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AN INTERINDUSTRY ANALYSIS OF CERTAIN

ASPECTS OF PROJECT MANAGEMENT

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AN INTERINDUSTRY ANALYSIS OF CERTAIN ASPECTS OF PROJECT MANAGEMENT

CHAPTER I

INTRODUCTION

In recent years, the term "project management" has begun to appear in business literature. Virtually every article on project management defines its use in the aerospace and/or construction industries and contains a large portion of general description. It appears that nothing, however, has been written on the application of project management in other industries, nor has much been written to present a unified picture of the project manager and his organization. In this study project management is defined as the gathering of the best available talent to accomplish a specific, and often complex, undertaking within time, cost, and/or quality parameters, followed by the disbanding of the team upon completion of the undertaking.

Purpose of the Study

This study has two major objectives. The first is to seek answers to questions such as:

1. What is the basic structure of the "average" or typical project organization?
2. What differences exist among project organizations used in aerospace, construction, and "other" industries?
3. What are the principal functions of a project manager?
4. What is the project manager's position in the overall management structure?
5. What is the project manager's span of management?
6. What are the essential characteristics of a good project manager?

The second objective is to obtain data from a sampling of firms in diverse industries that are presently using project management in order to scrutinize the above aspects of project management.

Scope of the Study

Although there is no official list of firms using project management, the "business" section of Moody's Industrial Manual, 1966, has been used as a guide in constructing one. An attempt has been made to contact firms thought to be using project management and original and follow-up questionnaires have been sent to more than 200 of them. Not all possible phases of the project organization and project management could be treated in this paper; rather, only the questions which appear to be of most interest in current literature have been considered for analysis. (The questionnaire sent to the participating firms is exhibited in Appendix C.)

Procedure of the Study

In making this analysis, four approaches have been taken to obtain the necessary data:

First, the current literature has been searched to ascertain what had thus far been published concerning project organization and the project manager.

Second, nine weeks have been spent on the job at the Manned Spacecraft Center in Houston, Texas, determining the nature of project management and observing how it functions. During this time, numerous interviews were conducted with the personnel of Project Apollo and North American Aviation, the largest NASA contractor for Project Apollo.

Third, questionnaires have been sent to firms throughout the nation that might be using project management.

Fourth, a field trip has been undertaken to four large eastern firms, and to a midwestern governmental agency. The purpose has been to gather additional data on the questions under analysis and to obtain information on several topics not covered in the questionnaire. These latter topics deal with the interrelationships which exist within the project organization and between the project and permanent organization.

<u>Structure of the Dissertation</u>

In Chapter II project management and project organization are defined and explained. The operations of a project organization are described in Chapter III with the Apollo Spacecraft Program Office used as a model. The results of the questionnaire analysis, compiled from the responses of seventy firms in aerospace, construction, and "other" areas, are reported in Chapter IV. The aspects under analysis in these areas are explained, and the conclusions reached are dealt with in the tables and charts. In Chapter V, information obtained through interviews in various industries on the topic of the project manager's authority (a topic not covered in the questionnaire) is presented. In this chapter, the analysis of project management across industry lines is completed. The conclusions of the study, as well as the recommendations, are presented in Chapter VI.

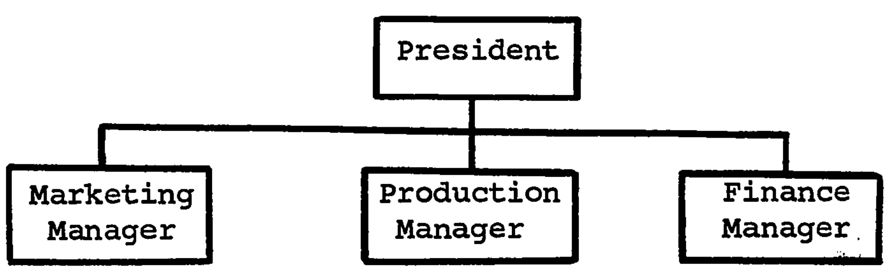
WHAT IS PROJECT MANAGEMENT?

CHAPTER II

The first phase of this research is an explanation of project management. For this explanation, a search of the related current literature has been undertaken.

All well run business, military, and church organizations have predetermined objectives and tailor-made organizational structures to assist them in attaining their objectives. The basic or organic functions are ascertained and the organization is structured to encompass them. The three main functions which must be performed in a manufacturing enterprise, for example, are production, finance, and marketing. Therefore, its basic organization chart will be as follows:

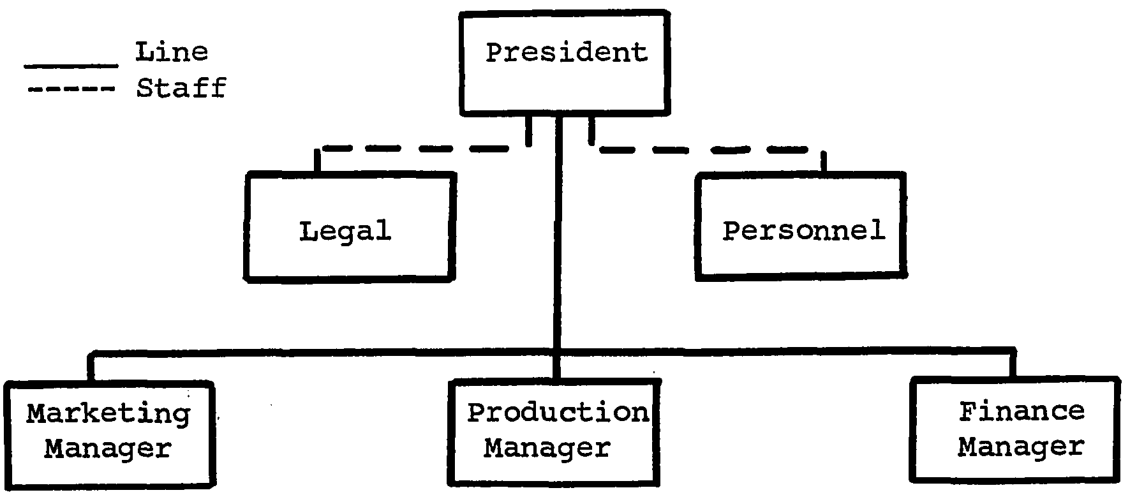
Diagram 2-1



A further breakdown of the organization will then be dependent on the particular objectives desired by the enterprise.

As the organization grows in size from this simple origin, staff departments such as legal and personnel may become necessary. The organization will then take the following form:

Diagram 2-2



Both these organization charts, while simple in design, contain the basic fundamentals of a line, or a line-staff, organization. These are two basic types of organization used in industry today. The fundamentals or principles of these types of organizations include such well-known concepts as the need for clearly defined objectives, the scalar principle, the principle of unity of command, the span of management principle, and all others that fall into this area of classical organization principles. In the past few years, however, another type of management has drawn much interest through its increased use in American industry. This is project management.

A Description of Project Management

Project management is defined in this research paper as the gathering of the best available talent to accomplish a specific and complex undertaking within time, cost, and/or quality parameters, followed by the disbanding of the team upon completion of the undertaking. Its definition should be construed in terms capable of encompassing a host of different organizational forms and diverse project objectives.[1]

If the organization cannot spare the personnel for the project or if it has no individuals with the required expertise, then recruiting of team members from outside the firm is necessary. The individuals who become a part of the project manager's team are chosen because they can directly contribute something to the project. Many are professionals or

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[1]A project organization could be used for any of the following undertakings: developing a new type of process for flour, redesigning a distribution system, designing a bank credit card system, or finding a cure for cancer.

persons highly skilled in a specific area. For these reasons, it is quite common for the team to be hand-picked. Thus, they represent the best available talent.

The project is specific in that the objective is clearly understood before the project is begun. It is complex and involves an undertaking that is unique in some way. The construction of bridges, dams, and tunnels would fit this definition, whereas the construction of several hundred homes, all alike in design and layout, would not. It is, therefore, possible that an undertaking which calls for project management by one organization would not warrant such treatment in a larger organization more knowledgeable in the area. Included under the term "complex" are the size and expense of the project, which are quite large.[2]

Trade-offs between time, cost, and quality parameters are often required to attain the best possible mix. Time would be important in the instance of a crash program or a project which is only part of a larger program and which must be coordinated with that program. Cost would be a parameter when the project is budgeted. Quality would be a parameter when the objective must pass certain quality tests before it is accepted.

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[2]John M. Stewart, "Guides to Effective Project Management," Management Review, Volume LV, (January, 1966), p. 62.

Finally, when the project is completed, the team members either go back to their original positions in the permanent organization, or, if they were hired from outside for this project exclusively, they are terminated. It is possible, of course, that a new project may be undertaken and the personnel could be transferred to it from the old project. In any event, the old project organization is discontinued or "deprojectmanagerized."[3]

The Genesis of Project Management

Project management could be traced back to the beginning of time if one wishes to stretch his imagination. Primitive men forming into a group for the expressed purpose of setting upon and killing a wild animal could be considered a project group or organization when this was done for the first time. It would be a unique and complex situation for the participants and would meet the criteria for project management set forth in the previous section. Moving further through history, the Pyramids and other great construction feats, from the Great Wall to the Panama Canal, could also be envisioned as examples of project management. Nor should *ad hoc* commit-

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[3]John F. Mee, "Ideational Items-Project Management," *Business Horizons*, Volume VI, (Fall, 1963), p. 53.

tees be overlooked, for some would qualify under the definition given previously.

The primary purpose here is not to trace the historical development and use of this concept. Rather, it is to ascertain the genesis of project management. Since it has only been in the last twenty-five years that project management has come to prominence as a method of organizing, most individuals when speaking of the genesis of project management prefer to talk of more modern uses of it. The chief guideline in their choice is that the project be more highly complex than those of earlier times. The project chosen most often by writers in business literature to demonstrate the genesis of project management is the Manhattan Project. Appendix A contains a personal letter bearing out this point from one of the current writers in the area of project management.

The Manhattan Project gathered the best available talent for its undertaking. It canvassed the country's universities for knowledgeable scientists, and it brought over from Europe scientists to complete the team. The project's objective was specific--to produce an atomic bomb. The project was complex because nothing like it had ever been done before, even though the theory had been established by

1939.[4] Time and quality parameters were major factors while cost was not. Once the project was completed, the group disbanded; some went to the Hydrogen Bomb project, and others returned to their former positions.

The origin of project management is thus a matter which can be determined only by intelligent conjecture. If the reader wishes to deal with modern project management in a highly sophisticated form, the Manhattan Project is the best starting point.

The Project Organization's Structure

The size and structure of a project organization can vary. In the opinion of one author in current literature, the four following diagrams outline the basic types of project organizations.

In Diagram 2-3, the project manager runs the project and is responsible directly to the president or a top company official. Any functional areas needed for the project are present in his project organization and the individuals report directly to him.

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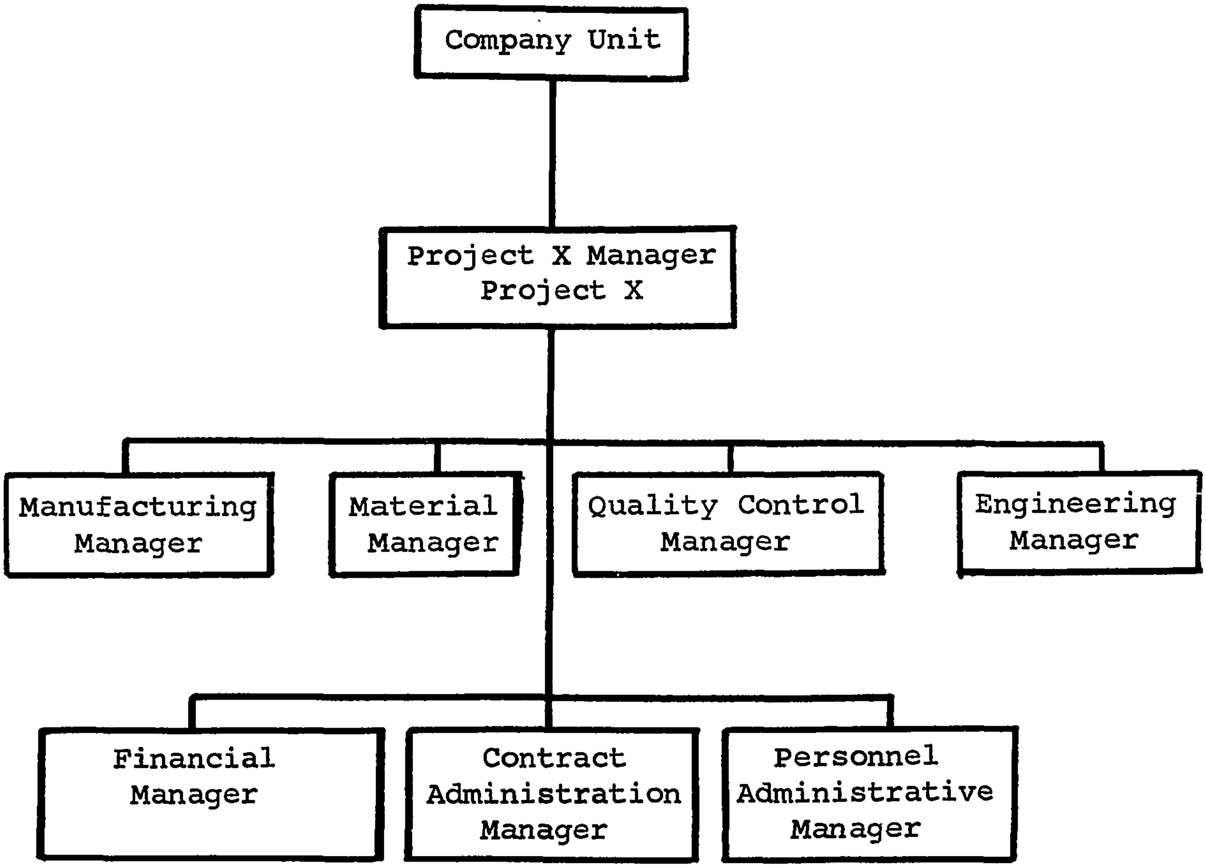
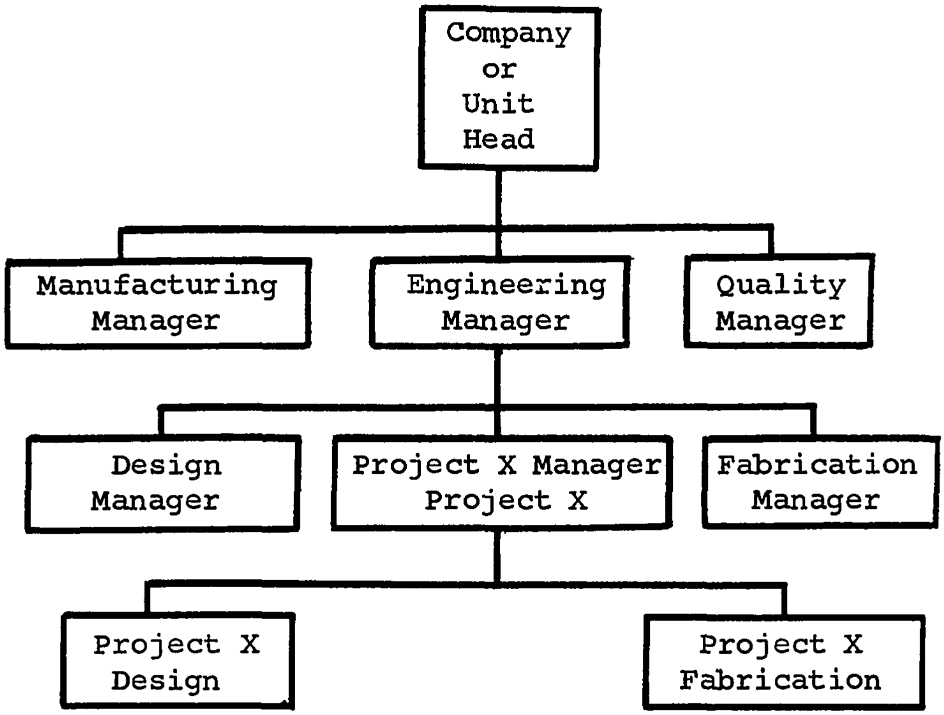
[4]Richard A. Johnson, Fremont E. Kast, and James E. Rosenzweig, The Theory of Management and Systems, (New York: McGraw-Hill, 1963), pp. 116-17.

Diagram 2-3



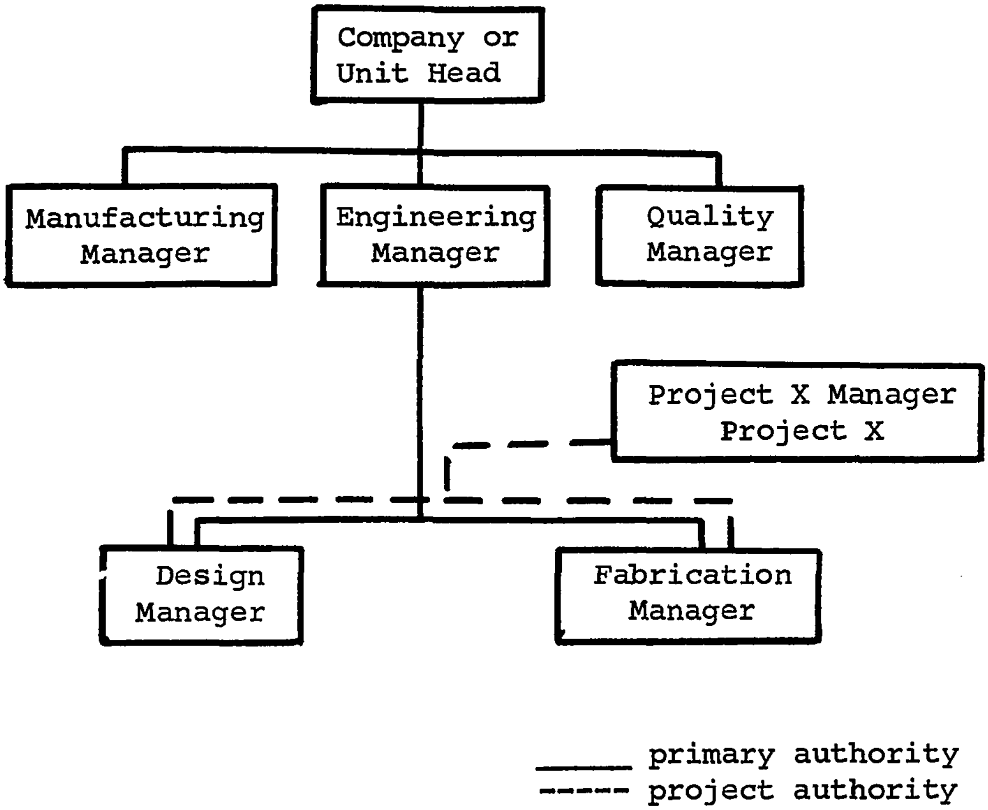
In Diagram 2-4 the same relationship exists between the project manager and his team as it did in Diagram 2-3. The difference is that the project organization is now within one of the company's departments, in this instance, the engineering department.

Diagram 2-4



In Diagram 2-5 the relationship between the project manager and his team has changed from that designated in Diagrams 2-3 and 2-4. Here the project manager has project authority only, and the engineering manager has primary, or line authority, over the team. This means that the project manager has authority over the design and fabrication managers only in matters dealing with the project. The latter two managers are also working on matters other than the project, and when doing so, they report to the engineering manager.

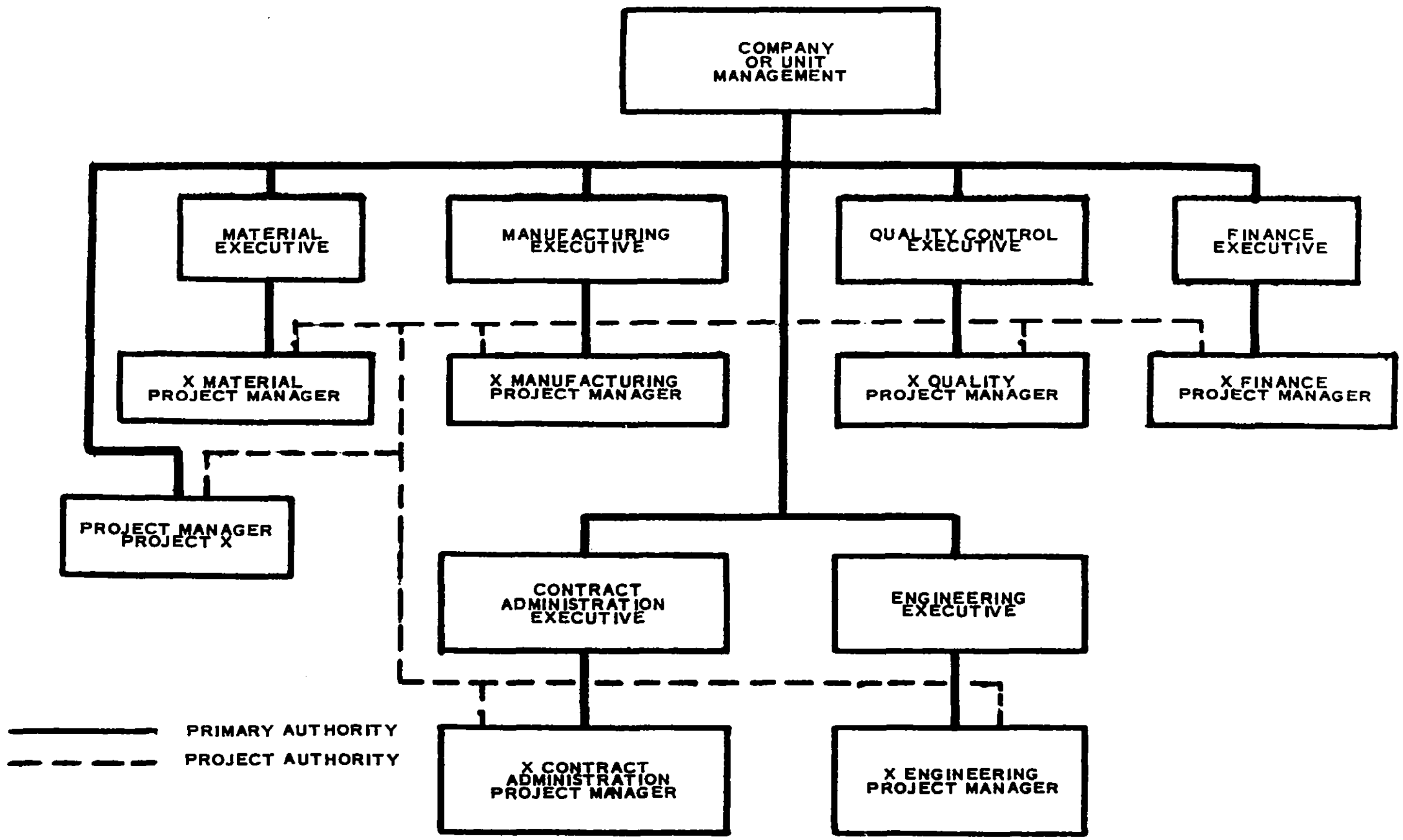
Diagram 2-5



In Diagram 2-6 on the following page, there are six project managers in each of the six functional areas. Each manager is directly responsible to the head of his respective functional department. The project manager of the entire project, located at the extreme left of the diagram, is charged with coordinating these individual project managers.[5]

[5]Allan Jangar, "Anatomy of the Project Organization," Business Management Record, New York, NICB Inc., (November, 1963), pp. 12-14.

Diagram 2-6


COMPANY OR UNIT MANAGEMENT
MATERIAL EXECUTIVE
MANUFACTURING EXECUTIVE
QUALITY CONTROL EXECUTIVE
FINANCE EXECUTIVE
X MATERIAL PROJECT MANAGER
X MANUFACTURING PROJECT MANAGER
X QUALITY PROJECT MANAGER
X FINANCE PROJECT MANAGER
PROJECT MANAGER PROJECT X
CONTRACT ADMINISTRATION EXECUTIVE
ENGINEERING EXECUTIVE
X CONTRACT ADMINISTRATION PROJECT MANAGER
X ENGINEERING PROJECT MANAGER
PRIMARY AUTHORITY
PROJECT AUTHORITY

In order to do this, it is evident that he must exercise considerable tact. Each of his functional project managers is responsible to him in project matters only. If the chief project manager is unable to obtain the performance he deems essential from a functional project manager, it is necessary for him to go through the respective functional department head to obtain corrective action. Thus, the project manager depends very heavily on the functional department heads to assist him in keeping the functional project managers within time, cost, and quality parameters. As in Diagram 2-5, the project manager has project authority and the functional managers have primary authority.

These four project organization charts can be thought of as being on a continuum, running from Diagram 2-3, where the project manager has his own group and possesses full authority in controlling it, to Diagram 2-6, where the project manager is heavily dependent on others.

Differences Between the Project and Permanent Organization

The line-staff organization has certain characteristics which distinguish it from the project organization.

First, the line-staff organization is a vertically structured organization. Authority runs from the top of the organization to the bottom. This is also true in some project organizations, as evidenced in Diagrams 2-3 and 2-4. In Diagrams 2-5 and 2-6, however, the organization is structured horizontally, because the project manager draws his team personnel from numerous functional areas. Thus, his authority is cutting across and conflicting with the normal organizational structure.[6] This often leads to a conflict between the project organization and the line-staff organization as a result of his cutting across and conflicting with the normal organizational structure.[7]

In the line-staff organization the functional manager has the authority to tell his staff what he wants done, and when and how they should do it. In project organizations such as those depicted in Diagrams 2-5 and 2-6, the project manager can tell the functional managers what he wants done and when he wants it done. However, how it will be done will be determined by the respective functional department.[8]

In a line-staff organization, each manager deals pri-

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[6]David I. Cleland, "The Project Manager-Manager Extraordinary," Defense Industry Bulletin, Volume V, (May, 1965), p. 2.

[7]John M. Stewart, "Guides to Effective Project Management," Business Horizons, Volume VIII, (Fall, 1965), p. 60.

[8]David I. Cleland, "Why Project Management," Business Horizons, Volume VII, (Winter, 1964), p. 82.

marily with one specific functional area. In a project organization the project manager often has to bring together diverse activities such as research, engineering, testing, and production.[9] This interfunctionalism is evidenced in all four diagrams.

In a line-staff organization, direct authority is possessed by the superior. In a project organization, however, the project manager does not have complete line authority over his own staff. He defines the job to be done, establishes the schedules, controls the funds, and maintains primary contact with the outside customer, if there is one. When relying upon his immediate staff or when using the services of those assigned to him on a part-time basis, he possesses what is called in the current literature "project authority." This is authority in project matters only.

In the line-staff organization, the individual managers possess the authority to promote and reward their subordinates in various ways. In the project organization, the project manager directs the team in the project but has little control over their promotions or raises.[10]

In a line-staff organization, the principle of unity

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[9]Cleland, Defense Industry Bulletin, p. 2.

[10]Cleland, Business Horizons, p. 84.

of command is adhered to very closely. In a project organization, this principle is often violated.[11] This was evidenced in Diagrams 2-5 and 2-6 where project authority was in use and the workers had two superiors.

In a line-staff organization, the firm has successive objectives and will exist indefinitely if its objectives are accomplished as planned. In a project organization, the entire organization will go out of existence once the objective is completed. Thus, the project organization works itself out of a job.[12]

In a line-staff organization, there is often a small percentage of professionals. In the project organization, however, virtually everyone falls into this category.[13]

Finally, in a line-staff organization, there are many repetitive tasks. Many similar problems will develop day after day. In the project organization, the problems and tasks are new and present unique or unusual situations. This is the reason for the assembling of a special team to handle

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[11]Cleland, Defense Industry Bulletin, p. 15.

[12]Paul O. Gaddis, "The Project Manager," Harvard Business Review, Volume XXXVIII, (May-June, 1959), pp. 90-91.

[13]Paul O. Gaddis, "Project Management," Encyclopedia of Management, ed. Carl Heyel (New York: Reinhold Publishing Co., 1963), II, p. 767.

the matter. There is an opportunity for all to concentrate on one major objective and the unique problems associated with it. Repetitive tasks can be handled by the functional organization. For example, in building the Apollo spacecraft, North American Aviation's project organization handles all the parts that are special items. Nuts, bolts, and other common items are produced for the project organization by the functional organization.

As shown in this chapter, the organizational form can be diverse. Thus, a case study of a project organization can be helpful in depicting the manner in which a project is carried out in actual practice. In Chapter III such a case study is presented.

A CASE STUDY: NASA'S APOLLO SPACECRAFT

PROGRAM OFFICE AT HOUSTON

CHAPTER III

The second phase of this research is a case study of project management at work, which has been undertaken to:

1. Clarify and amplify the information presented in Chapter II by showing project management in action,

2. Determine what questions about project management would be pertinent to a survey by questionnaire, and

3. Gather through personal observation information about project management which might not be obtainable through questionnaires.[1]

The most publicized application of project management appears in the aerospace industry. The largest project within this industry is the United States' manned spaceflight undertaking, placed under the supervision of the National Aeronautics and Space Administration (NASA) by President

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[1]It was essential, for example, to determine the major strengths and weaknesses of the project management approach, which could best be done through direct observation.

Eisenhower.[2] The undertaking has been divided into three distinct projects: Mercury, Gemini, and Apollo.

Project Mercury's primary objectives have been to:

1. Investigate man's capabilities in the space environment.

2. Develop manned space flight technology for use as a basis for the conduct of much more ambitious undertakings, including additional manned exploration of space and the planets.[3]

Project Gemini's primary objectives have been to:

1. Provide a logical follow-up to Mercury with a minimum of time and expense.

2. Subject two men and supporting equipment to long duration flights.

3. Effect rendezvous and docking with another orbiting vehicle, and to maneuver the combined spacecraft in space, utilizing the propulsion system of the target vehicle for such maneuvers.

4. Experiment with astronauts leaving the Gemini spacecraft while in orbit and determine their ability to perform extravehicular activities.

5. Perfect methods of re-entry and landing of the spacecraft at a pre-selected landing area.

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[2]NASA, Historical Sketch of NASA, (Washington, D.C.: NASA, 1965), pp. 6-9.

[3]NASA, Fact Sheet #195: Mercury Program, (Houston, Texas: NASA, 1965), p. 1.

6. Gain additional information concerning the effects of weightlessness, and physiological reactions of crew members during long duration missions, and other medical data required in preparation for the lunar missions of the Apollo program.

7. Provide the astronauts with required zero-gravity rendezvous and docking experience.[4]

Project Apollo's primary objective has been stated by the late President Kennedy when he said, "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to earth."[5] The specific objectives of Project Apollo are to:

1. Land two men on the moon.

2. Make limited exploration in the landing area.

3. Return the astronauts to earth safely with their lunar samples and photographs.[6]

To accomplish these objectives a lunar vehicle and spacecraft must be constructed, operating techniques must be worked out, and a flight program must be developed.

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[4]NASA, Fact Sheet #291: Gemini Program, (Houston, Texas: NASA, 1965), p. 1.

[5]John F. Kennedy, Second State of the Union Address to the Congress, May 25, 1961.

[6]NASA, Fact Sheet #292: Apollo Program, (Houston, Texas: NASA, 1965), p. 1.

Vehicle and the Lunar Mission

In order to understand how project management functions in the space program, a knowledge of the lunar vehicle and its mission is necessary. All spacecraft figures alluded to in this chapter are located in Appendix B.

The space vehicle the United States will use on its first lunar mission will be the Saturn V, which consists of two major parts, the boosters and the spacecraft. There will be three boosters on the Saturn V; the spacecraft will be placed on top of the third booster.

The first state will lift the vehicle off the launch pad. The second stage will then take over and carry the spacecraft to a predetermined height when it, too, will be dropped away. The third stage will put the spacecraft into earth orbit; and, once everything has been checked out on the spacecraft to prove it is ready for the lunar mission, the booster will carry it out of the earth's orbit and into space.

The spacecraft will consist of four distinct parts. On the top of the spacecraft will be a launch escape subsystem. If something should go wrong on the launch pad or during the initial phase of the flight, the escape subsystem will propel that part of the spacecraft carrying the crew away from the spacecraft proper and protect them from any danger. If all goes well, it will be jettisoned from the space vehicle when a predetermined height has been attained.[7]

The command module which is depicted in Figure 3-1 will be located directly beneath the launch escape subsystem. This part of the spacecraft will house the flight crew, the equipment necessary to control and monitor the spacecraft's systems, and the equipment for providing comfort and safety to the crew.[8]

The service module shown in Figure 3-2 will be placed just behind the command module. It will house the primary spacecraft propulsion subsystem, a reaction control subsystem, fuel cells and associated equipment for providing electrical power, and radiators for environmental control and electrical power subsystems for cooling.[9]

The lunar excursion module and adapter pictured in Figure 3-3 will be situated behind the service module. The lunar excursion module (LEM) will be contained within the adapter and the latter will rest directly on top of the boosters. Once the booster carries the spacecraft out of the

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[7]NASA, Apollo Spacecraft Project Development Plan, (Washington, D. C.: NASA, 1965), p. 10.

[8]*Idem*.

[9]*Ibid*., p. 11.

earth's orbit and into space, the adapter will be separated from the command and service module. The adapter will open up, and the command and service module (CSM) will then be turned around and the nose of the CSM will be docked in the "top" of the LEM and bring the LEM out of the adapter. Next, the CSM will be turned around and headed for the moon, pushing the LEM in front of it. The adapter and the remaining booster will be left behind.

When the CSM and the LEM arrive near the moon, two of the three astronauts will leave the command module through its nose and enter the LEM. Once in lunar orbit, the two vehicles will separate, and the LEM will go down and land on the moon. One of the astronauts will leave the LEM, carry out his assigned tasks, and return to the LEM. The two astronauts will then leave the surface of the moon via the LEM's ascent rocket engine and return to lunar orbit. The descent stage of the LEM will be left on the moon's surface. The ascent stage of the LEM will dock with the CSM in lunar orbit; and the two astronauts will return to the CSM, which will then leave the moon's orbit and start back for earth. The ascent stage of the LEM will remain in lunar orbit.

When the astronauts are ready to begin their descent into earth's atmosphere, they will check their position, drop off the service module, and begin their descent. Once they get through the atmosphere, three sets of chutes will break their fall. If all goes well, they will hit the water at about 20 miles an hour at, or close to, a predetermined point. The mission is shown in detail in Figure 3-4 in Appendix B.

The Contractors

To build a spacecraft capable of putting a man on the moon, NASA solicited contractor bids for the necessary hardware. This consists of the CSM (including the launch escape subsystem and the adapter), the LEM, Spacesuits, Acceptance Checkout Equipment, a Guidance and Navigation System, and some Mission Simulators.

The spacesuits are to be designed and built so that they are capable of providing safety and comfort to the crew during flight missions, whether within the command module or outside of it.

The Acceptance Checkout Equipment for the spacecraft is equipment capable of accomplishing this essential task in far less time than would be needed if it were done "manually" by a group of engineers. It has a command system which sends instructions to a computer. These instructions are received and interpreted by the computer which, in turn, sends appropriate instructions to the equipment under test. The test results are sent back to a display system, and the actual and desired results can be compared. Thus, much of the spacecraft can be checked out quickly and efficiently with this equipment.[10]

The Guidance and Navigation System is concerned basically with the midcourse correction changes that must be made by the spacecraft both on its trip to the moon and on its return. It contains instrumentation which will enable the crew to ascertain their position and a computer which will tell them what change(s) will be necessary.

The Mission Simulators are used as mission trainers for the flight crews. These simulators can be integrated with the Houston Mission Control Center so that an actual mission can be simulated. In this way, they can provide training for the flight crew and the group operating the control center simultaneously.[11]

The contractors building this equipment are also responsible for the ground support equipment which goes with

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[10]General Electric, Acceptance Checkout Equipment-Spacecraft, (Daytona Beach, Florida: General Electric).

[11]NASA, Apollo Spacecraft Project Development Plan, pp. 17-18.

the hardware. This ground support equipment consists of any non-flight implements or devices required to inspect, test, adjust, calibrate, appraise, gauge, and/or repair anything supporting the Apollo spacecraft.[12] Each of the prime contractors establishes the ground support equipment requirements for the part of the spacecraft he is building for the Manned Spacecraft Center. After these requirements are approved, the contractor is responsible for designing, manufacturing, and/or procuring the equipment.

Out of five competing companies, North American Aviation (NAA) has been awarded the coveted prime contract on the CSM, and with nine firms bidding, the Grumman Aircraft Engineering Corporation has been awarded the prime contract for the LEM. Other contracts and the companies which have been awarded them are: the Acceptance Checkout Equipment for the spacecraft, General Electric; the design of the Guidance and Navigation system, Massachusetts Institute of Technology; the manufacture of the Guidance and Navigation system, A. C. Electronics; the Mission Simulators, Link Corporation; and the Spacesuits, Hamilton Standard and International Latex. The magnitude of the project is evidenced in Figures 3-5 and

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[12] Ibid., p. 15.

3-6 in Appendix B where the names and respective locations of the contractors are shown.

Functions of the Three Space Centers

In carrying out Project Apollo, key roles are played by the Marshall Space Flight Center, in Huntsville, Alabama; the Kennedy Spacecraft Center at Cape Kennedy, Florida; and the Manned Spacecraft Center (MSC) located in Houston, Texas. The Marshall Center is charged with the building of the boosters for the space vehicles;[13] the Kennedy Center is responsible for handling the Apollo launch operations, facilities, and common ground support equipment;[14] and the MSC is charged with developing the Apollo spacecraft and its ground support equipment, as well as supporting any manned space flight missions.

Figure 3-7 depicts NASA's organization chart. The three space centers associated with Project Apollo are located within the Office of Manned Space Flight. Figure 3-8 shows the organization structure of the MSC, within which the Apollo Spacecraft Program Office (ASPO) is located.

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[13] NASA, Apollo Program Development Plan, (Washington, D. C.: NASA, 1966), pp. 1-2.

[14] Idem.

The Apollo Spacecraft Program Office

The ASPO is a project organization that has been formed for the specific purpose of monitoring the contractors mentioned previously. The head of the ASPO reports directly to the head of the MSC, but is responsive to program direction from NASA's Apollo Program Director.

The official functions designated to the ASPO are the following:

1. Program planning, including the preparation of preliminary and final project development plans and mission plans.

2. Supervision and direction of industrial contractors in the performance of contract work, including preparation of statements of work and other documents defining the responsibilities of the contractor; direction and supervision of contractor's work within the scope of the contract; and determination and implementation of required changes in the scope of work through the appropriate contracting office.

3. Determination of all schedules relating to the spacecraft and integration with the overall program schedules, including the review and approval of PERT networks.

4. Overall spacecraft systems engineering and integration, including engineering design work and systems engineering studies conducted by the contractors.

5. Planning and coordinating the individual flight missions.

6. Supervising and monitoring of the working

relationships between all contractors and NASA groups participating in the program and the resolution of interface programs.

7. Determining the work to be done in support of the program by other elements of the MSC within mutually agreed upon types and levels of effort.

8. Preparing program-cost estimates and assisting in integrating program funding requirements into the overall MSC and NASA budgets and other financial documents.

9. Collecting and consolidating the program reports from the contractors and preparing reports to meet the needs of the Director, other MSC organizations, and NASA headquarters.

10. Developing a ground and flight test program and arranging for the monitoring of these tests by either the contractor or the MSC, as appropriate.

11. Maintaining close liaison and working relationships with the vehicle and the tracking system managers, as well as resolving interface problems.

12. Establishing or appointing representatives or working groups or committees to facilitate program work.

13. Appointing and supervising Resident Apollo Program Office Managers at the principal work place of selected program contractors to report to the ASPO and to coordinate the direction and information at the contractor's plant.

14. Developing agreements with other NASA centers to work in support of the Apollo spacecraft projects.[15]

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[15]NASA, Apollo Management Manual, (Houston, Texas: MSC, 1964).

The ASPO is directly responsible for determining that contractors are within the time, cost, and quality parameters established by the contract. The contractors are also responsible for these parameters, as evidenced by the investigation of the Apollo spacecraft fire in January, 1967. The ASPO continually receive reports from the contractors and work along with them to prevent and overcome problems. The ASPO defines the test program; controls the building of the hardware, including changes; and maintains strong financial control of the project. In performing its tasks, the ASPO relies heavily on the support of the rest of the MSC. One of the important functions of the MSC Offices, shown in Figure 3-8, is providing this support. Before discussing how the ASPO's departments work and interface (coordinate) with the contractors, there are two concepts that must be presented because they are prerequisites to an understanding of project management within the ASPO. These are "configuration management and control" and "subsystem management."

Configuration Management and Control.--It is the responsibility of the ASPO to see that the spacecraft is built on schedule and within cost and quality parameters. Therefore, it is necessary to set up a method for both allowing and controlling changes made on the spacecraft. Once the spacecraft's objectives are determined, the contractor draws a preliminary design for the particular piece of hardware to be built. The design is reviewed by the ASPO, and, if everything appears to be correct, the contractor then designs the piece of hardware in detail. It is again reviewed when it is about 90% completed and a third time when it is completely designed. After the last two critical design reviews are completed, the piece of hardware is produced. A fourth review is then held to ascertain how close the item "as built" has come to the item "as designed." There is, finally, a fifth review, called the customer acceptance readiness review, which certifies that the piece of hardware meets specification requirements. The five reviews listed do not encompass all the reviews made but are the ones for which the ASPO is responsible. This reviewing process is called "phased programming" and is widely used by the ASPO. These reviews are shown in Figure 3-10. Once the basic design is approved, it serves as an initial baseline. This is what is meant by configuration management, e.g., building to a given configuration. By defining the hardware in term of specifications, a base is established for setting up schedules and program budgets so that formal control can be attained.

Any changes that are desired must be sent to a Configuration Control Panel (CCP) or Board (CCB), as shown in Figure 3-11. If the cost of the changes does not exceed $300,000, if there is only one system involved (CSM, LEM, Guidance & Navigation, Checkout Equipment or the Spacesuits), and if the changes will not affect the delivery schedule of the item, the CCP can handle it. The CCP is headed by the ASPO manager who is directly responsible for that piece of hardware. If it does not meet these three conditions, it must go to the CCB. The latter will meet with both ASPO and contractor personnel to obtain their opinions on the recommended change(s). A decision will then be made.

If a mandatory change arises, the contractor can be ordered to make the change before the ASPO fully evaluates the cost and schedule impact. The lower portion of Figure 3-11 illustrates this point about cost and schedule impact. Changes necessary to a launch are made immediately because they are mandatory. The evaluations of the cost and schedule impact of these changes must, however, be completed and sent to the MSC within sixty days. The entire process of building to a given configuration, and of deciding whether to allow changes to it, is called "configuration management and control."

<u>Subsystem Management</u>.--The ASPO, while it is charged with having the five pieces of equipment built, is dependent on the rest of the MSC for assistance. In using this assistance, the head of the ASPO relies most heavily on the Engineering and Development Office (E&D), shown in Figure 3-8, at the MSC. The head of E&D by previous agreement has assigned various engineers to work as subsystem managers for the CSM and the LEM. Each subsystem manager is assigned one of the subsystems on the CSM or LEM. The subsystem manager is responsible for the successful development of his particular subsystem, and he interfaces with an equal in the contractor's organization.

The specific functions of a subsystem manager are to:

1. Monitor the contractor's engineering effort related to the subsystem and associated ground support equipment design.

2. Monitor the contractor's implementation of applicable specifications.

3. Manage the contractor's and subcontractor's efforts related to subsystem development testing.

4. Manage, or initiate and conduct, as required, supporting subsystems studies and test programs to be conducted by E&D. Also, to initiate, and coordinate, as required, supporting subsystem and test programs to be conducted by the MSC.

5. Establish subsystem development schedules within the framework of the module or system development schedule, and insure that the contractor is meeting the sched-

ules. Also, to review and analyze subsystem schedule statuses and provide the ASPO with specific subsystem schedule information.

6. Monitor the contractor's and subcontractor's implementation of subsystem reliability efforts.

7. Review contractually required documentation as appropriate.

8. Support the quality control effort by providing information concerning quality control requirements for subsystems to the ASPO; review the quality control test and inspection procedures for subsystem components in conjunction with the RASPO at the contractor's site.

9. Support the ASPO by providing acceptance checkout equipment interface and checkout requirements for the subsystem.

10. Support the failure data center activity by providing appropriate inputs on failures occurring during development tests.

11. Provide the ASPO with detailed spacecraft interface information related to the scientific payload.

12. Provide the ASPO with specialized systems information in connection with preliminary and detailed test planning related to flight and integrated systems ground tests.

13. Provide the ASPO with specialized systems information in connection with specific mission plans.

14. Provide the ASPO with basic measuring requirements for the subsystems.

15. Provide, in accordance with procedures prescribed by the ASPO, detailed subsys-

tem resources requirements for use in budget development.

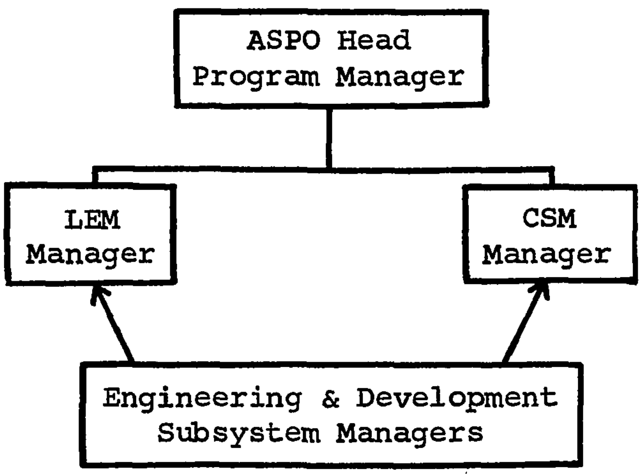
16. Provide the ASPO the logistic requirements related to the subsystem.

17. Support, as requested by the ASPO, contract negotiation efforts, including associated preparation and review.

18. Exercise control over the MSC's contacts with contractor personnel.[16]

The relationship between the head of the ASPO, his two direct assistants, each of whom is directly responsible for one of the two main pieces of hardware, and the subsystem managers, is illustrated by the following diagram:

Diagram 3-1

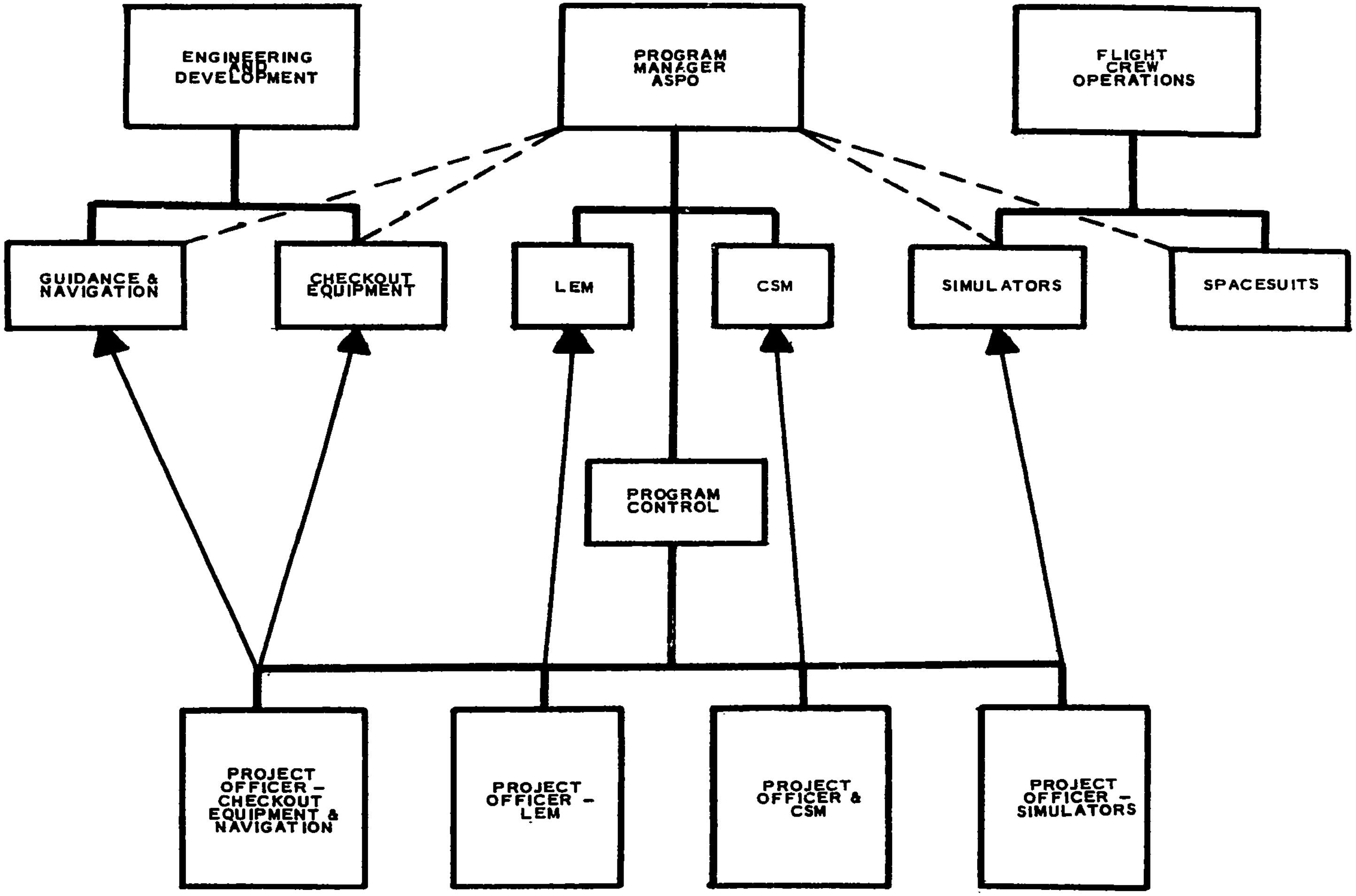


[16] *Idem*.

Although the subsystem managers support the head of the ASPO, they are within the Engineering & Development Office and responsible to the head of it. There are other subsystem managers who have been appointed for the checkout equipment, the guidance and navigation system, the simulators, and the spacesuits. Some of these are from Engineering and Development and some come from another MSC Office, Flight Crew Operations. The diagram on the following page shows the entire ASPO management organization in this area of subsystem management.

The Program Manager has the authority over the six pieces of hardware. His two assistants are handling the LEM and CSM for him. They both receive reports from the subsystem managers concerning the progress of the contractors on the various subsystems. In turn, bi-weekly PERT printouts, monthly reports showing the status of the subsystem, and similar kinds of data, all of which are a result of information given to the ASPO by the contractors on a prescheduled basis, are supplied to the subsystem managers. The flow of reports between all parties is shown in Figure 3-12. Although these managers oversee the contractor, they do not give orders to him. The Project Officers, shown in Diagram 3-2, do this. Any official correspondence flowing between the contractor and the ASPO flows through the respective project officer.

Diagram 3-2


ENGINEERING AND DEVELOPMENT
PROGRAM MANAGER ASPO
FLIGHT CREW OPERATIONS
GUIDANCE & NAVIGATION
CHECKOUT EQUIPMENT
LEM
CSM
SIMULATORS
SPACESUITS
PROGRAM CONTROL
PROJECT OFFICER – CHECKOUT EQUIPMENT & NAVIGATION
PROJECT OFFICER – LEM
PROJECT OFFICER & CSM
PROJECT OFFICER – SIMULATORS

To understand how project management works in this complex undertaking, it is essential to perceive the relationship between the ASPO, the MSC offices, and the contractor.

The ASPO Offices

Each office in the ASPO, illustrated in Figure 3-9, plays a vital role in managing the project.

Resident Apollo Spacecraft Offices. The Resident Apollo Spacecraft Offices (RASPO's) are the ASPO's on-site representatives at the contractor's plants. All correspondence being sent to the contractor by NASA first goes through the RASPO, if there is one at the contractor's plant. This office is NASA's official interface with these contractors. Its job entails coordinating the activities of and providing administrative services to NASA representatives from the Marshall Space Flight Center and the MSC, as well as other governmental agencies.[17]

Reliability, Quality, and Test Division. The RQ&T Division has primary authority for developing and monitoring policies and procedures which will assure the reliability and quality

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[17] *Idem.*, and Personal Interview with RASPO personnel, July, 1966.

of the systems and components of the Apollo spacecraft. It is responsible for the certification and qualification requirements of the spacecraft's hardware items. Another of its major objectives is aiding in the resolution of any equipment failures that take place in the spacecraft, the ground support equipment, or the checkout equipment.

The division is broken into three distinct functions as shown in Figure 3-9. The reliability personnel are basically concerned with whether or not the design is suitable for mission performance. The quality personnel oversee the process being used to build the hardware and the inspection of it at predetermined points. They determine the quality of the material to be used by the contractor and decide if any material not meeting the prescribed requirements can still be used. They are also charged with seeing that cleanliness is maintained in the work areas, the spacecraft, and the materials. The test branch has authority for reviewing subsystem qualification test data and making sure that if a failure has taken place all interested parties are notified. All failures must be reported to NASA within twenty-four hours.

For reliability and quality assurance activities, the

RQ&T office also assists the ASPO by supplying information on budgets, schedules, resource requirements, and contracts, as well as assessing status reports dealing with the reliability and quality efforts of the contractors and NASA offices supplying the equipment.[18]

CSM and LEM Project Engineering and Checkout Divisions. The CSM Project Engineering and Checkout Division has the authority for the technical monitoring of the CSM and the checkout activities associated with it. The LEM Project Engineering and Checkout Division has the same authority for the LEM. Both divisions are concerned with the overall production of the hardware and the tests that are to be run on it. In the performance of such functions, each division is separated into three offices as shown in Figure 3-9. The Spacecraft Office is charged with seeing that the piece of hardware is technically adequate and produced on time. The GSE Site Activation Checkout Office is concerned with establishing ground support equipment schedules for the delivery of the equipment to the test sites and for insuring that it supports

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[18] Apollo Management Manual and Personal Interview with RQ&T Division head, July, 1966.

the checkout of the vehicle. The Ground Test Office is responsible for managing the detailed test planning and test activities that are associated with the hardware.[19]

Mission Operations. The Mission Operations division performs three basic functions. First, it determines that the flight program preceding the lunar mission establishes the readiness of everything involved in the mission. Second, it verifies that the spacecraft is operated on its various missions in a manner consistent with its design philosophy, and that no additional demands are made on it. Third, it makes a postflight evaluation to review what has been done and then puts together a flight test report. These three basic functions are performed by the four following departments: the Systems Operations branch which plans the lunar mission; the Operations Integration branch which is responsible for the orientation of the crew to the spacecraft; the Mission Planning branch which places apparatus on the spacecraft for the purpose of sending back information on the condition of the spacecraft during the mission; and the Test Evaluation branch which is charged with analyzing this post-flight data.

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[19] Apollo Management Manual and Personal Interview with Project Engineering personnel, July, 1966.

The division as a whole provides support to the flight control personnel during the mission by making recommendations with regard to any changes which are to be made. As brought out initially, they also propose a philosophy concerning the guidelines to be used in conducting the mission.[20]

Systems Engineering. The basic functions of the Systems Engineering division are to identify and specify the technical requirements for the spacecraft and to identify engineering problems as the spacecraft moves from manufacturing into the flight program. Working with the subsystem managers and the contractor, they agree upon a preliminary design. They then oversee this design to determine if and when it becomes non-functional and what corrective action must be taken. The division also aids the contractor in determining specific tests to run.

In performance of its functions, the Systems Engineering division is divided into four branches, as depicted in Figure 3-9. The Engineering group carries out the preliminary engineering designs, evaluates the flight test results to determine if there is a need for design modifications, and pro-

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[20] Apollo Management Manual, and Personal Interview with Mission Operations personnel, July, 1966.

vides engineering services to correct any problems relating to design difficulties. The Experimental Integration group handles the interface involved between the experiments and the government furnished equipment (GFE) going on board the spacecraft. The crew equipment, the food, the GFE, and the experimental equipment on board must be integrated in the spacecraft so that everything is placed in just the right area and maximum use of all space is made. The Guidance Control group sees that the guidance and navigation and the stability and control systems are incorporated into the total spacecraft system. The Systems Integration branch makes sure that all parts of the space vehicle work in accordance with one another.[21]

Program Control Division. The divisions described thus far may be considered as being concerned with management from a technical standpoint. The program control division is, however, basically administrative management. It is responsible for developing the resources and scheduling the plans of the Apollo spacecraft and simulator programs.

The management of the Apollo spacecraft entails dealing with forty companies, each having contracts of over $5,000,000,

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[21] Apollo Management Manual and Personal Interview with Systems Engineering personnel, July, 1966.

as well as with many smaller companies. There are 100,000 people employed in the Apollo spacecraft program; the budget is in excess of $6,000,000,000, and the current spending rate is over $4,000,000 a day. In the bi-weekly reports 70,000 PERT activities are included, and there are many additional activities not covered therein.

The program control division must be ever conscious of NASA's responsibilities which are: to define the requirements for the hardware, to approve the approach taken by the contractor, to test and certify the production of the spacecraft, to provide GFE on time, to provide the necessary resources, and above all, to be concerned about the contractor and his people. By the latter is meant that NASA must be willing to help the contractor when he encounters problems. NASA must try to understand his problems for only in this way can the space agency hope for maximum performance from the contractor. The division's specific functions are to:

1. Integrate the overall spacecraft development schedule as defined in the Apollo Spacecraft Development Plan, prepare and submit ASPO schedule reports to the OMSF, and interface with other MSC elements and the OMSF in scheduling activities.

2. Integrate the overall project resource requirements, control, and reprogram resources provided to the ASPO and interface for the ASPO with the Resources Management Division on budgets and finances.

3. Standardize the ASPO concepts and procedures related to cost reporting systems and monitor the implementation of these reporting systems.

4. Perform the duties of the MSC Apollo Data Manager and control the overall Apollo spacecraft documentation policy.

5. Develop, implement, and operate the Apollo Configuration Management system.

6. Prepare feeder information for preparation of the OMSF Apollo Development Plan.

7. Serve as the focal point of the information flow between the ASPO and the ASPO contractors, assuring timely, coordinated action as required.

8. Monitor all proposed changes and technical directions sent to the contractors to assure consonance with the contracts or assure appropriate action to change the contracts, if necessary.

9. Coordinate the ASPO and the E&D activities required for contract negotiation.

10. Provide assistance and direction to the contractors through the contracting officers as required on contractual interpretation problems.

11. Coordinate facility requests with the Engineering Division and assist the Engineering Contracting Officers in preparing justification for and approval of contractor facility requests.

12. Coordinate the General Electric Apollo Support efforts at Houston and maintain record copies of all work requests submitted to the General Electric-Apollo-Houston organization.

13. Coordinate all the ASPO efforts relating to the preparation, review, and negotiation of contractual documents, both for initial contracts and contract changes.

14. Coordinate surveillance and schedule aircraft and other transportation for the movement of various equipment and major items to various manufacturers of test sites supporting the Apollo program.

15. Develop and manage the Apollo transportation schedule used to establish the vehicle transportation requirements for the Apollo hardware.

16. Manage and monitor the fuel and propellant requirements for all contractor and MSC test sites.

17. Be responsible for the timely identification and acquisition of the facilities, GSE, tools, spares, repair parts, training, and support documentation at the appropriate locations to insure support of the checkout and launch.

18. Provide Project Officers for specified contracts who are responsible to the Chief, Program Control Division for:

    A. "signing off" for the ASPO all directives to the contractors within the scope of the contract,

    B. placing requirements on the MSC's functional organizations for review or action on contractor-generated correspondence or documents,

    C. assuring proper coordination on all proposals, direction, and correspondence to the contractor,

    D. advising the appropriate elements of

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the ASPO's management on all proposed directives or contractor generated correspondence warranting their attention,

E. reviewing all proposed directives and contractor-generated information in relation to the contract, and initiating action with the contracting officer or other functional organizations when required,

F. maintaining visitor and information control on matters relating to the contracts and subcontracts,

G. arranging and coordinating all regular meetings involving senior NASA and contractor personnel,

H. coordinating closely with the Resident Manager, insuring that the latter is kept cognizant of all significant activities involving the contract.[22]

To perform these functions the division, which is shown in Figure 3-9, is divided into five groups.

The first of these, the Program Planning and Integration group, is divided into eight distinct functional groups: integrated planning, presentation and special assignments, manufacturing, transportation, configuration management, government furnished equipment, resources support, and incentive contracting.

Integrated Planning Group. This group prepares and

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[22] Idem.

updates the Master Apollo schedule, which serves to integrate the entire mission by taking cognizance of all schedules in the Apollo program. Where schedule changes are necessary, this group interfaces with headquarters in Washington and the contractor and incorporates the new changes into the master schedule.[23]

Presentation and Special Assignments Group. These individuals deal with requests by NASA personnel, industry, and libraries for Apollo documentation. Members of the group process the Weekly Management Report, which shows the past week's activities of the ASPO, Engineering and Development, and the two large RASPO offices; they also prepare the Quarterly Status Report, which is a compilation of bi-weekly reports, and the Program Development Plan, which explains the Apollo program in depth. The group prepares information for the Annual Program Review, which is given to Mr. James Webb, Director of NASA, and other top officials of NASA. They also gather information for the Bureau of the Budget presentation, a special annual presentation to the Congressional subcommittee; and, information for random presentations to distinguished visitors to the MSC. Members of this group prepare the

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[23] Apollo Management Manual, and Personal Interview with Integrated Planning group, July, 1966.

information that the Program Manager or his assistant will use when giving an address. Finally, they clear any news releases by the contractors to the news media and work with the MSC's Public Affairs office on local news releases and exhibits.[24]

Manufacturing Group. These people participate in manufacturing reviews, provide information and reports on manufacturing for incentive scoring, and evaluate the contractor's tool design and tool use. They support the subsystem managers, when requested, by monitoring GSE manufacturing, and arrange and participate in manufacturing meetings with the NASA contractors. The group also helps evaluate facility requests by the contractors.[25]

Transportation Group. This group is responsible for scheduling aircraft or other transportation for moving NAA, Grumman, and/or A.C. Electronics equipment to the various manufacturers or test sites supporting the Apollo program. The group also prepares program budget forecasts for Apollo fuels and propellants to be used in developing the annual budget,

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[24] Apollo Management Manual, and Personal Interview with Integrated Planning group, July, 1966.

[25] Apollo Management Manual, and Personal Interview with Presentation and Special Assignments group, July, 1966.

and it develops and distributes monthly consolidated fuel and propellant consumption reports indicating the amounts consumed by NASA and the contractors.[26]

Configuration Management. One person serves as the ASPO CCP secretary in the configuration management area. He establishes the agenda and dates for the CCP meetings and reviews proposals for engineering changes in order to assure appropriate administration and technical coordination for facilitating CCB/CCP decisions.[27]

GFE Group. A member of the Planning and Integration Group prepares and maintains a master equipment status book which contains a record of all the government furnished equipment (GFE) sent to the contractors. He is responsible for seeing that the status book is kept current; for ascertaining that the GFE is properly identified by part number, serial number, and drawings; and finally, for assuring that proper controls are used by the contractors for accountability, change control, and transfer of accountability.[28]

Resources Group. These individuals oversee the allocation of resources and make recommendations to the head of

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[26] Apollo Management Manual.

[27] Idem.

[28] Idem.

the program control division regarding the resources, especially manpower, that the contractors will need. Their performance of cost and schedule evaluations, as well as their analyses and comparative cost studies of Mercury, Gemini, and Apollo put them in an excellent position to advise the head of the program control division. They also interface with NASA headquarters on these resources and budget matters.[29]

It is the duty of the incentive-contracting staff in the program and planning group to help rate the contractor as to the number of incentive points he has earned and to make recommendations to an incentive evaluation committee which analyzes their recommendations.

The contracts written by NASA are basically of three types: fixed price, cost plus fixed fee, and cost plus incentive fee. The fixed fee contracts call for a specific cost figure and are used when purchasing articles in which there is little contractor risk. The cost plus fixed fee (CPFF) is used in those undertakings which involve research because there is little known about the area, and without a guarantee to cover costs, the risk would be too great for the contractor. The cost plus incentive fee (CPIF) is used

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[29] Apollo Management Manual and Personal Interview with Resources Management group, July, 1966.

in those undertakings which involve research because there is little known about the area, and without a guarantee to cover costs, the risk would be too great for the contractor. The cost plus incentive fee (CPIF) is used where there is risk but much more knowledge of the area than in the CPFF contract. All NASA's large contracts for the spacecraft have been changed from CPFF to CPIF contracts to correct such poor results as excessive spending and failure to meet schedules. Now the government and the contractor share the risk. The maximum possible fee is 15% and the contractor's guaranteed minimum is 3%.[30]

Contract Engineering Groups and Mission Simulator Group. The other four groups or branches in the Program Control division are the three Contract Engineering Branches (CEB's) and the Mission Simulator Branch.[31]

The CEB's and the simulator branch perform basically the same functions. In the area of contract engineering, the two work with the contracting officer in preparing both the

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[30]Personal Interview with Incentive Contracting group, July, 1966.

[31]All are headed by project officers, as was shown in Diagram 3-2 outlining subsystem management earlier in the chapter. The functions of the project officers have also been listed earlier, at the end of the Program Control division's functional statement on page fifty.

initial contract and incorporating changes into it. When changes in the contract are under review by the ASPO management, information is provided concerning the contractual impact of the change. There is coordination among the ASPO, the CEB and simulator branches, and the subsystem managers who are responsible for the subsystem under study.

In the area of program plans and schedules, both groups are concerned with whether or not the hardware schedules are being met. Thus, they are cognizant at all times of the schedule interfaces between the various pieces of hardware and the overall Apollo program. Should there be discrepancies in the schedule, they assist the program by recommending possible solutions. Their review and analysis of PERT reports and other control data help to determine the schedule status of each piece of hardware, and bring out any problem areas that exist. The groups make recommendations to the Program Manager for resolving schedule problems, and arrange special meetings to solve these problems. It is also their function to see that the subsystem managers get the PERT printouts and 533 financial report forms. Figure 3-12 gives a good illustration of the information flow that takes place within the MSC and between the MSC and the contractor.

Their function in the area of program resources is to determine the total resources, including manpower and finances, necessary to carry out the hardware program; in fulfilling this function they develop a fiscal year budget and examine manpower plans submitted by the contractors and subcontractors.

In the area of configuration management, the two groups establish configuration requirements with the contractor by participating in the setting of baselines. They are also responsible for seeing that all configuration changes are maintained.

In the area of manufacturing and facilities, the two manage manufacturing activities to assure the effective use of manufacturing resources in the production of the hardware. They see that the contractor's manufacturing, tooling, and facility activities conform with program requirements and plans. The two monitor test-site activation and test operations planning to assure the coordination and adequacy of the available resources.[32]

This case study shows the functions that are performed by the ASPO at the MSC. Through this case study information has been gathered to help devise the questionnaire sent out to the various businesses.

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[32] Apollo Management Manual.

Results of the ASPO Study

The case study of the ASPO has been successful because it attained its three basic objectives.

The first objective has been to clarify the definition of project management. The ASPO has been shown to be a group of highly skilled individuals brought together to accomplish a specific objective within time, cost, and quality parameters. The study has shown, as brought out in Chapter II, that project organizations can take diverse forms and have varied objectives. The ASPO and its contractors are both examples of project organizations despite the fact that one builds hardware and the other monitors that effort. The case study re-emphasizes the description of project management given in Chapter II.

The second objective has been to gain an insight into areas to be further researched through a questionnaire. The following information on the ASPO has been used to assemble part of the questionnaire, the second objective:

A. The training of project personnel has been found to be very heavily engineering, physics or mathematics oriented. Few business administration personnel are on the project. The top managers have technical backgrounds. Two questions have been formulated in the questionnaire to see whether this relationship between the type of project and the background of the manager is present in all project organizations.

B. A very important function in the project is that of obtaining rapid feedback so control can be maintained. This is done through the financial and scheduling reports discussed earlier. To obtain data on the question--Is control always so important to a project organization?--the type of reports submitted on a periodical basis have been requested in the questionnaire.

C. The project organizations, depicted in Chapter II, show four project organizations along a spectrum extending from completely independent to heavily dependent. The ASPO is a semi-independent organization, as shown in Diagram 2-6, since it performs many functions itself but also relies on other MSC offices for assistance. To answer the question--Do all project organizations fall into this semi-independent category or is the spectrum in Chapter II closer to reality?--the functions of both the project organization and the project manager have been requested. The managers sent the questionnaire have also been asked to list whether the project organization's functions are independent, semi-independent or dependent on the functional organization.

Four distinct advantages of ASPO have become apparent on the basis of the interviews conducted and the research of the Apollo literature. The ASPO:

1. Permits concentration on a specific objective

2. Operates with a minimum of manpower

3. Reschedules personnel well in advance of project completion, and

4. Allows the project manager to motivate his personnel.

The first three have been incorporated into the questionnaire to determine if they are also present in other project organizations. They are as follows:

A. A prerequisite for using a project approach is the need to concentrate on a specific objective. This has been explained in Chapter II. The ASPO has just such an objective. The time, cost, and quality constraints are so great that it is impossible to allow the functional areas to operate independently. A project manager is needed to coordinate their efforts.

> The traditional management theory of Henri Fayol and Frederick Taylor is not suitable for managing large, single projects, such as those in the construction industry, or in manufacturing when a costly product requires the coordinated involvement of several organizations.[33]

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[33] *Idem.*

The ASPO's use of a project rather than a functional approach helps it coordinate and control the project. As a result, a question has been included in the questionnaire to determine why a project approach is being used by each firm.

B. The ASPO personnel feel that a project approach allows it to run its project with a minimum of manpower. With a functional organization it would be necessary to increase the personnel in proportion to increases in the dollar size of the project, since the organization would be compelled to have greater coordination across functional lines without a central figure to provide it. The ASPO has been able to operate efficiently under a project approach as the dollar value of the project becomes larger. Questions concerning the number of people on a project and its dollar size have been placed on the questionnaire to determine if there are manpower savings in other project organizations.

C. The area of rescheduling of personnel has been investigated. The current literature indicates that if personnel are not reassigned until the project is in its last weeks, they may become frustrated and begin dividing their allegiance between the project and the functional manager.

> Because the duration of a project is well defined, it is only human for the scientists and engineers who work on it to come to anticipate their next assign-

> ment....This can result in a kind of divided allegiance, in which the engineers look to others outside the project who may be able to help them in gaining their next assignment.
>
> The project manager must counter this tendency to cast about for the next task, for it will diminish his effective control of the present task.[34]

This drawback is not present at the ASPO; project personnel are rescheduled months ahead of time, as has been evidenced in Projects Mercury, and Gemini, which preceded Apollo. This, however, does raise a question for analysis concerning the period of time between announcing the new assignment of the personnel and the end of the current project.

D. One advantage, however, has not been placed on the questionnaire. This is the project manager's ability to motivate his personnel. The inability of many project managers to reward or promote their team members is constantly emphasized in the current literature.

> One of the project's biggest problems is how to get full support when the functional people are responsible to someone else for pay, raises, promotions, and other expected line superior-subordinate relationships.[35]

The disadvantage is not present in the ASPO. The project manager did determine the raises and promotions of his personnel.

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[34] Gaddis, p. 769.

[35] Cleland, Business Horizons, p. 82.

Since the ASPO is an exception to the rule, it is virtually impossible to compare the ASPO's effectiveness in this area with other organizations using a project approach. This subject, therefore, has not been included in the questionnaire. Nevertheless, the project manager's control and his ability to reward his team members is a distinct advantage which merits recognition.

The third objective has been that of gathering information through personal observation. The ASPO has two major disadvantages, it has been learned.

A. The ASPO has fallen into one of the major pitfalls of project management by overevaluating its importance. In discussing this overevaluation when it takes place in a laboratory, a current writer says:

> If,..., the members of the project work well together, they gain an inflated opinion of the importance of their project and do their best to short-cut and otherwise interfere with the smooth operation of normal and necessary laboratory procedures.[36]

The ASPO does the same with regard to the contractor. The solutions to problems and the interpretation of policies are given by the ASPO to the contractor, who is told what he must

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[36]Herbert A. Shepard, "Pattern of Organization for Applied Research and Development," Management Readings Toward A General Theory, ed. William B. Wolf (Wadsworth Publishing Company, 1964), p. 246.

do by the ASPO. The ASPO and NASA appear to make the contractor a mere production department for their plans. In an interview one contractor expressed the viewpoint that, since the government is paying the fee, the contractor's organization will not object when it comes to deciding how things should be done. Apparently the ASPO is doing little to overcome this drawback of overevaluating its importance.

B. The ASPO tends to overstress any discoveries in the management area as "new." This disadvantage was clearly observable and appears to be a result of the first drawback mentioned above. In discussing this area one writer has said:

> The tendency of the project group to think of itself as a problem-solving unit leads the members to avoid consulting the literature, the files, and knowledgeable people in the laboratory who could help. The project form of organization produces more heat than light.[37]

Although this latter sentence does not describe the situation at the ASPO, a failure to consult current literature does prevail. An example of a "discovery" made at the ASPO was that PERT-COST is not feasible for a very large project. Through 1965 there was only one book in print entitled <u>Project Management</u>. In that text the author, in talking about projects at or above $100 million, says, "The real weakness of PERT-COST

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[37] <u>Idem</u>.

is that the input information is rearranged but still only comes to the project manager as a mass of information which he must analyze."[38] Did the project personnel not consult the current literature? It appears that they did not, although the text quoted was in print in 1963. This example indicates that the ASPO personnel must read the current literature and keep abreast of changes and developing concepts in the management area, especially project management.

Other weaknesses also exist in the ASPO project organization. These appear to be weaknesses that can be present in any organization, however, and are not unique in project management organizations. They include the following:

A. The force of personality plays too large a role in this project organization, for some incumbents of top management positions are very personable but seem to lack managerial ability. They appear disorganized and their leadership ability is not as great as others in lower managerial positions; nor do they appear, on the basis of interviews to be as experienced as some of their subordinates. Although this drawback is based on extremely subjective "evidence" the writer feels it is definitely present.

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[38]John S. Baumgartner, Project Management, (Homewood, Illinois: Richard D. Irwin, 1963), p. 47.

B. There are few management trained personnel; the persons in charge usually are engineers or mathematicians. Their skills put the ASPO in a good position to monitor the contractor from a technical standpoint but in a relatively weak position to manage itself internally. This is a reason for the periodic reorganizations that take place in ASPO departments. Its inability to use its talent in the best possible manner has resulted in changes in the personnel and organization to overcome apparent weaknesses.

C. A management trainee is not given formal management courses but rather is rotated throughout the ASPO and then assigned to the department of his choice; this results in management training being obtained only on the job. More formal management training would greatly bolster the ASPO organization.

D. The technical orientation of personnel in the ASPO is heavily engineering, putting them in a position to talk the same language as the contractor. The age of the ASPO personnel, however, appears to be a drawback, as it is between twenty-seven and twenty-nine. Thus, many of the men are insufficiently experienced to monitor the contractors, who are usually older and have had many years of experience in their fields.

The disadvantages found at the ASPO may exist in other project organizations as well. It is felt, however, that questions dealing with these kinds of disadvantages of project management would reveal little.

In this research study all three initial objectives, stated on page twenty-one, have been attained. Since, however, the ASPO is unique in that it is a project organization which monitors other project organizations, it has been thought desirable to spend some time at a prime NASA contractor. The two basic reasons for this are to:

1. See whether the manner in which the prime contractor interfaces with the ASPO would be useful in determining further how project management works, and

2. See whether any answers could be obtained to the questions presently developed for the questionnaire and to see if any others could be formulated on the basis of this further research.

These answers could then be compared to what has been found at the ASPO. The firm chosen has been North American Aviation (NAA), Apollo's largest prime contractor. One week has been spent interviewing NAA personnel and reading NAA functional statements and official manuals. The following presents a summary of what has been learned.

North American Aviation

NAA has the authority for designing, analyzing, developing, manufacturing, and conducting field operations with regard to the CSM. In Figure 3-13 the corporate structure of NAA is shown; Figure 3-14 depicts its Space and Information Systems Division; and in Figure 3-15 the Apollo Program Structure is exhibited. The NAA project organization is performing basically the same functions as the ASPO.

The Manufacturing group, shown in Figure 3-15, is concerned with assembling the spacecraft and installing its various subsystems. The pieces of the spacecraft which do not require special production are produced by the central manufacturing division (not part of the NAA project organization). The others are produced by the project organization or by the subcontractors. The latter manufacture the subsystems, while the Apollo manufacturing group turns out items concerned with the spacecraft's structure.

The Site Activation personnel equip the sites at the NAA plant, and then turn them over to the test people as locations in which to test the spacecraft. The logistics people make sure that all equipment is delivered on time.

Members of the Test and Operations group, shown in Figure 3-15, are responsible for ground preparation and ground checkout. They conduct a complete systems checkout of the vehicle after final assembly to ascertain that each of the systems works individually, and in an integrated fashion with the rest of the spacecraft's systems. The checkout is watched by the RASPO people, who in turn report to the Reliability, Quality, and Test division in the ASPO.

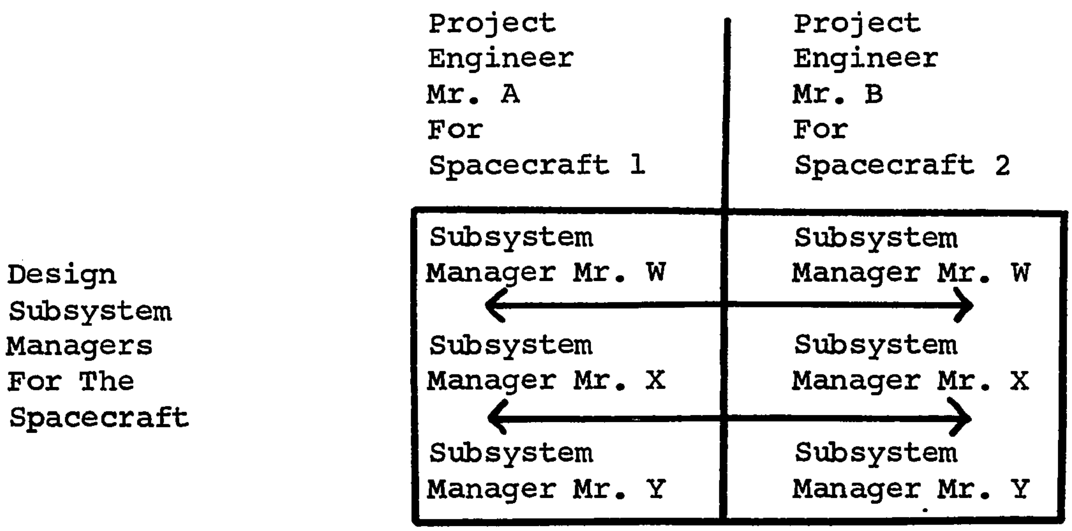
The interface with the Kennedy Space Center concerns the Florida Operations Staff, while the Quality and Reliability Assurance personnel are responsible for the quality and assurance areas. The latter operate generally in manufacturing and test operations.

In the aforementioned NAA departments, the majority of the functions being performed are similar to those being carried out by the ASPO. The logistics, test, quality, and systems engineering functions are all carried out by the ASPO. The only operations not being performed by the ASPO are the manufacturing operations and the Florida Operations, which are the responsibility of the Kennedy Space Center.

In the Engineering department all groups can be traced to the ASPO for similar content by their names alone, except for the Spacecraft Design departments. These persons are performing a dual role. They are responsible for an area in the spacecraft design department and also serve as the equivalent of the MSC's Engineering and Development subsystem managers. Their function is to oversee a particular subsystem and all the parts of that subsystem which are being produced by the subcontractors.

The Project Engineering group has a project engineer for each spacecraft, and a number of subsystem managers for that spacecraft. The subsystem manager handles the same subsystem on each spacecraft and thus has numerous superiors, depending on which spacecraft is under discussion. The project engineers authorize changes in the spacecraft upon receiving the change authorization, and are responsible for costs and budgets for the entire spacecraft. The following diagram shows the relationship which exists between the project engineers and the design subsystem managers.

Diagram 3-3



The project engineers each handle one spacecraft. The design subsystem managers handle one specific system in each of the spacecrafts.

The Planning and Control department determines the manpower needs, budgets, and costs for the engineering personnel. This function is similar to that performed by the resources management staff in the ASPO.

Many of the functions performed by the ASPO are carried out by the program planning and control personnel in the NAA who draw up schedules and oversee budgets for the entire project. The head of this NAA department is equivalent to the head of the ASPO Program Control Division.

Functions of the Contracts department are similar to those of the Procurement and Contract personnel who are supporting the ASPO's program control division. The department negotiates proposals with the customer, participates in changes in the contract, and makes sure everyone is familiar with the terms of the contract.

It is the duty of the Material group to purchase all specialized parts needed for the spacecraft. They purchase, among other things, the major parts of the CSM's subsystems from the subcontractors. Once they wish to enter into an agreement with their potential subcontractor, they must get

NASA's permission. Having completed this, it then becomes the job of the Material people to see that the subcontractors are producing on time, and within cost and quality parameters. The project engineer for the individual spacecraft must, therefore, scrutinize the performance of the Material group. The subsystem manager for a particular system must oversee this subcontractor, who is sending continuous reports on his progress. NAA, just as the ASPO, has representatives in the subcontractor's plants for the purposes of quality and reliability control. The same relationship existing between the ASPO and NAA exists between NAA and its subcontractors. The management of the project is similar to the ASPO's except for the manufacturing area and the Florida operations. The only other major difference is that, while NAA is responsible for the CSM, the ASPO is responsible for the entire Apollo spacecraft consisting of the LEM, the CSM, the guidance and navigation system, the simulators, the spacesuits, and the checkout equipment.[39]

Results of the NAA Study

This study of NAA has been successful in accomplishing its objectives.

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[39]Personal Interviews with NAA project personnel, July, 1966.

The organizational relationships between the ASPO and NAA have been studied, thereby giving a better insight into the complexity of the entire Apollo project; and certain questions formulated at the ASPO have been asked of NAA personnel to determine whether they should also be included in the questionnaire. The following are the answers given:

A. At NAA, as in the ASPO, there is a relationship between the type of project and the manager's qualifications.

B. The major types of reports submitted by NAA to the ASPO are of a financial and scheduling nature. Control is the main reason for these reports. It is important to ascertain how useful reporting is to a project organization, and whether there is any relationship between the kind of project and the type of report requested by the managers.

C. It has been found through interviews and the reading of functional statements that the NAA project organization is semi-independent. In some matters it depends on the permanent organization, and in some it is independent.

The four advantages of project management at the ASPO have been investigated at the NAA to see if they were present in the latter project organization also.

A. As in the ASPO, the major reason given for using project management has been that it permits concentration on one prime objective. NAA is convinced that a functional organization could not accomplish this. It also agrees with the ASPO personnel that planning and control are the prime functions to be performed and that a project organization would accomplish these functions more efficiently than a functional organization.

B. At the ASPO, a manpower saving between dollar and manpower has been discussed. Although no affirmation of this has been given by the NAA, the personnel believe that this might well be the case, and recommend obtaining data concerning this area in the questionnaire.

C. Contrary to what has been found at the ASPO, the project manager does not have the authority to reward or promote his personnel. The interviewees have been firm, however, in stating that this is not a drawback, *per se*. They feel that in their organization the *esprit de corps* has not been affected. It is because of their argument that it may not be a deterrent to good morale, and that this is a widely followed method of handling personnel in other project organizations, that this area for analysis has been omitted from the questionnaire.

D. In rescheduling their personnel, NAA has indicated that it gives ample notice and thus, as in the ASPO, overcomes what the current literature considers a possible drawback of project management. They are cognizant of the troubles that might arise from a last minute rescheduling of project personnel.

The drawbacks evidenced in the ASPO could not be studied in detail at NAA because of the short time period involved. No disadvantages to the use of project management have been given by the personnel when interviewed on this topic. The only drawback mentioned has been that of the ASPO monitoring NAA. Some personnel feel NAA could do a better job if it functioned independently of the ASPO. As mentioned earlier, the area concerning drawbacks to project management has been omitted in the questionnaire because it is believed that satisfactory answers may not be given.

The main benefit derived from the NAA case study is that it shows the similarity of the ASPO and the NAA project organizations. Although certain facts ascertained at the ASPO cannot be verified at NAA, there are no areas in which the two differ widely.

The information gathered is not sufficient to constitute an analysis of project management, but it seems to be adequate as a basis for developing a useful questionnaire.

It has been determined that what is needed is to increase the number of areas under analysis, and then obtain answers to the questionnaire from numerous and diverse companies using project management. The seven areas for analysis brought out in both the ASPO and NAA case studies have been supplemented with other questions to form the questionnaire shown in Appendix C. The results of this questionnaire are reported in Chapter IV.

QUESTIONNAIRE ANALYSIS

CHAPTER IV

In the third stage of the research, copies of a questionnaire have been sent to approximately 210 firms. After a search of Moody's Industrial Manual, 1966, these firms have been chosen as most likely to be using project management. Responses to the questionnaire have been received from sixty per cent of those queried, as the following indicates:

Firms Mailed Questionnaires	210
Total Responding:	126
Respondents Using Project Management	50
Respondents Not Using Project Management	76

Respondents using project management who identified themselves are listed in Appendix D. Other respondents chose not to identify themselves.

The questionnaires that have been returned by firms that use project management have been divided into three groups for purposes of analysis: aerospace firms, construction firms, and "other" firms. It has been found that projects reported by other than aerospace and construction firms are extremely diverse; they range, for example, from the installation of a computer system to undertaking a cost-feasibility study for new products. It would be virtually impossible to subdivide this last group to obtain additional homogeneous groups.

Ten areas of analysis have been taken from the questionnaire data. These are:

A. Analysis for General Information on the Project Organization

  1. Correlation between Dollar and Manpower Size

  2. Correlation between Manpower Size and Number Hired from Outside the Firm

  3. Correlation between Dollar Size and the Life of the Project

B. Analysis of the Project Organization

  1. Reasons for Employing Project Management

  2. Basic Type of Project Organization

  3. The Place of the Project Organization in the Organization Structure

C. Analysis of the Project Manager

  1. Background of the Project Manager

  2. Span of Management

3. Releasing and Rescheduling of Personnel

4. Control Over the Project

In the first three areas, correlation analyses have been used. In dealing with correlations the likelihood that a given result could have occurred through chance increases when the "population" is small. The "population" of the three industry categories is the number of questionnaires returned. In order to eliminate this chance factor, sound statistical practice demands that a specified correlation between the variables be present. For each category, the number of questionnaires returned and the specific correlation sought before it can be considered significant are as follows:

TABLE 4-1

	Aerospace	Construction	"Other"	Overall Analysis
Number of Questionnaires	26	21	23	70
Correlation Desired	.500	.549	.525	.310[1]

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[1]John E. Freund and Frank J. Williams, Elementary Business Statistics: A Modern Approach, (Englewood Cliffs, New Jersey: Prentice Hall, 1964), p. 444.

When these correlations are obtained, the chance of random occurrence is a mere one per cent.[2]

Analysis for General Information on the Project Organization

In this section on general analysis, correlations have been computed from the questionnaire data. Three questions have been asked. First, is there any correlation between the dollar and the manpower size of the project organizations? This is a prelude to the questions: "Are there any manpower savings as the project gets larger?" and "Can the size of a project increase without a proportionate increase in manpower?" Second, is there any relationship between the number of people on a project and the number hired from outside the firm? Third, is there any relationship between the dollar size of the project and its duration?

Dollar Size-Manpower Size. The coefficient of correlation between dollar and manpower size has been run. It has proved significant within all three areas. Since not all questionnaires contained responses to the questions on this topic, the correlations on page seventy-nine must be revised upward. The following correlations based on the number of responses

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[2] Idem.

have been considered meaningful:

	Number of Questionnaire Responding	Correlation Sought
Aerospace	24	.500
Construction	20	.561
"Other"	19	.575

The correlations reveal the following information:

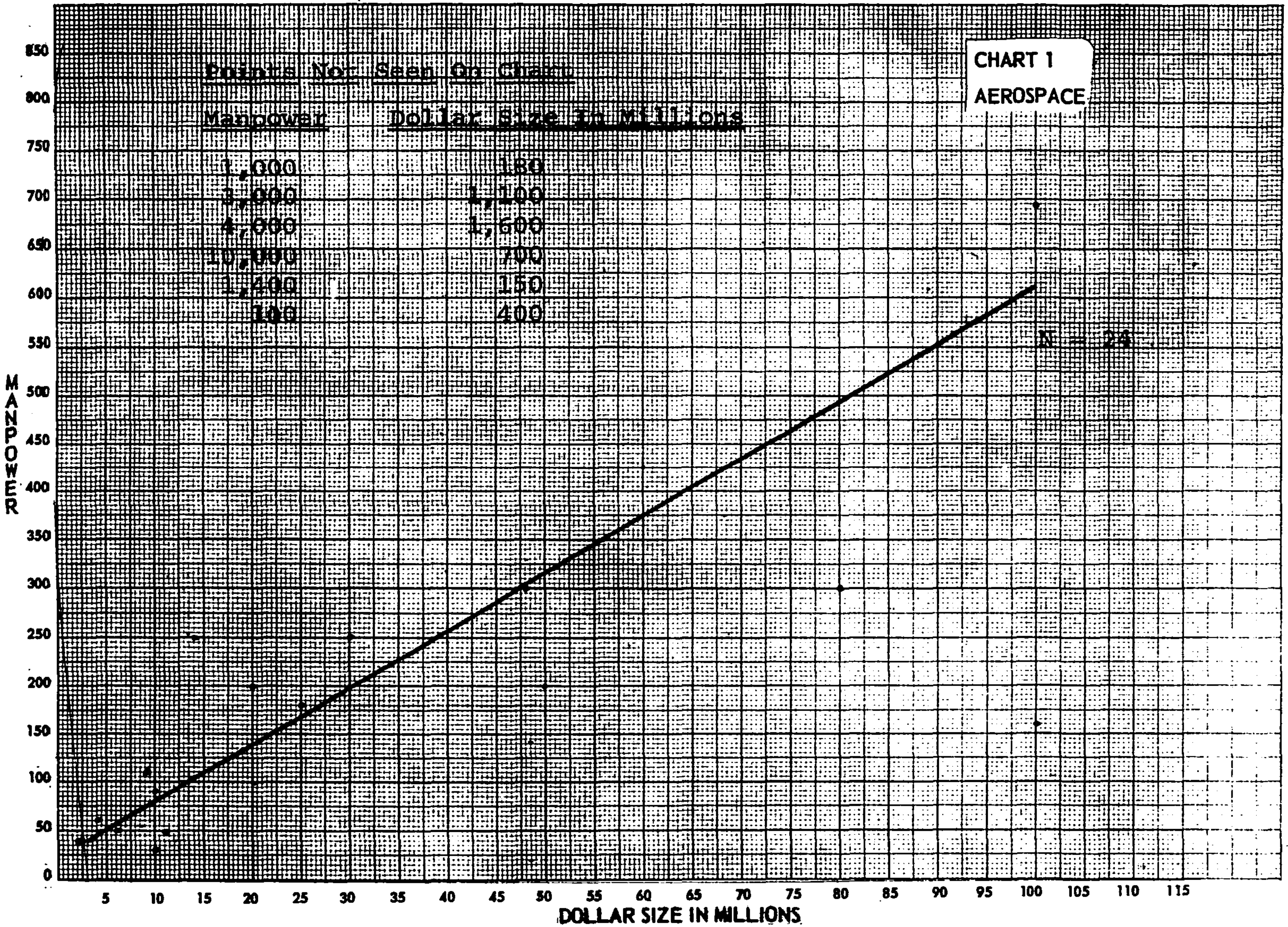
Aerospace	.570
Construction	.760
"Other"	.961
Overall	.606

Thus the data is meaningful.

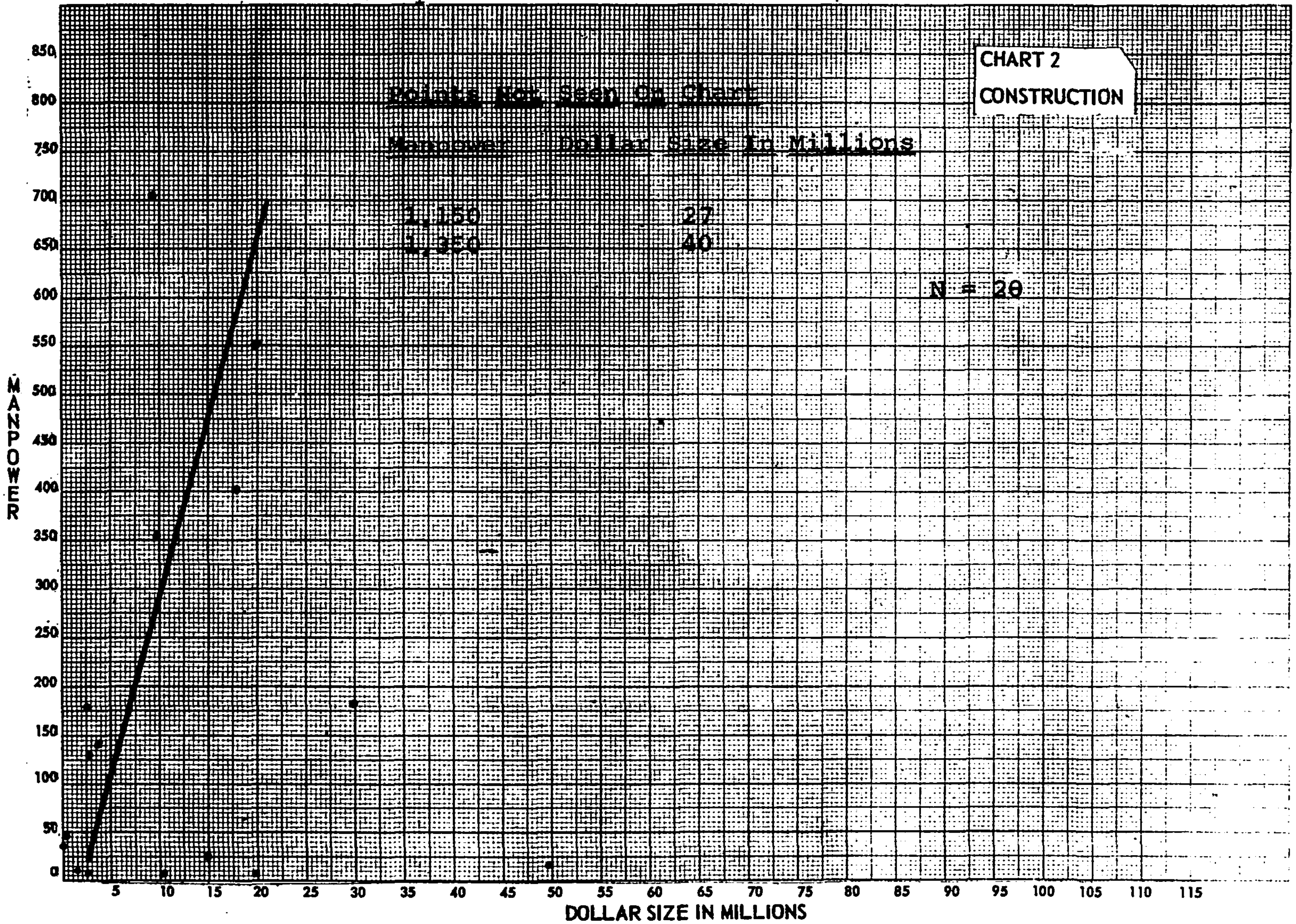
These figures show the correlations between dollar and manpower size to be highest in the "other" area and lowest in aerospace. The graphs of the correlations are on the following pages and each contains a trend line computed by the least-square method. A further analysis of the questionnaire data is revealed in Table 4-2.

Based on the correlations, the relationship between dollar and manpower size declines as the project's dollar size increases; therefore, the greatest dollar value per man should occur in aerospace, then construction, and finally "other." The graphs indicate this trend. Table 4-2, however, does not. It shows that while aerospace projects average approximately

Relationship Between Dollar and Manpower Size in All Three Areas



Relationship Between Dollar and Manpower Size in All Three Areas



Relationship Between Dollar and Manpower Size in All Three Areas

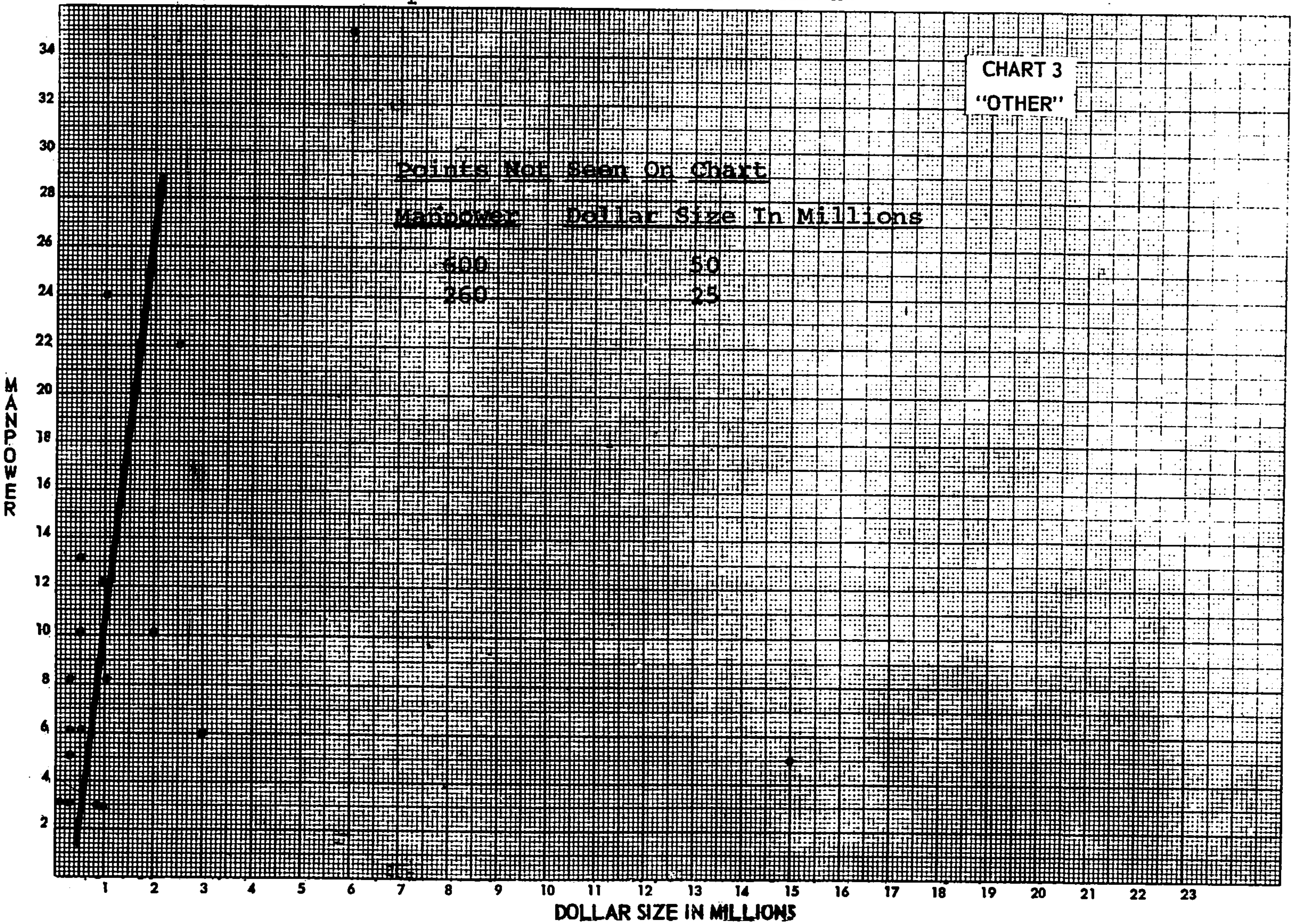


TABLE 4-2

	Aerospace	Construction	"Other"
Total Dollar Size in Millions	5,768	286	112
Total Number of Personnel	23,773	6,311	1,271
Average Dollar Size in Millions	221.85	13.62	4.87
Average Number of Personnel	914	300	55
Dollar Value Per Man in Thousands	240	45	50

$240,000 per man, construction projects average only approximately $45,000 per man and "other" projects average approximately $90,000 per man. Thus, as the average dollar size of the projects increase, there is not an increase in the dollar size per man on the construction projects. However, a few of the construction and "other" projects deviate significantly from all the others in their respective groups. By dropping these latter projects the data in Table 4-3 remain in the areas of construction and "other." Savings in manpower now appear in the last two columns. This table illustrates that there is a greater dollar value per man on the construction projects than on the "other" projects. For construction pro-

TABLE 4-3

	Construction	"Other"
Total Dollar Size in Millions	284	22
Total Number of Personnel	6,236	361
Average Dollar Size in Millions	13.52	1.00
Average Number of Personnel	197.0	15.7
Dollar Value Per Man in Thousands	69.0	63.6

jects it is $69,000 per man, and for "other" projects the figure is $63,570 per man. As a result of eliminating from the computations the projects that deviated exceptionally from the norm, the figures show manpower savings. As the size of the project gets larger the number of personnel on the project does not increase in as great a proportion. It is not possible to say whether manpower savings are greater in project than in functional organizations. However, it can be stated that there are these savings in manpower as the project size increases, and the questions asked at the beginning of the subsection on this topic can be answered affirmatively.

Manpower Size-Hiring from Outside the Firm. The correlations between manpower size and hiring from outside the firm have been computed. Since not all questionnaires contained responses to the questions on this topic the correlations on page seventy-nine must again be revised upward. The following correlations will indicate meaningful data:

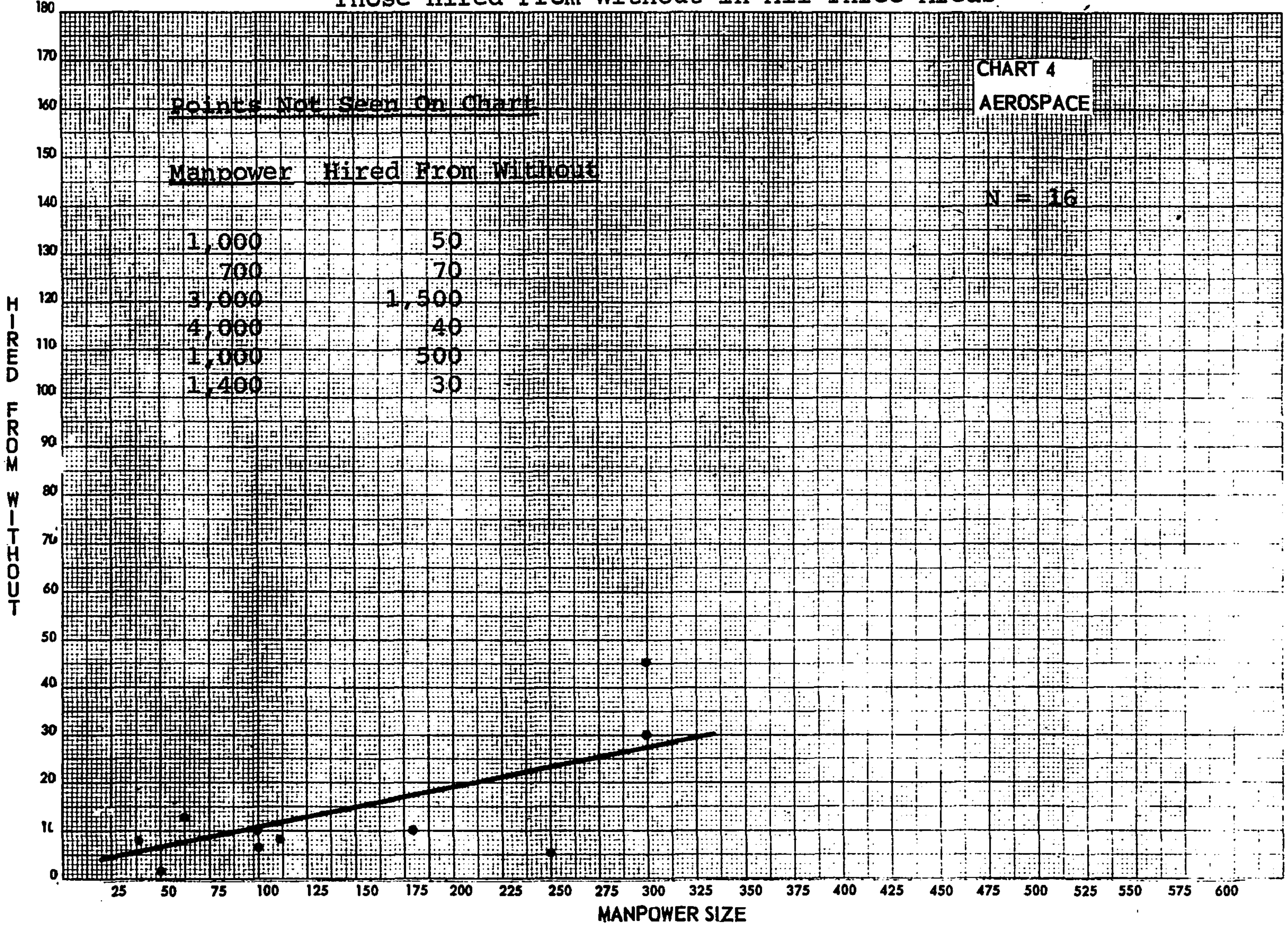
	Number of Questionnaires Responding	Correlation Sought
Aerospace	16	.623
Construction	21	.549
"Other"	20	.561

The correlations in this area are:

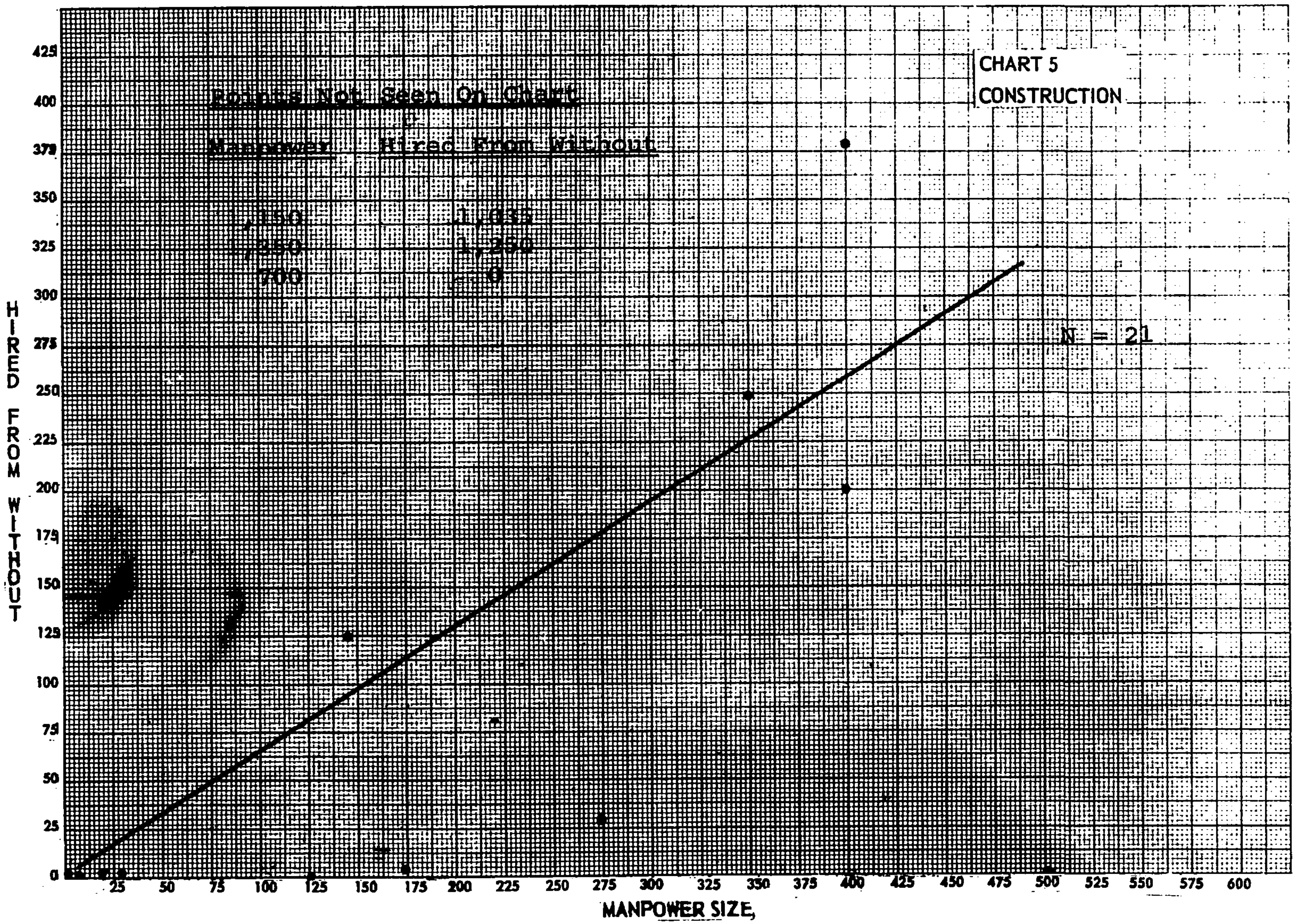
Aerospace	.927
Construction	.874
"Other"	.957
Overall	.916

These correlations appear to indicate that hiring team members from outside the firm is very common. This is true in both small and large projects. The graphs on the following pages also illustrate this. The reason why projects hire from outside the firm has not been researched through the questionnaire. However, it appears logical that the project manager is attempting to recruit personnel with expertise in areas vital to the project. The team members are profession-

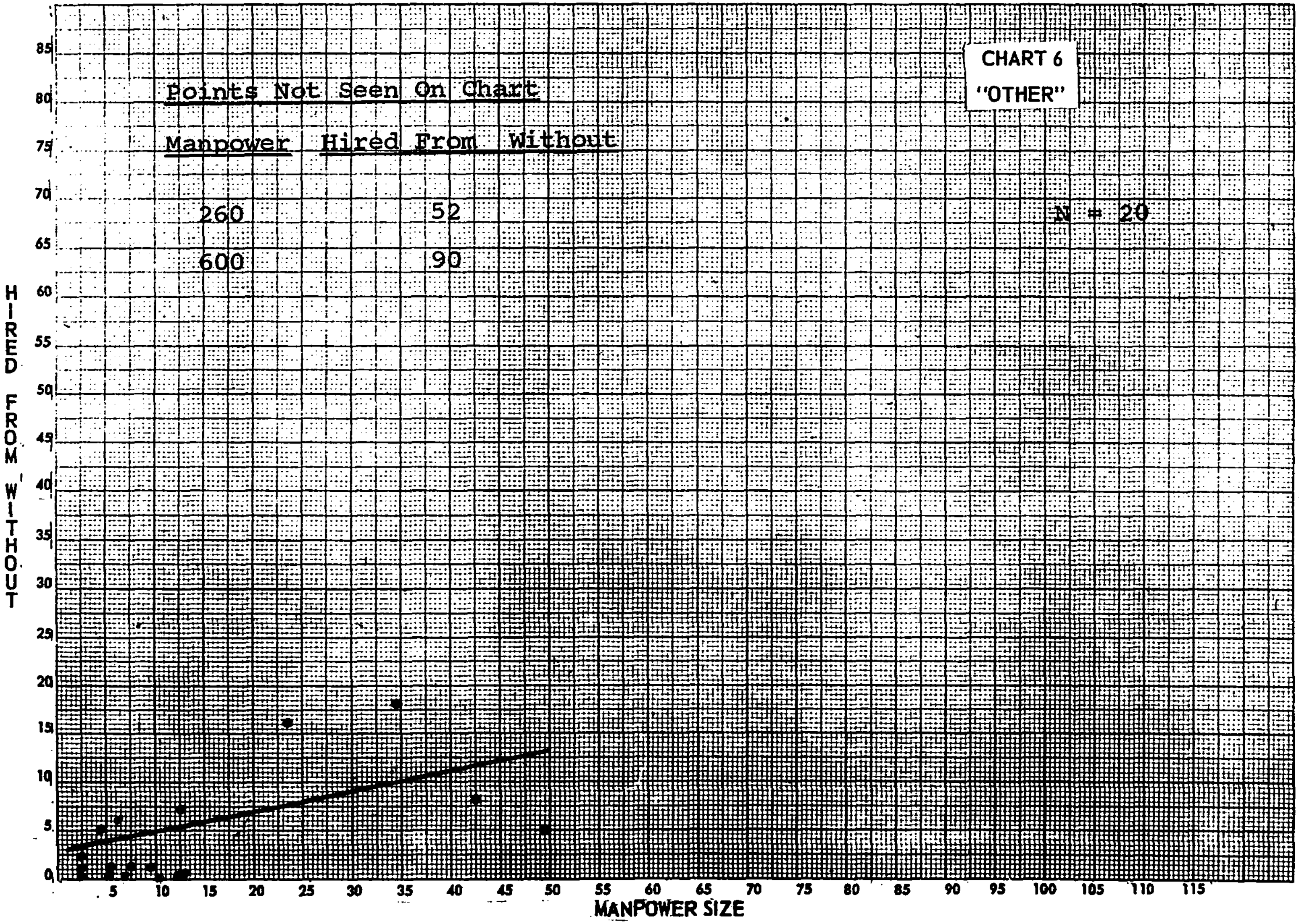
Relationship Between Manpower Size and
Those Hired From Without In All Three Areas



Relationship Between Manpower Size and
Those Hired From Without in All Three Areas



Relationship Between Manpower Size and
Those Hired From Without in All Three Areas



als. This is brought out by Paul O. Gaddis, who writes, "The project manager is managing a higher proportion of professionals /than the conventional manager./[3] Thus, obtaining these highly skilled individuals appears to be the reason for such a high correlation between the manpower size and hiring from outside the firm.

Dollar Size-Life of the Project. Correlations have been computed between the dollar size of the project and its duration. In aerospace projects, the life of the projects range from one to fifteen years. In construction and "other" projects it varies between one and five years. The data obtained from all seventy questionnaires show the following correlations:

Aerospace	.871
Construction	.535
"Other"	.451
Overall	.859

Among aerospace projects, there is a strong correlation between dollar size and the life of the project. In construction firms, the correlation is below .549, the correlation necessary for ninety-nine per cent reliability, as shown on page seventy-nine. Among "other" projects, it is also below the acceptable .525 correlation, as shown on page seventy-nine. Overall, the correlation is high but this has

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[3]Gaddis, "Project Management," p. 767.

been caused by the heavy weighing by the aerospace figures.

Why is the correlation between the dollar size and the life of the project higher in aerospace than in the construction or "other" areas? The data from the questionnaire do not provide an answer to this. An analysis of the data, however, shows that the correlations are lowest in the "other" area where the average dollar size of the project is $1 million and highest in the aerospace area where the average dollar size of the project is $221.85 million. These figures are located in Table 4-2 on page eighty-five. As the dollar size increases so does the duration of the project. It appears logical to conclude, therefore, that these larger projects must be budgeted or planned to cover a given time duration. An example of this is Project Apollo where the time length and dollar size have already been determined. The annual dollar amount is allocated to the project by the Congress and the space agency must work within this budget. A second reason for the correlation may well be the complexity of the aerospace projects, which will increase the time period necessary for completing the undertaking.

In the construction and "other" project questionnaire returns, planning of this complex nature does not appear as vital. Many of the projects can be finished very quickly because they lack the technical complexity and the budgetary constraints present in aerospace. As projects become larger these two constraints seem to play a larger role and it is, therefore, concluded that the complexity and the budgetary constraints of a project are major factors in determining the life of a project.

Three conclusions have been reached in these general areas of the project questionnaire analysis.

First, there are manpower savings as the dollar size of the project increases.

Second, there is a direct relationship between the manpower size of a project and its need to go outside the organization to staff the project.

Third, the life of a project is influenced by many factors. The prime ones appear to include the budgetary constraints of the project and the complexity of the undertaking.

Analysis of the Project Organization

In this section an analysis of the project organization has been undertaken. Three questions have been asked. First, why is a project organization rather than a functional organization used for the undertaking? Second, what are the characteristics of the basic type of project organizations?

Third, where are project organizations located in the permanent organization structure?

The Reasons for Employing Project Management. Each project manager has been asked why a project approach is used rather than a functional approach. The answers have been divided into two groups on the basis of the dollar size of the repondent's project. The following data have been obtained and show the percentage of cooperating firms that consider the four reasons for using a project approach, as listed in Table 4-4, to be either "very important" or "important."[4]

These questionnaire data indicate that "management control" is the major reason the firms responding are using a project approach. As has been brought out earlier, the project organization is used to allow complete concentration on a particular undertaking, something difficult to accomplish with a functional organization. The findings from the questionnaire coincide precisely with what the case studies and the current literature have revealed: the project approach is used to bring together and control diverse activities.

> The total perspective of a project is lost among functional departments. They can be guilty of "tunnel vision"--that is, a concern only for

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[4]The questionnaire is exhibited in Appendix C.

TABLE 4-4

Aerospace	Reasons for Employing Project Management			
	Cost	Scheduling	Management Control	Required by Customer
$50 million or over	90%	90%	100%	100%
Under $50 million	93%	73%	100%	91%
Construction				
$10 million or over	91%	100%	91%	33%
Under $10 million	88%	100%	88%	66%
"Other"				
$5 million or over	100%	100%	100%	33%
Under $5 million	100%	90%	100%	70%

> their portions of the task without regard for the impact of their actions on the company and the project.[5]

> Such an organizational relationship /project management/ prevents any one functional manager from overemphasizing his area of interest in the project to the neglect of the overall project goals.[6]

The project approach, as shown in Table 4-4, is also

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[5] C. J. Middleton, "How to Set Up A Project Organization," Harvard Business Review, (Volume XLV, Number 2, March-April, 1967), pp. 74-75.

[6] Cleland, "Why Project Management?" p. 83.

considered a useful management approach for scheduling and cost purposes. One hundred per cent of the "other" questionnaires listed cost as a reason for using project management as did over ninety per cent of the aerospace questionnaires. The table also shows that scheduling is a prime reason for using project management. One hundred per cent of the construction firms report that they use project management for scheduling purposes. The aerospace and "other" areas also feel scheduling is a prime reason for adopting a project approach.

The fourth reason for employing project management, as shown in Table 4-4, "Required by Customer," is virtually a unanimous response among all aerospace projects. These projects are federal government undertakings. In small "other" projects "Required by Customer" is again a common response. Many of these latter projects are also government sponsored, such as installing computers in federal agencies, and in state planning projects where the federal government is providing the funds. In company sponsored projects "Required by Customer" is not a frequent response. This, it appears that the federal government is a prime influence in the use of project management, especially in aerospace.

Two conclusions have been drawn. First, the main reason for using a project organization appears to be overall management control. Second, the federal government is responsible for many of today's project organizations, especially those in aerospace, because the project approach is required under the terms of the contract.

Another area researched under this topic, concerning why a project approach is used, is that of major reports. These are reports which the project manager uses to help him direct and control the project. The reasons given for using a project approach have been listed as management control, cost, and/or scheduling. "Required by Customer" has been omitted because it has little influence on the types of reports submitted. To ascertain whether the answers given in Table 4-4 are valid, the major reports have been sought. If the reasons for using project management are indeed management control, cost, and scheduling, then the major reports should be closely related to these functions. This is logical because if cost is a reason for using project management then one of the major reports should be on cost. The following major reports have been noted in the questionnaires and are listed first, second, and third based on the number of times each was chosen. Some project managers listed only a few major reports and others listed upwards of half a dozen.

Only those reports listed by half the questionnaires are shown.

Aerospace

1. Cost
2. Scheduling
3. Progress

Construction

1. Cost
2. Progress
3. Scheduling

"Other"

1. Cost
2. Progress

The results present the three major reasons given earlier (management control, cost, and scheduling) and thus support the previous conclusion concerning why project management is used.

Basic Type of Project Organization. In order to ascertain the basic type of project organization, organization charts have been requested from all companies. However, since this alone will not show how dependent or independent the project organization is with respect to the functional organization, a statement of the basic functions of the project have also been requested. The project manager has been asked to relate whether the basic functions have been performed independently of the permanent organization, or whether the project is semi- or completely dependent on the permanent organization for performance of these functions.

The answers reveal the following data in the areas of aerospace and construction:

TABLE 4-5

	INDEPENDENT	SEMI-DEPENDENT	DEPENDENT
Aerospace			
Major Functions:			
Engineering & Design	36%	28%	36%
Production	15%	35%	50%
Test	30%	25%	45%
Construction			
Major Functions:			
Engineering & Design	35%	40%	25%
Procurement	17%	42%	41%
Construction	48%	21%	31%

The two categories of firms have each been divided into two groups, according to dollar size, to determine if one group has more independence than the other. The following data have been compiled:

TABLE 4-6

	INDEPENDENT	SEMI-INDEPENDENT	DEPENDENT
Aerospace			
$50 million or over:			
Engineering & Design	67%	11%	22%
Production	27%	36%	37%
Test	40%	30%	30%
Under $50 million:			
Engineering & Design	17%	37%	46%
Production	0%	33%	67%
Test	20%	20%	60%
Construction			
$50 million or over:			
Engineering & Design	41%	41%	18%
Procurement	23%	33%	44%
Construction	54%	19%	27%
Under $10 million:			
Engineering & Design	24%	38%	38%
Procurement	0%	67%	33%
Construction	0%	60%	40%

The data in Tables 4-5 and 4-6 show that project organizations which are larger from a dollar standpoint have more independence than the smaller ones. However, all project organizations are somewhat dependent on the functional organization. The largest projects are in aerospace, and these are greatly independent of their functional organizations. However, they are dependent on the latter to perform the production function for them, due to the high cost of duplicating expensive manufacturing facilities. One of the NAA interviewees brought out that aerospace firms are very careful about avoiding the duplication of manufacturing facilities. At NAA it has been shown that the central manufacturing division produces all common items and the project organization's manufacturing facilities produce only specialty items. It is, therefore, quite logical to find the aerospace project organizations being dependent on the functional organizations to perform this function for them. In construction projects, the building or construction function is the most independent of the functional organization in projects over $10 million. In these large projects hiring from outside the firm is common and thus the project manager is independent of the functional organization to a large degree. However, in smaller projects, the construction personnel are assigned by the functional construction department from within the permanent organization and the project manager must use the functional managers to assist him. Thus, Tables 4-5 and 4-6 show that the project organizations in this analysis are semi-independent. They are independent of the functional organization in performing some functions and dependent upon it for performing others.

The "other" category is not analyzed in the above fashion because it is not possible to designate a few major functions. The wide variety of projects leads to a great diversity of major functions. Although similar projects have somewhat similar functions, there is not an overall group. The functions are directly related to the specific projects and the latter are diverse. In these "other" projects, however, the same dependence upon the functional organization is evidenced as the following data indicates:

TABLE 4-7

	INDEPENDENT	SEMI-INDEPENDENT	DEPENDENT
All Functions From the "Other" Area	43%	20%	37%

The reasons for the high degree of independence in the "other" area is the large number of project organizations which have independent design and engineering departments. The data show, however, that these project organizations are all dependent to some degree upon the permanent organization. And so, the "other" projects appear to be similar to the aerospace and construction projects. Thus, Diagram 2-6 in Chapter II probably is illustrative of the average project organization, irrespective of the industry involved. Illustrations of project organizations are shown in Appendix E so the reader can see the formal relationships between some project and permanent organizations.

Place of the Project Organization in the Organization Structure. Two questions have been asked about the place of the project organization in the permanent organization: Where does the project organization fit into the corporate structure, and are larger projects located higher in the organizational structure than smaller ones?

The following data have been derived from the questionnaire. The areas are each divided into two sections to determine if dollar size has any effect.

Two conclusions have been reached in this area from the questionnaire and from the organization charts which were submitted. First, the larger the dollar size of the project the further up the organizational chart the project organization is located. This conclusion is evident from Table 4-8. Second, all project organizations are located within two echelons of the vice-presidential level. This

TABLE 4-8

	Project Manager Reports to VP or Above	Project Manager Reports Below VP
Aerospace		
$50 million or above	72%	28%
Under $50 million	15%	85%
Construction		
$10 million or above	58%	42%
Under $10 million	37%	63%
"Other"		
$5 million or above	33%	67%
Under $5 million	21%	79%

conclusion was obtained through study of the organizational charts submitted and is not shown in Table 4-8.

When firms in the aerospace, construction, and "other" areas are analyzed in this respective order, the survey reveals a decreasing percentage of project organizations which report directly to the vice-president. The smaller the dollar size of the project organization the lower the level at which it reports, down to two levels beneath the vice-president. Thus, there appears to be a correlation between the dollar size and the place of the project organization in the corporate structure.

In this section on the project organization four conclusions have been reached.

First, the principal reason for choosing a project organization approach over a functional approach is to obtain overall management control, and to allow the group to place primary emphasis on the project objective.

Second, the federal government is responsible for many project organizations in existence.

Third, the basic project organization can perform some of its functions independently of the functional organization, but for others it is dependent on the latter. The largest projects manifest much more independence in operation than do the smaller ones.

Fourth, the dollar size of the project appears to be a factor in determining the position the project organization occupies in the permanent structure. The projects that function in the higher organizational echelons are those that are larger dollarwise. Of the project organizations surveyed, none has been positioned more than two levels below the vice-presidential level.

Analysis of the Project Manager

The third and final section of the questionnaire analysis is concerned with the role of the project manager. The questions that have been asked are: What is his background? What is his span of management? How well does he meet two of the criticisms in the current literature with respect to the releasing and rescheduling of personnel? How great is his control over the project?

Background of the Project Manager. Examination of the positions held previously by the project managers shows that they have distinctly different backgrounds. In almost all instances the training of the project managers, however, is directly related to the type of project being undertaken. This is common among project managers as brought out by Baumgartner, who writes:

> On a major space vehicle project, for example, the project manager is a propulsion expert. On an early warning system project he is a marketeer, because the effort involves a number of organizations with which he must become acquainted through marketing activities. In an intelligence system involving heavy modification of the "standard" electronic equipment involved, he is an industrial engineer. On an advanced global tracking network, he is a mathematician.[7]

There is also a percentage of past project managers who

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[7] Baumgartner, pp. 11-12.

have responded that they are presently undertaking another project. This is revealed by the project managers in answer to the question, "What was your previous job?" The following responses show the percentage of those who were project managers on their previous assignment.

TABLE 4-9

	Project Manager on Last Project	
Aerospace	Yes	No
$50 million or over	38%	62%
Under $50 million	54%	46%
Construction		
$10 million or over	50%	50%
Under $10 million	28%	72%
"Other"		
$5 million or over	0%	100%
Under $5 million	4%	96%

The project approach is not new in the aerospace and construction industries, but it is in the "other" category of firms. It is interesting to find that organizations seem to employ their project managers for a second project in aerospace and construction, as seen in Table 4-9. This information points up the need for further analysis. Why are project managers reassigned to direct new projects? One possible answer is the following statement by a writer in the current literature.

> By virtue of the interfunctional experience gained under pressure, the project manager often matures in the course of a project, becoming a more valuable manager. But he may have trouble slowing down to a normal organizational pace. His routine job is likely to seem less attractive in terms of scope, authority, and opportunity to contribute to the business.[8]

Regardless of the reason, aerospace and construction firms appear to be building a pool of experienced project managers.

Span of Management. Information with respect to the number of subordinates who report to the project manager (span of management) has been undertaken. Factors affecting the span have also been sought. The data compiled in Table 4-10 reveal that the dollar value of the projects varies widely, but the span of management does not. It fluctuates between two and eleven. The overall mean is seven and the overall median and mode are six. Dollar size does affect the span to some degree, however. Projects over $10 million show a span of management of eight while those under $10 million show a span of five. This is not a very large difference and indicates that the dollar size of the project does not have a great affect on

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[8] Stewart, Business Horizons, p. 62.

TABLE 4-10

Aerospace	Dollar Size (In Millions)	Span of Management
	180	4
	50	4
	10	7
	20	2
	11	3
	25	9
	1,100	11 (2 staff)
	1,600	7
	150	10 (2 staff)
	80	8 (4 staff)
	20	8 (2 staff)
	14	8 (6 staff)

Mean--6.75
Median--7.5
Mode--8

Construction	Dollar Size (In Millions)	Span of Management
	27	6
	3	4
	30	6
	10	5
	9	6
	20	6
	10	10 (6 staff)
	11	5

Mean--6
Median--6
Mode--6

"Other"	Dollar Size (In Millions)	Span of Management
	15.0	3
	.1	7
	25.0	3
	.125	4
	.2	3
	.2	6

Mean--4.3
Median--3.5
Mode--3

Overall

Mean--7
Median--6
Mode--6

the span. A Booz, Allen, and Hamilton report made in 1961 on a number of aerospace firms states that the span of management for most of the firms surveyed is over eight. This is considered high by the firms.[9] The questionnaire data in Table 4-10 indicates that the span of management in the aerospace firms in this study is seven. Although the two studies did not cover the identical firms the data does indicate that the span may well have decreased in recent years in this industry. Whether the span has gone down or not, the dollar size of

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[9]Booz, Allen, and Hamilton, "Field Survey Report of Organizational Practices, AEROSPACE INDUSTRY," Private Report, 1961.

these projects has gone up. For this latter reason specifically the effect of dollar size on the span is considered to be negligible. It seems reasonable to conclude, therefore, that the project manager himself is the one responsible for the span.

Releasing and Rescheduling of Personnel. One area of emphasis in the current literature is that which deals with the morale of the project employees. The practice of releasing employees, who have been brought in from the outside, at the end of the project or failing to reassign them until the project is virtually complete, can be detrimental to their morale and to the success of the project. This prompts the question in the survey: Are all personnel who are brought in from outside to work specifically on the project released upon project completion? If the answer is yes a slow-up by these project employees might take place. The following information on this question has been obtained from the questionnaire:

TABLE 4-11

Aerospace	Hired From Outside	Released Upon Project Completion
	50	--
	12	12
	70	--
	5	--

Aerospace (Cont'd.)	Hired From Outside	Released Upon Project Completion
	2	--
	10	10
	1,500	"few"
	40	--
	4	--
	30	30
	6,000	2,000
	30	--
	45	30
	6	--
	10	--
	17	--
Construction	1,132	1,035
	1	--
	2	--
	380	388
	380	388
	1,336	1,308
	16	--
	125	125
	200	--
	0	250
"Other"	15	--
	18	7
	1	--
	5	--
	7	--
	90	90
	5	--
	52	--
	2	--
	16	--
	1	--
	6	6
	5	3
	6	4
	8	--
	1	--
	1	--

Sixty-two percent of the aerospace firms replying indicate that they hire from outside the firm. For construction, this figure is forty-six percent, and for "other" firms, it is seventy-five percent.

The following data further illustrate this area under analysis:

TABLE 4-12

	Average Personnel Per Project	Average Hired From Outside The Firm	Average Released Per Firm
Aerospace	914	301	83
Construction	300	170	166
"Other"	55	10	5

A number of points are of interest. First, the average aerospace project involves a larger number of personnel and hires a larger number of outside personnel than either of the other two areas, although construction hires a greater percentage.

TABLE 4-13

Percentage Released of Those Hired From Outside The Firm	
Aerospace	27%
Construction	98%
"Other"	46%

Aerospace firms also release the smallest percentage as shown above in Table 4-13. In aerospace, thirteen of the sixteen firms hiring from outside the firm have indicated that they release fewer employees, if any, than they hire. Five of the ten construction firms that hire from without report the same practice, as do fifteen of the seventeen "other" firms. The reason that the percentage of construction and "other" employees released is so high (despite the fact that the majority of firms did not let go as many as they took on) is that in these industries the firms hiring large numbers from outside tend to let them go. The firms hiring only a few persons keep them. The percentage of construction workers released is high because construction firms tend to hire labor in the local area and release them when the project terminates. In aerospace, however, the figures indicate that the personnel tend to go on to another project when the initial one is completed. They are not laid off in as large percentages.

Since there are workers who are being laid off when the project is over, it appears logical to conclude that there may well be a decline in progress. In commenting on this, one writer in the current literature says, "The project group never voluntarily ends its own life, and cutting off a project or breaking up a group may be a very difficult administrative problem."[10]

The current literature has brought out an interesting point of which the firms using project management must be aware. It should be pointed out that none of the three groups release all of those hired from outside the firm. This is shown in Table 4-12. There may well be an incentive for the project personnel to perform at top efficiency as all groups retain some of their personnel irrespective of the source from which they have come. It must be re-iterated, however, that some firms do not keep any of these personnel (nine of forty-three).

The second question dealt with not reassigning personnel well ahead of the completion of the present assignment, causing them to become worried and apprehensive about their next jobs. The current literature was cited earlier on this point (page sixty-one). This has been fully researched and the following data have been obtained concerning rescheduling of project personnel. Each group is divided into two sections according to dollar size, to ascertain whether or not this is a factor in rescheduling.

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[10] Shepard, p. 247.

TABLE 4-14

	Rescheduling of Personnel
Aerospace	
$50 million or over	4 months
Under $50 million	2 months
Construction	
$10 million or over	3 months
Under $10 million	4 months
"Other"	
$5 million or over	3 months
Under $5 million	4 months

The smaller projects appear to give longer notice of future assignments in the categories of construction and "other." Among aerospace firms, however, the larger firms give the longest period of advance notice. All questionnaire returns indicated that advance notice was given, however. Forty-eight of the seventy firms gave specific answers and the remainder indicated they also gave ample time. This answer conflicts with the current literature cited earlier and indicates that further research would be profitable.

The following conclusions have been reached concerning the releasing and rescheduling of personnel.

First, approximately fifty percent of those hired from outside the firm have been retained after the project ends, according to the questionnaire survey. Aerospace firms have retained the greatest percentage.

Second, two to four month rescheduling of project personnel is average and, therefore, the current literature appears in need of revision or further research, because it states that this is a drawback present in project organizations. No evidence of this is found in the case studies or in the questionnaires. All personnel are rescheduled months before the end of the project.

Control Over the Project. To ascertain the extent of the project manager's control over the project, the functional statements have been studied. It is evident from the data presented earlier that virtually all the project organizations are in some way dependent upon the functional organization. A pertinent question is: How strong is the control of the project manager over the entire project? (His control over personnel is discussed in Chapter V.) Compilation of the survey data indicates that in all instances the project manager is in virtually complete control of the project. He frequently participates in establishing the budget, makes the major decisions for the project, allocates the project's resources, and establishes the production time schedule. The following functional statements are typical of each given category of firms studied, and are reported verbatim from the questionnaires.

Aerospace

The specific duties of the Project Manager and his staff are as follows:

A. Define program scope

B. Allocate and control funds

C. Establish work accomplishment schedules

D. Define and direct technical efforts

E. Identify the necessary services (facilities, tooling, personnel) to accomplish work

F. Monitor and evaluate program progress, and take corrective actions as required

G. Report program progres to the customer and through the Project Director to top management.

Construction

BASIC RESPONSIBILITIES

Customer liaison
Subcontractor liaison
Total cost control
Requisitioning
Overall schedule maintenance
Start-up and trouble shooting

Encompassing the responsibilities are the following items:

1. Review and clarify all necessary specifications and estimates prior to release to the Engineering Department.

2. Clear with the customer all questions relating to a job assigned to him. Changes, involving increases or decreases in cost, should be referred to the Production Manager for instructions.

3. It is the Project Manager's responsibility to supply design information required by Engineering from customer, vendors, and others.

4. Arrange with Purchasing, Engineering, and the Manager of Construction for laying out a complete schedule of Engineering, Purchasing, and Construction programs which provide appropriate lead times for the orderly and economic execution of the contract, compatible with the overall delivery commitment.

5. Work with the Manager of Construction in drafting a detailed plan of construction, providing the appropriate number of craftsmen for each operation in proper sequence to insure a most economical program.

6. Follow the job through Engineering, Purchasing, and Erection and act as customer contact with general engineering and/or construction questions, which cannot be settled readily by the Construction Manager or his Erection Supervisor in the field.

7. Although the Manager of Construction is responsible, through his Erection Supervisor, for the assignment of appropriate manpower and the economical execution of the construction program compatible with the schedule approved by the Project Manager, the Project

Manager must maintain weekly contact with progress of construction and immediately report to the Vice-President of Operations and/or the Executive Vice-President, through the Production Manager, any critical developments affecting scheduled progress or costs.

"Other"

The functions of the Project Manager are as follows:

A. Direct overall interpretation of contract and implementation of needs

B. Plan for and obtain personnel to staff needs

C. Plan and control budgets for the project

D. Provide technical consultation and guidance for staff

E. Review and approve all technical schedule-type correspondence to the customer

F. Provide progress reports to customer and management.

Whether the project manager should be very powerful or not is a relative matter. The objectives being sought will determine the answer. Diagram 4-1 on the following page shows this. A project manager who is too strong or too weak can be detrimental to the permanent organization. A balance is needed between the two organizations. This research also indicates this conclusion as it shows the typical project organization to be semi-independent of the functional organization.

In this section five conclusions have been reached concerning the project manager.

First, project managers appear to be reassigned on new projects and the companies that use project management, especially in the areas of aerospace and construction, are establishing a pool of well-trained project managers.

Second, the span of management is more a function of the project manager than it is a function of the dollar size of the project.

Third, the project personnel hired from outside the firm may well be a reason for slow-ups since a sizable proportion are replaced.

Fourth, the rescheduling of individuals appears to be adequate, and this study indicates, therefore, that a modification of the current literature, with respect to this aspect, is in order.

Fifthly, the project manager on the average project is in control of his project despite his reliance upon the functional organization which tends to hamper him somewhat, as will be shown in Chapter V.

Overall Summary

The twelve aforementioned conclusions illuminate the general area of project management. One overriding factor appears throughout: as projects in the construction and "other" areas move toward greater magnitude they tend to take on the same characteristics found in aerospace projects. This was shown in section one of this chapter. Sections two and three show that, despite the conscientious attempt to discover the dissimilarities which exist among the three areas, there are more similarities than dissimilarities present.

Thus far in the analysis of the data and information derived from research, various aspects of the project organization have been discussed. There is, however, one additional major aspect which has been brought out but not yet fully analyzed--the relationships between the project and permanent organizations. The results of the analysis in this area are presented in Chapter V.

PROJECT ORGANIZATIONAL RELATIONSHIPS AND A GENERAL OVERVIEW OF THE PROJECT APPROACH

CHAPTER V

The purpose of the first part of this chapter is to elaborate on the relationships which exist between various project organizations and the functional organization. As evidenced in Chapter II, the project manager has project authority, but not line authority. This situation leads to a series of questions such as: What exactly does it mean? How does this affect him? Does it make the job more difficult? Are there any differences in impact if industry lines are crossed?

In order to scrutinize all aspects of the project manager's job, interviews with personnel of a large firm have been held in each of the following areas--aerospace, construction, chemical, and consumer products. Finally, an interview with a project organization in state government has been undertaken.

One day has been spent with each one of these organizations. The reason for choosing these five is their location. Four of the five are located within a short distance of each other and have been covered on a one week interview trip. The other is located within convenient driving distance.

The latter part of this chapter examines the responses given by those interviewed throughout this study on the advantages and disadvantages of project management. This is an area that should be of prime importance to anyone interested in project management, and it is felt that some interesting information has been obtained from actual project personnel. The question of which organization principles apply to the project organization is discussed at the end of this chapter. The question of whether there are any organizational principles that apply only to project management is also covered.

Aerospace. In the aerospace firm interview, it has been found that individuals from the various functional areas which are necessary to support the project are assigned to the project manager. The project budget is in the project manager's hands, and the salaries of the personnel are predetermined by company policy. Thus, no conflict exists in these areas. One individual from each of the five functional areas serves as liaison for the project manager in obtaining personnel in that functional area and also takes charge of his respective area for the project manager.

Since the project manager has no line authority, it is of prime importance for him to rely on the functional department heads to support him in directing his personnel. To win their support, one objective is of major importance--to prove his competence on the project. Success on previous projects or good results with the present one leads to strong support from the functional heads. To this extent, therefore, the project manager has to earn his authority.

Besides the lack of line authority over the functional personnel, the project manager lacks authority over some of the manufacturing facilities. It becomes necessary, therefore, to establish and assign priorities. His success on the project is dependent upon his ability to persuade the functional managers to give him a high priority so that there is no delay in turning out the necessary equipment and parts for his contract.

Personality characteristics play a key role in the project-permanent organizational relationships. The project manager has authority to send back to the functional manager any personnel assigned to the project whom he does not find to be capable. To send them back, however, might well be a reflection on the selectivity of the functional manager who has assigned them in good faith. Thus, the project manager prefers to leave such personnel on the project unless he finds them to be completely incompetent. In a case of this kind, he attempts to persuade the functional manager to replace them of his own accord, and thus avoid a touchy situation. Only if the functional manager does not do so, would the project manager ask that another person be assigned. Since the project manager does not have the authority to order what he wants, he uses his personal powers of persuasion to the greatest advantage in obtaining it indirectly.

The project manager's dependence upon the functional organization for maximum project support makes it necessary for him to show strength in the areas of technical competence, persuasion, negotiation, and reciprocal favors. He has to influence the functional personnel to assist him, and he, in turn, has to reciprocate when possible. The job of the project manager in aerospace is more difficult than it is in other industries because of his lack of line authority and his dependence on the functional people in the areas of personnel and facilities. However, by exercising his strengths in the aforementioned areas it is possible to obtain maximum assistance from the functional organization. Whether this can be done effectively depends on the personal characteristics of the project manager.

Although no attempt is made to generalize by claiming that all aerospace project managers conform to this pattern, it is found in this type of project that all managers have an authority-gap caused by the lack of line authority. This statement is based on the ASPO and NAA case studies and the questionnaires returned on aerospace projects. Due to the authority-gap, extreme care in dealing with project personnel and functional personnel is required.

Construction. In the construction interview it has been found that there are many aspects of project management which are similar to those of aerospace. The project manager in the construction firm has the right to reject personnel assigned to the project as does the aerospace project manager. The necessary personnel are provided from the functional departments to assist him on the project. He exercises great caution in rejecting personnel assigned, as does the project manager in the aerospace firm.

Although he has no line authority over the personnel, his "right" to exercise authority seems to be taken for granted. His need to "earn" his authority does not seem to be a factor. While the project manager in the aerospace division appears to put great importance on getting along with the functional personnel, because they are so important to the project, the construction project manager runs his project as virtually an autonomous unit. The main reason for this seems to be that the aerospace project manager is heavily reliant on the functional organization, and the construction project manager is not, as shown in Tables 4-5 and 4-6.

This latter point is true in two respects. First, the construction project manager either has the facilities he needs at his disposal or can rent them. In aerospace they are much too expensive and are specialty items. Second, the largest proportion of the construction project manager's team is made up of construction workers hired in the local area, and the project manager has line authority over them. He can demand and obtain action from a large percentage of his project team because he has the authority to fire as well as hire. The aerospace project manager is not in this position.

These characteristics of the project organization in the construction firm could well account for the distinct lack of pressure between the project and permanent construction organization and within the former organization. The project manager in this enterprise appears to have much more freedom than his counterpart in the aerospace firm. The areas of technical competence, persuasion negotiation, and reciprocal favors with the functional organization are important, but are not identical to those of aerospace. In the latter organization, the project manager seems to exert considerable ingenuity to get assistance from the functional organization, while in the construction organization, the functional organization seems much more willing to aid the project organization. The fact that the gravity of the undertaking in aerospace is so much greater than in lower-priority industries, however, may account, in part at least, for the markedly higher tension which prevails there than in the construction firm.

Chemicals. In an interview at a chemical firm, it has been learned that the industry makes little use of project management. This finding has been verified by the questionnaire returns as only one firm reported use of it, the one later chosen for this interview.

The project manager in the chemical project is assigned not to a contract, as is typical in aerospace and construction, but rather to a specific undertaking, such as a chemical process. This project is undertaken on behalf of the corporation, and not a customer, as is typical in the two industries discussed earlier. A team is assigned to the project manager, and he has the right to reject any assigned personnel. However, the number assigned is usually only four or five and so this prerogative is seldom exercised. Each member of the team plays a much more significant role than in the other two projects, which are of greater magnitude.

Contrary to the situation in the other types of projects, the project manager has no control over the budget. In fact, there is no budget. Instead, when a particular project comes into existence, because the firm wishes to develop or further research a process and a team approach is believed to be most desirable, the personnel are taken from their functional areas, assembled, and assigned the necessary equipment and facilities. The team members are paid by their functional managers.

This project is similar in many ways to the first two described in the chapter. The project manager is responsible for obtaining necessary equipment from the functional departments and for controlling his personnel by working through the functional managers. Although his role is similar to that of aerospace managers in these respects, his ability to obtain that earned authority plays a very minor role. The outside pressures from customers are non-existent, and the budget and time constraints are not strong. This autonomy permits the project manager to perform his assignment, without needing to manifest more than one of the traits needed in a good aerospace or construction project manager--that of technical competence. This characteristic alone serves to motivate the team personnel, and to establish a strong esprit de corps. The project manager's rapport with the permanent organization depends upon proving that he is performing the project within the time, cost, and quality parameters. Aside from that, he is under no pressure from them.

Based on these three projects, it appears that the type of project, its dollar size and manpower size, and the demands made on it from a time, cost, and quality standpoint greatly influence the project-permanent organizational relationships.

Consumer Products. In the consumer products firm interview a hybrid-type project organization is witnessed. The project manager starts off the project with a team assigned by the various functional departments. They are responsible to their respective functional managers and their salaries are paid by them. The project manager has a small budget for paying only his immediate staff of six persons. During this stage of the project, the project manager is quite like the aerospace project manager, for he depends upon the functional managers to assist him by managing his personnel. His personnel are developing a new product based on consumer-research findings.

During the research, development, and manufacturing stages the project manager's team changes as product emphasis changes. The project manager's main function is to see that the master plan for manufacturing the product is followed. A slightly different approach exists in this type of undertaking from other project organizations described here. While the personnel assigned the project are working on a given consumer product they remain in the functional organization. The functional manager is, in reality, working for the project manager even though he receives no money from the project manager in the form of salaries, and even though the project manager has no direct authority over him. The master plan is used by the project manager to keep everyone on time. Weekly status, progress, and cost reports on the project are sent to the top managers. The project manager uses the functional managers to keep the personnel assigned to the project within the parameters. Directing the personnel and managing the facilities is the job of the individual functional managers.

Once the product has been manufactured, the project manager becomes a product manager. He stays with the product, being responsible for sales and most importantly for profits.

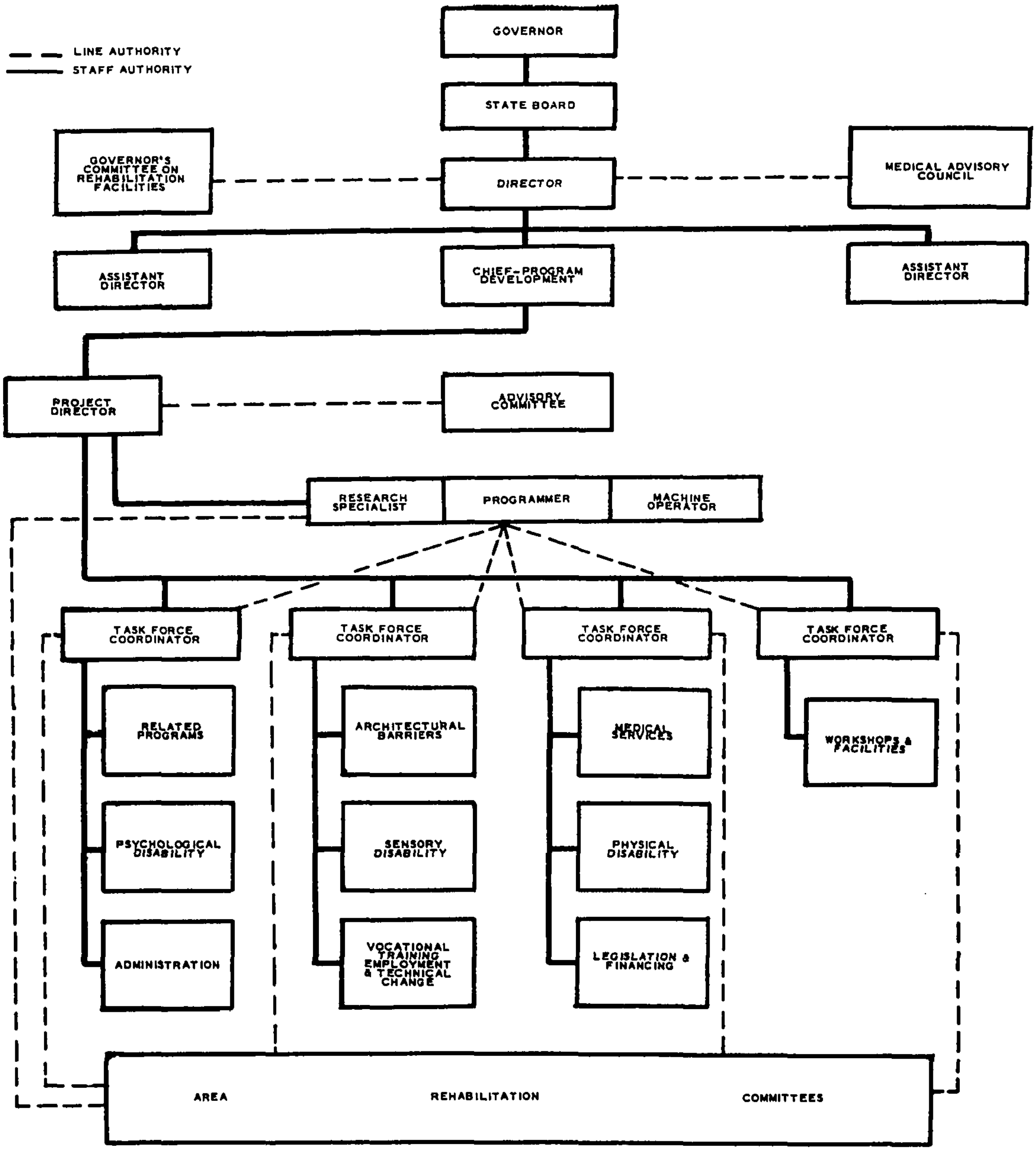
This is what is meant by an earlier reference to a hybrid-type organization. The relationship between the project and permanent organization disappears because the project organization has become part of the permanent organization. The project manager could at this point start over and pick up a second product, and become a product manager for it as well. His relationship with the permanent organization is, however, quite different from that evidenced in aerospace or construction because the product is in the project organization only for research, development, and initial manufacturing, after which it phases into the functional organization.

The overriding factor in the project-permanent organizational relationships is profit. The weekly report system tends to insure that all personnel are working as hard as possible. The project-permanent organizational relationships are seldom strained largely because the project organization possesses project authority to see that the functional managers are on time and within cost. If they are not, the weekly progress meetings enforce the project manager's authority. These progress meetings are held with the top functional executives. Managing personnel and obtaining priorities on equipment are the responsibilities of the functional managers. This type of project organization falls within the broad definition of project management and shows another interesting example of project-permanent organizational relationships.

State Government. In the state governmental agency interview, the project organization focused upon has been the Vocational Rehabilitation Agency. The prime objective of this group is to put together by 1975 a master plan for vocational rehabilitation services for the state. Similar projects are now being undertaken in almost every state in the union through funds provided by the federal government. A typical project organization in this area is presented on the following page.

The Project Director has a staff of seven assigned by the Vocational Rehabilitation Agency. The research specialist, the programmer, and the machine operator serve in a staff capacity to both the task forces and the area committees. The task forces, as can be seen in the organization chart, are concerned with ten specific study areas. These task forces will develop a picture of overall state needs and estimates of overall state resources in the area of vocational rehabilitation. The data will then be forwarded to the area rehabilitation committees. These committees are set up to cover the state geographically, and individuals in each region serve on the respective committees. It is their task to ascertain precisely what the needs of the given area are, and to set up

Diagram 5-1


LINE AUTHORITY
STAFF AUTHORITY
GOVERNOR
STATE BOARD
GOVERNOR'S COMMITTEE ON REHABILITATION FACILITIES
DIRECTOR
MEDICAL ADVISORY COUNCIL
ASSISTANT DIRECTOR
CHIEF-PROGRAM DEVELOPMENT
ASSISTANT DIRECTOR
PROJECT DIRECTOR
ADVISORY COMMITTEE
RESEARCH SPECIALIST
PROGRAMMER
MACHINE OPERATOR
TASK FORCE COORDINATOR
TASK FORCE COORDINATOR
TASK FORCE COORDINATOR
TASK FORCE COORDINATOR
RELATED PROGRAMS
PSYCHOLOGICAL DISABILITY
ADMINISTRATION
ARCHITECTURAL BARRIERS
SENSORY DISABILITY
VOCATIONAL TRAINING EMPLOYMENT & TECHNICAL CHANGE
MEDICAL SERVICES
PHYSICAL DISABILITY
LEGISLATION & FINANCING
WORKSHOPS & FACILITIES
AREA REHABILITATION COMMITTEES

priorities for the services and programs needed. They are also to determine whether there are any barriers to vocational rehabilitation services in their area.

It is the project manager's function to coordinate the work of his task forces and the area rehabilitation groups. The project manager has authority only over the team that consists of the three staff personnel and the four coordinators. He can obtain support from the functional managers should he have any difficulties in directing his immediate team. The task force and area rehabilitation groups are made up, however, of private citizens interested in assisting state vocational rehabilitation. They must be persuaded to help. Their role is important, but they differ from other project teams in that they are not under anyone's direct authority. They volunteer their services, and as is often the case with volunteers, they must be treated with extreme tact and diplomacy in order to get the desired performance from them. A dynamic personality and powers of persuasion on the part of the project manager are of great importance as management tools in this situation. Because the project manager lacks line authority over the volunteers he has a very difficult task, for he is responsible for motivating them.

To obtain performance, each manager uses specific techniques. The individual interviewed believes that the most effective way to obtain performance is to ascertain who the leaders in the group are, and to work through them to get cooperation. These individuals in turn help coordinate the team as a working unit. In her opinion, the most important aspect of project management is the motivation of volunteers to function satisfactorily. She reports that doing research for the volunteers tends to cause the group to lose interest. When they do their own research and compile their own data, they have a sense of accomplishment, and their group leader develops a sense of responsibility. As they perform their duties, the volunteers begin to discover the importance of the project. It must be re-emphasized, however, that although this type of project is one in which the inter-project organizational relationships are of greatest importance, the approach taken by this interviewee is not necessarily the best one in all instances. How the project manager will earn his authority is situationally determined. This case study does present a different area of emphasis from those presented earlier, and shows how diverse the project manager's relationships can be.

Summary of Project Organizational Relationships

The diverse forms which can be taken by a project organization are reported in the first part of this chapter. The amount of authority delegated to the project manager, the degree of cooperation he can secure from the permanent organization, the specific personal traits he should have or must develop, and the overall relationships which will prevail in the project organization itself, as well as between the project and permanent organization, are situationally determined. Technical competence, a capacity for negotiation, a persuasive personality, and the ability to arrange for reciprocal favors are qualities of considerable importance to a successful project manager. This study indicates, however, that the relative importance of each of these qualities varies considerably from firm to firm and from one type of industry to another.

A General Overview of the Project Approach

In completing this research study, two final questions have been asked to the interviewees. First, are there any inherent advantages and/or disadvantages to project management? Second, what organizational principles apply to the project organization, and are any new ones applicable?

The first question has been asked of each individual interviewed in connection with this study. Answers have been obtained from more than fifty project managers and team personnel. On the advantage of the project approach, the answers are basically the same. Everyone believes that the prime advantage of the project organization is its ability to focus on one particular objective and bring all the project resources to bear on that objective. This is also the conclusion reached in Chapter IV under "The Reasons for Employing Project Management," where it was said that overall management control was the prime reason.

Questions with respect to the disadvantages of project management have proven to be a disconcerting area, for most individuals answered that there are none. Those who did report a disadvantage said it occurs in the over-use of the project organization. This complaint took two forms: first, that it is used where it is not needed and where the functional organization would have sufficed; and second, that it duplicates present facilities, which makes the project organization more independent of the permanent organization. The questionnaire analysis in Chapter IV indicates that these latter disadvantages are not present in the project organizations responding to the questionnaire.

The second question which has been asked about management principles applicable to the project organization has proven to be puzzling to the persons interviewed, and the answers are not very meaningful. A search of the texts on management principles reveals that there are, however, no classical principles which do not apply to project management. Nor have any principles applicable to the project organization only been uncovered in this study. There are two classical principles that appear to be violated intentionally in projects studied in this research, however. First, the principle of unity of command is violated; second, the principle of parity of authority and responsibility (authority and responsibility should be equal) is not present. The project manager has complete responsibility for the project but does not have complete authority over the personnel. Aside from this, however, both the project and the permanent organizations are subject to the basic, classical principles of management as explained in current basic management texts.

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER VI

Conclusions

The conclusions that have been reached about project management in this research study are the following:

1. There are manpower savings in project organizations as the dollar size of the project increases.[1]
2. There is a direct relationship between the manpower size of a project and its need to go outside the permanent organization to staff the project.
3. The life of a project is not related to its dollar size but rather is the result of a previously determined time table. This is the reason aerospace projects run so long and

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[1]The bases for conclusions 1-12 are contained in Chapter IV.

construction projects do not.

4. The federal government is responsible for many of the large aerospace projects in existence.
5. The major reason for using a project approach is to obtain overall management control and place primary emphasis on the project objective.
6. Virtually every project organization is dependent in some way on the permanent organization, although many project organizations do perform some of their major functions independently of the permanent organization.
7. Projects which are larger, from a dollar standpoint, are located at higher echelons in the organizational structure than smaller projects. All projects in the research are, however, within two levels of the vice-presidential echelon.
8. In industries using the project approach, it appears that a manager who has functioned on one project is often chosen to manage another and thus a pool of experienced project managers is emerging in the aerospace and construction industries.

9. The effect of dollar size on the span of management is negligible. The span appears to be a function of the project manager's judgment as to what he feels is best for him in his particular project.
10. In agreement with the current literature, this study concludes that the fact that project personnel are hired from outside the firm could account for project slowups, because the men know they are going to be released upon project completion.
11. In disagreement with the current literature, this study concludes that the time period for rescheduling is two to four months on the average, which is adequate time and prevents frustration or concern over the next assignment. It is not a last minute move, as might have been gathered from literature on the subject.
12. The project manager, despite his reliance upon the permanent organization, possesses great authority over the project.
13. Although there appears to be an authority-

gap in all project organizations it is of greatest concern in aerospace because the time, cost, and quality parameters are both greater and more urgent than in any other industry.[2]

14. A forceful but pleasing personality, the ability to establish rapport, and the capacity to maintain functional reciprocity with the permanent organization are important characteristics of a project manager.

Recommendations

The purpose of this research has been to draw conclusions about project management. The areas analyzed are diverse. However, the conclusions do form a basis for three recommendations.

One, a more formalized approach is needed in the use of project management in non-aerospace undertakings. By formalizing the approach managements will find they can begin to understand project management in greater depth. They will be forced to do so. This formalization in such areas as con-

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[2]The bases for conclusions 13 and 14 are contained in Chapter V.

struction, where the project management approach is accepted as everyday procedure, will aid managements in obtaining greater benefits from the project approach. They will begin to understand what project management is and what it can do. A knowledge of the potential and limits of project management can be of great benefit to those using or thinking of adopting the project approach. Only through a formalizing of the project approach can benefit be derived. This first recommendation ties in directly with the third one.

Two, the decision whether to adopt a project management approach must be carefully weighed by any manager considering it. The areas analyzed in this study are some of those which must be considered in determining whether or not to use a project approach. Any predisposition on the part of the management toward either a functional or a project approach, before investigating the advantages and disadvantages to the particular firm, can be detrimental to the attainment of the firm's objectives.

In this research it has been found that a project approach has been used when the project was specific, complex, and had to be accomplished within time, cost, and/or quality parameters. If an affirmative answer can be given to the following questions:

> Does a particular corporate undertaking lend itself to a project approach based on the definition?
>
> Are planning and control of prime importance?

then project management may be the preferred approach. It has been found in this research study that there are also many disadvantages to the project approach if the company cannot answer comprehensively still other questions, such as:

> Will the project manager and the project team have enough independence to be able to do their job without being hampered?
>
> Are there criteria that can be used to determine how much independence is "enough?"
>
> Where will the permanent organization get a project manager, and what will be done with him when the project is complete?
>
> Is an authority-gap inevitable, and, if so, what effect will it have?
>
> Where will the project be placed in the organiaztional structure?

These and other questions analyzed in this study are crucial to an understanding and evaluation of project management.

Three, the future potential of the project management approach is very great. The areas and undertakings for which it can be used are unlimited. Firms having crash programs or complex undertakings may well find project management to be the desired approach. Its use in installing computers, building aircraft, and drawing future plans has been alluded to in this research. The spectrum along which project management can be successfully used is broad. There appears to be a great interest in project management in the "other" area, and because it is the largest of the three areas analyzed it may well contain the greatest potential for further developing and refining the project management approach. Future uses of project management are great because the approach is not reserved for any one specific undertaking but is flexible and can be widely used. Its potential should not be underrated.

The findings of the study do not warrant a simple unqualified recommendation of project management to any firm. Information about project management derived from the research has, however, led to conclusions that should be helpful to any firm endeavoring to decide whether or not to use the project approach. Prior planning, coupled with careful consideration of all factors involved, has been shown to be prerequisite to an intelligent decision on whether or not to use the project management technique. The conclusions also emphasize the importance of objectivity in weighing the respective advantages and disadvantages of project management.

Results of the research suggest that project management should never be adopted merely because it is in vogue, nor should the technique be chosen only because a competitor has decided to use this approach. To be effective, project management must fit into the permanent organization structure of the firm.

In the event that a company is required under federal contract to adopt project management, a discerning study of the findings of this research would be advantageous. Questions covered here are essential ones which must be answered by a firm in its attempt to determine how its functional organization can adjust to a project management approach. The recommendation that such an approach demands perceptive prior planning is one that should be emphasized when project management is contractually required.

Further analysis by each individual organization is necessary, however, to take into consideration specific variances and distinct characteristics of the firm. It must be recognized also that the project approach is a management tool, not an organizational panacea. If the manager of a firm contemplating adoption of the project management approach fully understands this fact, he has become aware of a basic principle: that no technique solves all problems; it may, indeed, create new ones. The operative recommendation of this study is that a painstaking analysis of the respective advantages and disadvantages of project management in relation to the specific situations and conditions that exist in an individual firm must be conducted before a decision is made as to whether to adopt project management.

APPENDIX A

PAUL O. GADDIS
SUITE 2715
200 PARK AVENUE
NEW YORK, N.Y. 10017

June 1, 1966

Mr. Richard M. Hodgetts
Graduate Assistant
The University of Oklahoma
Norman, Oklahoma 73069

Dear Mr. Hodgetts:

I have received your letter of May 24. In answer to your question: Yes. I believe that the Manhattan Project was the origin of sophisticated project management. I hope that this comment will be helpful.

Sincerely yours,

Director, Overseas Investment
Westinghouse Electric Int'l.

APPENDIX B

NASA-S-66-11059

COMMAND MODULE

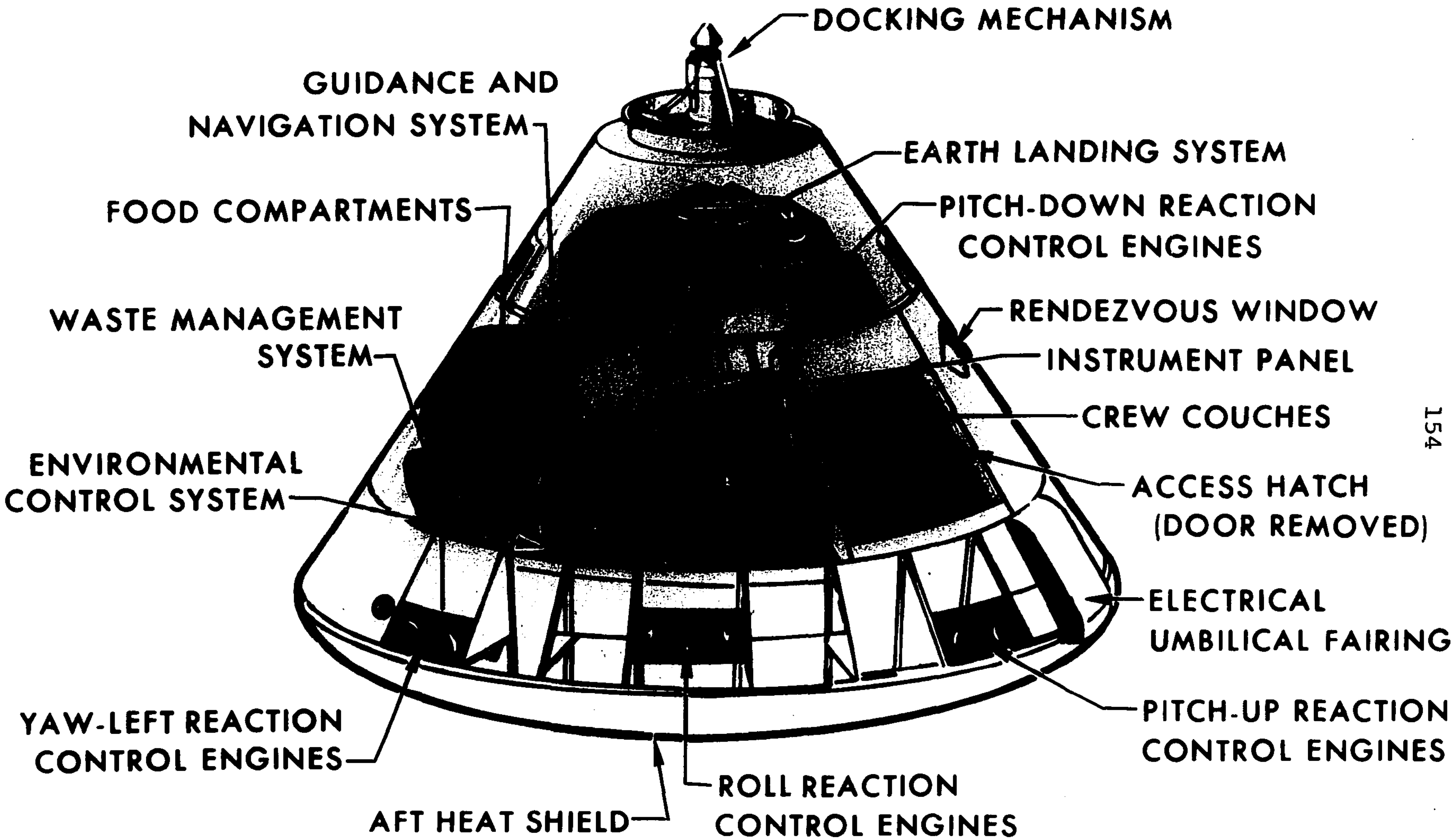


Figure 3-1

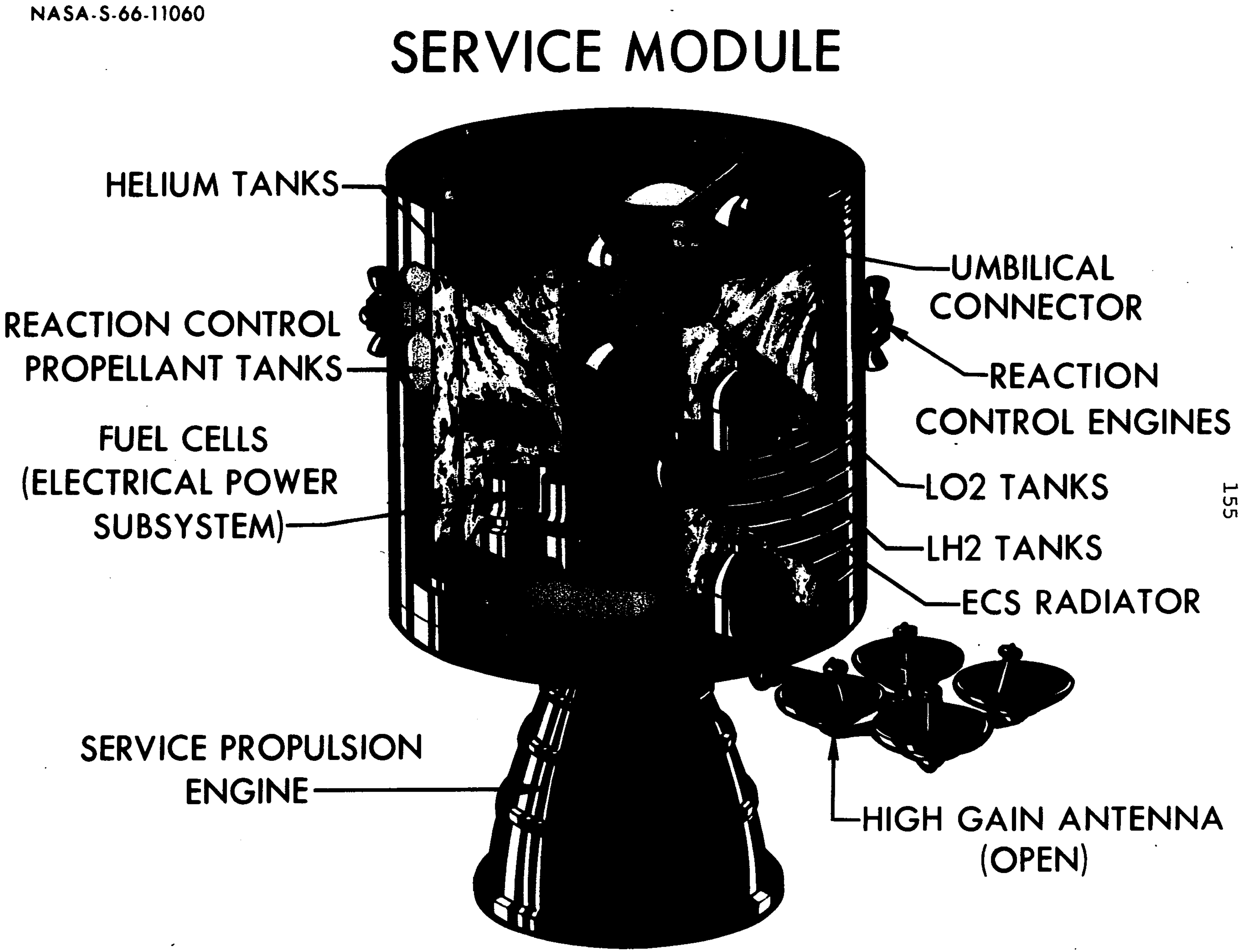
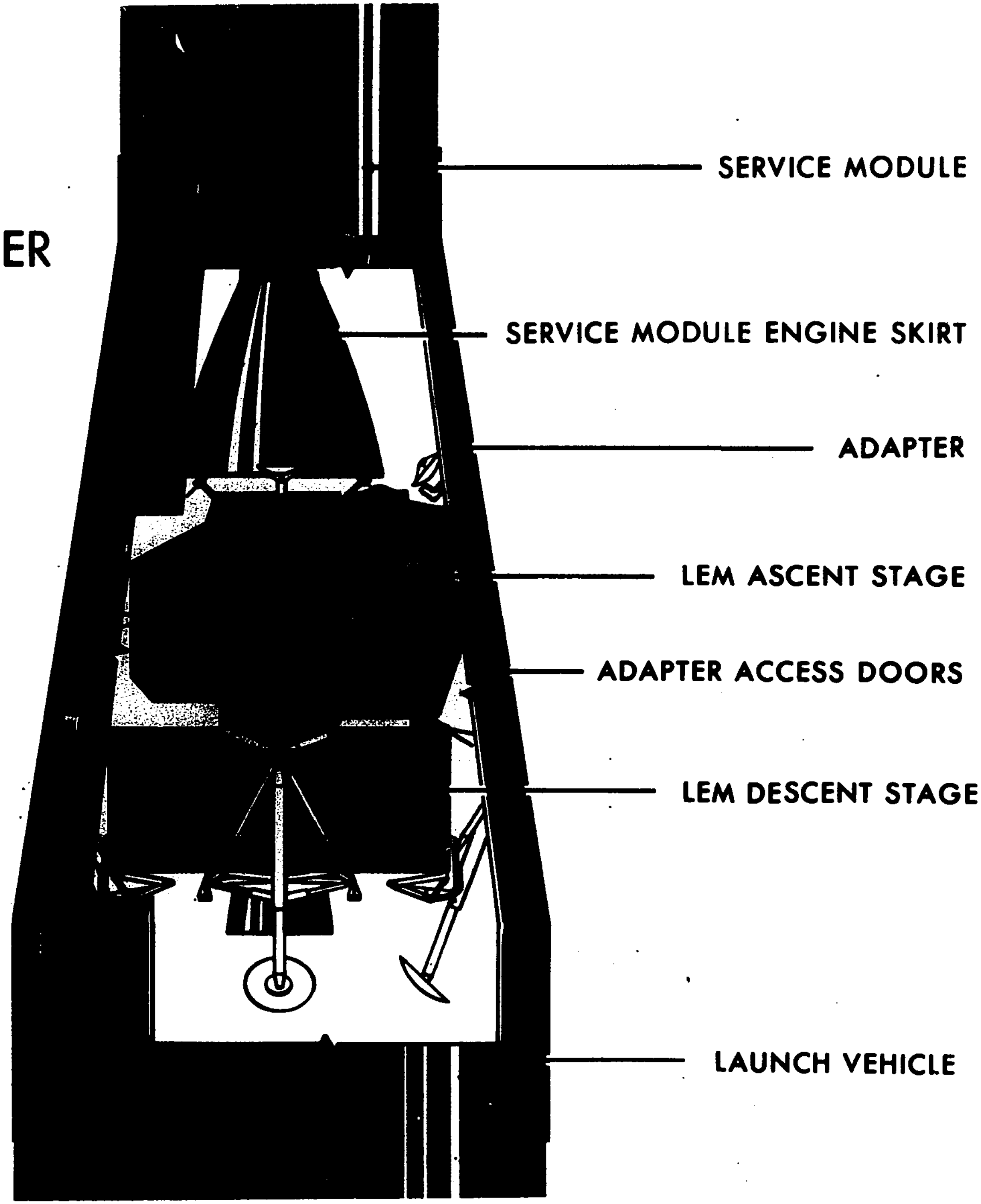

NASA-S-66-11060
SERVICE MODULE
HELIUM TANKS
REACTION CONTROL PROPELLANT TANKS
FUEL CELLS (ELECTRICAL POWER SUBSYSTEM)
SERVICE PROPULSION ENGINE
UMBILICAL CONNECTOR
REACTION CONTROL ENGINES
LO2 TANKS
LH2 TANKS
ECS RADIATOR
HIGH GAIN ANTENNA (OPEN)

Figure 3-2

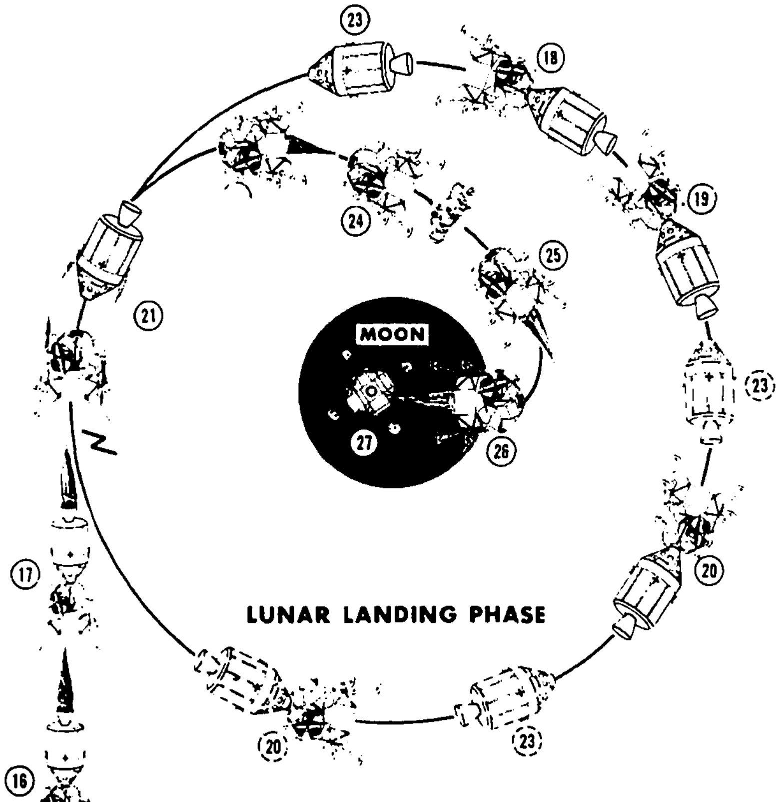
602

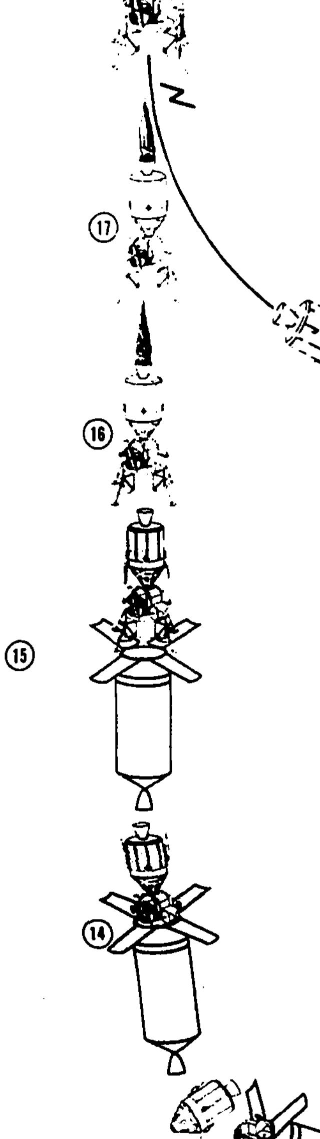
LEM IN ADAPTER

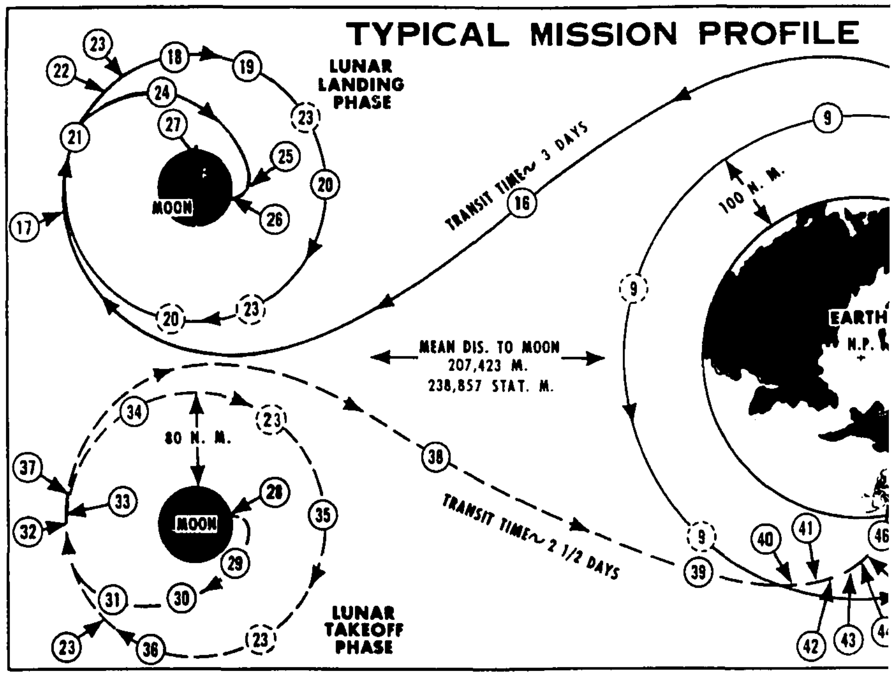


SATURN V APO

LUNAR ORBITAL RENDEZVOU

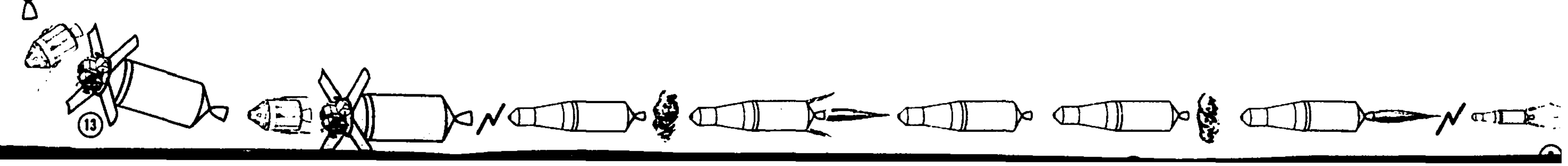






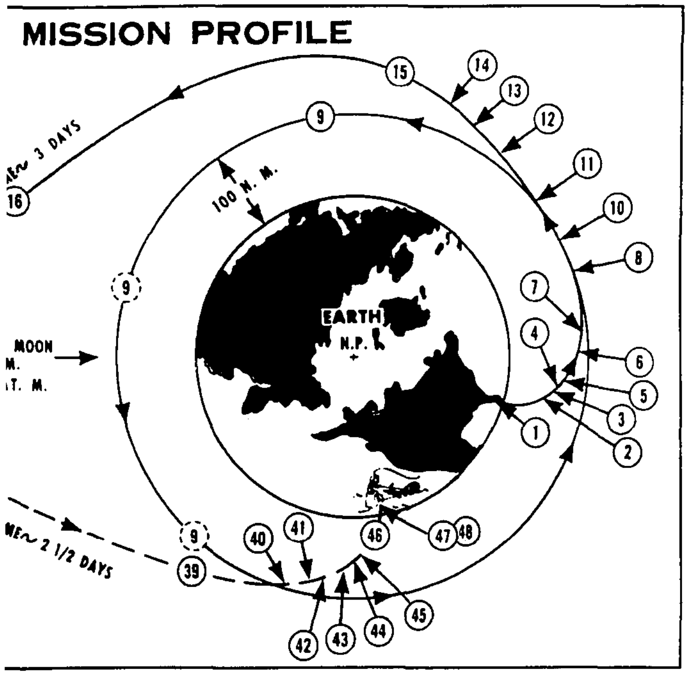
SEQUENCE OF OPERATIONS *

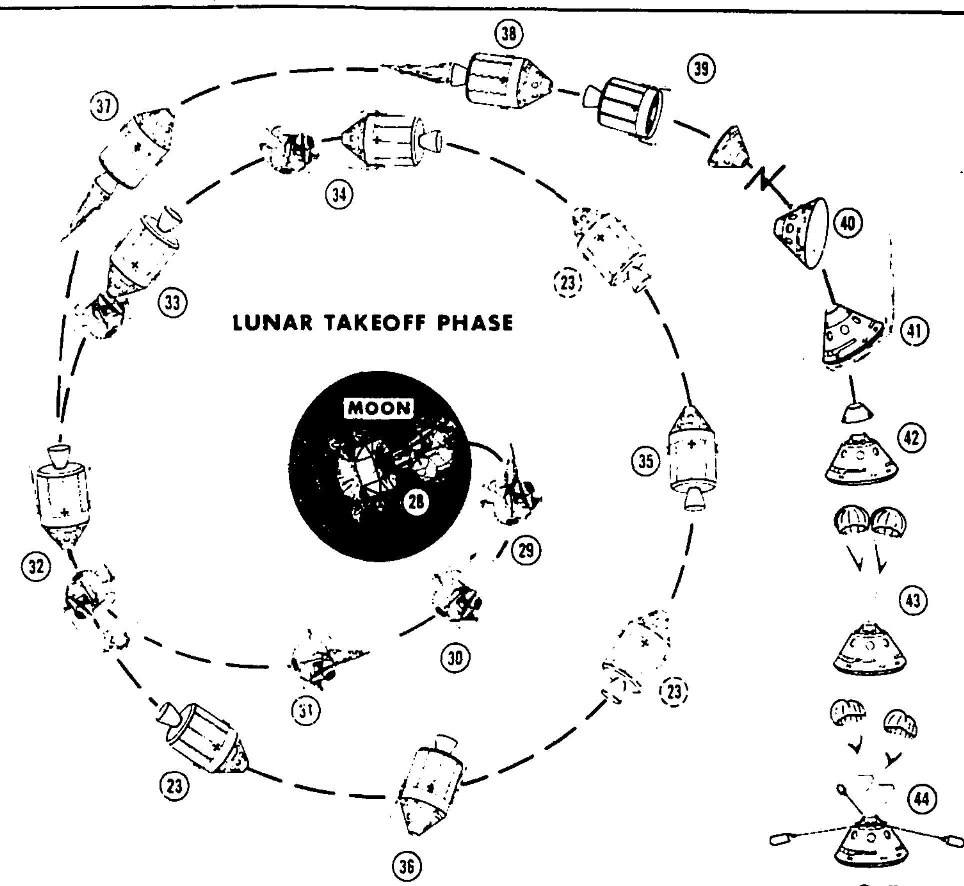
1. S-IC STAGE IGNITION & VEHICLE LAUNCH
2. S-IC STAGE CUTOFF & JETTISON (IGNITE S-IC RETRO & S-II ULLAGE ROCKETS)
3. S-II STAGE IGNITION & THRUST BUILDUP
4. JETTISON S-II AFT INTERSTAGE (AT APPROX. FULL THRUST)
5. LAUNCH ESCAPE SYSTEM JETTISON (AFTER FULL S-II THRUST & VEHICLE STABILIZATION)
6. S-II STAGE CUTOFF & JETTISON (IGNITE S-II RETRO & S-IVB ULLAGE ROCKETS)
7. S-IVB STAGE IGNITION & ORBITAL VELOCITY BUILDUP
8. INSERTION INTO 100 N. M. (185KM) EARTH PARKING ORBIT & S-IVB ENGINE CUTOFF
9. EARTH PARKING ORBIT COAST (CHECKOUT CREW & EQUIPMENT)
10. IGNITE ULLAGE ROCKETS, S-IVB RE-IGNITION & THRUST BUILDUP TO ESCAPE VELOCITY
11. INJECTION INTO EARTH-MOON TRANSIT & S-IVB ENGINE CUTOFF
12. EXPLOSIVE SEPARATION OF FORWARD SECTION OF SPACECRAFT/LEM ADAPTER
13. CSM SEPARATION FROM LEM/I.U./S-IVB & CSM TURN AROUND
14. CSM DOCKING TO LEM/I.U./S-IVB
15. JETTISON APOLLO ADAPTER SECTION, I.U. & S-IVB
16. MIDCOURSE CORRECTION [IGNITION (S) & CUTOFF (S) OF SM PROPULSION]*
17. SM IGNITION & BRAKING INTO LUNAR PARKING ORBIT, ENGINE CUTOFF
18. LUNAR PARKING ORBIT COAST (CHECKOUT CREW, EQUIPMENT & LEM)
19. CREW TRANSFER (2 MEN) FROM CM TO LEM
20. PRE-DESCENT LEM CHECKOUT & LAHDING SITE RECONNAISSANCE
21. SEPARATE LEM FROM CSM & TURN AROUND LEM TO DESCENT ATTITUDE
22. LEM LANDING STAGE IGNITION & BURNING OUT OF CIRCULAR ORBIT INTO HOHMAN TRANSFER ELLIPSE •
23. CSM CONTINUES IN LUNAR PARKING ORBIT (1 MAN)
24. LANDING STAGE PROP. CUTOFF & DESCENT TO NEAR LUNAR SURFACE
25. LEM LANDING STAGE RE-IGNITION AND COMPLETION OF HOHMANN TRANSFER
26. LEM HOVER, TRANSLATION, DESCENT MANEUVERS & LUNAR LANDING
27. LUNAR STAY (SCIENTIFIC EXPLORATION, EXPERIMENTS, & SAMPLE GATHERING)
28. LEM LUNAR LAUNCH STAGE IGNITION & LAUNCH (LEAVE LANDING STAGE ON MOON)
29. LUNAR LAUNCH STAGE POWERED ASCENT TO HOHMANN TRANSFER ELLIPSE
30. LUNAR LAUNCH STAGE PROP. CUTOFF & COAST TO LUNAR ORBIT VIA HOHMANN ELLI
31. MIDCOURSE CORRECTION [IGNITION (S) & CUTOFF (S) OF MAIN PROULSION]*

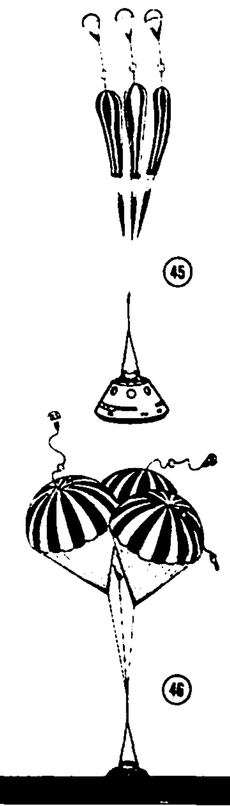


V APOLLO

. RENDEZVOUS MODE



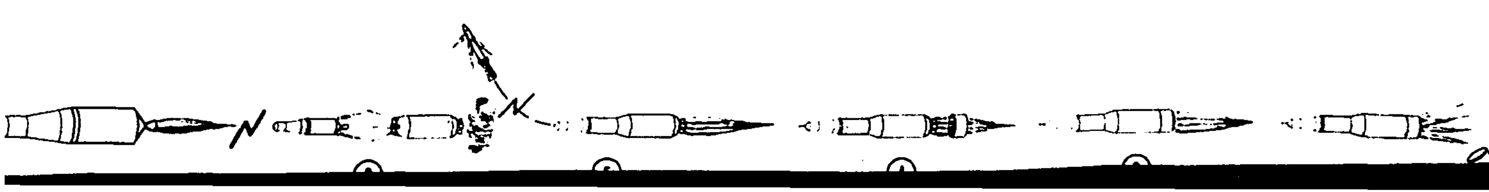


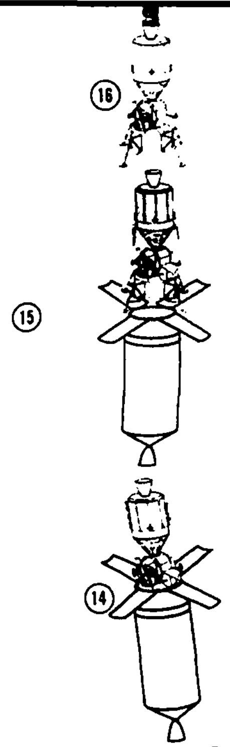


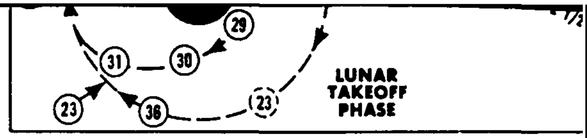
CUTOFF (S) OF SM PROPULSION]*
KING ORBIT, ENGINE CUTOFF
CREW, EQUIPMENT & LEM)
ITE RECONNAISSANCE
D LEM TO DESCENT ATTITUDE
OUT OF CIRCULAR ORBIT INTO HOHMANN

T (1 MAN)
TO NEAR LUNAR SURFACE
MPLETION OF HOHMANN TRANSFER
UVERS & LUNAR LANDING
PERIMENTS, & SAMPLE GATHERING)
NCH (LEAVE LANDING STAGE ON MOON)
O HOHMANN TRANSFER ELLIPSE
OAST TO LUNAR ORBIT VIA HOHMANN ELLIPSE*
CUTOFF (S) OF MAIN PROULSION]*

32. MAIN ENGINE FIRING INTO CIRCULAR ORBIT, ENGINE CUTOFF, RENDEZVOUS & DOCKING
33. TRANSFER OF CREW (2 MEN) & SCIENTIFIC MATERIAL FROM LUNAR LAUNCH STAGE TO CM
34. JETTISON LEM LAUNCH STAGE (CONTINUES IN LUNAR ORBIT)
35. CHECKOUT OF CREW & CSM PRIOR TO LUNAR ORBIT ESCAPE
36. CSM ASSUME ATTITUDE FOR LUNAR ORBIT ESCAPE
37. SM IGNITION, INJECTION OF CSM INTO MOON-EARTH TRANSIT, ENGINE CUTOFF
38. MIDCOURSE CORRECTION [IGNITION (S) & CUTOFF (S) OF SM PROPULSION]*
39. CM SEPARATION AND JETTISON OF SM
40. CM ESTABLISH RE-ENTRY ATTITUDE
41. CM EARTH ATMOSPHERE RE-ENTRY & AERODYNAMIC MANEUVER TO NEAR LANDING SITE
42. JETTISON FWD. COMPARTMENT HEAT SHIELD (AT 24,000 FT.)
43. DROGUE CHUTE DEPLOYMENT (BY MORTAR) 2 SECONDS LATER
44. DROGUE CHUTE RELEASE AND SIMULTANEOUS PILOT CHUTE DEPLOYMENT (BY MORTAR)
45. MAIN CHUTE DEPLOYMENT (REEFED CONDITION) FOR EIGHT SECONDS
46. FINAL DESCENT WITH FULL CHUTE
47. WATER LANDING AND MAIN CHUTE RELEASE
48. WATER RECOVERY







SEQUENCE OF OPERATIONS *

1. S-IC STAGE IGNITION & VEHICLE LAUNCH
2. S-IC STAGE CUTOFF & JETTISON (IGNITE S-IC RETRO & S-II ULLAGE ROCKETS)
3. S-II STAGE IGNITION & THRUST BUILDUP
4. JETTISON S-II AFT INTERSTAGE (AT APPROX. FULL THRUST)
5. LAUNCH ESCAPE SYSTEM JETTISON (AFTER FULL S-II THRUST & VEHICLE STABILIZATION)
6. S-II STAGE CUTOFF & JETTISON (IGNITE S-II RETRO & S-IVB ULLAGE ROCKETS)
7. S-IVB STAGE IGNITION & ORBITAL VELOCITY BUILDUP
8. INSERTION INTO 100 N. M. (185KM) EARTH PARKING ORBIT & S-IVB ENGINE CUTOFF
9. EARTH PARKING ORBIT COAST (CHECKOUT CREW & EQUIPMENT)
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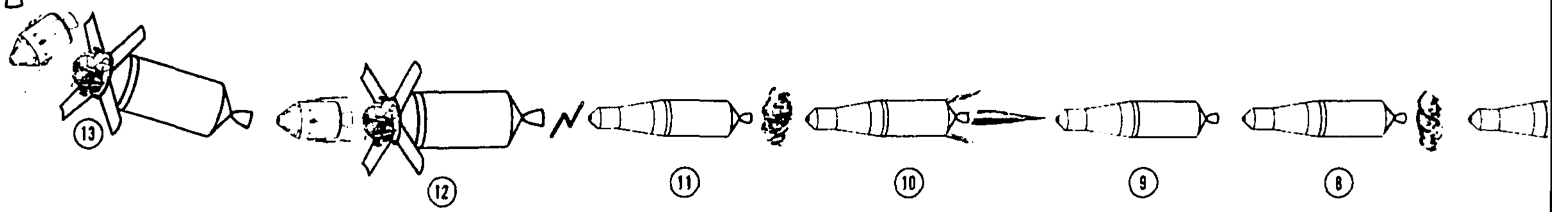
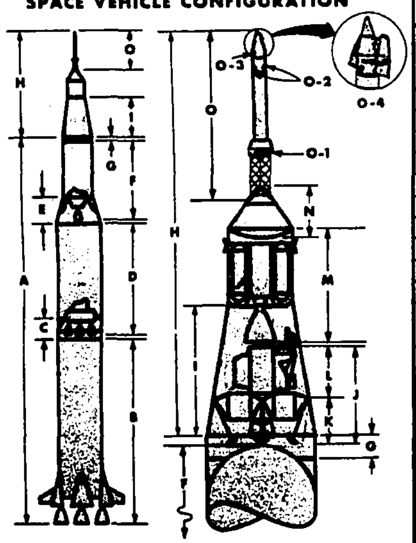
16. MIDCOURSE CORRECTION [IGNITION (S) & CUTOF
17. SM IGNITION & BRAKING INTO LUNAR PARKING O
18. LUNAR PARKING ORBIT COAST (CHECKOUT CREW, E
19. CREW TRANSFER (2 MEN) FROM CM TO LEM
20. PRE-DESCENT LEM CHECKOUT & LANDING SITE REC
21. SEPARATE LEM FROM CSM & TURN AROUND LEM
22. LEM LANDING STAGE IGNITION & BURNING OUT O TRANSFER ELLIPSE •
23. CSM CONTINUES IN LUNAR PARKING ORBIT (1 M
24. LANDING STAGE PROP. CUTOFF & DESCENT TO NE
25. LEM LANDING STAGE RE-IGNITION AND COMPLETI
26. LEM HOVER, TRANSLATION, DESCENT MANEUVERS
27. LUNAR STAY (SCIENTIFIC EXPLORATION, EXPERIME
28. LEM LUNAR LAUNCH STAGE IGNITION & LAUNCH (LE
29. LUNAR LAUNCH STAGE POWERED ASCENT TO HOH
30. LUNAR LAUNCH STAGE PROP. CUTOFF & COAST TO
31. MIDCOURSE CORRECTION [IGNITION (S) & CUTOF

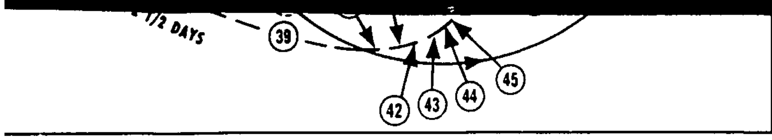


SPACE VEHICLE CONFIGURATION



TECHNICAL DATA *

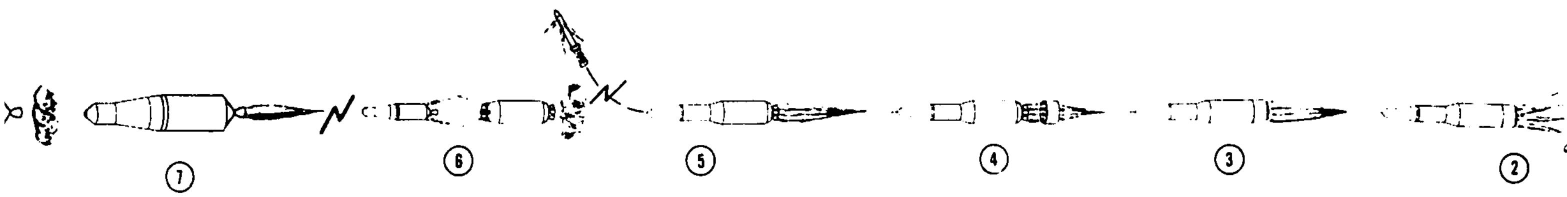
DESCRIPTION	MISSION	WEIGHT (LBS) #	LENGTH (FT.)	DIAMETER (FT.)	
A. 3 STAGE SATURN V LAUNCH VEHICLE	PAYLOAD TO PARKING ORBIT & ESCAPE VELOCITY	426.5 K	281.2	VARIES	
B. S-IC BOOSTER (SEE NOTE 8-B)	INITIAL LIFT-OFF	300.0 K	138.0	33.0	
C. S-IC/S-II INTERSTAGE ADAPTER	TRANSMITS THRUST FORCES FROM S-IC TO S-II	15.0 K	18.3	33.0	
D. S-II SECOND STAGE (SEE NOTE 8-B)	VEHICLE VELOCITY BUILDUP FOR ORBITAL INJECTION	80.0 K	81.6	33.0	
E. S-II/S-IVB INTERSTAGE SHROUD	TRANSMITS THRUST FORCES FROM S-IC & S-II TO S-IVB	6.0 K	19.0	21.6 TO 33.0	
F. S-IVB THIRD STAGE (SEE NOTE 8-A,B)	APOLLO INJECTION INTO EARTH ORBIT AND EARTH-MOON TRANSIT	22.0 K	58.6	21.6	
G. LAUNCH VEHICLE INSTRUMENT UNIT (I. U.)	GUIDANCE & CONTROL OF LAUNCH VEHICLE	3.5 K	3.0	21.6	
H. APOLLO SPACECRAFT	LUNAR BRAKING, ORBIT, LANDING, LAUNCH & EARTH RETURN	96.6 K		VARIES	3
I. I.U./APOLLO INTERSTAGE ADAPTER	TRANSMITS LAUNCH VEHICLE THRUST TO CSM, HOUSES & SUPPORTS LEM		27.8	12.8 TO 21.6	
J. LUNAR EXCURSION MODULE (LEM)	MANNED LUNAR LANDING AND TAKE OFF		19.3	(27 + WITH	2 H
K. LEM LUNAR LANDING STAGE (SEE NOTE 8-A,C)	LUNAR ORBIT(S) BRAKING, LUNAR HOVERING, TRANSLATION, DESCENT & LANDING	90.0 K	9.8	LEGS EXTENDED)	1 H
L. LEM LUNAR LAUNCH STAGE (SEE NOTE 8-A)	LUNAR LAUNCH & INJECTION INTO LUNAR ORBIT		9.5	15	1 H
M. SERVICE MODULE (SM) (SEE NOTE 8-A,B)	MIDCOURSE CORRECTIONS, LUNAR BRAKING & ESCAPE PROPULSION		24.7	12.8	1 H
N. COMMAND MODULE (CM)	MANNED LUNAR ORBIT & EARTH RETURN. MAIN APOLLO CONTROL		11.1	12.6	
O. APOLLO LAUNCH ESCAPE SYSTEM (LES)	CREW ESCAPE DURING ABORT	6.6 K	33.8	2.2	
O-1 LAUNCH ESCAPE MOTOR	PULLS CM CLEAR OF ABORTED LAUNCH VEHICLE	-	-	-	
O-2 TOWER JETTISON MOTOR	JETTISONS TOWER AFTER SUCCESSFUL LAUNCH OR ABORT	-	-	-	
O-3 PITCH MOTOR	PROVIDES TURN DIRECTION FOR LES TOWER OR LES/CM	-	-	-	
O-4 CANARD SURFACES	ORIENTS C/M TO BLUNT-END-FORWARD TRAJECTORY	-	-	-	
LOR VEHICLE (TOTAL)	MANNED LUNAR LANDING AND RETURN	6,000 K	363.4	MAX 33.0	14 A
CSM = CM/SM	# UNDERLINED WEIGHTS INCLUDE LIQUID PROPELLANTS; OTHERS ARE DRY				

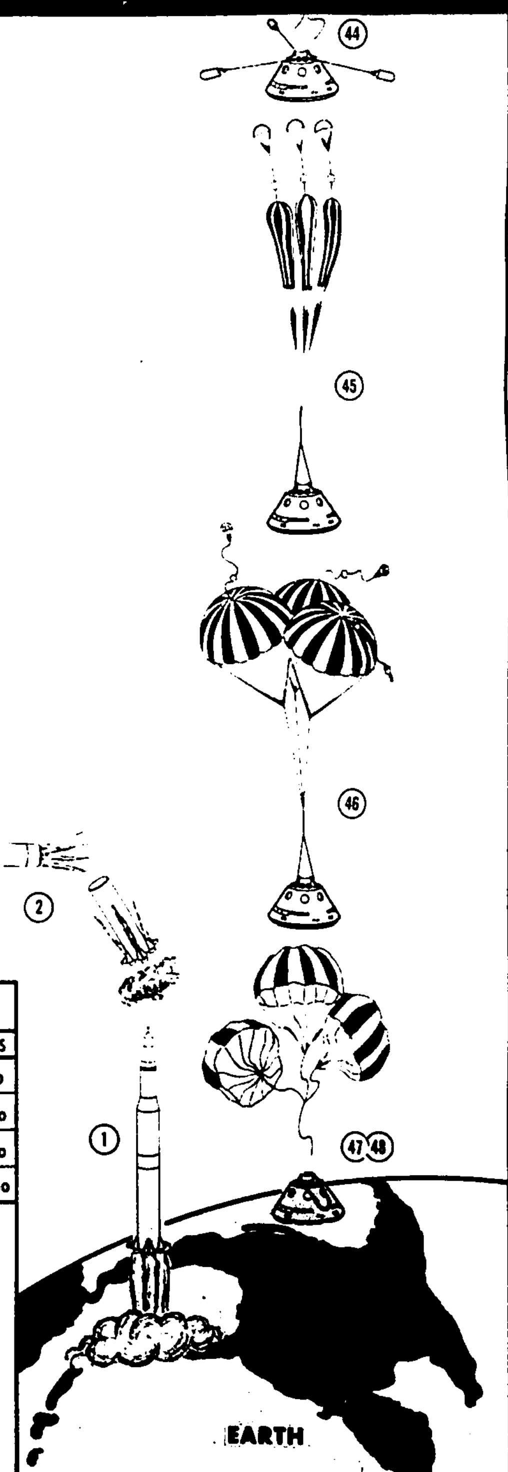


ION (S) & CUTOFF (S) OF SM PROPULSION]*
UNAR PARKING ORBIT, ENGINE CUTOFF
HECKOUT CREW, EQUIPMENT & LEM)
CM TO LEM
ANDING SITE RECONNAISSANCE
N AROUND LEM TO DESCENT ATTITUDE
BURNING OUT OF CIRCULAR ORBIT INTO HOHMANN

KING ORBIT (1 MAN)
DESCENT TO NEAR LUNAR SURFACE
N AND COMPLETION OF HOHMANN TRANSFER
ENT MANEUVERS & LUNAR LANDING
ATION, EXPERIMENTS, & SAMPLE GATHERING)
ON & LAUNCH (LEAVE LANDING STAGE ON MOON)
ASCENT TO HOHMANN TRANSFER ELLIPSE
TOFF & COAST TO LUNAR ORBIT VIA HOHMANN ELLIPSE●
ION (S) & CUTOFF (S) OF MAIN PROULSION]*

32. MAIN ENGINE FIRING INTO CIRCULAR ORBIT, ENGINE CUTOFF, RENDEZVOUS & DOCKING
33. TRANSFER OF CREW (2 MEN) & SCIENTIFIC MATERIAL FROM LUNAR LAUNCH STAGE TO CM
34. JETTISON LEM LAUNCH STAGE (CONTINUES IN LUNAR ORBIT)
35. CHECKOUT OF CREW & CSM PRIOR TO LUNAR ORBIT ESCAPE
36. CSM ASSUME ATTITUDE FOR LUNAR ORBIT ESCAPE
37. SM IGNITION, INJECTION OF CSM INTO MOON-EARTH TRANSIT, ENGINE CUTOFF
38. MIDCOURSE CORRECTION [IGNITION (S) & CUTOFF (S) OF SM PROPULSION]*
39. CM SEPARATION AND JETTISON OF SM
40. CM ESTABLISH RE-ENTRY ATTITUDE
41. CM EARTH ATMOSPHERE RE-ENTRY & AERODYNAMIC MANEUVER TO NEAR LANDING SITE
42. JETTISON FWD. COMPARTMENT HEAT SHIELD (AT 24,000 FT.)
43. DROGUE CHUTE DEPLOYMENT (BY MORTAR) 2 SECONDS LATER
44. DROGUE CHUTE RELEASE AND SIMULTANEOUS PILOT CHUTE DEPLOYMENT (BY MORTAR)
45. MAIN CHUTE DEPLOYMENT (REEFED CONDITION) FOR EIGHT SECONDS
46. FINAL DESCENT WITH FULL CHUTE
47. WATER LANDING AND MAIN CHUTE RELEASE
48. WATER RECOVERY





DIAMETER (FT.)	ENGINE TYPE	TOTAL THRUST (LBS.)	LIQUID PROPELLANT CAPACITY (LBS.)
VARIES	5 F-1, 6 J-2	-	5,560 K
33.0	5 F-1 LOX/RP-1	7,500 K (SEA LEVEL)	4,400 K
33.0	-	-	-
33.0	5 J-2 LOX/LH_2	1,000 K (VACUUM)	930 K
21.6 TO 33.0	-	-	-
21.6	1 J-2 LOX/LH_2	200 K (VACUUM)	230 K
21.6	-	-	-
VARIES	3 HYPERGOLIC STORABLES**		76.4 K
12.8 TO 21.6	-	-	-
(27 + WITH LEGS EXTENDED)	2 HYPERGOLIC STORABLES	-	
	1 HYPERGOLIC STORABLE	10.5 K (VACUUM)	
15	1 HYPERGOLIC STORABLE	3.5 K	
12.8	1 HYPERGOLIC STORABLE	21.9K	
12.6	NONE	-	-
2.2	3 SOLID FUEL MOTORS	-	-
-	SOLID FUEL	150 K FOR 3+ SECS.	-
-	SOLID FUEL	33 K FOR 1.2 SECS.	-
-	SOLID FUEL	2.5K FOR .5 SECS.	-
-		-	-
MAX 33.0	14 MAIN PROPULSION ENG'S.	-	-

K = 1000

PHYSICAL DATA

		EARTH	MOON
MEAN DIAM. IN MILES	NAUTICAL	6,875	1,877
	STATUTE	7,917	2,161
SURFACE GRAVITY		1 G	1/6 G
ATMOSPHERE		AIR	VACUUM
TEMPERATURE (°F)	IN SUN	MEAN 57.2°	+212°
	IN SHADOW		-243°

APPROXIMATE VELOCITIES REQUIRED

	MPH	KNOTS
INJECTION INTO 100 N. M. EARTH ORBIT	17,400	15,100
INJECTION INTO EARTH - MOON TRANSIT	24,300	21,100
INJECTION INTO MOON-EARTH TRANSIT	5,100	4,400
EARTH ATMOSPHERE RE-ENTRY	24,400	21,200

NOTES:

1. COAST PERIODS ARE BETWEEN POSITIONS 8 & 10, 11 & 16, 16 & 17, 17 & 22, 24 & 25, 30 & 31, 31 & 32, 32 & 37, 37 & 38, 38 & 41. (NO MAIN PROPULSION SYSTEM IN OPERATION).
2. ULLAGE ROCKET FIRING REQUIRED BEFORE IGNITIONS 3, 7, AND 10 TO FORCE PROPELLANTS TO BOTTOM OF TANKS BEFORE MAIN PROPULSION IGNITION
3. *MULTIPLE RESTARTS (AS REQUIRED DURING COAST PERIODS FOR TRAJECTORY CORRECTIONS).
4. **ENGINES THAT USE A FUEL AND OXIDIZER BIOPROPELLANT, STORABLE AT NORMAL TEMPERATURES, THAT IGNITE SPONTANEOUSLY WHEN THE FUEL & OXIDIZER ARE MIXED.
5. ●AN OPTIMUM FLIGHT PATH USING AN ELLIPTICAL COASTING TRANSFER WITH POWERED FLIGHT AT LAUNCH AND TERMINAL POINTS ONLY (VS. CONTINUOUS BURN) TO CONSERVE PROPELLANTS.
6. ~ INDICATES SCALE CHANGE IN STAGE AND MODULE SKETCHES.
7. ★ THESE DIAGRAMS HAVE BEEN PURPOSELY ALTERED IN SCALE AND PERSPECTIVE TO BETTER SHOW CONFIGURATIONS AND OPERATIONAL SEQUENCE, AND ARE FOR INFORMATIONAL PURPOSES ONLY. FOR CLARITY'S SAKE, VERY LITTLE CONSIDERATION HAS BEEN GIVEN TO RELATIVE MOTIONS AND POSITIONS OF THE EARTH VS. THE MOON DURING ELAPSED TIME INTERVALS SHOWN. THIS CHART REPRESENTS ONE OF SEVERAL TYPICAL PROFILES CURRENTLY BEING CONSIDERED AND IS SUBJECT TO CONTINUOUS CHANGE. ALL TECHNICAL DATA SHOWN IS APPROXIMATE.
8. PROPULSION SYS. CAPABLE OF (A) RESTART (B) GIMBALLING (C) THROTTLING

MARSHALL SPACE FLIGHT CENTER	
E-R 500	DECEMBER 15, 1964
ENGINEER: B. E. ABBOTT	ILLUSTRATOR: JOE MADDOX

NASA-S-66-1628 FEB 14

APOLLO SPACECRAFT
GOVERNMENT CONTRACTOR HARDWARE TEAM

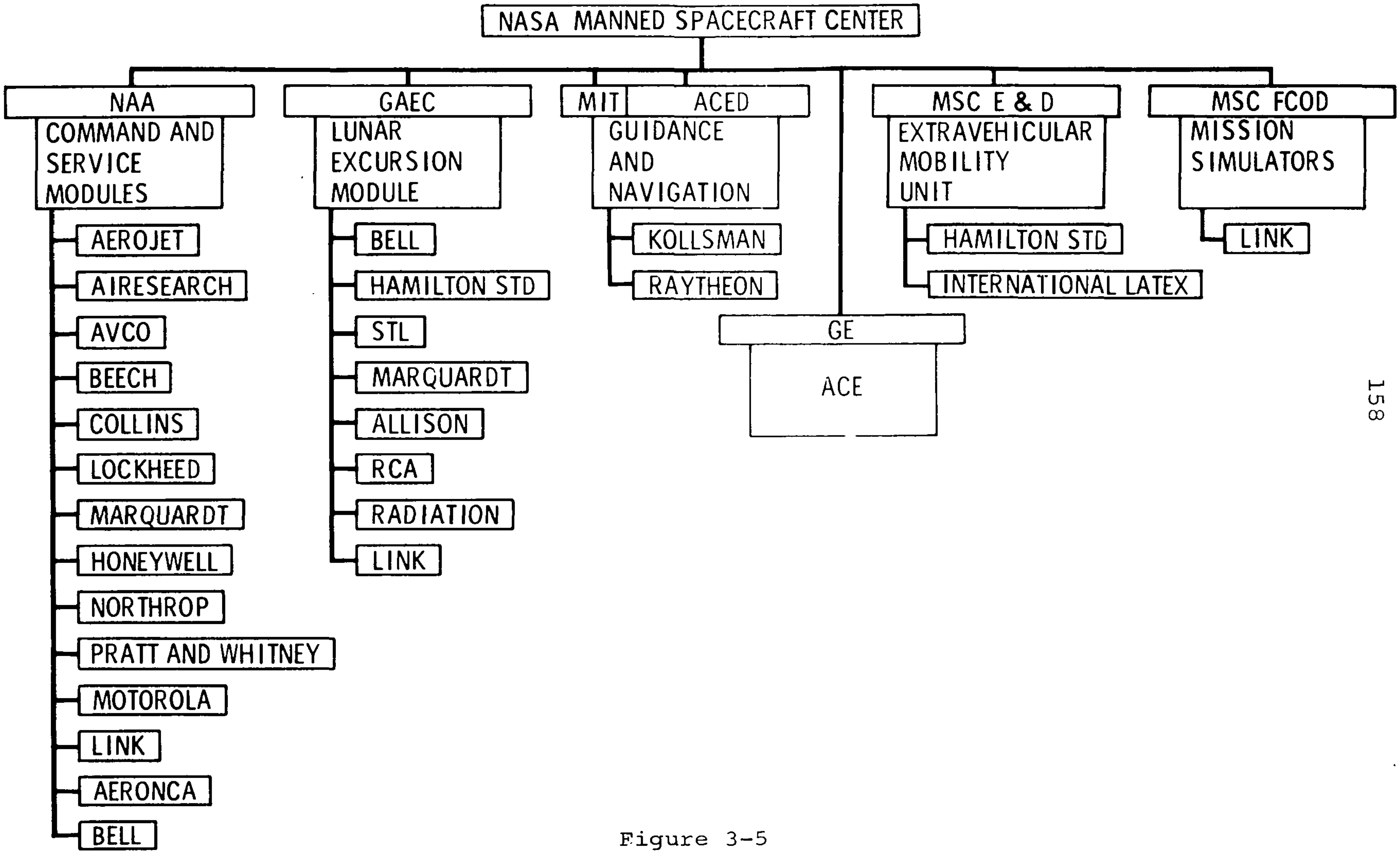


Figure 3-5

NASA-S-66-8932

APOLLO SPACECRAFT CONTRACTORS

CONTRACTS AND SUBCONTRACTS $5,000,000 AND OVER

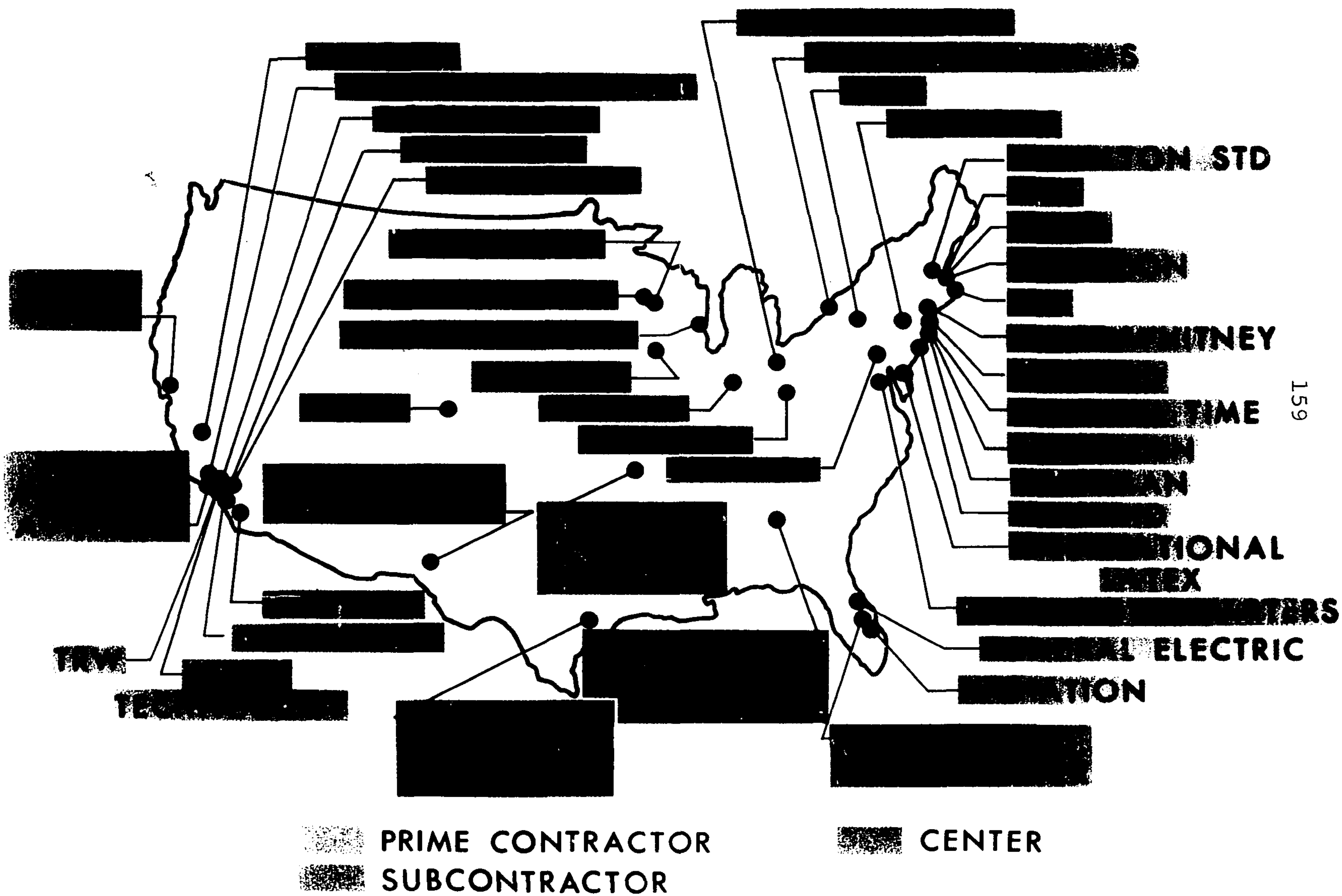


Figure 3-6

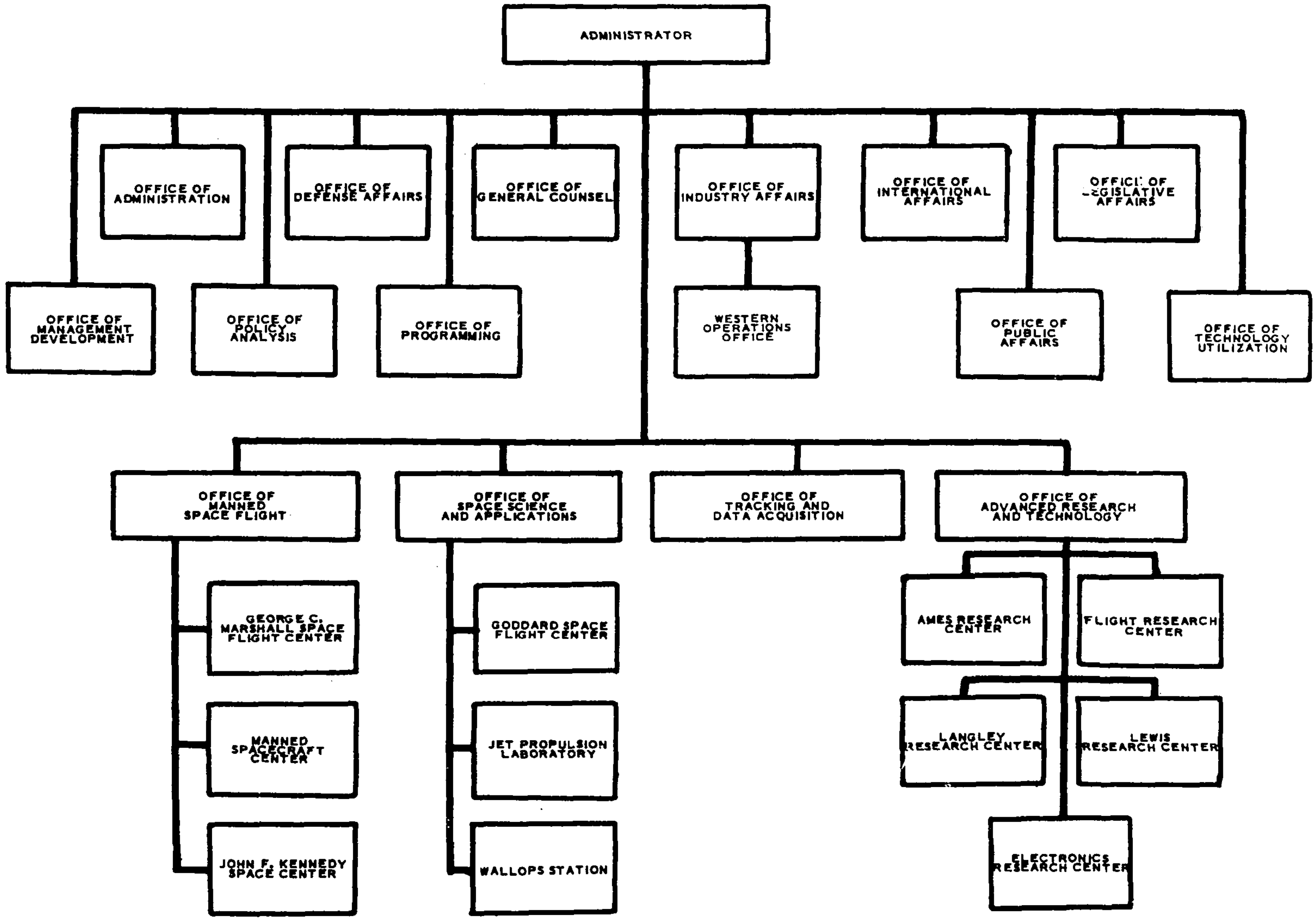

ADMINISTRATOR
OFFICE OF ADMINISTRATION
OFFICE OF DEFENSE AFFAIRS
OFFICE OF GENERAL COUNSEL
OFFICE OF INDUSTRY AFFAIRS
OFFICE OF INTERNATIONAL AFFAIRS
OFFICE OF LEGISLATIVE AFFAIRS
OFFICE OF MANAGEMENT DEVELOPMENT
OFFICE OF POLICY ANALYSIS
OFFICE OF PROGRAMMING
WESTERN OPERATIONS OFFICE
OFFICE OF PUBLIC AFFAIRS
OFFICE OF TECHNOLOGY UTILIZATION
OFFICE OF MANNED SPACE FLIGHT
OFFICE OF SPACE SCIENCE AND APPLICATIONS
OFFICE OF TRACKING AND DATA ACQUISITION
OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY
GEORGE C. MARSHALL SPACE FLIGHT CENTER
MANNED SPACECRAFT CENTER
JOHN F. KENNEDY SPACE CENTER
GODDARD SPACE FLIGHT CENTER
JET PROPULSION LABORATORY
WALLOPS STATION
AMES RESEARCH CENTER
FLIGHT RESEARCH CENTER
LANGLEY RESEARCH CENTER
LEWIS RESEARCH CENTER
ELECTRONICS RESEARCH CENTER

Figure 3-7

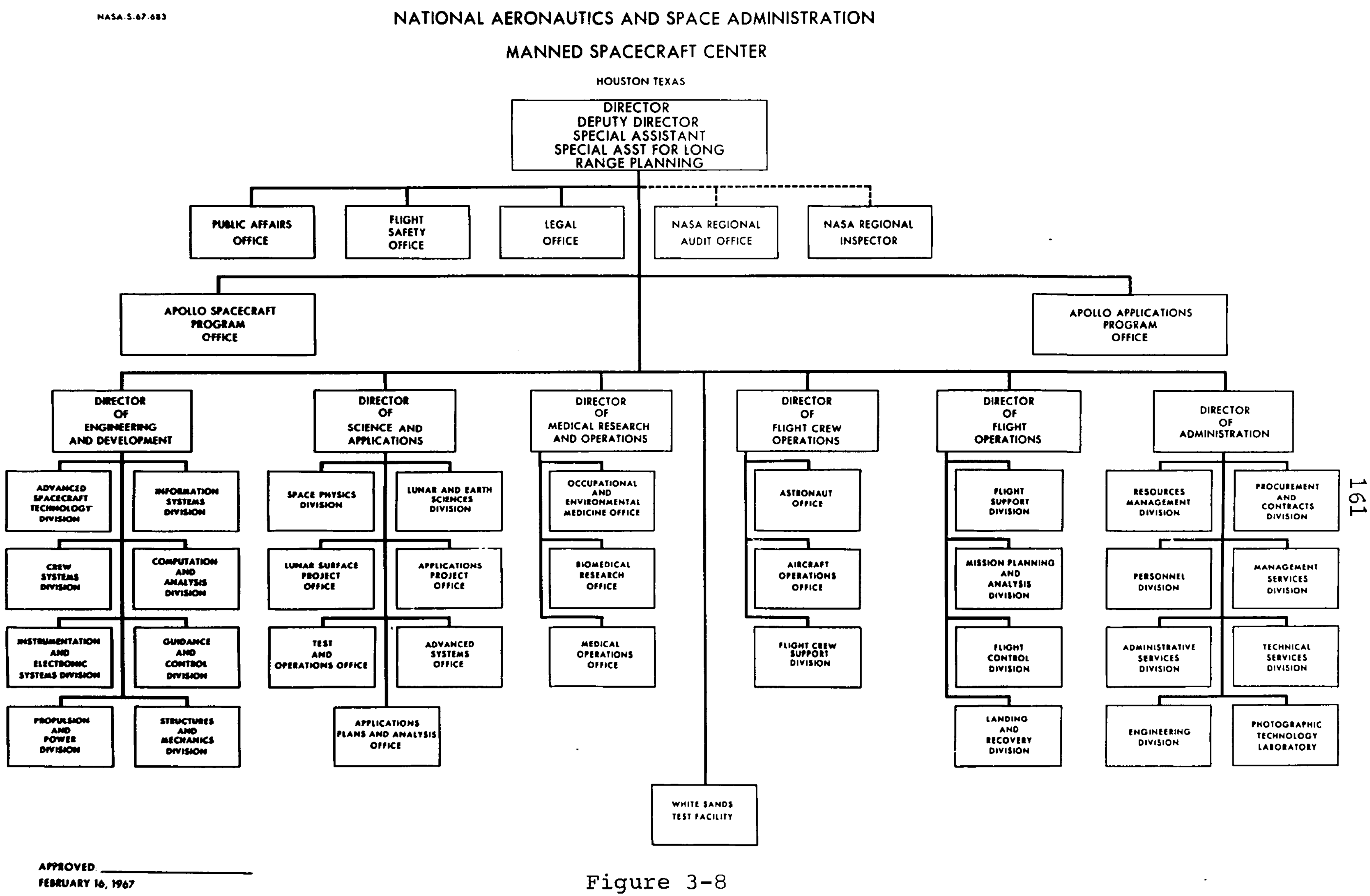

NASA-S-67-683
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON TEXAS
DIRECTOR
DEPUTY DIRECTOR
SPECIAL ASSISTANT
SPECIAL ASST FOR LONG RANGE PLANNING
PUBLIC AFFAIRS OFFICE
FLIGHT SAFETY OFFICE
LEGAL OFFICE
NASA REGIONAL AUDIT OFFICE
NASA REGIONAL INSPECTOR
APOLLO SPACECRAFT PROGRAM OFFICE
APOLLO APPLICATIONS PROGRAM OFFICE
DIRECTOR OF ENGINEERING AND DEVELOPMENT
ADVANCED SPACECRAFT TECHNOLOGY DIVISION
INFORMATION SYSTEMS DIVISION
CREW SYSTEMS DIVISION
COMPUTATION AND ANALYSIS DIVISION
INSTRUMENTATION AND ELECTRONIC SYSTEMS DIVISION
GUIDANCE AND CONTROL DIVISION
PROPULSION AND POWER DIVISION
STRUCTURES AND MECHANICS DIVISION
DIRECTOR OF SCIENCE AND APPLICATIONS
SPACE PHYSICS DIVISION
LUNAR AND EARTH SCIENCES DIVISION
LUNAR SURFACE PROJECT OFFICE
APPLICATIONS PROJECT OFFICE
TEST AND OPERATIONS OFFICE
ADVANCED SYSTEMS OFFICE
APPLICATIONS PLANS AND ANALYSIS OFFICE
DIRECTOR OF MEDICAL RESEARCH AND OPERATIONS
OCCUPATIONAL AND ENVIRONMENTAL MEDICINE OFFICE
BIOMEDICAL RESEARCH OFFICE
MEDICAL OPERATIONS OFFICE
WHITE SANDS TEST FACILITY
DIRECTOR OF FLIGHT CREW OPERATIONS
ASTRONAUT OFFICE
AIRCRAFT OPERATIONS OFFICE
FLIGHT CREW SUPPORT DIVISION
DIRECTOR OF FLIGHT OPERATIONS
FLIGHT SUPPORT DIVISION
MISSION PLANNING AND ANALYSIS DIVISION
FLIGHT CONTROL DIVISION
LANDING AND RECOVERY DIVISION
DIRECTOR OF ADMINISTRATION
RESOURCES MANAGEMENT DIVISION
PROCUREMENT AND CONTRACTS DIVISION
PERSONNEL DIVISION
MANAGEMENT SERVICES DIVISION
ADMINISTRATIVE SERVICES DIVISION
TECHNICAL SERVICES DIVISION
ENGINEERING DIVISION
PHOTOGRAPHIC TECHNOLOGY LABORATORY
APPROVED
FEBRUARY 16, 1967

Figure 3-8

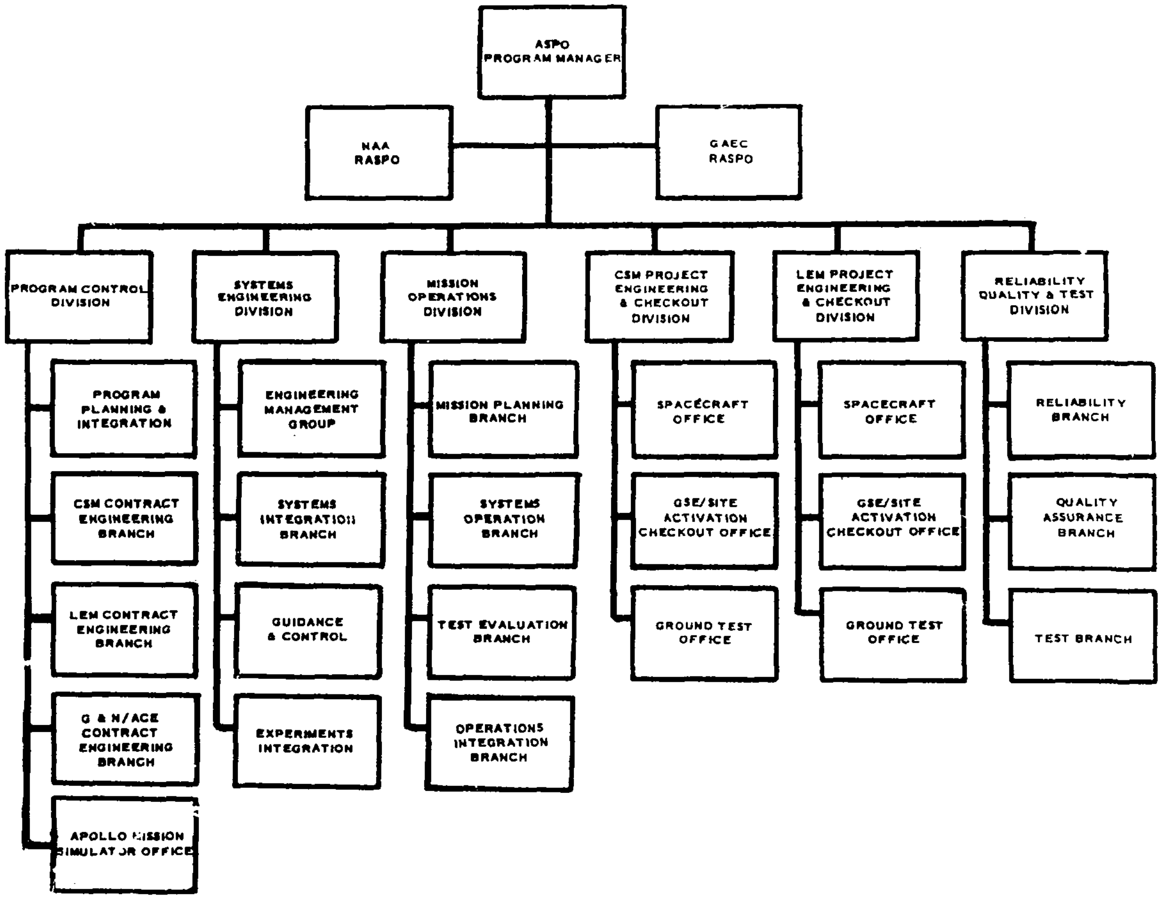

ASPO PROGRAM MANAGER
NAA RASPO
GAEC RASPO
PROGRAM CONTROL DIVISION
SYSTEMS ENGINEERING DIVISION
MISSION OPERATIONS DIVISION
CSM PROJECT ENGINEERING & CHECKOUT DIVISION
LEM PROJECT ENGINEERING & CHECKOUT DIVISION
RELIABILITY QUALITY & TEST DIVISION
PROGRAM PLANNING & INTEGRATION
CSM CONTRACT ENGINEERING BRANCH
LEM CONTRACT ENGINEERING BRANCH
G & N/ACE CONTRACT ENGINEERING BRANCH
APOLLO MISSION SIMULATOR OFFICE
ENGINEERING MANAGEMENT GROUP
SYSTEMS INTEGRATION BRANCH
GUIDANCE & CONTROL
EXPERIMENTS INTEGRATION
MISSION PLANNING BRANCH
SYSTEMS OPERATION BRANCH
TEST EVALUATION BRANCH
OPERATIONS INTEGRATION BRANCH
SPACECRAFT OFFICE
GSE/SITE ACTIVATION CHECKOUT OFFICE
GROUND TEST OFFICE
SPACECRAFT OFFICE
GSE/SITE ACTIVATION CHECKOUT OFFICE
GROUND TEST OFFICE
RELIABILITY BRANCH
QUALITY ASSURANCE BRANCH
TEST BRANCH

Figure 3-9

NASA-S-66-1630 FEB 14

PROGRAM BASELINE

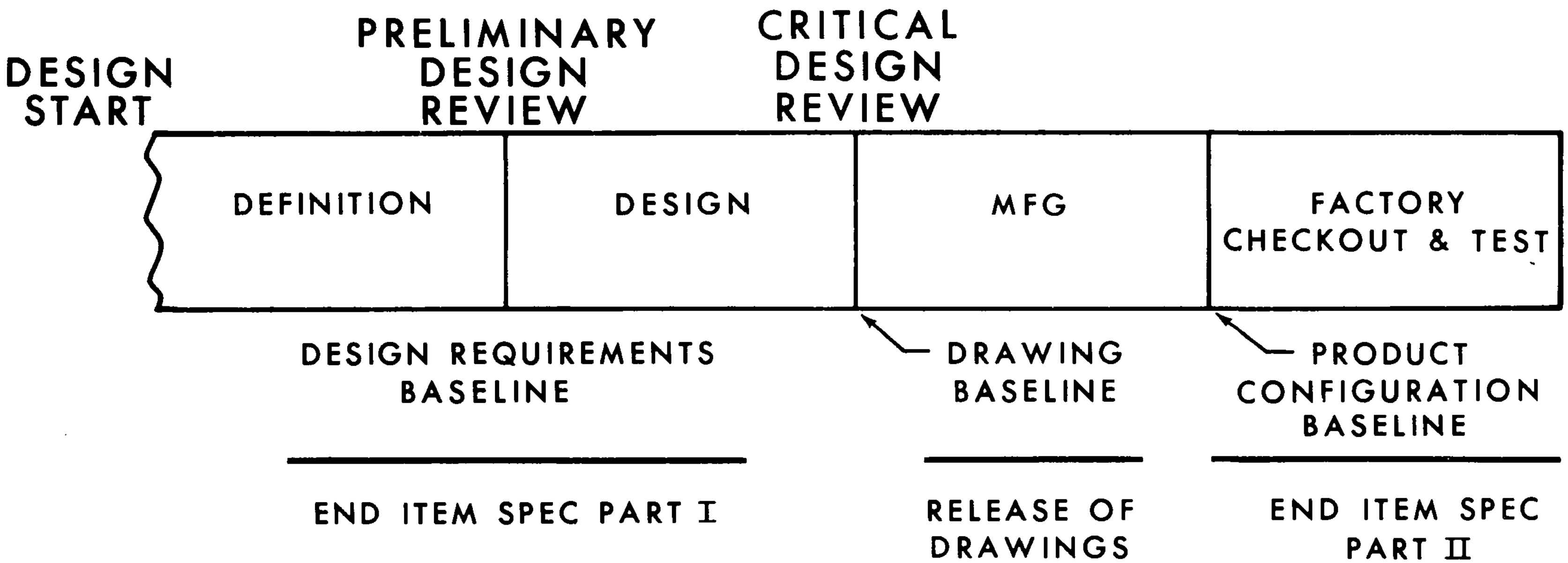


Figure 3-10

NASA-S-65-9688

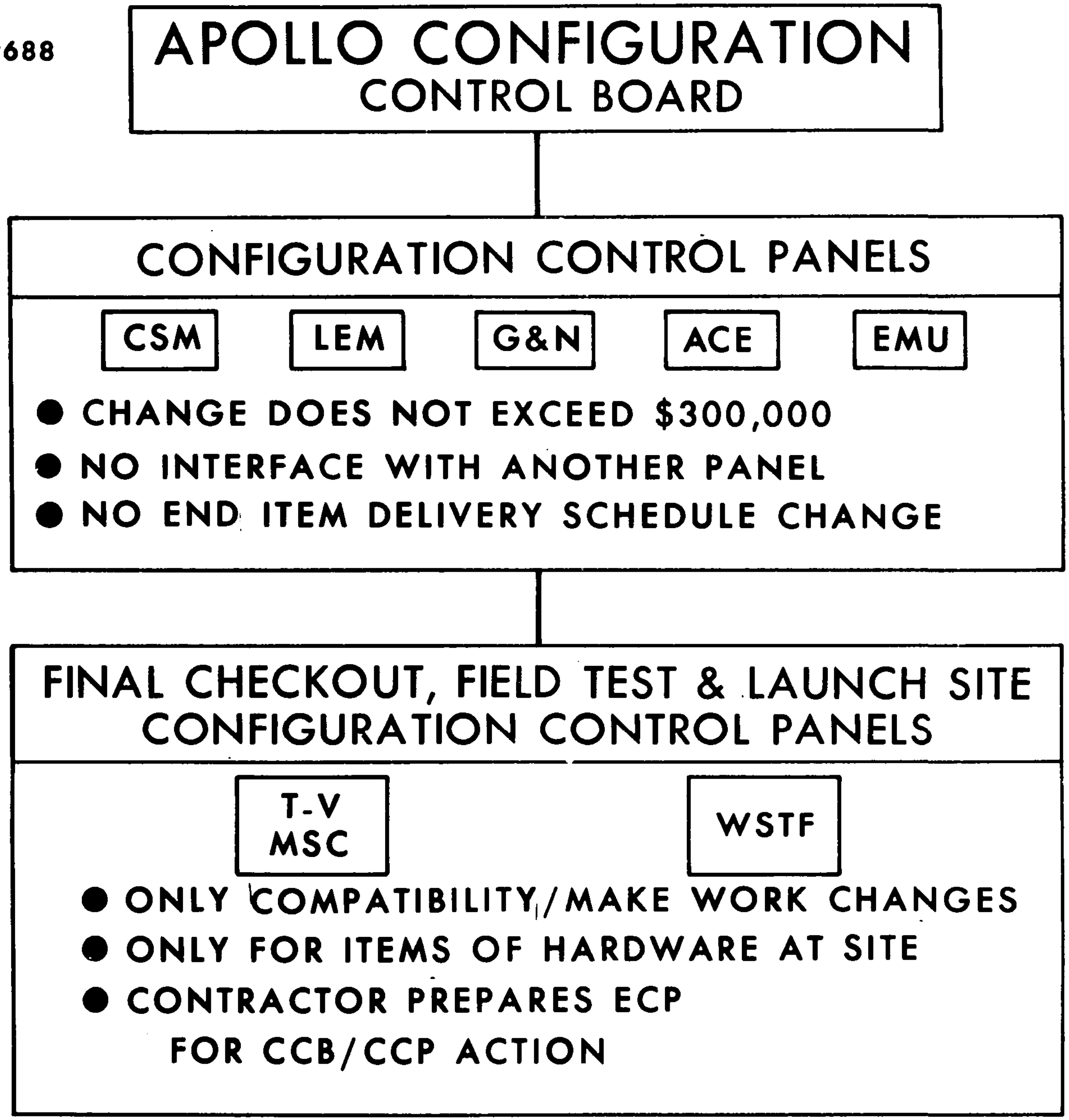


Figure 3-11

NASA-S-66-7561

PROGRAM MANAGEMENT INFORMATION FLOW

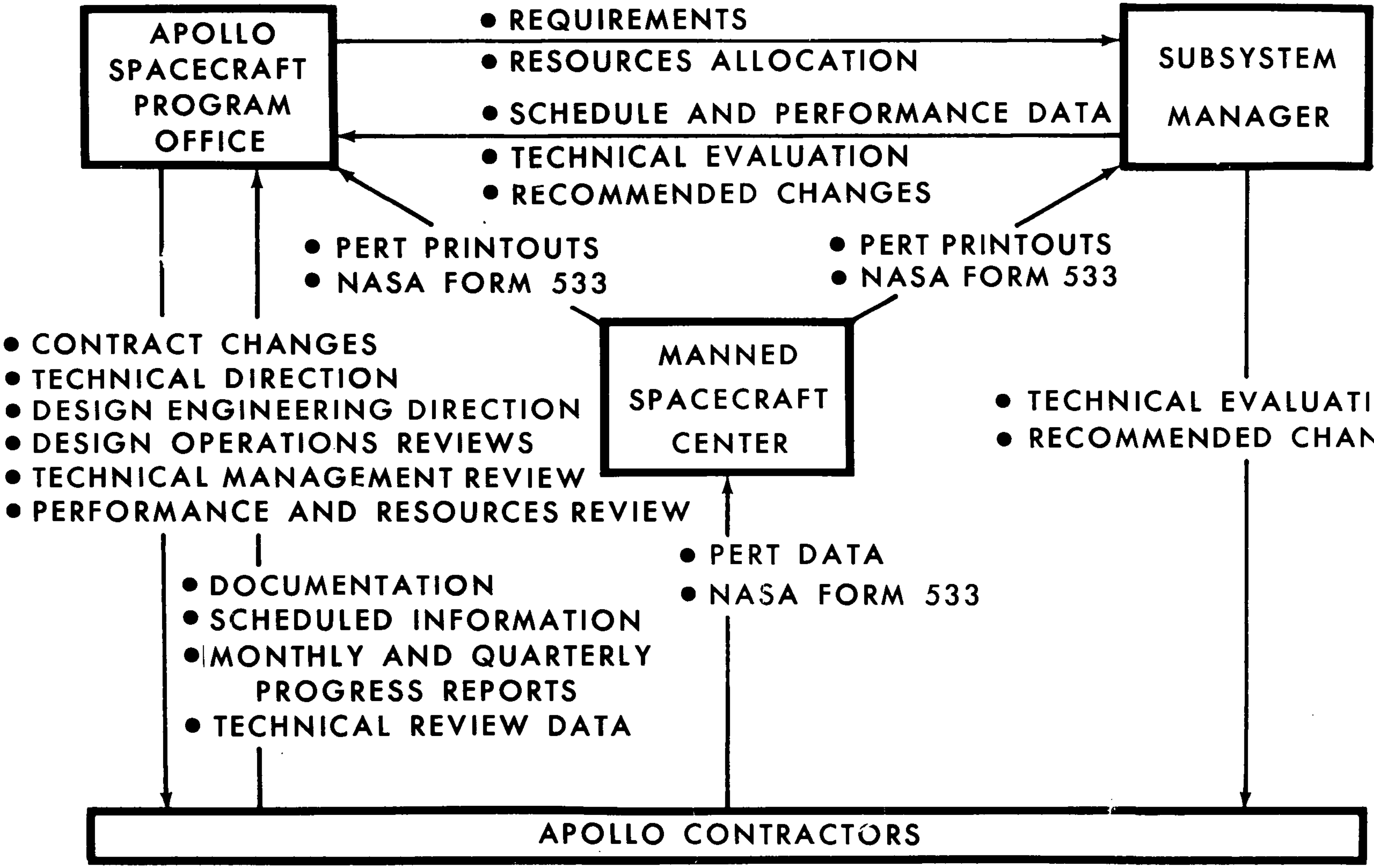


Figure 3-12

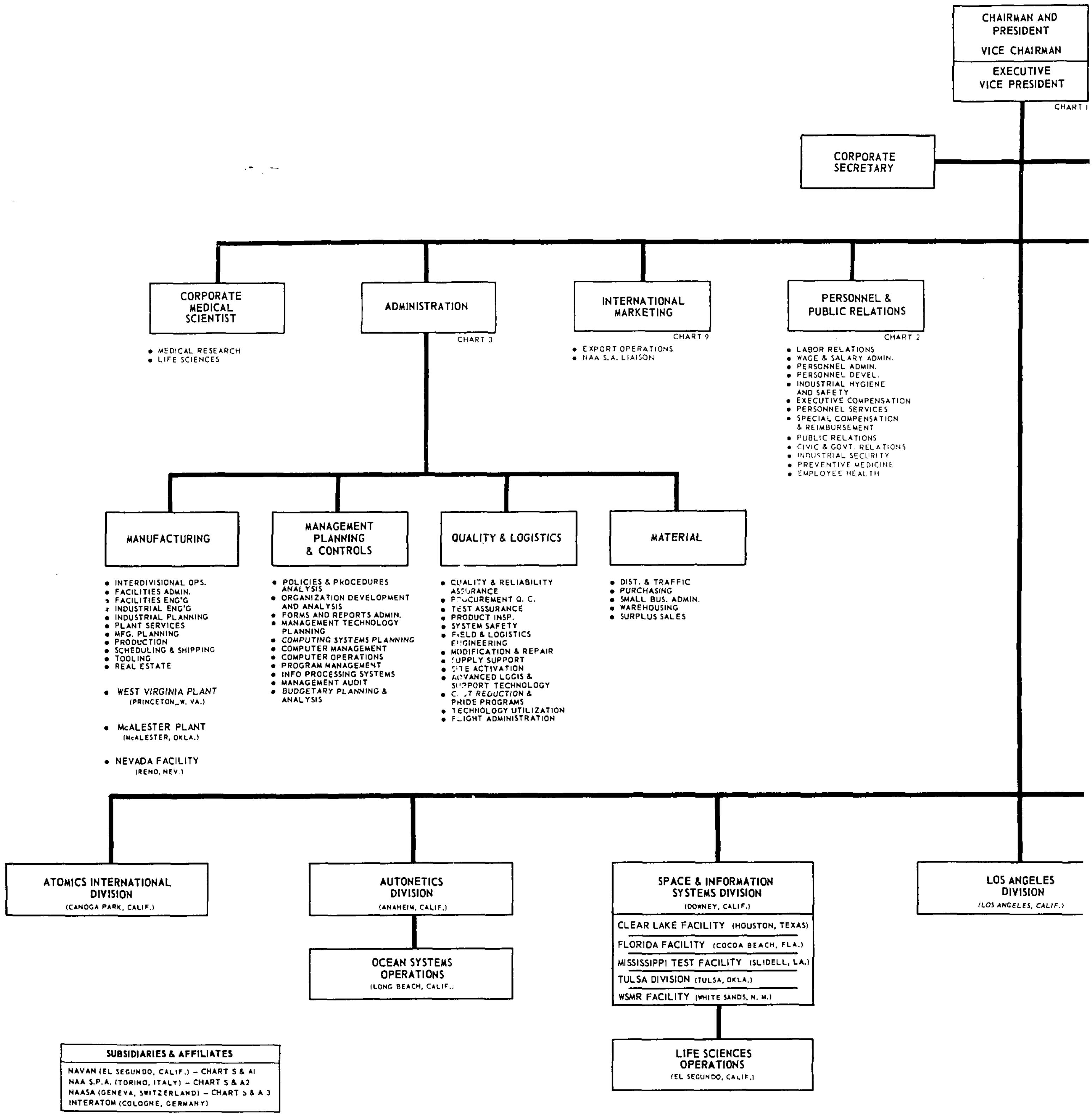

CHAIRMAN AND PRESIDENT
VICE CHAIRMAN
EXECUTIVE VICE PRESIDENT
CHART I
CORPORATE SECRETARY
CORPORATE MEDICAL SCIENTIST
• MEDICAL RESEARCH
• LIFE SCIENCES
ADMINISTRATION
CHART 3
INTERNATIONAL MARKETING
CHART 9
• EXPORT OPERATIONS
• NAA S.A. LIAISON
PERSONNEL & PUBLIC RELATIONS
CHART 2
• LABOR RELATIONS
• WAGE & SALARY ADMIN.
• PERSONNEL ADMIN.
• PERSONNEL DEVEL.
• INDUSTRIAL HYGIENE AND SAFETY
• EXECUTIVE COMPENSATION
• PERSONNEL SERVICES
• SPECIAL COMPENSATION & REIMBURSEMENT
• PUBLIC RELATIONS
• CIVIC & GOVT. RELATIONS
• INDUSTRIAL SECURITY
• PREVENTIVE MEDICINE
• EMPLOYEE HEALTH
MANUFACTURING
• INTERDIVISIONAL OPS.
• FACILITIES ADMIN.
• FACILITIES ENG'G
• INDUSTRIAL ENG'G
• INDUSTRIAL PLANNING
• PLANT SERVICES
• MFG. PLANNING
• PRODUCTION
• SCHEDULING & SHIPPING
• TOOLING
• REAL ESTATE
• WEST VIRGINIA PLANT (PRINCETON, W. VA.)
• McALESTER PLANT (McALESTER, OKLA.)
• NEVADA FACILITY (RENO, NEV.)
MANAGEMENT PLANNING & CONTROLS
• POLICIES & PROCEDURES ANALYSIS
• ORGANIZATION DEVELOPMENT AND ANALYSIS
• FORMS AND REPORTS ADMIN.
• MANAGEMENT TECHNOLOGY PLANNING
• COMPUTING SYSTEMS PLANNING
• COMPUTER MANAGEMENT
• COMPUTER OPERATIONS
• PROGRAM MANAGEMENT
• INFO PROCESSING SYSTEMS
• MANAGEMENT AUDIT
• BUDGETARY PLANNING & ANALYSIS
QUALITY & LOGISTICS
• QUALITY & RELIABILITY ASSURANCE
• PROCUREMENT Q. C.
• TEST ASSURANCE
• PRODUCT INSP.
• SYSTEM SAFETY
• FIELD & LOGISTICS ENGINEERING
• MODIFICATION & REPAIR
• SUPPLY SUPPORT
• SITE ACTIVATION
• ADVANCED LOGIS & SUPPORT TECHNOLOGY
• PRIDE PROGRAMS
• TECHNOLOGY UTILIZATION
• FLIGHT ADMINISTRATION
MATERIAL
• DIST. & TRAFFIC
• PURCHASING
• SMALL BUS. ADMIN.
• WAREHOUSING
• SURPLUS SALES
ATOMICS INTERNATIONAL DIVISION (CANOGA PARK, CALIF.)
AUTONETICS DIVISION (ANAHEIM, CALIF.)
OCEAN SYSTEMS OPERATIONS (LONG BEACH, CALIF.)
SPACE & INFORMATION SYSTEMS DIVISION (DOWNEY, CALIF.)
CLEAR LAKE FACILITY (HOUSTON, TEXAS)
FLORIDA FACILITY (COCOA BEACH, FLA.)
MISSISSIPPI TEST FACILITY (SLIDELL, LA.)
TULSA DIVISION (TULSA, OKLA.)
WSMR FACILITY (WHITE SANDS, N. M.)
LIFE SCIENCES OPERATIONS (EL SEGUNDO, CALIF.)
LOS ANGELES DIVISION (LOS ANGELES, CALIF.)
SUBSIDIARIES & AFFILIATES
NAVAN (EL SEGUNDO, CALIF.) – CHART 5 & A1
NAA S.P.A. (TORINO, ITALY) – CHART 5 & A2
NAASA (GENEVA, SWITZERLAND) – CHART 5 & A 3
INTERATOM (COLOGNE, GERMANY)

Figure 3-1

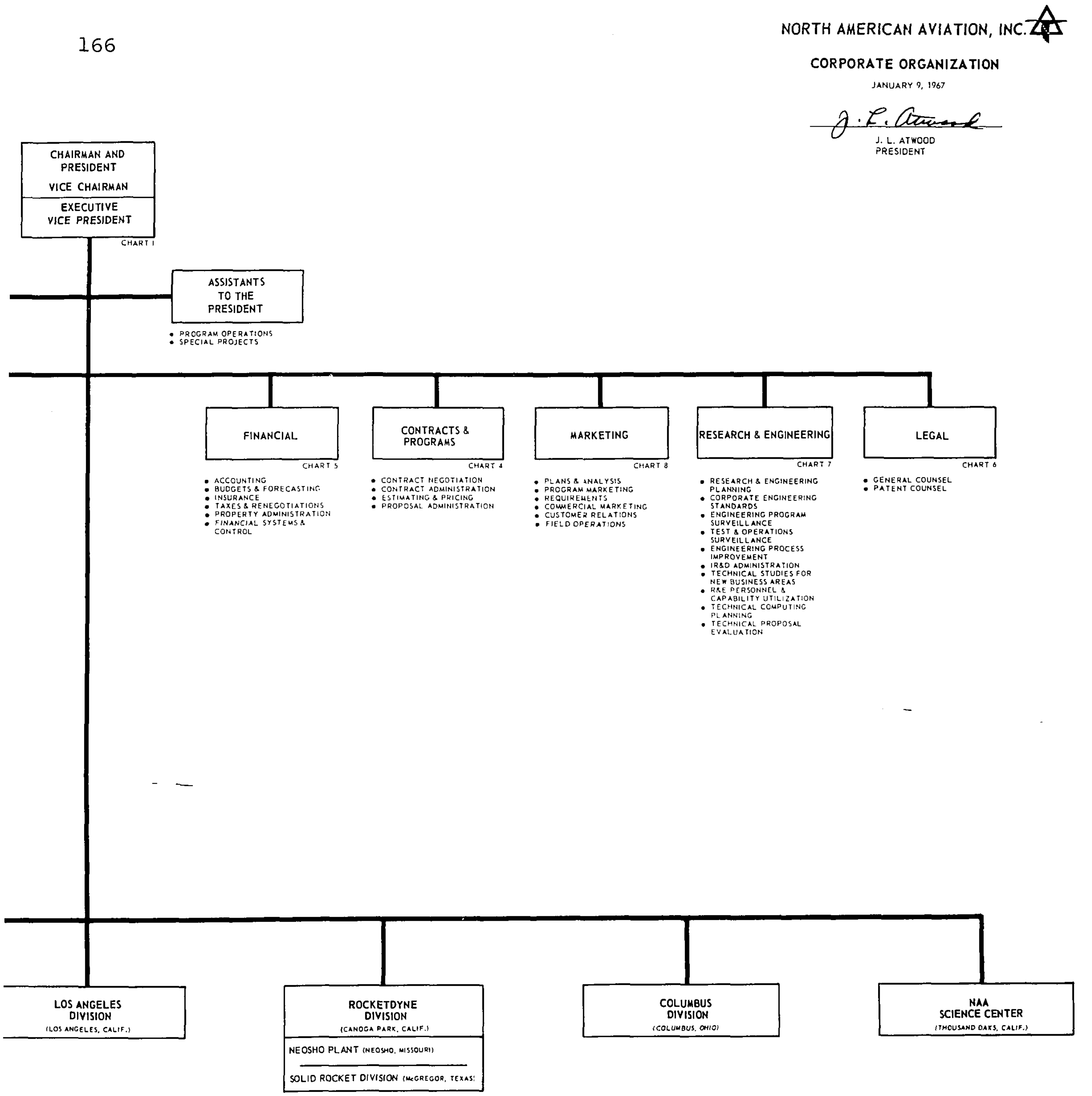

NORTH AMERICAN AVIATION, INC.
CORPORATE ORGANIZATION
JANUARY 9, 1967
J. L. Atwood
J. L. ATWOOD
PRESIDENT
CHAIRMAN AND PRESIDENT
VICE CHAIRMAN
EXECUTIVE VICE PRESIDENT
CHART 1
ASSISTANTS TO THE PRESIDENT
• PROGRAM OPERATIONS
• SPECIAL PROJECTS
FINANCIAL
CHART 5
• ACCOUNTING
• BUDGETS & FORECASTING
• INSURANCE
• TAXES & RENEGOTIATIONS
• PROPERTY ADMINISTRATION
• FINANCIAL SYSTEMS & CONTROL
CONTRACTS & PROGRAMS
CHART 4
• CONTRACT NEGOTIATION
• CONTRACT ADMINISTRATION
• ESTIMATING & PRICING
• PROPOSAL ADMINISTRATION
MARKETING
CHART 8
• PLANS & ANALYSIS
• PROGRAM MARKETING
• REQUIREMENTS
• COMMERCIAL MARKETING
• CUSTOMER RELATIONS
• FIELD OPERATIONS
RESEARCH & ENGINEERING
CHART 7
• RESEARCH & ENGINEERING PLANNING
• CORPORATE ENGINEERING STANDARDS
• ENGINEERING PROGRAM SURVEILLANCE
• TEST & OPERATIONS SURVEILLANCE
• ENGINEERING PROCESS IMPROVEMENT
• IR&D ADMINISTRATION
• TECHNICAL STUDIES FOR NEW BUSINESS AREAS
• R&E PERSONNEL & CAPABILITY UTILIZATION
• TECHNICAL COMPUTING PLANNING
• TECHNICAL PROPOSAL EVALUATION
LEGAL
CHART 6
• GENERAL COUNSEL
• PATENT COUNSEL
LOS ANGELES DIVISION
(LOS ANGELES, CALIF.)
ROCKETDYNE DIVISION
(CANOGA PARK, CALIF.)
NEOSHO PLANT (NEOSHO, MISSOURI)
SOLID ROCKET DIVISION (McGREGOR, TEXAS)
COLUMBUS DIVISION
(COLUMBUS, OHIO)
NAA SCIENCE CENTER
(THOUSAND OAKS, CALIF.)

Figure 3-13

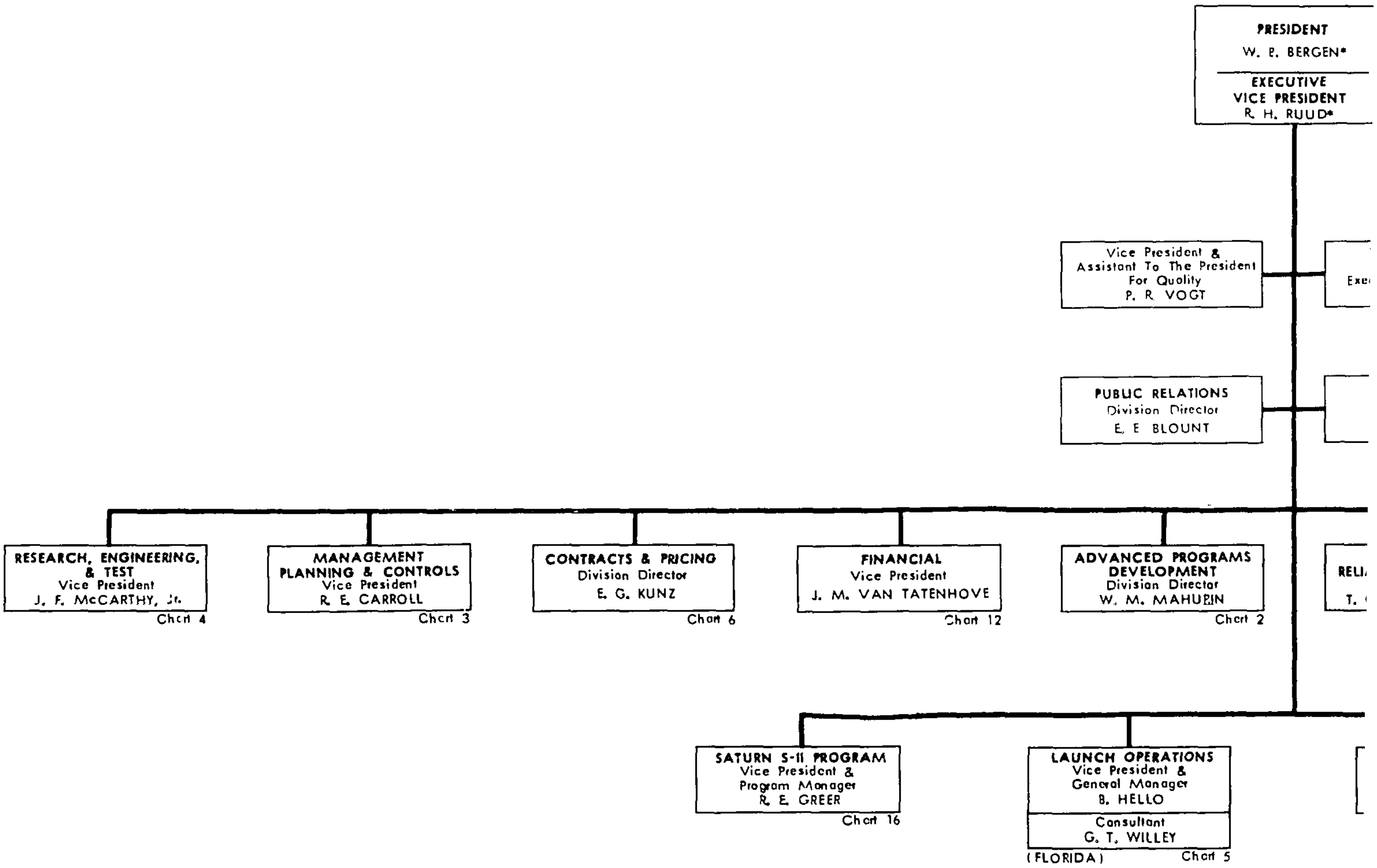

PRESIDENT
W. B. BERGEN*
EXECUTIVE VICE PRESIDENT
R. H. RUUD*
Vice President & Assistant To The President For Quality
P. R. VOGT
Exe
PUBLIC RELATIONS
Division Director
E. E. BLOUNT
RESEARCH, ENGINEERING, & TEST
Vice President
J. F. McCARTHY, Jr.
Chart 4
MANAGEMENT PLANNING & CONTROLS
Vice President
R. E. CARROLL
Chart 3
CONTRACTS & PRICING
Division Director
E. G. KUNZ
Chart 6
FINANCIAL
Vice President
J. M. VAN TATENHOVE
Chart 12
ADVANCED PROGRAMS DEVELOPMENT
Division Director
W. M. MAHURIN
Chart 2
RELI
T.
SATURN S-II PROGRAM
Vice President & Program Manager
R. E. GREER
Chart 16
LAUNCH OPERATIONS
Vice President & General Manager
B. HELLO
Consultant
G. T. WILLEY
(FLORIDA)
Chart 5

Figure 3-1

North American Aviation, Inc. Space Division

May 1, 1967

APPROVED: W B Bergen
W. B. BERGEN
PRESIDENT

• VICE PRESIDENT
NORTH AMERICAN AVIATION, INC.

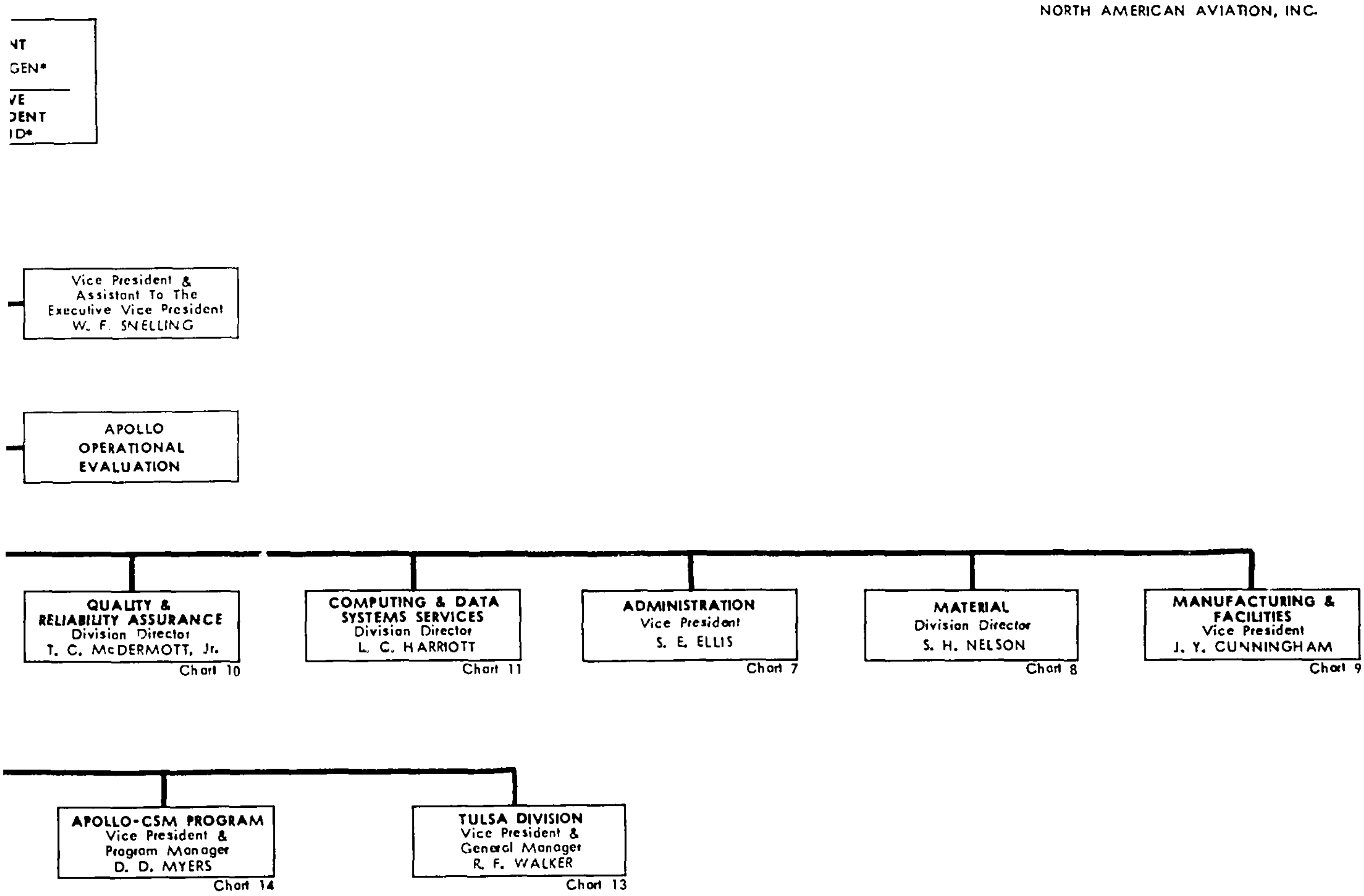
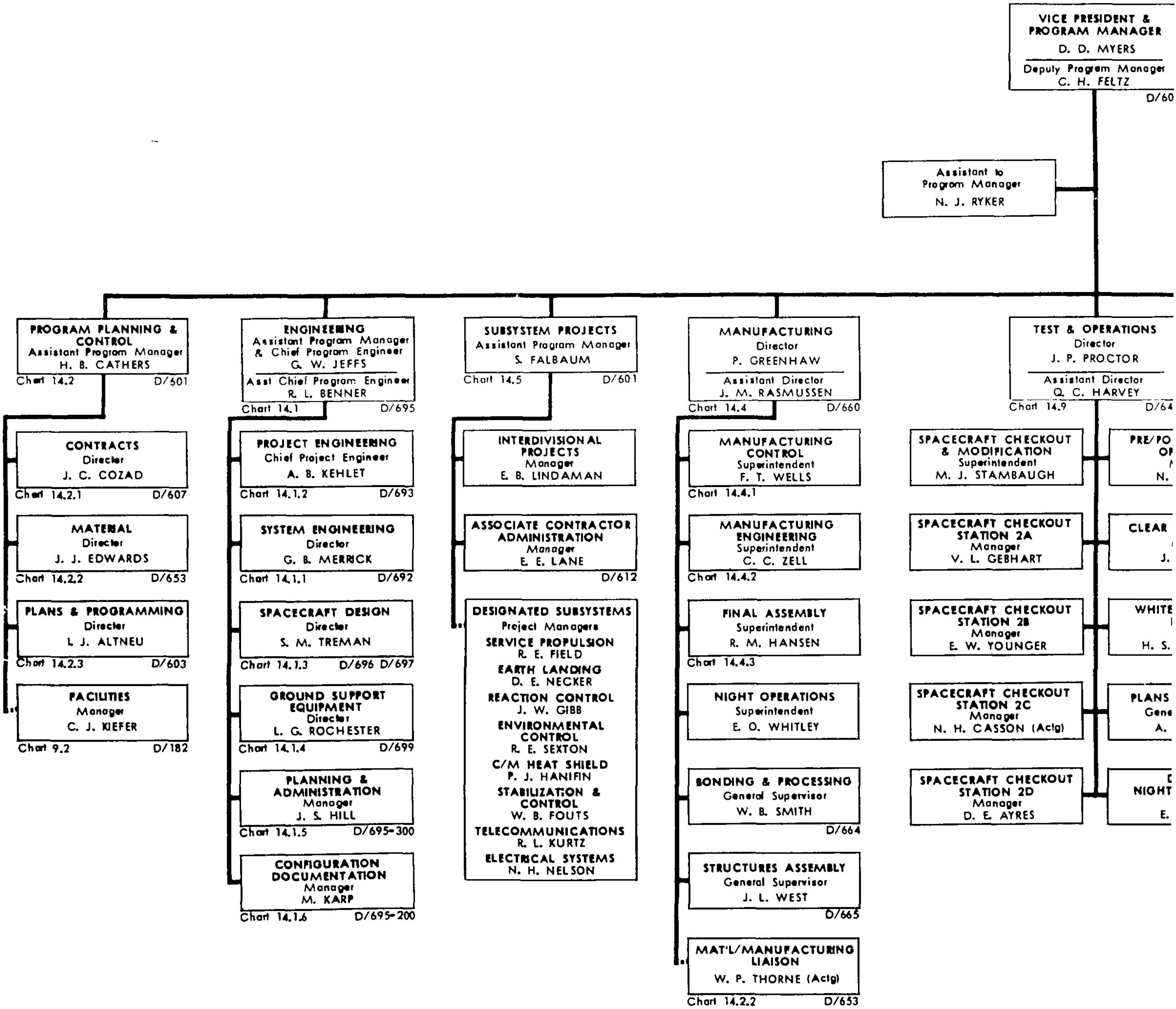


CHART 1



VICE PRESIDENT & PROGRAM MANAGER
D. D. MYERS
Deputy Program Manager
C. H. FELTZ
D/60
Assistant to Program Manager
N. J. RYKER
PROGRAM PLANNING & CONTROL
Assistant Program Manager
H. B. CATHERS
Chart 14.2 D/601
ENGINEERING
Assistant Program Manager & Chief Program Engineer
G. W. JEFFS
Asst Chief Program Engineer
R. L. BENNER
Chart 14.1 D/695
SUBSYSTEM PROJECTS
Assistant Program Manager
S. FALBAUM
Chart 14.5 D/601
MANUFACTURING
Director
P. GREENHAW
Assistant Director
J. M. RASMUSSEN
Chart 14.4 D/660
TEST & OPERATIONS
Director
J. P. PROCTOR
Assistant Director
Q. C. HARVEY
Chart 14.9 D/64
CONTRACTS
Director
J. C. COZAD
Chart 14.2.1 D/607
MATERIAL
Director
J. J. EDWARDS
Chart 14.2.2 D/653
PLANS & PROGRAMMING
Director
L. J. ALTNEU
Chart 14.2.3 D/603
FACILITIES
Manager
C. J. KIEFER
Chart 9.2 D/182
PROJECT ENGINEERING
Chief Project Engineer
A. B. KEHLET
Chart 14.1.2 D/693
SYSTEM ENGINEERING
Director
G. B. MERRICK
Chart 14.1.1 D/692
SPACECRAFT DESIGN
Director
S. M. TREMAN
Chart 14.1.3 D/696 D/697
GROUND SUPPORT EQUIPMENT
Director
L. G. ROCHESTER
Chart 14.1.4 D/699
PLANNING & ADMINISTRATION
Manager
J. S. HILL
Chart 14.1.5 D/695-300
CONFIGURATION DOCUMENTATION
Manager
M. KARP
Chart 14.1.6 D/695-200
INTERDIVISIONAL PROJECTS
Manager
E. B. LINDAMAN
ASSOCIATE CONTRACTOR ADMINISTRATION
Manager
E. E. LANE
D/612
DESIGNATED SUBSYSTEMS
Project Managers
SERVICE PROPULSION
R. E. FIELD
EARTH LANDING
D. E. NECKER
REACTION CONTROL
J. W. GIBB
ENVIRONMENTAL CONTROL
R. E. SEXTON
C/M HEAT SHIELD
P. J. HANIFIN
STABILIZATION & CONTROL
W. B. FOUTS
TELECOMMUNICATIONS
R. L. KURTZ
ELECTRICAL SYSTEMS
N. H. NELSON
MANUFACTURING CONTROL
Superintendent
F. T. WELLS
Chart 14.4.1
MANUFACTURING ENGINEERING
Superintendent
C. C. ZELL
Chart 14.4.2
FINAL ASSEMBLY
Superintendent
R. M. HANSEN
Chart 14.4.3
NIGHT OPERATIONS
Superintendent
E. O. WHITLEY
BONDING & PROCESSING
General Supervisor
W. B. SMITH
D/664
STRUCTURES ASSEMBLY
General Supervisor
J. L. WEST
D/665
MAT'L/MANUFACTURING LIAISON
W. P. THORNE (Actg)
Chart 14.2.2 D/653
SPACECRAFT CHECKOUT & MODIFICATION
Superintendent
M. J. STAMBAUGH
SPACECRAFT CHECKOUT STATION 2A
Manager
V. L. GEBHART
SPACECRAFT CHECKOUT STATION 2B
Manager
E. W. YOUNGER
SPACECRAFT CHECKOUT STATION 2C
Manager
N. H. CASSON (Actg)
SPACECRAFT CHECKOUT STATION 2D
Manager
D. E. AYRES

Figure 3-1

SPACE and INFORMATION SYSTEMS DIVISION

NORTH AMERICAN AVIATION, INC.

APOLLO PROGRAM

December 13, 1966

APPROVED: [signature]

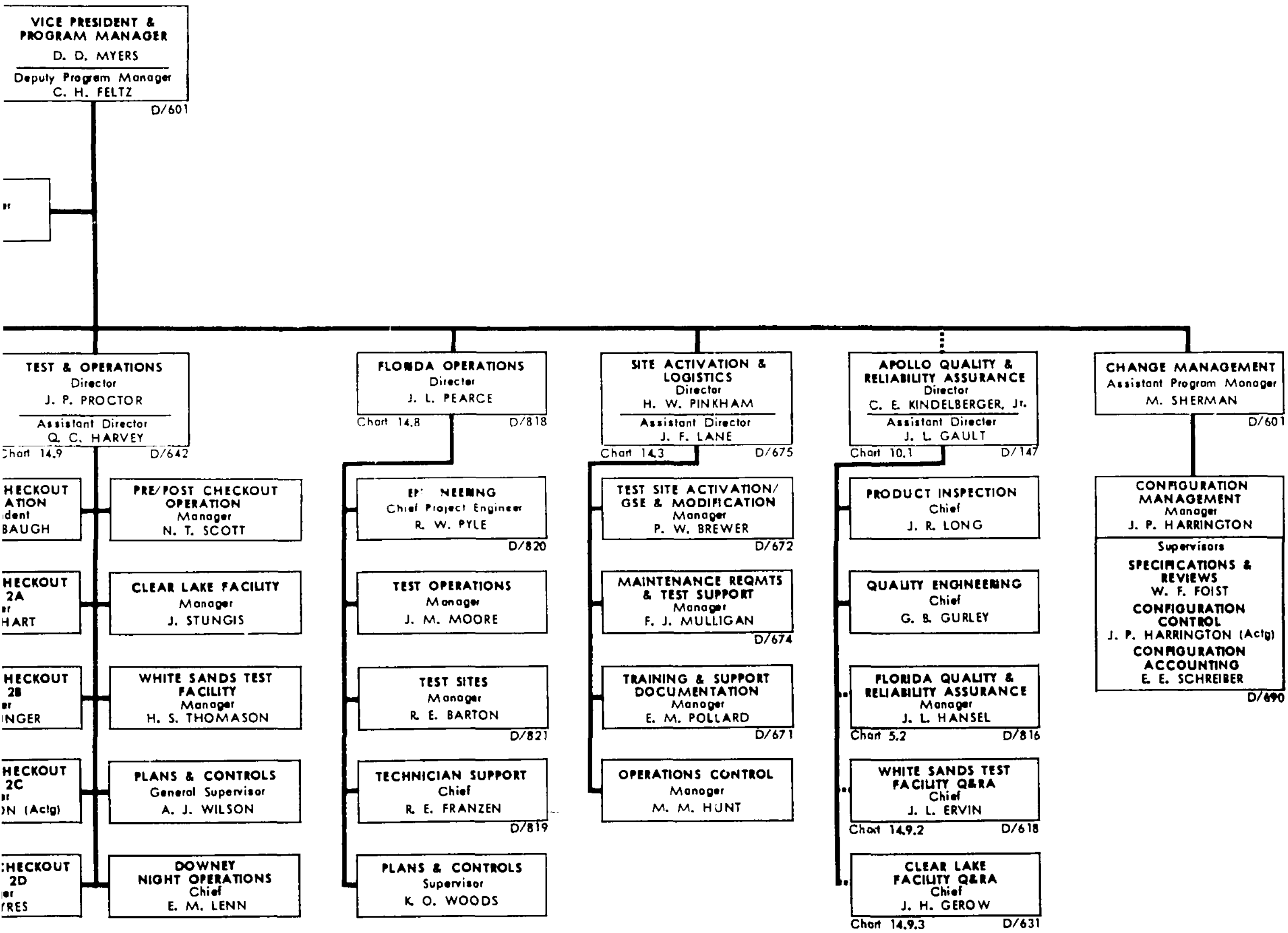


Figure 3-15

CHART 14

APPENDIX C

CONFIDENTIAL QUESTIONNAIRE

INSTRUCTIONS:

Please answer the following questions to the extent possible. If additional space is needed, feel free to write on the back or attach additional sheets. If some of the questions can be answered by enclosing functional statements or organizational charts, please do so. Also, please use this questionnaire for data on one specific project only.

I. GENERAL

1. In what specific type of undertaking are you using project management:

aerospace	____	research & development of consumer products	____
airplane construction	____	other (please explain	____
bridge, ship construction	____		
development of heavy equipment	____		

2. Is this project being undertaken for a customer _____ or for the benefit of the corporation itself _______? If "other" please explain.

3. What is the approximate dollar size of the project?

4. What will be the approximate duration of the project from start to finish?

II. PERSONNEL

<u>In answering this section, please omit any of your subcontractor personnel engaged in the project</u>.

1. a) How many personnel are on the project? _____

   b) What percentage of these were hired from outside the company for project specifically? _____

   c) What percentage of the personnel are assigned to the project on a part time basis only? _____

2. a) How long before the end of the average team member's stay on this project will be his next assignment be determined? _____

   b) What percentage of your personnel do you estimate will be assigned back to the permanent organization? _____

   c) What percentage of your personnel will leave the company when the project is completed? _____

   d) Of those leaving, what percentage will be let go because they cannot be placed or because they were hired only for this specific project? _____

3. a) Were you hired as the project manager from outside of the firm? _____

   b) What was your previous department and title?

   c) Briefly, what did your previous job entail?

III. ORGANIZATION

1. What is the title of the person to whom you report directly?

2. Exactly what are your functions as a project manager? (Please enclose a functional statement and an organizational chart of both the project organization and the overall firm if available.)

3. What are the major functions which must be performed in order for the project organization to accomplish its objective, e.g., research, engineering, design, test, etc? For each please check whether the project organization has the "in-house" capability for performing that function (independent) or whether it is semi-independent or completely reliant (dependent) on the permanent organization to do that job for it.

	Major Function	Independent	Semi-Independent	Dependent
1.				
2.				
3.				

4. Please check how the following are rated as criteria in deciding to use a project organization rather than letting the regular functional organization handle the job?

	Very Important	Important	No Difference	Poor	Very Poor
1. Costs Involved					
2. Scheduling					
3. Management Control					
4. Required by Customer					

5. ________ 6. ________ 7. ________

Are there any criteria, other than those listed in numbers 1-4, which you or your organization use in choosing a project organization? Please indicate in numbers 5-7.

5. What kinds of reports do you submit on a periodical basis, e.g., costs, quality, scheduling, etc? Please rank them in order of importance based on your opinion and/or the feedback you get. How often is each submitted? (Feel free to enclose any forms you feel would clarify your answer.)

6. Title of the person filling out the questionnaire. ________

7. Would you like a copy of the survey results? Yes___ No ___

If yes: Name________________
Address________________

Please return to the University of Nebraska, College of Business Administration, in the enclosed self-addressed envelope. Thank you for your answers.

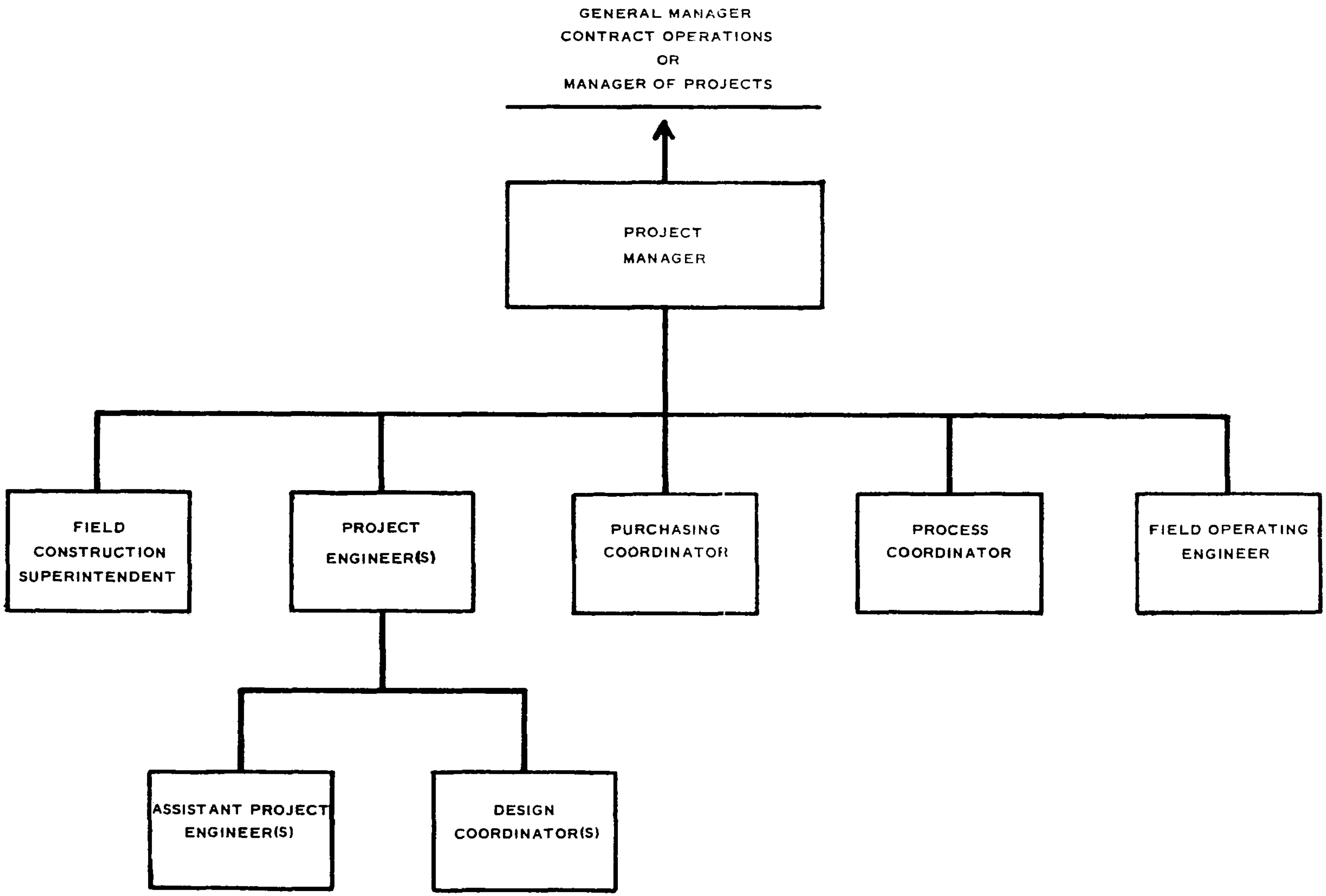
APPENDIX D

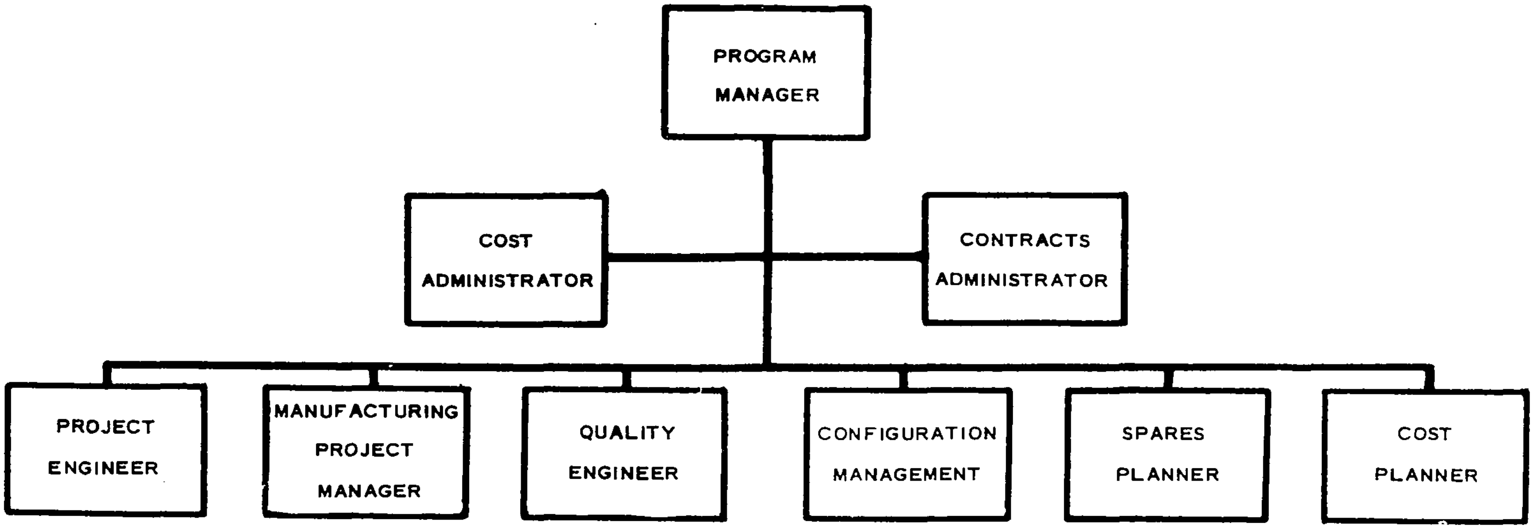
PARTIAL LIST OF FIRMS WHICH PARTICIPATED IN THE STUDY*

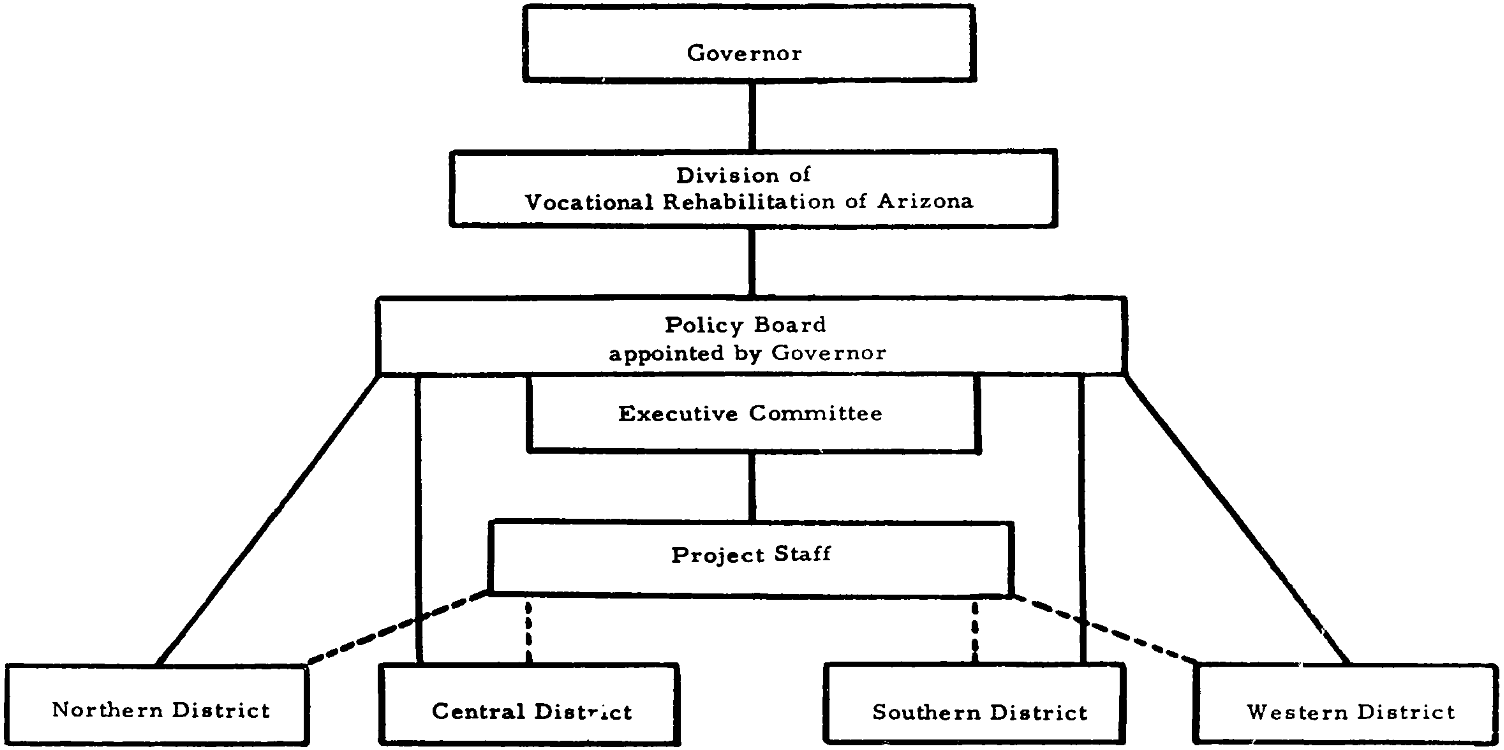
Abbott Laboratories
Allied Chemical Corporation
Arundel Corporation
Avco Corporation
Bell & Howell Company
Blaw-Know Company
Boeing Company
Celanese Corporation of America
Cincinnati Milling Machine Company
Control Data Corporation
Dorr-Oliver Incorporated
Douglas Corporation
Foster-Wheeler Corporation
Foxboro Company
General Electric Company
General Precision Incorporated
Goodyear Tire & Rubber Company
Hamilton Standard Corporated
Hercules Corporation
Honeywell Incorporated
International Business Machines Corporation
Johns Manville Corporation
M. W. Kellogg Company
Kimbery Clark Company
Martin Company
Maryland Shipbuilding & Dry Dock Company
McKay Machine Company
Mead Johnson & Company
Midland Ross Corporation
North American Aviation Incorporated
Otis Elevator Company
Parke Davis & Company
Radiation Incorporated
Raytheon Incorporated
Rockwell-Standard Corporation
Salem-Brosius Incorporated
Union Carbide Corporation
United States Rubber Company
Vocational Rehabilitation Agency: Arizona, Illinois, Michigan, Nebraska, New York, Texas
Wilson & Company

*Not all firms are included because not all identified them selves.

APPENDIX E


GENERAL MANAGER
CONTRACT OPERATIONS
OR
MANAGER OF PROJECTS
PROJECT MANAGER
FIELD CONSTRUCTION SUPERINTENDENT
PROJECT ENGINEER(S)
PURCHASING COORDINATOR
PROCESS COORDINATOR
FIELD OPERATING ENGINEER
ASSISTANT PROJECT ENGINEER(S)
DESIGN COORDINATOR(S)

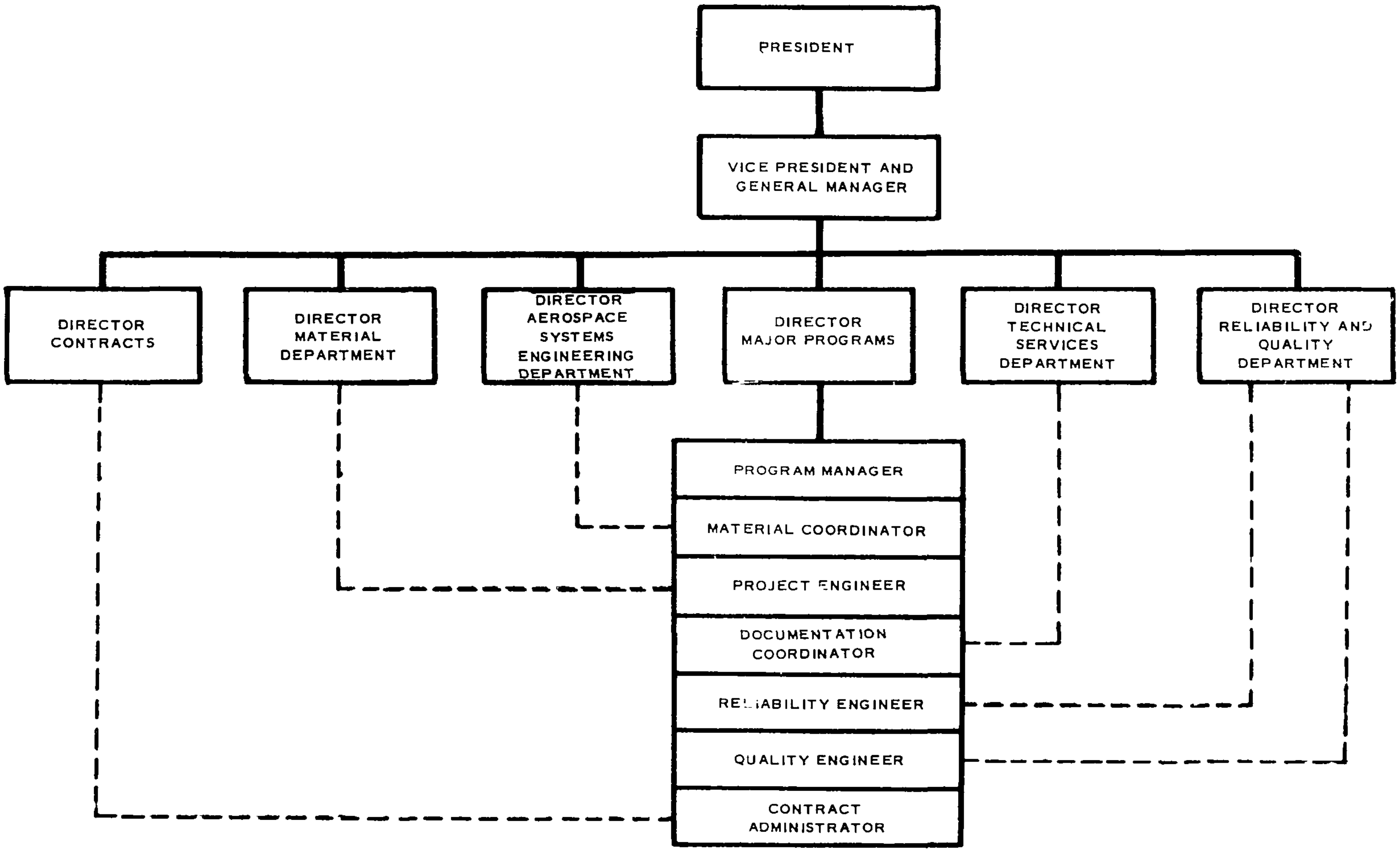

PROGRAM MANAGER
COST ADMINISTRATOR
CONTRACTS ADMINISTRATOR
PROJECT ENGINEER
MANUFACTURING PROJECT MANAGER
QUALITY ENGINEER
CONFIGURATION MANAGEMENT
SPARES PLANNER
COST PLANNER

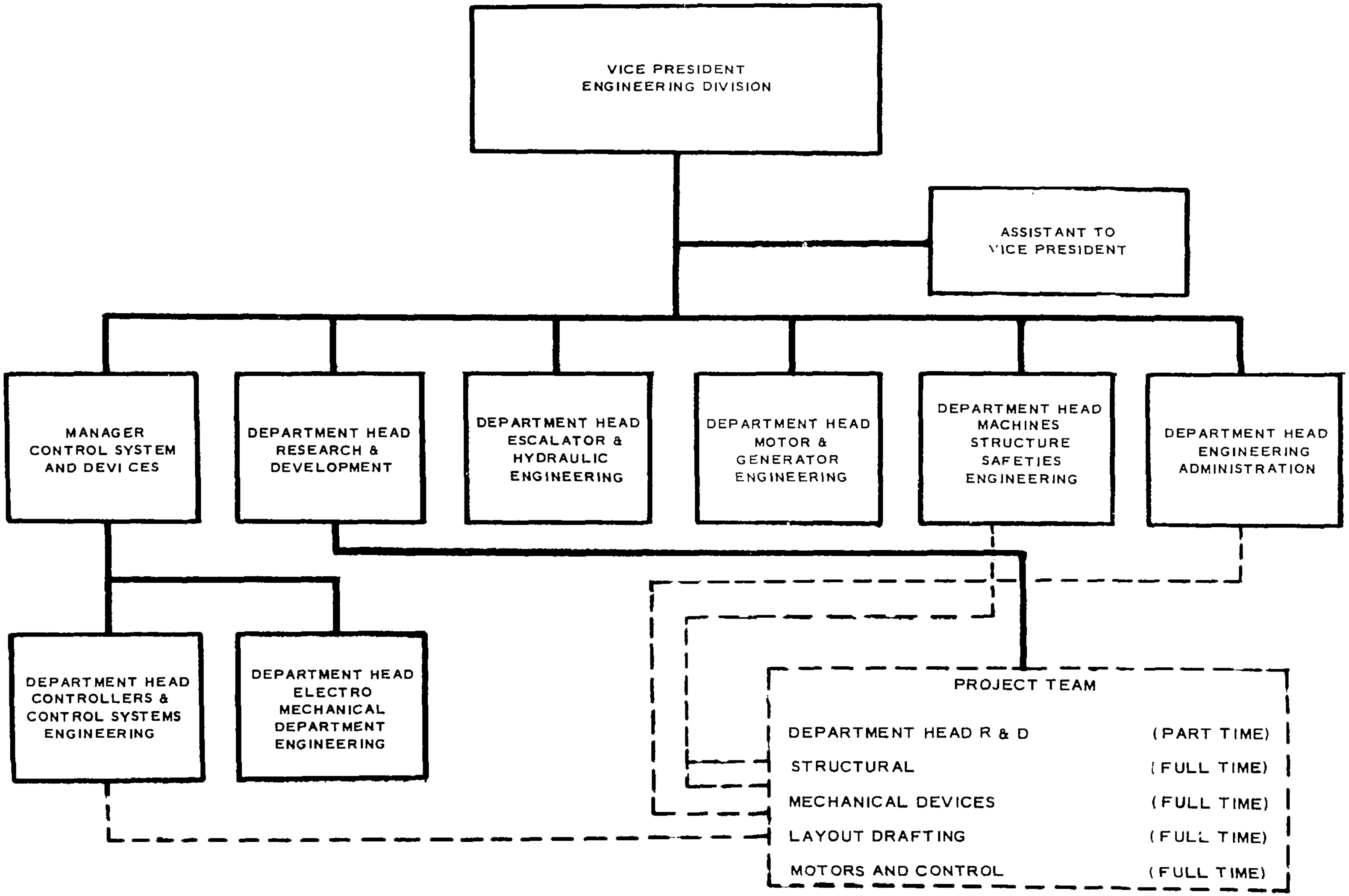


Study Groups

Data Collection and Analysis
Analysis of Previous Statewide and Local Studies
Pilot Programs
Assimilation and Implementation

STATEWIDE PLANNING FOR VOCATIONAL REHABILITATION -- ORGANIZATIONAL CHART


PRESIDENT
VICE PRESIDENT AND GENERAL MANAGER
DIRECTOR CONTRACTS
DIRECTOR MATERIAL DEPARTMENT
DIRECTOR AEROSPACE SYSTEMS ENGINEERING DEPARTMENT
DIRECTOR MAJOR PROGRAMS
DIRECTOR TECHNICAL SERVICES DEPARTMENT
DIRECTOR RELIABILITY AND QUALITY DEPARTMENT
PROGRAM MANAGER
MATERIAL COORDINATOR
PROJECT ENGINEER
DOCUMENTATION COORDINATOR
RELIABILITY ENGINEER
QUALITY ENGINEER
CONTRACT ADMINISTRATOR


VICE PRESIDENT
ENGINEERING DIVISION
ASSISTANT TO
VICE PRESIDENT
MANAGER
CONTROL SYSTEM
AND DEVICES
DEPARTMENT HEAD
RESEARCH &
DEVELOPMENT
DEPARTMENT HEAD
ESCALATOR &
HYDRAULIC
ENGINEERING
DEPARTMENT HEAD
MOTOR &
GENERATOR
ENGINEERING
DEPARTMENT HEAD
MACHINES
STRUCTURE
SAFETIES
ENGINEERING
DEPARTMENT HEAD
ENGINEERING
ADMINISTRATION
DEPARTMENT HEAD
CONTROLLERS &
CONTROL SYSTEMS
ENGINEERING
DEPARTMENT HEAD
ELECTRO
MECHANICAL
DEPARTMENT
ENGINEERING
PROJECT TEAM
DEPARTMENT HEAD R & D (PART TIME)
STRUCTURAL (FULL TIME)
MECHANICAL DEVICES (FULL TIME)
LAYOUT DRAFTING (FULL TIME)
MOTORS AND CONTROL (FULL TIME)

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