiveness of the board, panel, working group structure; none indicate there was anything wrong with the structure per se. There are six types of problems identified; they are:

1. Failure to acknowledge existence of a "system" of boards, panels, and working groups, with consequent inadequate knowledge by organization members on how the mission planning function was accomplished,
2. Late and piecemeal development of board structure;
3. Duplication and overlap in functions and responsibilities of certain boards, etc.
4. Lack of coordination between boards, panels, and working groups
5. Failure to adequately delegate authority to boards and failure

in clarifying types of decisions which boards can make;

6. Making decisions first and then only using system to advise of decision made; otherwise going around system.

Some typical comments are:

> The Apollo 'system' of mission planning did not grow out of a centrally conceived plan understood and sanctioned by management. It represented a piece meal response to problems of coordination at the point in time when the problems had grown to a point where they could not be ignored. The Apollo job could have been done with fewer panels/boards/groups and with less wasted effort if care had been taken early in the program to layout an integrated plan of such groups.
>
> More advertisement; i.e., make the system known to all management levels and to individual engineers and analysts. Since the Apollo mission planning system was continuing to develop as we went, the big picture of this system wasn't always clear at lower management and worker levels. This was not intentional; it just didn't always filter at an appropriate rate.
>
> In general, the "system" is an extremely useful management technique that we should use in future programs. However, the major problems associated with the Apollo system was the lack of an overall, clearly identified integration of these efforts. On too many occasions the functions being performed by various panels and working groups were duplicated by other panels and working groups which tended to reduce the overall effectiveness.
>
> Make system more rigorous . . . there are things being done that should have board approval, i.e., working troops are under the table getting things into missions without knowledge or approval by management.[1]

Advantages and Recommendations

The respondents provided some very useful information concerning significant advantages of this system as well as making recommendations for improving utilization in other programs. Listed below, in order, is a summary of the advantages respondents listed, a summary of recommendations made and, last, some typical comments.

A. Summary of advantages:

1. It forced needed coordination, both laterally as well as vertically.
2. It was an excellent mechanism for systematic early and thorough communication.
3. It helped solve some organization problems.

B. Summary of recommendations:

1. Design overall system at an early date in program
2. Issue instruction which define boards, etc.
   a) scope and authority
   b) objectives
   c) interrelationships
3. Make system usage more disciplined
4. Review charters regularly
5. Key to use is firm management control
6. Provide good support by line organizations
7. Provide participants group-discussion training

C. Some typical comments are:

1. The system of boards ensured primarily that the appropriate people and therefore, their

organizations, communicated before the fact of mission planning decisions. In previous programs we got in trouble where such communications were not effected. On Apollo the mechanism and therefore the results avoided much of this. Do not be misled. You have to do more than permit communication. Any system must force it, if the system is to work.

2. You should recognize that many of these panels had very different interests--i.e., some strictly technical, some strictly management oriented and some in between. Those such as data priority--FOP's were extremely useful and Apollo could not have survived without at least a similar mechanism. The CCB was useful because it forced upper management to participate. All of course provided a terrific means of communication and coordination. The board and panel technique is good . . .

3. Panels, in my opinion, will be needed for future programs but should be held to a workable number, organized in some fashion and the charter reviewed regularly.

4. Success of the board depends on
   a) Initiative, energy and leadership of board chairman
   b) Board having clear-cut objectives
   c) Good support of board by cognizant organizations. Decisions aren't made by board and presented to management as fait accompli; board function is essentially staff function. But it's great to be sure data and understanding of problem are complete, and to help define who's responsible for what.

5. It was a disciplined way to bring the 'right' people together and to make decisions and to maintain a record of these decisions. Information flow both vertically and horizontally was a major benefit from such activities.

6. The keys are to have firm management control, and the best coordination

possible (especially laterally in addition to the usual vertical).

7. The Apollo mission planning system worked. It forced needed organizations and between the line organizations and management.[2]

Summary

The questionnaire, which was answered by 71 percent of the population provides important substantiating data in support of the three working hypotheses. Further, significant information regarding the effectiveness of committee action is presented which both contradicts much in the literature concerning the effectiveness of committee action and which also suggests how committee action might be made more effective.

In support of Hypothesis I, evidence is presented which shows that the majority of respondents consider the board, panel, working group developed in support of Apollo mission planning to be an integrated, hierarchical system similar to a formal line organization. Further, although some difficulty was experienced with the question, evidence is advanced which indicates that the principal function of the boards, etc., is lateral coordination. Other evidence is advanced which shows substantial group decision-making usage. At the same time it is shown that while participation in these groups involves members working to a moderate amount for two supervisors, little or no difficulty is experienced in supervisor-employee relations.

In support of Hypothesis III, evidence is presented which shows that an increase in line supervisory participation increases the capability of the cross-function group. Further, a substantial number of respondents indicate that supervisory participation in these groups is the principal factor integrating the committee activities with line organization activities.

In support of Hypothesis III, evidence is presented which shows that the boards, panels, and working groups are very effective in ensuring that the proper personnel are involved in decision-making functions. Moreover, 74 percent of the respondents indicate that the overall quality of mission planning improved over 50 percent by use of the committee structure. In addition, 64 percent of the respondents indicate that the Apollo mission planning function could not be accomplished without this committee structure. Evidence is also presented which shows that 80 percent of respondents consider that the boards, panels, and work groups, in accomplishing their principal functions, are in the excellent-to-good range; 91 percent indicate that the structure is in the excellent-to-good range in accomplishing lateral coordination.

Additional data shows that 45 percent of respondents consider their time spent in committee to be more effectively utilized than work in line organization activities; only 10 percent considered their time to be less effectively utilized. Moreover, 55 percent consider the caliber of individuals (of same grade level) is better in committee work compared with comparable individuals in line organizations; only 1 percent considered their caliber lower.

Finally, 39 percent consider that the board, panel, working group structure contributes very much to creative results, only 18 percent thought the contributions of the groups as not important.

A significant fact highlighted by questionnaire responses is the high regard that the respondents had for the effectiveness of committee action. This factor is considered in more detail in later chapters.

The comments of 21 of the 71 respondents who answered the free-form Question 22 were especially useful. These comments are useful both in explaining the structure's relative deficiencies as well as in providing very meaningful information as to the advantages of such organizational arrangements.

It is interesting to note that all of the problems identified are directed at deficiencies in the broad structure operation rather than toward the structure concept itself. Principal advantages of the board structure are: (a) it <u>forces</u> needed coordination, rather than just <u>allowing</u> coordination and (b) provides a systematic method for early, full and continuous coordination. Recommendations are: (1) that similar cross-function structures should be used in the future and (2) to be most effective, the cross-function structure should be deliberately designed early in the program's life.

In the next chapter the findings developed in the last four chapters will be summarized and conclusions reached.

FOOTNOTES

1. Comments are taken from 4 different responses to Question 22 of the subject questionnaire. Questionnaire responses are in possession of this researcher.

2. Comments are taken from 7 different responses to Question 22 of subject questionnaire.

CHAPTER VIII

CONCLUSIONS

Manned Spacecraft Center has developed a highly effective lateral organizational pattern in accomplishing its Apollo manned spaceflight mission planning activities. A key element in this organizational structure is the cross-function group, with its strong emphasis on supervisory participation. To a large extent, Rensis Likert's concept of multiple, overlapping groups which, as he states, has "unique resources"[1] for R & D organizations, furnishes a definite conceptual basis for describing this lateral coordinating and control structure. Furthermore, a survey of the literature indicates a striking deficiency in concepts of, and especially organizational techniques for lateral coordination, which might otherwise provide insights for explaining this organizational pattern.

These conclusions emerge from a research investigation designed to: (1) study and analyze the MSC Apollo mission planning organizational structure and (2) interpret the results of this study in terms of relevant concepts in the field of organizational theory. This subject area is chosen for investigation for two basic, overlapping reasons. First, it is a key organizational unit in the successful Apollo lunar landing program, the world's most complex

R & D undertaking. Therefore, for possible future application, the management and organizational techniques utilized in the undertaking deserve study to determine which of these techniques contributed most to the success of the program. Second, the MSC Apollo mission planning structure exhibits apparently singular lateral organizational patterns which bear characteristics common to Likert's multiple, overlapping groups. If it develops that the mission planning structure is, in fact, utilizing an organizational pattern similar to that proposed by Likert, the significance of this finding is compounded.

With the foregoing considerations in mind, three working hypotheses are formulated. First, the organizational structure developed to perform MSC Apollo mission planning is a highly representative example of the multiple, overlapping group structure proposed by Likert for large R & D organizations. Second, the major factor integrating the activities of these cross-function groups into the overall mission planning organization is participation in these groups by line supervisors. Third, the MSC Apollo mission planning board, panel, working group structure is an extremely valuable tool in achieving successful coordination in a complex organizational environment.

The research design formulated to these working hypotheses involves three approaches. First, a survey of the literature to identify relevant concepts which might provide an interpretive insight into the organizational structure under analysis. Second, an examination of the mission planning structure utilizing agency

secondary sources to describe and analyze the functions, duties, membership and interrelationships of the component parts. The third approach is a questionnaire surveying participants of the board, panel, working group structure to determine their evaluation of certain board, panel, working group factors: principal functions, effectiveness in performance of functions, effectiveness of time utilized, contribution to creative results, participative decision-making, effectiveness of supervisory participation, overall contribution quality of mission planning function, and other similar factors. The next section briefly reviews the MSC environment; the following sections present the results of the implemented research design.

A Common Goal

The environment of the MSC Apollo mission planning structure is extremely complex and dynamic. The first overriding consideration has been the goal of a manned lunar landing prior to 1970; it is the unifying objective. The second consideration is the interrelatedness of all work effort; decisions reached at one end of the country concerning hardware can seriously impact mission planning considerations across the country, and vice versa. Recognition of the need for close coordination is wide spread and, consequently, the needed integrating mechanisms were established. This is particularly true in the mission planning area where it is much more difficult to develop adequate tests and where much of the capability is reflected in a man's knowledge rather than in a developed piece of hardware.

As a result of the foregoing there is a constant need for coordination and flexibility. This need is also reflected in the management practices which stress flexible organizations to meet changing the situations as the program moves from the design phase through the development and test phases and finally into the flight phase.

Each of these elements have their impact on the MSC Apollo mission planning organization and serve as a unifying force.

Likert's Concept

Based on an analysis of its organizational structure and responses from the questionnaire, it is determined that the MSC Apollo mission planning system is, to a significant degree, a representative example of Likert's concept of overlapping groups. Whether or not it is "highly representative" is debatable; the question arises because the lateral organizational pattern, rather than being implemented as a specific management tool, evolved as the situation demanded and, as some of the respondents to the questionnaire indicate, there are, or were, certain overlapping areas which could be improved. It is significant, however, that modifications which the respondents, from their viewpoint, suggest for improvement would make it a "highly representative" example. The remainder of this section is a description and analysis of this structure.

The Apollo mission planning structure consists of six line organizations, five functional and one project office. All six

organizations perform other functions in addition to their Apollo mission planning activities during the period under consideration. The mission planning efforts of these personnel are integrated, along with other methods, by a system of twelve boards, panels, and working groups. It is this lateral overlapping of these boards, panels, and working groups across the vertical line organizations that results in the singular matrix organization.

Analysis of secondary data shows the average total of board, panel, working group membership is approximately 121 persons, of whom 58 percent are supervisors from all four levels of the line organization. Supervisors also serve as chairmen of eleven of the twelve cross-functional groups. Eighty-nine percent of the respondents to the questionnaire consider these boards, panels, and working groups to be an integrated structure; 66 percent consider them to be in a hierarchical arrangement similar to a formal line organization. Ninety-seven percent indicate that group decision-making is used. Further, while 54 percent indicate that participation in the cross-functional groups results in working at least moderately for two supervisors, 94 percent indicate little or no difficulty in supervisory relations as a result.

The above described data are evaluated against previously established evaluation criteria in the research design and, consequently, based on this data and other data presented in the next section, it is determined that the MSC Apollo mission planning structure is representative of Likert's concept of multiple, overlapping groups.

As indicated above, however, there is some limitation as to extent of the representation as the cross-function group concept has not been established and maintained, at least originally, on a systematic basis. This fact is brought out to a limited extent in reviewing the secondary sources where some overlapping in responsibilities became evident. It is brought out more succinctly by a number of the respondents who indicate such problems as: failure to acknowledge existence of board structure earlier, late and piecemeal development of the board structure, duplication and overlap in certain areas and lack of coordination in certain instances. However, the use and recognition of the board structure is constantly developing and maturing and as a result, efforts may already have taken place to use this concept more systematically. For example, the respondents in making comments for improving the structure suggest both early design of the system, as well as clear definition of: scope and authorities, objectives and interrelationships.

Effective Supervisory Participation

Of paramount importance in both Likert's concept as well as in the MSC Apollo mission planning structure is the critical role of the supervisor. For it is the supervisor who ensures that throughout the structure there is both an effective decision-making approach as well as a vertical information flow. This concept of supervisory participation in the cross-functional group cannot be overstated, for without such participation the cross-function groups will become ineffective in the face of line hierarchy pressures.[2]

Two answers in the questionnaire corroborate this thesis that the supervisor's role is critical. First, of five factors listed, 61 percent of the respondents indicate that a chairman who is also a supervisor in the line organization is the principal factor integrating line and cross-functional activities. The next highest factor involves the person who is a cross-function member and who is also a supervisor in the line organization. The third through fifth factors, involving formal procedures and cross-function members who are non-supervisors, are ranked substantially lower.

The second question involved an increase in line supervisory participation in cross-function groups. Eighty-one percent of respondents indicate that the capabilities of the cross-function groups increased very much-to-moderately as the result of an increase in supervisor participation.

Productive Lateral Coordination

One of the basic assumptions of the study is that the organizational elements that compose the study are highly successful organizations. This assumption is based on three considerations. First, members of the MSC Apollo mission planning structure performed a key role in the successes of the Apollo spaceflight missions as well as in previous programs. Second, many leaders of these organizations have been recognized nationally by their peers in professional organizations as outstanding technical managers. Third, these organizations have been recognized numerous times as outstanding teams; most recently several key members were awarded the Medal of

Freedom, the United States' highest civilian award, by President Nixon, for the team's overall performance in real-time mission planning in support of Apollo XIII.

Given the preceding assumption, one objective of the questionnaire was to determine to what extent the board, panel, working group structure contributes to the quality and effectiveness of the overall Apollo mission planning function. The determination made is that not only was the overall quality of the total mission planning effort substantially enhanced but that the mission planning function could not have been accomplished without these boards, panels, and working groups. Moreover, respondents' replies pertaining to the high effectiveness of these cross-function groups differ substantially from that which might have been expected from the literature considering the wide range of the derogatory comments about committee activities. In this regard, the key role played by supervisors in committee activities could prove to be a decisive one.

Eighty percent of the respondents indicate that the board, panel, working group structure is very effective in ensuring that the proper personnel are involved in making decisions. Sixty-four percent of the respondents said that mission planning could not be accomplished without the broad structure. Ninety-four percent said that the boards, panels, and working groups are in the excellent-to-good range in performing the lateral coordination function. Most amazing of all, 39 percent indicate that the board, panel, working group structure improves overall mission planning quality in excess

of 75 percent; another 35 indicate the improvement to be in excess of 50 percent.

In regard to the effectiveness of committee action their answers are as follows. Eighty-two percent indicate that the boards, panels, working groups contribution to creative results to be moderate or very much. Fifty-five percent indicate that the board members are of a better caliber than comparable level line personnel. Forty-five percent indicate that their time was better utilized in committee action than in line activities; only 10 percent indicate their time was not as well spent in cross-function groups.

Vertical/Lateral Organization

As we have seen from the foregoing discussions, the superior in the MSC Apollo mission planning structure occupies a position(s) that is strategic not only in normal vertical relationships but also in lateral relationships. His position in these lateral relationships, either as chairman or member of a committee, enables him to coordinate his activities with the other six line organizations. And, although he normally spends less than one-fourth of his time in these activities, he considers them indispensable; he also considers that they increase the quality of mission planning by one-half. What does the literature say about such lateral relationships?

In reviewing the works of major authorities of the last seventy years in the field of organization theory, one is struck by the relative absence of discussion of lateral coordination:

there is especially a lack of concepts for developing lateral organizational structures. For the first fifty years of this century, the major authorities--Taylor, Fayol, Mooney and Reiley, White, Willoughby, Gulick, Urwick, and Weber, were concerned primarily with hierarchical relationships. To them, the matter of lateral coordination is primarily an organizing function. If the organizing is accomplished properly, that is, if the same types of functions are assigned to one organization under one supervisor, the lateral coordination problem is resolved. Thus, in theory, if there are lateral coordination problems, they are problems of poor organization. While these authorities recognize that some lateral coordination was necessary, in the main they consider it as a necessary evil to solve ". . . abnormal situations . . ."[3] These authorities generally also recognize the necessity for lateral coordination in their concepts of line-staff. Staff has responsibility for horizontal or lateral coordination; yet to them, staff is also a hierarchical function.[4]

However, the manner in which these authorities deal with lateral coordination may only reflect the organizational situation at their time. For at that time much of the work was process work in which each group dealt with the product it had in serial fashion, with contact minimized between units in the process. Today we are being faced, more and more, with large problems or projects which require a multi-disciplinary, overlapping, joint approach. It is this new element in the organization's environment which requires that lateral coordination be treated as an ongoing responsibility

rather than as an abnormal situation.

On the other hand, there were three major authorities who, during these first fifty years of the century, developed concepts which are relevant to today's problems. Mary Parker Follett's concepts are most relevant to this study. While her treatment of the coordination is too extensive to discuss here, her four basic concepts of coordination can still be used as guidelines. In fact, in view of our environment today, they are more important than ever. To Follett, the principal elements of coordination are: early, direct, reciprocal (that is, not just a relating of parts, but a mutual adjusting within) and continuous.[5]

The other two authorities are Chester I. Barnard and Herbert A. Simon. Barnard suggests concepts which are very similar to those later advanced by Likert. He discusses the need to: (a) consider the small unit organization, (b) recognize that executives serve as members of two or more units or systems of communication, and (c) recognize that the supervisory role is a coordinating role.[6] He does not discuss lateral coordination specifically, it is implied. In like manner, while Herbert A. Simon, in his classic work, Administrative Behavior, doesn't discuss lateral coordination per se, he does imply in his treatment of decision-making, that organizations must be structured to ensure that premise information flows directly to decision-making centers.[7] In a later work, he adds a dimension to coordination when he suggests that in instances of variable and unpredictable situations, coordination by feedback should be utilized.[8]

In the 1950;s there began a general broadening of the field of organization theory. Concepts from the fields of communication theory, cybernetics, group dynamics, decision-making, and systems analysis provided new insights for looking at organizations. The majority of the work in these areas has resulted in a tendency to look at organizations laterally as well as horizontally. However, the emphasis has been more with theoretical explanations of isolated phenomena rather than with developing theories of organizational structure.

In the early 1960's the major works of Douglas McGregor, Rensis Likert, Tom Burns and G. M. Stalker, and Warren C. Bennis were published. By then it was recognized that modern organizations must have new capabilities to deal with rapidly changing environments.[9,10] The key to the new organizational capability involves a new insight into the nature of the individual in the organization--basically McGregor's Theory Y man.[11] Concurrently it was recognized that there is a continuum of organizational management patterns.[12, 13] The flexible, more adaptive organization pattern is termed "organic" by Burns and Stalker,[14] "participative" by Likert.[15] Likert also introduced the concept of the linking pin, the idea that organizations consist of small units which are linked together by certain persons who are members of two or more of each of these groups.[16] This linking pin concept has been adopted by many of the leading organization theorists including McGregor,[17] Bennis,[18] and Pelz and Andrews.[19] Pelz and Andrews have recently suggested that lateral coordination serves a dual purpose. In addition to the

normal organizational function of ensuring that activities are coordinated, Pelz and Andrews' studies show that in R & D organizations, increased lateral contacts among peers is directly correlated with increased performance.[20]

In a recent work, Systems Analysis and Project Management, David Cleland and William King deal extensively with project management in all its aspects. They fail, however, to discuss the lateral coordination within the project management organization. On the other hand, they do suggest a tool for analyzing lateral coordination --the Linear Responsibility Chart (LRC). An application of the LRC is discussed in the next chapter.

Conclusions

In summary, it is concluded that the three hypotheses have been proven. The MSC Apollo mission planning structure is representative of Likert's concept of multiple, overlapping groups. Supervisors do perform an essential, even critical role in ensuring the effective integration of cross-function activities and line organization activities. The use of the multiple, overlapping group structure is an extremely valuable, and in this instance, indispensable tool in achieving highly successful coordination in a complex organizational environment.

It is considered that these findings are highly significant. Today, as many of our problems grow, both in size and complexity, the necessity for lateral coordination increases by orders of magnitude. Here is a tool which has proven itself. While this is but one case and the environmental conditions were favorable to its

development, a designed systematic application to other problems and projects may prove to be equally profitable under different conditions.

Another finding considered significant, is the highly effective nature of committee action within this system. The role performed by supervisors in the lateral group structure was of paramount importance. Independent of the overall use of the multiple group concept, the structure of committee action based on this concept may prove to be very profitable.

Yet another finding which is considered significant, although negative in nature, is the relative deficiency in the literature concerning lateral coordination concepts and associated organizational techniques. This is obviously an organizational area to which considerable attention must be devoted if the problems which managers must face today are to be solved effectively. For modern organizations must no longer be thought of as hierarchical patterns of authority and control, but rather as vertical/lateral patterns of coordination--in Mary Parker Follett's terms, coordination that is early, direct, interpenetrating and continuous.

FOOTNOTES

1. Rensis Likert, "Chapter V, Organizational Dynamics: Building Effective R & D Departments," an issue paper prepared for the Program for Advanced Study in Public Science and Administration, University of New Mexico, 1969, p. 20.

2. Rensis Likert, The Human Organization (New York: McGraw-Hill Inc., 1967), pp. 165-166.

3. Luther Gulick, "Notes on the Theory of Organization" in Papers on the Science of Administration, ed. by Luther Gulick and L. Urwick (New York: Institute of Public Administration, 1937), p. 33.

4. L. Urwick, "Organization as a Technical Problem" in Papers on the Science of Administration, p. 64.

5. Dynamic Administration: The Papers of Mary Parker Follett, ed. by Henry C. Metcalf and L. Urwick (New York: Harper and Brothers, 1941), p. 28.

6. Chester I. Barnard, The Functions of the Executive (Cambridge, Mass.: Harvard University Press, 1960), pp. 91, 216.

7. Herbert A. Simon, Administrative Behavior (New York: Macmillan Company, 1947), pp. 154-155.

8. James G. March and Herbert A. Simon, Organizations (New York: John Wiley and Sons, Inc., 1958), p. 160.

9. Peter Drucker, The Age of Discontinuity (New York: Harper and Row, Publishers, 1969), pp. 171-187.

10. Warren G. Bennis, Changing Organizations (New York: McGraw-Hill, 1966), pp. 174-175.

11. Douglas McGregor, The Human Side of Enterprise (New York: McGraw-Hill Book Company, Inc., 1960).

12. Rensis Likert, New Patterns of Management (New York: McGraw-Hill Book Company, Inc., 1961), pp. 222-233.

13. Tom Burns and G. M. Stalker, The Management of Innovation (London: Tavistock Publications, Ltd., 1961), p. 118.

14. Ibid., p. 118.

15. Likert, New Patterns of Management, p. 222.

16. Ibid., p. 113.

17. McGregor, The Human Side of Enterprise, pp. 175, 229, 240.

18. Bennis, Changing Organizations, p. 12.

19. Donald C. Pelz and Frank M. Andrews, Scientists in Organizations (New York: John Wiley and Sons, Inc., 1966), p. 32.

20. Ibid., p. 52.

21. David I. Cleland and William R. King, Systems Analysis and Project Management (New York: McGraw-Hill, Inc., 1968).

22. Ibid., pp. 188-223.

CHAPTER IX

RECOMMENDATIONS

The complexity of modern organizations requires that increasingly sophisticated tools be developed to adequately analyze and manage the intricate operations which are necessary to provide the flexibility to adapt to rapidly changing environmental factors. As indicated in the previous chapter, many authorities in the field now indicate that developing these necessary capabilities involves an increasing lateral communication and coordination. Yet, concepts and associated techniques for developing necessary lateral coordination patterns are meager. The purpose of this chapter is: (a) to suggest to the practicing manager certain methods which can be utilized until more adequate conceptual tools become available, and (b) to suggest to researchers certain areas where further investigation is indicated.

For the Manager

The practicing manager, in organizing his operations, has normally followed the lead of the traditional or administrative management theories. That is, his purpose in the past has been to neatly segregate related functions into organizational units and then to integrate their activities by means of a hierarchical structure. He recognized, of course, that there would be many

problems of lateral coordination but this was an inherent function of the superior and therefore was left mainly in the realm of day-to-day operations. What has happened in actual practice is that the superior in many instances has failed in accomplishing this co-ordination responsibility; the reasons are many, e.g., too busy, didn't realize coordination was necessary, or was afraid of losing some of his authority. This is a rather polar case but it does emphasize the general traditional approach.

The first recommendation is that an additional step be taken in the organizing process, and, subsequently, later periodic organizational reviews. The additional step involves a systematic analysis of lateral patterns of organization; that is, identifying inter-relationships, defining requirements for lateral communication and coordination, defining associated duties and responsibilities, and also establishing coordinating mechanisms. These must be documented, promulgated, and updated in a similar manner as other management documents. In fact, the manager will do well to go one step further in this process of analyzing lateral patterns within his organization; he will also analyze the lateral relations of his organization with those of other organizations with which it interacts. For these outside lateral relations, in many instances, have as much impact on his operations as do his internal lateral patterns.

A second recommendation made is that in this process of organizational analysis, a schematic chart or matrix be utilized

which portrays lateral or horizontal relationships. A typical arrangement for such a chart, which has come to be called a Linear Responsibility Chart (LRC)[1] is to have positions or organizational units arranged across the top of the chart and functions, responsibilities, or activities down the left hand side. The interrelationship between these positions and functions is then shown by a set of symbols or numbers which indicate degrees of types of responsibility for each related position and function. Figure 9, on the next page, is a simplified version of a linear responsibility chart.

There are a number of advantages to using this type of chart. First, it aids the user in changing his concept of organization. As the old, traditional organization chart served or serves as a useful tool in showing vertical, or authority relationships, the linear chart can show both vertical as well as horizontal relationships. Second, it enables the manager to see his operations as an integrated system;[2] on a single chart, all of the major interrelationships can be shown.

Now, it might be questioned that in view of the rapidly changing nature of lateral coordinating patterns whether it is practicable or feasible to try to stay cognizant of lateral relations. The answer is yes. One might not be able to keep current concerning all lateral relationships; the same, moreover, is true of vertical changes. But it is neither necessary, nor can a manager keep track of all such changes. There is a middle ground, however, within which the manager can operate. The depth of horizon-

LINEAR RESPONSIBILITY CHART

Project Systems	Organizational Units (Functionally Organized)				
	Unit # I	Unit # II	Unit #III	Unit # IV	Unit # V
Project Overview	1,5,2	2,3,4	2,3,4	2,3,4	2,3,4
System A	3	1,2,5	2,3,4	2,3,4	--
System B	3	2,3,4	1,2,5	2,3,4	--
System C	1,5	2,3,4	2,3,4	--	3,4
System D	1,5	--	4	2,3,4	2,3,4
System E	3	1,2,5	2,3,4	--	2,3,4
System F	3	1,2,5	--	--	--

Assigned Responsibilities

1. Provides direction
2. Does work
3. Coordination required
4. Reviews and recommends
5. Approves

Figure 9

tal analysis and associated LRC charting depends on the manager. In any event the organizational world is becoming increasingly complex, consequently, the manager must adapt his tools to these new complexities.

A hird recommendation pertains to the use of committees. Too often, it appears, that committees fail because they are treated as something apart from the normal organization; too often they are treated or become as autonomous bodies. This concept is incorrect. As this study shows, successful committees are as much an integral part of the ongoing organization as any line unit. Together with line units they require: (a) competent members, (b) an able supervisor or chairman, and (c) an integration of their activities with the organization's overall activities.

For the Researcher

Four areas of study are recommended for further research. The first involves a broad criticism of the general lack of concepts which can be used by the practicing manager. The next two recommendations involve study of organizational areas which are broader, but related to the current study. The fourth, and last recommendation, is a study of the possible application of the concepts utilized in the MSC Apollo mission planning structure to social areas.

First, as indicated in the introduction of this chapter, there is a deficiency of concepts and associated techniques for developing lateral coordination patterns. While there have been a large number of experiments accomplished and broad theoretical

generalizatians developed in the fields of group dynamics, communications theory, decision-making and systems analysis, there is little or nothing available as a practicable, unifying concept by which a manager can systematically use this information. The best he can do is use the salt and pepper approach--a dash of group dynamics, a sprinkle of communications theory, a sprig of decision-making, and stir it together using the systems analysis approach. While recognizing that there is no magic formula available, there must be some better way to organize the currently available knowledge in order that it is better available for use.

The second area recommended for possible study is the entire MSC organization as a lateral coordinating mechanism. The MSC Apollo mission planning structure is but one of six types of different lateral coordination patterns (see Chapter IV) that Wesley L. Hjornevik, former Associate Director, MSC, identifies as being used in that organization.[3]

The third area recommended for possible study as a lateral coordination is the entire Apollo Program structure, including NASA Headquarters, the NASA field centers, Apollo contractors and, to a limited extent, other government agencies. There are a series of boards, panels, and working groups which unite these organizations in performing their Apollo functions. It should prove worthwhile to determine the effectiveness of a board, panel, working group structure across inter-organizational lines.

The fourth area recommended for study is the possible application of MSC Apollo mission planning lateral coordination patterns

to social areas. Many of the concepts utilized in the MSC Apollo mission planning structure are the same as those which Mary Parker Follett suggested for use in solving the Nation's social problems almost forty years ago. The time may now be ripe for her ideas.

FOOTNOTES

1. David I. Cleland and William R. King, Systems Analysis and Project Management (New York: McGraw-Hill, Inc., 1968), p. 196.

2. Ibid., p. 198.

3. Wesley L. Hjornevik, "Chapter IV, Guiding Working Relationships Among Scientific Engineering and Administrative Professionals," an issue paper prepared for the Program for Advanced Study in Public Administration, University of New Mexico, 1969, p. 25.

APPENDIX

APPENDIX

Dear Mr.

As you may be aware, for the past eight years I have been a member of Chris Kraft's staff. I am currently participating in a science administration fellowship program at the University of New Mexico. As part of that program, I am engaged in a project to document one of the management techniques which MSC has used in accomplishing the Apollo program objectives. The technique under study is the complex "system" of boards, panels and working groups that MSC used to achieve Apollo objectives associated with mission planning. As a key member of the Apollo mission planning team your assistance is solicited to arrive at certain determinations. Essentially what is requested is that you complete and return the attached questionnaire.

Why document this management technique? There are a number of reasons. First, the board-panel-working group structure developed somewhat informally at MSC. If it has proven to be a useful tool, we should take a closer look to see how it operates in order that it might be used even more effectively in the future. Second, a number of individuals have suggested that the management techniques used by NASA in managing the Apollo Program might be "state-of-the art" and should be applied to other problem areas. James Webb espouses this view and has said that he considers the <u>how</u> and <u>way</u> NASA managed Apollo: "may constitute as important a contribution to our Nation...to its ability to move...forward into the future...as the space capabilities themselves." It appears that MSC's development of this "system" of board-panel-working group structure to effect lateral coordination might constitute such an improved management technique. It therefore should be documented for possibly broader use in other organizations and other fields. Third, a leading management authority, Dr. Rensis Likert, University of Michigan, has developed a theoretical concept which embodies elements which appear very similar to the board-panel-work group structure. He suggests that this should be the way large, complex organizations develop <u>in the future</u> in order to coordinate complex R&D operations. If MSC's board-panel-working group structure is representative of his theoretical concept it could prove to be an important factor in the empirical verification of this concept.

With these considerations in mind I request your support to this project. As soon as the results of the questionnaire and other analyses related to this project are correlated, I will send you the results of the preliminary findings. Later, when the study is formally completed, a copy of that report will also be forwarded to you.

I would appreciate if you would return this questionnaire to me by Friday, March 13, 1970. If you have any questions or if there is some way that I may be of assistance to you, you may contact me at the address listed below or at the telephone number (Area Code 505: 265-1153).

My thanks for your assistance.

Yours sincerely,

Leslie J. Sullivan
320 Wellesley Place, N. E.
Albuquerque, N. M. 87106

Attachment

Addressee

Please return to:
Leslie J. Sullivan
320 Wellesley Pl. N.E.
Albuquerque, N. M. 87106

Phone: 505-265-1153

The MSC Apollo Mission Planning Board-Panel-Working Group Structure (Internal only)

On the following pages is a series of questions about aspects of the Apollo mission planning process. You are asked to select the answer which, in your opinion, is most appropriate. Indicate answer by a check ( ). If you feel more than one answer is appropriate indicate priority by marking by number with one (1), etc. indicating the highest priority. If you desire to comment about the issue posed by the question just jot it down in the question area or at the comment area at the end of the questionnaire.

Listed below are the boards, panels and working groups considered to constitute an essential part of MSC mission planning process. If you have additions, please indicate.

1. Apollo Spacecraft Configuration Control Board
2. Apollo Spacecraft Software Configuration Control Board
3. Crew Procedures Configuration Control Board
4. Data Priority Coordination (Mission Techniques Document Coordination) Working Group(s)
5. Data and Requirements Control Panel
6. Flight Operations Plan Meetings
7. Radiation Constraints Panel
8. Lunar Surface Operations Panel
9. Extravehicular Activity Task Force
10. Apollo Abort Working Group
11. Consumables Subsystem Working Group
12. Mission Change Review Group

Additions

_____

_____

_____

It is recognized that some of the above groups met infrequently; however, information is needed on all of the panels, etc. to develop a complete picture. Also, if you served on more than one panel, etc. it would be desirable if you would complete the questionnaire for each panel on which you participated.

For purposes of this study the time period under consideration is from July 1, 1968 to June 30, 1969. It is recognized that the answers in many instances may be subjective, but in any case, your best estimate will contribute to the total picture.

1. In what capacity did you serve on the board, panel, or working group?

____Head ____Member ____Both

2. What percentage of your time was devoted to the Apollo mission planning function?

____75-100% ____50-75% ____25-50% ____0-25%

3. What percentage of your time spent in Apollo mission planning was directly tied to work on board, panel, or working group (e.g. preparing for, attendance at, follow up)?

____75-100% ____50-75% ____25-50% ____0-25%

4. To what extent were the following principal functions of the board, panel, or working group?

	75-100%	50-75%	25-50%	0-25%
Horizontal coordination	____	____	____	____
Vertical coordination	____	____	____	____
Identifying problems	____	____	____	____
Providing solutions	____	____	____	____
Making decisions	____	____	____	____
Other (identify)	____	____	____	____
_____	____	____	____	____

5. How effective was the board, panel, working group in performing the following functions?

	Excellent	Good	Fair	Poor
Horizontal coordination	____	____	____	____
Vertical coordination	____	____	____	____
Identifying problems	____	____	____	____
Providing solutions	____	____	____	____
Making decisions	____	____	____	____
Other (identify)	____	____	____	____
_____	____	____	____	____

6. How effective was utilization of time in board, panel, working group meetings compared to utilization of time within your functional organization?

____much better ____better ____about the same
____not quite as good ____poor

7. What was the caliber of the individuals on the board, panel, working group compared to the caliber of the rest of the mission planning organization personnel of comparable grade level?

____much better ____better ____about the same
____not quite as good ____poor

8. To what extent did the board, panel, working group structure contribute to creative results?

____very much ____moderately ____not very much

9. To what extent were decisions arrived at by group participation rather than one individual making the decision at the board, panel, working group meetings?

____very much ____moderately ____not very much

10. To what extent did the board, panel, working group structure result in the members working, in effect, for two or more bosses?

____very much ____moderately ____little ____not at all

11. To the extent that the board, panel, working group structure did involve a person working for two bosses what difficulties were encountered?

____many ____moderate ____little ____none

12. To what extent did the board, panel, working group structure ensure that the proper personnel were involved in making mission planning decisions?

____very much ____moderately ____slightly

13. It is assumed that in the period from November, 1966 through March, 1967 (e.g. emphasis having shifted from Gemini to Apollo, etc.) there was a significant increase in the number of line supervisors who became members of various Apollo boards, panels, and working groups. Does such an increase in membership increase the capabilities of the boards, panels, and working groups?

____very much ____moderately ____slightly

14. To what extent does the "system" of boards, panels and working groups that finally evolved constitute a hierarchical arrangement similar to the formal organization?

____very much ____moderately ____slightly ____not at all

15. To what extent do you consider the complex of boards, panels, working groups to be an integrated system?

____very much ____moderately ____slightly

16. To the extent that the complex of boards, panels, working groups was a system, what was the principal integrating factor? Check appropriate block for each item.

	Very much	Moderate	Slight
Formal procedures	____	____	____
Members who were non-supervisors in their respective organizations	____	____	____
Members who were supervisors in their respective organization	____	____	____
Heads who were non-supervisors in their respective organization	____	____	____
Heads who were supervisors in their respective organization	____	____	____

17. What was the significance of the board, panel, working group structure in the Apollo mission planning process?

____Extremely important, mission planning could not have been accomplished without it
____Important, but functions it performed could have been accomplished by informal groups or other methods
____Not too important, functions it performed were peripheral to mainstream mission planning effort

18. To what extent did the board, panel, working group structure increase the overall quality of mission planning?

____75-100% ____50-75% ____25-50% ____0-25%

19. Was there a similar group, formally organized, performing the same functions for

A. Mercury? ____Yes If yes, its name was _____

____No, coordination performed informally

____Other _____

_____

B. Gemini? ____Yes If yes, its name was _____

____No, coordination performed informally

____Other _____

_____

20. To what extent did a similar hierarchy of semi-formal boards, panels, working groups exist under previous programs? (See list of Apollo groups at beginning of Questionnaire)

A. Mercury
____much more ____about the same
____slightly less ____much less

B. Gemini
____much more ____about the same
____slightly less ____much less

21. To what extent should a mechanism similar to the board, panel, working group structure be used in the future for other large, complex operations?

_____probably in most instances
_____moderately, depends on the circumstances
_____little, this is probably an isolated instance where it could be effective

22. Comments (Concerning MSC Apollo mission planning "system" of boards, panels and working groups or concerning its use as a management technique in the future; e.g. in looking back now would you improve the Apollo system of boards, panels and working groups?)

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