

An Evaluation of How NASA Project Managers Manage Complex Projects

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Introduction

The current approach to project management often misses a key ingredient, the project manager. The importance of the project manager in project management is often stated, but the critical role that they play becomes obscured in the details of how to manage a project, and misses the larger picture of what really goes on in the project. This paper describes the results of a study that looked at an alternative view of project management with the project manager as the key ingredient. The study examined ten contemporary projects in the National Aeronautics and Space Administration (NASA) using the project manager as the focal point of the project. Interviews with these project managers provided some insightful results about how they managed, and why they manage the way they do.

Background

The importance of project management is well recognized. Project management is the single most important management development in the second half of the 20th century (Archibald, 1976).

Today the concept behind project management is being applied in such diverse industries and organizations as defense, construction, pharmaceuticals, chemicals, banking, hospitals, accounting, advertising, law, state and local governments, and the United Nations (Kerzner, 1995).

As an efficient and effective means for achieving a one time, unique requirement, in a strictly defined period of time, the role of project management in managing technology in the 21st century will be even greater. The majority of the academic and popular literature about project management however, and the practitioners of project management whether industry or government, tend to focus on the skills, techniques, and tools necessary or desirable for how-to-do, or how-you-should-do project management. It takes a special person to be a project manager who can adapt what they bring to the project to manage it effectively, and efficiently.

Some project managers are undoubtedly unique. The premise of the study reported on is that some NASA project managers are unique. Unique at least from their fellow team members, their managers, and from their colleagues in the same disciplines. Some reports in the literature suggests that this premise may indeed be true (Archibald, 1974; Kezbom et al., 1989; Gadeken, 1997). These reports also provide some hints about what makes a good project manager. There is little documented however, about what the project manager *has* that makes them inherently good at what they do. One author does put the competencies needed in management into perspective.

Boyatzis (1982) points out that the job identifies *what* is expected of a person, the organizational environment establishes *how* they are to go about doing it, and an individual's competencies drive *why* s/he does it a certain way. The premise advocated in this paper is that these personal competencies are not just learned, but are an inherent part of a project manager's personal make up. The following discussion provides a view of how these personal competencies are demonstrated by NASA project managers in managing complex projects.

Discussion

The projects selected for the study were an opportunistic sample of contemporary NASA projects. They range in size from tens of millions, to several hundreds of millions of dollars, and cut across all four of the NASA enterprises of Space Science, Earth Science, Aero-Space Technology, and Human Exploration and Development of Space. The disciplines involved include advanced aeronautics, planetary science, biotechnology, space instruments, and launch vehicle development. The educational backgrounds of the participating project managers are in the fields of aeronautical, mechanical, and electrical/electronics engineering, physics, and mathematics. The variety of projects chosen, the different technical areas involved, the various educational disciplines of the project managers, and the project locations at four different NASA centers helped to reduce bias in the data toward any one of these variables.

In-depth, active interviews with the project managers provided the majority of the data collected for the study, and examined the project manager as the centerpiece of each project. The goal was to identify how and why they managed their projects the way they did. During the interviews they described in detail how they established and structured their projects, managed their project teams, addressed problems, and handled influences affecting the project.

Establishing the Project

How the project is established is important to the project manager. Although the projects themselves may be very complex, the project managers formulated them based on a few simple guidelines. An important aspect addressed by the participants in establishing their projects was the building of a framework that the project would operate within. Key elements of the framework include early participation of the project manager in structuring the project, defining the project goal and success factors, choosing the project team, and creating clear and firm guidelines for managing the project.

Early involvement of the project manager in the project was important. Many of the project managers participated in developing the technology involved in the project before the project formally began. This increased their ability to influence project formulation in positive ways. It gave them insight into how the project would be best structured to suit their personal strengths and weaknesses. Simplicity describes the preferred project structure. They chose to focus on particular items or methods they were most comfortable with such as personally creating the work breakdown structure (WBS): "I broke it down to the 3rd and 4th element level." Another formulated a detailed budget: "I had a 300 element budget." And in one case a six-month project definition study provided the insight needed to create a

simple project structure: "we configured (it) so the project objectives would fit into the available budget, and sold them on what we could do for the money." Other approaches also innovated in unique ways. One put similar systems together in a WBS rather than using a traditional breakdown by major components and interfaces. Whatever the choice of structure, it was simple and fit the project managers skill-set and intuitive feeling for the situation. It was also directed toward the project goal.

In establishing their projects, the goal of each project and its success factors was made crystal clear. There was no ambiguity about the desired outcome: "the product is the science." One project manager described their success factor as, "when it flies—it works!" Another interpreted it as, "if (the scientists) don't brag about it after the mission, it was a failure." The project managers were also outspoken about the importance of personally choosing the project team members.

Most of the project managers were able to choose their key, permanent team members. This was partly because of their early involvement during project development, and partly by their outright demand to do so. In some cases the team members chosen had also been involved in the early technology development for the project, and were logical choices for the team. Smaller was also better for these project teams. The project managers preferred to have as small a team of full time members as possible. These full time team members were, as would be expected, in the few key roles established by the project structure. Second only to the project team in importance was setting up the rules for managing the project.

Managing the Project

Critically important to the project managers was to establish guidelines for how the project conducted its business. A clear role structure defined day-to-day operations. The project manager made certain the team members knew each other's separate roles and the role of the project manager. The project manager is in charge of the project, period. The team members are the technical experts, not the project manager. They also established a few operating rules that were simple, and that everyone knew; it was clear and direct how the team would communicate, find problems and solve them, make decisions, and handle conflict and outside influences.

A variety of methods were used to communicate among the team members. All of these methods involved sharing information quickly and effectively across the team, but also for keeping it simple. Periodic meetings predominated among the methods of communicating, with wide variations in how they were used. Weekly or biweekly meetings were most common, but were held only when necessary and not at all if there was nothing important to discuss as a group. In some cases meetings involved external players through scheduled video conferencing or telephone conferencing with a support contractor. Email was another primary method of communicating. One project manager wanted to quickly get information in writing and distributed to preempt questions from external sources. Another collected emails from team members during the week and sent out an extensive weekly email status report to the whole team. Meetings for this team were focused on issues, not status. Periodic briefings to management and program offices were a necessary part of all the projects, and were usually done by the project manager alone, or with a minimum of key team members.

Problem finding was a constant and important and issue. For many project managers, "putting together the right information for the many technical issues we had was a very difficult task." As a non-technical expert the project manager needed, "a deep enough understanding of the engineering so I can tell if they're doing something dumb" or by getting, "technically educated enough to know when something is going wrong." Among the techniques used were information gathering and peer reviews for major changes. Probing by the project manager was another way to bring out softness in the technical disciplines: "you ask questions and just keep poking at it until you turn the rock over and find out what's underneath." A unique style used by one project manager with an extremely tight flight schedule was a "shotgun" approach. All of the team members sat in a circle and each described the problem or element of the problem as they saw it. Once everyone understood the problem they would backtrack to identify the most likely causes.

Problem solving approaches also varied. Common techniques included asking key questions, listening to arguments, putting the right information together, and using parallel or multi-tasking approaches to identify immediate, action-oriented solutions. The team using the shotgun approach to identify problems handled problem solving the same way by identifying multiple solutions and implementing them simultaneously, while continuing to gather information about other probable causes and approaches. They prioritized solutions not by only the most likely, but by what could be tried quickly. It was always, "the most important thing is to try something—you've got to start implementing potential solutions."

Decision-making was kept very simple. The project managers accepted their responsibility for the whole project. In every case they made it clear, that any decision affecting project risk, cost, or schedule would be made by them. Most of the project managers stated that they preferred consensus but also made it clear they had no qualms about making decisions if there was no consensus: "this is not a democracy and its not a debating society." Schedule demands drove most of their decisions because of the need to meet a launch date or other inviolate time requirement. Cost growth greater than 15% could result in project cancellation, so there was not a lot of wiggle-room with cost either.

There was no luxury for any kind of ambiguity in resolving conflict within the project. The project managers understood their role in needing to deal with conflict, whether it was comfortable for them or not. They advocated a clear need to get conflict out in the open, deal with it, and to move on.

Maintaining balance in managing the technical issues, risk, cost, and schedule was a challenge the project managers dealt with effectively and efficiently. In most cases the project schedule drove the completion of technical requirements: "its very much like buying a ticket on a commercial airplane; the plane's going to leave and if you want to be onboard you've got to be there at gate time." When choices needed to be made, meeting the technical requirements was always the most critical, and inviolate of the requirements.

Project Manager Characteristics

An embedded goal of the study was to determine if the project managers knowingly, or unknowingly, followed their own advice and met their own criteria about what a NASA project manager needs to have. The participants were asked what key attributes a project manager needs, and how they would identify those attributes in a prospective project manager. There were a number of general observations. One claimed that, because the human is a biological system and there are no identical biological systems, there could be no recipe for a project manager. Another said that it was an "innate" capability. There were however, a number of general characteristics defined as being "necessary." These characteristics were described as, "fairly obvious (to identify) early in their career if they can't handle five things at once."

Knowing who you are is an important part of the project manager's tool kit. This includes the need to work within personal strengths and fill in for personal weaknesses. This filling in often took the form of having a Deputy who was strong in a critical area where the project manager was weak. It is important for the project manager to be in charge, "not a wimp" but also not an overly controlling, "task master." A strong case was made for good interpersonal skills. These skills ranged from the ability to listen and communicate to having close interpersonal relationships with the team members: "it takes someone who is personable, personally likeable, and comfortable with people in social situations."

The project manager also needs to be a big-picture person, sometimes described as a visionary: "you need the project manager to be a visionary because those people usually delegate." A willingness to delegate was repeated throughout the interviews with some reluctance: "I'm not comfortable with it, but I do it."

Demonstrated technical and managerial competencies were expressed as strong needs for a project manager. Most of the participants had minimal, and in some cases no, formal project management training. There was an expressed need however, for a good technical understanding, but universal agreement about the non-requirement for a project manager to be a technical expert. This was defined as having a combination of enough, "technical horsepower" to understand the technical issues in a broad sense, and to use interpersonal relationships "to get the people to get the job done." One project manager stated it as, "number one you've got to understand the technical things to be good enough to understand what's going on." Although it was repeatedly made clear that technical decisions were the responsibility of the technical experts, this was tempered by the project manager's probing and asking questions of the technical experts to gain understanding about problems and the potential impacts of various decision choices. The most mentioned desired trait for a project manager was a broad experiential background in project work with demonstrated successful experience: "its just one of those things that comes with experience." Terminology used to describe this experiential need included a track record of success, "and the way to get that is to just get in (project management) and find out how well you do." A need to be nimble and innovative was also important. This implied having the flexibility to adapt to the constant change occurring in a project as new information evolves throughout its life cycle.

A NASA project manager needs a particular work ethic with the conviction to commit whatever it takes to get the job done. They put themselves second behind a lot of things and were willing to commit themselves one-hundred percent to that project: "it's a mentality where he's got to be willing to put his nose to the grindstone and work hard." Or, as one stated it:

Getting here from there is a very painful process. Project work is hard work and it is painful, and there are a lot of bad days. (Project managers) often work real hard, and in some cases endure incredible stress and fatigue; its not an easy job, it's a very demanding, full-time, grind them out thing. It takes a lot of patience and perseverance.

Essential for all of the project managers was a willingness to confront outside influences. Most handled contacts outside the project themselves in order to shield the team: "I think my main job is to protect the team, I take all the grief." One project manager described it as providing, "a membrane around the project team." It is important to confront anyone who wants to interfere with the project. Confronting their own managers appeared to be a challenge they willingly accepted: "you've got to be able to stand up and tell your management what you think; you might lose but you've got to be willing to say it." Some used terms like, "going toe-to-toe with them" and, "just not letting them do it, you can do it if you're willing to be fired." One project manager went directly to their Center Director for relief from attempts at micro-management, and got it. Another simply refused to be influenced by attempts at micro-management and won the battle of wills. Another project manager went over the head of their program manager and yelled at the next level manager because of a proposed budget cut. The cut was reduced to an amount the project could absorb and still survive. Another preferred a "bad-cop, good-cop" approach, where a team member would be the person to "lash out" at someone external to the project, and the project manager would act as the arbitrator on the issue. Whatever the methods employed to deal with external influences, they worked.

Summary

Managers of complex NASA projects establish and manage their projects within a simple framework as shown in Table 1. The project manager uses this framework to establish and manage the project and maximize the effectiveness of their personal characteristics. It is important to them to be involved early so they can structure the project appropriately for their needs, and to choose the project team members to fit that structure. The framework also allows the project team to operate within a clear, simple, and appropriate structure, with clear roles defined and few rules. In describing the characteristics necessary in a project manager, there were a number of common themes that are shown in Table 2. For the most part, the project managers exemplified the characteristics they saw as needed in a project manager.

Conclusions

NASA project management is about developing things that do not currently exist. Its worth lies in capturing new science, developing new capability, and advancing new technology. The findings of the

study provide new insight about NASA project managers. The NASA project manager brings a common framework to managing complex projects that complements their personality, personal strengths, and adapts to their weaknesses that was clearly expressed across the various projects in the study. This framework identifies a need for early involvement of the project manager to structure the project, to define a clear project goal and success factors, and to choose their project team. These are critically important in establishing the project. In managing the project to achieve the project goal, they clearly define the roles of the team members and themselves and operate with just a few rules that makes their management both common, and unique. Common because of the use of a similar framework across many projects, and unique because of how they adapt that framework to their personal strengths and weaknesses. A similar approach may be useful in examining comparable projects in other areas of government and industry to better understand what the project manager personally brings to these project arenas.

References

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FRAMEWORK	FACTOR	DESCRIPTION
Establishing the Project		
	Early Involvement	Being involved during early development of the project provides the project manager with the opportunity to understand, and structure the project in ways that fit their strengths and weaknesses, and their preferred personal style.
	Clear Project Goal & Success Factors	There is little ambiguity about what the project is to achieve. The project manager clearly and succinctly defines the project's goal for the team, and why it is important. The minimum necessary to meet the project goal is done thoroughly and completely.
	Project Team	Choosing a small team of key project members allows the project manager to compensate for their strengths and weaknesses.
Managing the Project		
	Clear Team Roles	Everyone knows his or her own role on the team and that of each other key person. The project manager is not the technical expert on the project; the specialist team members are responsible and accountable for technical issues. The project manager handles all external contacts.
	Few Rules	A few, simple rules are established to manage the project. <ul style="list-style-type: none"> - Real time communications using the established method - Problem finding & solution using the established method - Decision making <ul style="list-style-type: none"> The project manager makes decisions when the team cannot reach consensus. The project manager makes all final decisions affecting project risk, budget, and/or schedule - Internal conflict is brought out and dealt with firmly
	Balance	Maintaining balance in managing the technical issues, risk, cost, and schedule are dealt with effectively and efficiently. Technical requirements are always the most critical to meet.

TABLE 1. Project Management Framework

CHARACTERISTIC	DESCRIPTION
Self Knowledge	Knowing your strengths and weaknesses, and who you are is an important part of your personal tool-kit. Using personal strengths and filling in for weaknesses, perhaps with a Deputy, is crucial in a project.
Big Picture Person	A big-picture person is needed as project manager to be able to stay out of the day-to-day details, and to maintain a focus on the larger issues.
Demonstrated Technical and Managerial Competence	Experience on or with projects is needed for becoming competent at project management. It quickly identifies whether you can or cannot do it well, both technically and managerially.
Work Ethic	It takes 100% or more of the project manager's personal commitment to the project, with everything else coming second.
Willingness to Confront	Dealing with external challenges requires self-confidence and a thorough understanding of the project. It means being willing and able to confront outside influences, including your own management, as an essential requirement.

TABLE 2. Characteristics Desired in Project Managers

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