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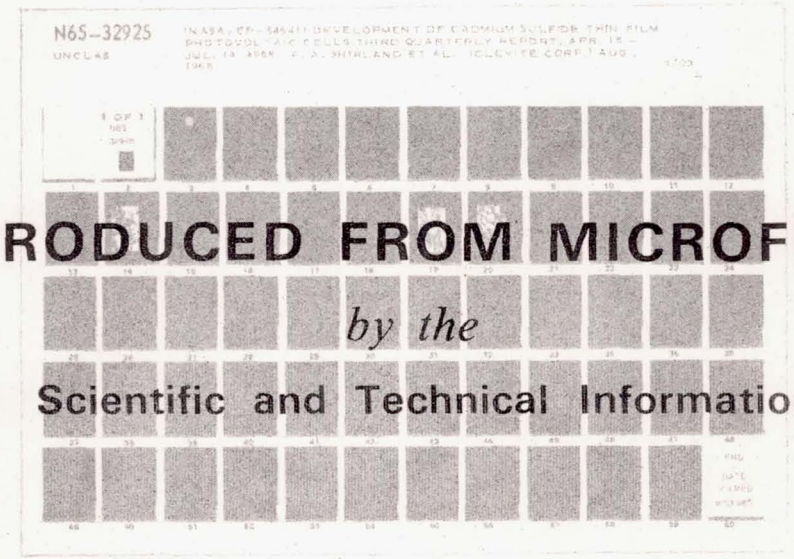

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THE APOLLO PROJECT MANAGER: ANOMALIES AND AMBIGUITIES

by

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ABSTRACT

This article deals with some of the problems that Apollo project managers face in the everyday operation and implementation of the manned space effort. The emphasis is on the focal position of the project manager rather than on an overall systems concept of project management. Five areas of anomalies and ambiguities in terms of problem resolution and management strategies are discussed: (1) maintaining the balance between technical and managerial emphasis; (2) risk acceptance/rejection; (3) surviving environmental restraints; (4) the significance of project communication; and (5) penetrating organizational boundaries. Discussion of these areas gives some preliminary insights into the management styles of the effective project managers and opens significant areas for future research on the management of large-scale, complex undertakings such as Apollo.

INTRODUCTION

Since its inception, the Apollo Program has generated a charismatic quality beyond that of any other government program. However, relatively little attention has been given to the actual management of Apollo beyond a brief overview of its primary activities. The objective of this article is to examine the management of Apollo from the focal position of the Apollo project managers who are responsible for managing the critical hardware components for the Saturn/Apollo rocket. The underlying assumption is that these managers play a crucial role in the Apollo effort and their collective performance is an important determinant of the efficiency, quality, and ultimately, the success of the Apollo missions. Their responsibilities for coordinating, mobilizing, and allocating diverse resource requirements, both in terms of manpower and materials, places these individuals in unique management positions. Their roles often demand the balancing of conflicting situations which produce a conglomerate of anomalies and ambiguities which must be resolved to meet project objectives. This article addresses some of the anomalies and ambiguities and how the Apollo project managers adapt to them.[1]

Through the efforts of a multidisciplinary research team and with the cooperation of the National Aeronautics and Space Administration (NASA) the authors interviewed numerous project managers,

subsystem managers, and research and development project engineers participating in the Apollo program.[2] The analysis of field interview data has revealed several response patterns which seem indicative of some of the key managerial problems that the Apollo project managers face. In the attempt to view the management of Apollo from the perspective of the individual project manager rather than from an overall systems concept of organization, this article focuses on those problem areas that demand interpretation by each project manager according to the cues in his environment.[3] Five areas will be examined in the following sections: (1) the balance between technical and managerial emphasis; (2) risk acceptance/rejection; (3) surviving environmental restraints; (4) the significance of project communication; (5) penetrating organizational boundaries.

For a clearer perception of the significance of these five areas in terms of the project manager's focal positions, the relationships between the project managers and the research and development project engineers and the project counterparts within contracting organizations should be briefly delineated. This triad of interrelationships is a significant characteristic of the Apollo model of project management as most clearly evidenced by operations at the Marshall Space Flight Center (MSFC) field center location in Huntsville, Alabama. (See Figure 1)[4].

Within MSFC, primary responsibilities for the Apollo Program are handled by two segments of the total organization, Program Management

PROJECT MANAGER, PROJECT ENGINEER,
AND CONTRACTOR INTERFACES:
MSFC/APOLLO MODEL

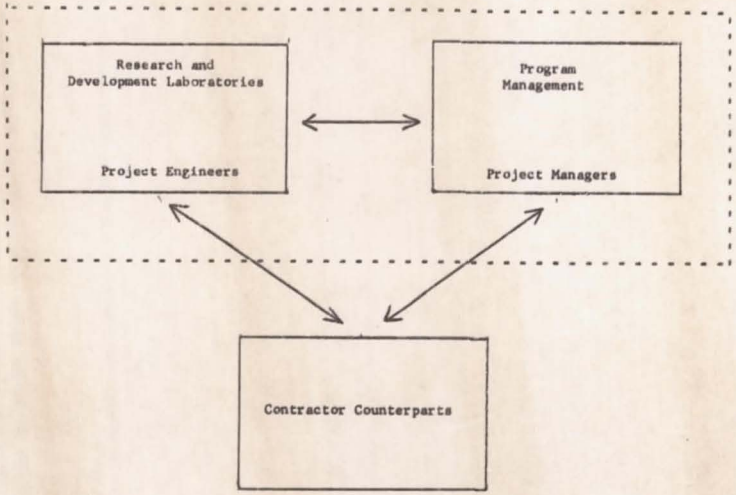

FIGURE 1

(PM) and Research and Development (R&D). Each segment of the organization has a specific role to perform. The project managers within PM are collectively accountable for all project tasks assigned to MSFC and are responsible for meeting task objectives within designated cost, schedule, and performance parameters. The research and development project engineers within R&D are accountable for providing maximum technical support to the project managers. In addition to the interfaces between PM and R&D, constant interface must be maintained with contractor organizations outside of the NASA.

In a real sense, this triad functions as the total project team. In the following discussions, the basic nature of these interrelationships should be kept in mind.

THE BALANCE BETWEEN TECHNICAL AND MANAGERIAL EMPHASIS

In the management of Apollo, the project manager must maintain a consistent balance between his technical and managerial activities. When the project manager is directly confronted with a problem which may disrupt task performance within the designated objectives of the project, both a technical decision and a managerial decision are usually needed for ultimate resolution. For example, if research and development personnel inform the project manager that a critical component of the Saturn V Rocket has only an "X" reliability factor, the project manager must weigh the technical decision of whether or not to accept the recommended reliability quotient against the overall management considerations of budget and schedule.

A potential problem for the project manager lies in the possibility of over-stressing either the technical or the management aspects of the problem. The resolution of this problem appears to be in the project manager's understanding of his technical function and how to maintain the technical balance. While the management considerations, as evidenced by the KSFC/Apollo model, are clearly the responsibility of the project manager, a certain latitude is open in terms of his delving into detailed technical problems. He may either become deeply involved in the engineering problems or he may leave the details to other experts and maintain a more distant position.

Through analysis of interview data, the most successful strategy appears to be to display an understanding of and acute interest in the technical aspects of the problem while leaving its more detailed resolution to other specialists on the project team. Two statements by project team members emphasize this point.

> I. I've had experiences where I felt that the project manager was trying to exert too much influence in the technical areas in an attempt to make the decision himself.
>
> II. All organizations suffer from having a man too interested in understanding everything. If that's the project manager's interest, I feel that he's misplaced. He can do a job, but it shouldn't be in management. He should be in a technical job...You sometimes can't reward a technical man... you put him in a management box and he makes things miserable. He's miserable and the people under him are miserable.[5]

Again, the implication is that to maintain the technical balance, the project manager should remain somewhat apart from the details. The underlying reasoning for this position is that while a project manager

draws on unique and diverse organizational resources in terms of expert manpower, there should remain some protection of each team member's professional prerogatives. In the case of research and development inputs, their guarded interests lie in the technical areas. If the project manager over-stresses his technical function, this has the effect of usurping research and development commitments and creating technical imbalance.

While it is generally desirable for the project manager to leave most of the technical detail to other team members, there are, at least, two mitigating conditions: (1) the perceived technical competence of the project manager; and (2) his ability to effectively use his project team. One might hypothesize that a project manager has a certain amount of positional charisma and that the degree of that charisma is, in part, a function of the type of engineering background he has. Although no unanimity of opinion was expressed by the Apollo project managers and by research and development engineers, several project participants believed that research and development experience is almost a prerequisite for an effective project manager. "Getting one's hands dirty," for example, in engineering is perceived as an important preparation for the project manager position not only in terms of technical experience but as a means of establishing necessary alliances with individuals in the research and development areas. One research and development engineer commented on the above point as follows:

> I guess one of my gripes about some project managers is that they haven't really come up through the ranks. In other words, if you look at their background, and there are exceptions, they have come from unrelated fields and most of them have really never served in the bowels of the organization, down in engineering...

An important determinant in maintaining the technical balance, therefore, may be the project manager's earned respect and technical competence as perceived by project participants in the research and development areas. The degree of that perceived expertise may be important in determining how the project manager copes with technical problems; the man who has come up through the ranks may be in a better position to resolve technical problems than the man from an unrelated field or coming from a position outside of the NASA.

As suggested, the project manager draws upon diverse organizational resources. In maintaining the balance between technical and managerial emphasis, the project manager's use of his project team is critical. The effective use of the project team was described by one project manager in the following context:

> A good project manager has to surround himself with experts. He doesn't need to be an expert engineer, an expert in finance, an expert in contracting, etc. He does, however, need a working knowledge of these things. For example, when an engineer starts talking to him about longitudinal oscillations, he has to know what the man is talking about. The prime thing that a project manager needs is the ability to listen and comprehend what his people are telling him.

A fundamental quality of the Apollo project manager is the ability to assimilate knowledge from several sources, evaluate the recommendations, and make decisions based on this wide range of information. As another project manager stated: "...to me, this is what makes a real project manager."

RISK ACCEPTANCE/REJECTION

There are two categories of risk that seem especially relevant to project managers: (1) project risk; and (2) professional risk. Project risk involves the failure to do an adequate management job which results in project failure either in terms of performance or in terms of critical budget or schedule deviations. Professional risk centers around the possibility of professional obsolescence as the result of long-term project affiliation.

Project risk may be identified with the project manager's final responsibility for meeting and maintaining the performance, schedule, and budgetary objectives of the project. His success and the recognition of his ability as a manager, in part, depends upon his achievements in these areas. In effect, the project manager is the focal person in a constantly exposed responsibility system. Complicating these responsibilities are the necessary interfaces with other project managers and their hardware systems. For example, in the Apollo Program, the project managers in charge of launch vehicles and engines must maintain a constant interface with each other. In this sense, the project manager not only has responsibility for his own project, but shares the responsibility for other project manager's hardware.

In terms of project risk, two rather different perceptions were found to exist among the Apollo project managers. The disparity in conceptualizing project risk may be illustrated by the following two quotations.

I. If my hardware didn't work and it failed in lift-it would be a catastrophic occurrence. I would completely expect to be replaced. Put it that way.

II. If you don't want to accept the responsibility you don't have to, you just buck it up to the next manager and if he doesn't want to make the decision, he can go to the program manager.

In the first instance, the project manager perceives his responsibility as final and complete with the risk of project failure resting entirely on his shoulders. In the second case, the project manager is left with an option of whether or not to accept complete responsibility in critical areas. The first case is relatively unambiguous, however, the second leaves assumption of project risk up to the individual manager. Further research may provide a workable hypotheses for understanding under what conditions and what behavioral variables determine the amount a risk a particular project manager is willing to assume. The purpose here is to point out that project managers perceive risk differently.

Apart from project risk, the project manager is confronted with professional risk in terms of obsolescence. In effect, advancement of the state of the art may bypass the project manager who is unable to keep up with the rapidly changing practices in his engineering field. This is especially relevant in a program like Apollo where some of the major hardware projects have a life cycle of eight to ten years. One project manager who had been in his position a number of years stated the implications of professional risk in the following manner: "I'm an obsolete engineer, I'm an untrained manager, and I'm too old to go back to school."

SURVIVING ENVIRONMENTAL RESTRAINTS

While the concept of project management is often defined in terms of its flexibility, the antithesis of the traditional bureaucratic model of organization, many Apollo team members have indicated that certain environmental parameters develop over time which either diminish the effectiveness of or place additional constraints on the programmatic organization. It was suggested that the project organization is not immune to Parkinson's Law. As the project matures over its life cycle, various systems and constraining mechanisms become attached to the organization which produce rigidities within the total project system. For example, over the life of Apollo, various "staff offices" at the field center levels and at Headquarters have gradually placed rather stringent demands on the project organization in terms of data reporting systems, audits, and various types of control requests. One project manager explained that, over time, a project loses its flexibility.

> First you start out with a small organization and call it the NASA. As you expand that organization you have more and more staff people at Headquarters and you have more people thinking up reasons why there's a need for a report. So, pretty soon you get hit with directives, some from Headquarters, some from every level. Many of these directives require reporting; we've got a lot of people who think it would be real nice to have this report or that report.

The project members must cope with increasing amounts of paperwork while maintaining peak efficiency in all areas of original responsibility. They must survive the new systems.

While documenting the system may have obvious negative connotations, Apollo participants have also expressed its positive aspects in terms of self protection. In a program like Apollo extensive documentation, while somewhat laborous, has the effect of clearly stating each participant's position with regard to controversial performance areas. If future anomalies develop, the manager may rely on extensive documentation as a means of self protection. This can be conceptualized as one of the informal roles of the documentation procedure. One project member, for example, indicated that after the SA-204 fire the amount of documentations increased throughout the entire Apollo effort.

Aside from documenting the system, another variable that may be a restraint on the project manager is the Civil Service regulations and requirements. These regulations, because of their rigidities, become a problem for the project manager in selecting, training, and molding a viable project team. For example, a project manager may not be able to choose his own men for his project staff no matter how qualified or how necessary they might be in terms of a particular task requirement. The man must first be "freed" from his present organizational position. One project manager alluded to the problem in this way:

> Nobody gets assigned to a job around here. You have to get permission from the people you work for. If a promotion is involved, it makes it extremely difficult for them not to allow the man to go, I guess, by law they really couldn't refuse to release him if a promotion was involved. But if it's just a lateral transfer, and say I really need a good strong project engineer, even if the center is in trouble and a man is around who isn't doing very much, if the person who is supervising his a.. a feels strong about him and won't let him go, then you almost can't get him no matter how badly you need him...and that's kind of bad.

The problem of assigning manpower to build the most effective project team also appears in the reverse situation. If a team member's performance is below an acceptable level, the project manager may also have problems in "spinning-off" personnel. One project manager concerned about the effectiveness of some members of his team made this comment.

> I've got three people I could do completely without. But, if I asked for their release from this project, I would most likely have to give up my three best men, so, I just sit here and don't say anything.

The examples here only briefly touch the problems the Apollo project manager faces in surviving the system. If the project manager is evaluated in terms of how he meets his task responsibilities, any mechanism constraining optimum efficiency and flexibility is, in a real sense, a threat to the manager's capability of surviving the total project system.

THE SIGNIFICANCE OF PROJECT COMMUNICATIONS

As previously suggested, the project team consists of diverse professional inputs. The basic motivations of various team participants in their diverse organizational roles often cause difficulties for the project manager in his effort to reconcile various task problems. The general pattern for a project team in Apollo consists of a triad of organizational interfaces which includes the project manager and his sub-system managers, the research and development engineer and his supporting personnel, and the contractor's project personnel. Although all three groups comprise the project team, conflicts may arise among team participants both from a functional perspective and from the viewpoint of personal motivation. To go back to an earlier example, if the project manager and the contractor accept a reliability index of "X" on a critical component of the Saturn V and the

research and development project team members insist on a reliability of "9", a conflict of interests may develop. The project manager may want to persuade research and development to relax their desired performance level while at the same time not compromise their professional position too greatly. This may require some delicate maneuvering by the project manager to keep research and development personnel motivated and to maintain their high competence level. One project manager suggested that communication was the critical input in this type of situation.

> You have to understand who you are dealing with. An engineer in the laboratory may feel that we should settle for nothing less than zero leakage on a certain seal. He has a certain background, a certain psychological makeup that you have to understand, appreciate, and not violate. You can't tell a guy like that, go to hell you don't understand the problem. This guy can be a Ph. D. and he can darn well know exactly what he's talking about. So you've got to find within your own means the mechanisms for communicating with that engineer...and then again you've got to realize that he's communicating with us.

One strategy employed by the project manager to deal with conflicts either with research and development or with the contractor is a preventive measure; to communicate forcibly, but tactfully, his stance on various issues such as the budget and schedule status of the project. By constantly communicating this with team members the project manager, in effect, places some stated parameters on the activities of the research and development team members and the contractor.

The effectiveness of the project manager's strategies in terms of minimizing and resolving conflicts among team personnel depends, to a large extent, on his influence over project participants. His influence may, in turn, be a function of how he handles recommendations for engineering changes made by either research and development or the

contractor. The project manager must know when to accept and when to reject change proposals in order to maintain the motivational level of project participants and to achieve the overall objectives of the task under consideration. Constant rejection of change recommendations may lower both the motivation of participants and diminish the project manager's influence in coordinating participants toward project objective within the designated project parameters. Conversely, the process of accepting engineering change proposals or requests on a piece of hardware is equally important to the project manager. One manager stated:

> I think it takes a person with a good technical background and good management qualities. He should be the type that can accept other people's work without a whole lot of picking; he should be the kind of person who can accept things done a little differently than he would do them...

In this light, the project manager's influence over all team members appears critical to maintaining project direction and control.

PENETRATING ORGANIZATIONAL BOUNDARIES

Research and observation leads one to believe that the personality of the project manager is crucial for success in meeting the various project objectives. There have been many examples of the importance of personality in achieving effective project performance. While some of these examples have already been alluded to in the prior discussion, the following paragraphs illustrate some of the key areas where the project manager's personality either helps or hinders him in task performance.

The concept of project management is based on the premise that it utilizes diverse inputs and resources as they are needed from the total organization of which it is a part. In effect, the project organization co-exists with the larger institutional organization and shares resources with it. In the Apollo Program, the project manager does not have "direct authority" or as sometimes called, "formal authority" over all of the needed resources, especially technical manpower inputs provided by the various research and development laboratories. To utilize these resources, however, the project manager must cross lines of authority by penetrating various functional areas of the organization. As previously suggested, the Apollo project manager utilizes the expertise in the Research & Development organization of his field center. He does so by learning how to penetrate the particular organization where he needs assistance. Although the Apollo project manager has final responsibility for the project, again, he does not have direct authority over the laboratories. There is a formal matrix of relationships defining the various primary interface points which represent the primary contacts in the labs. However, over a period of time, the project manager, in effect, constructs his own "informal contacts." He is able to do this by "learning" the organization and the participants within each part of the sub-organization who can help him. Part of this success in establishing these informal contacts is dependent upon his personality. This is not to say that personality is not important in dealing with the formal contacts, but is even more crucial when the project manager seeks assistance in special problem areas. The following example illustrates in part, the role of the informal contact.

> Project manager X experienced several anomalies with leakage around the seals of a hydraulic pump. His formal contacts within the laboratories had failed to arrive at an adequate resolution for the problem. The project manager learned via the laboratories' grapevine that engineer Y had previously done extensive work on a similar problem in another program. The engineer subsequently had been transferred to an administrative position in another laboratory. The project manager learning of this, established contact with the engineer and in time the problem was successfully resolved.

Illustrating the differences between the formal matrix contacts and the informal "invisible matrix" contacts one might hypothesize that matrices are efficient for delineating people-to-people contacts, but are somewhat ineffective in aligning the problem-to-problem interfaces.

Beyond the establishment of informal contacts, the project manager's personality plays a significant role in accepting and rejecting alternative ways of resolving problems associated with his task responsibilities. In the Apollo project organization, as mentioned previously, there are three "sets" of inputs comprising the project team - the Research and Development organization, the contractor's organization, and the project organization. When problems develop, these three parties meet and attempt to resolve the problem. Each party may have widely differing objectives which makes problem resolution a delicate process for the participants. The Research and Development team member may be concerned with diverse performance requirements which he thinks should be met in order to provide an extra margin of safety. To meet these specifications, it would require rather exten-

sive revisions in the hardware. The contractor sees the problem in a different manner. He believes that the Research and Development monitors are being overly concerned with the province of performance and really don't see the realities of the situation (the contractor's Research and Development specialists have by this point, made exhaustive studies and are convinced the problem is not that critical and can be worked by making some relatively minor modifications). The project manager, although respecting both positions, views the total situation differently. The project manager is committed by his program superiors to a rigid project completion schedule. He knows that it is important for him and the project to meet that schedule. Consequently, at such a meeting, his objective is to evaluate both the Research and Development team member's suggestions and the industrial contractor's suggestions and reach a decision. Hopefully for the project manager, the decision will be a smooth and efficient one which will not tamper with the team's cohesive qualities. In effect, the project manager must balance the objectives of the project with the things that motivate others connected with the project. As one project manager stated, "I suppose that my job might be one of solving the problem of solving the problem." Another project manager made the following statement when discussing the personality of the project manager in this context:

> Let's say you're in a meeting with NASA representatives and contractor representatives. On one side of the table you have NASA specialists in contracts, R&D, and finance. On the other side of the table you have experts from the contractor in contracts, R&D, manufacturing and finance. Out of this group of technical experts in their own fields you've got to coordinate them in such a constructive way that by the end of the day - there's a product - there's a decision.

In the decision making process, therefore, the personality of the project manager plays a vital role. He must display constraint and flexibility in perfect balance through personal awareness of the conflicting variables in the environment. The analysis of the five areas discussed in this article (managerial and technical balance, risk, surviving the system, communication, and penetrating the system) hopefully gives some preliminary insights into the nature of the project manager's role in the programmatic environment. Extension of any one of these areas may provide a viable framework for extensive future research in the management of project organizations for the focal position of the project manager.

[1]The research for this article was supported by a NASA research grant #NsL 33-022-090 to Syracuse University to investigate the "Role of the Project Manager."

[2]The primary data source for this article is field interview data collected by the Syracuse University/NASA Research Team. Interviews were conducted at two NASA field centers, George C. Marshall Space Flight Center at Huntsville, Alabama, and Manned Spacecraft Center at Houston, Texas. Both Apollo project managers and research and development managers and engineers were interviewed. All respondents were confidential.

[3]For an overall systems view of project management see: John S. Gaffney, Project Management, Richard D. Irwin, Inc. (Homewood, Illinois), 1963; David I. Cleland and William R. King, Systems Analysis and Project Management, McGraw-Hill Book Company (New York), 1968; and James M. Webb, Space-Age Management, McGraw-Hill Book Company (New York), 1969.

[4]While variations of the MSFC model exist at other field center locations, the basic interfaces among project managers, research and development project engineers, and contractor counterparts are maintained in some organizational form throughout NASA/Apollo operations. The MSFC triad, however, is the most clearly identifiable matrix.

[5]All quotations in this article are from field interview data and will not be noted beyond this point. The name of the participant, his field center location and his hardware responsibility are strictly confidential and cannot be cited.