Understanding the Manager of the Project Front-end

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ABSTRACT

Historical data and new findings from interviews with managers of major National Aeronautics and Space Administration (NASA) projects confirm literature reports about the criticality of the front-end phase of project development, where systems engineering plays such a key role. Recent research into the management of ten contemporary NASA projects, combined with personal experience of the author in NASA, provide some insight into the relevance and importance of the project manager in this initial part of the project life cycle. The research findings provide evidence of similar approaches taken by the NASA project manager.

BACKGROUND

Product development *is* project management. This paper addresses the product development cycle from a micro point of view of the *definition phase* of the product life-cycle before detailed design and development begins. This definition phase of the project cycle is sometimes called the "fuzzy front end" (Burkhart, 1994). The decisions that are made in this phase move the product through morphology from its desired functionality into a (hopefully desired) product. However, similar to traveling from one point to another in a car, boat, or airplane, this phase can be difficult because there are any number of ways to get from here to there. Some ways of course are more efficient in both time and cost, and those are the most desirable alternatives to choose, unless you are simply out sightseeing.

Figure 1.is a generic product development cycle, sometimes called an inverted "bathtub" (Smallwood 1973). The various curves in the figure show the relationship between investment spent, and income generated, with breakeven occurring some long time after the product is launched. The portion of the figure of interest here is the small part at the very far left of the figure, before product introduction. The purpose of focusing on this early portion of the cycle is because of its key importance to product development, and especially to overall product cost and development time. This very early stage of the product life-cycle is characterized by a relatively low rate of expenditure which allows for exploring multiple changes in product features with low cost penalties (Bacon et al., 1994). Paradoxically, the majority of the cost committed in

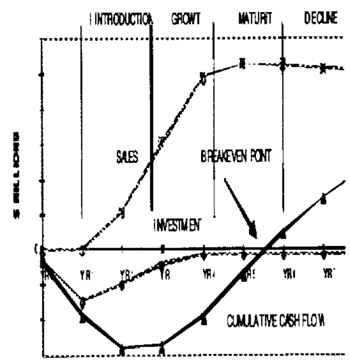

Figure 1. Product Development Cycle

new product development also occurs in this early part of the development cycle as shown in Figure 2. (Chase & Aquilano, 1995).

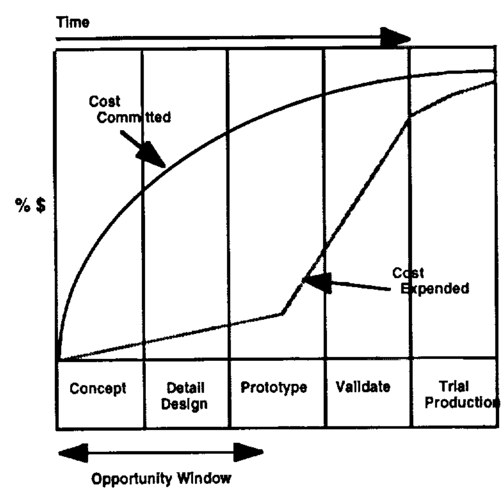

Figure 2. Product Cost Commitment

It therefore seems intuitive that the emphasis in product development should be on spending time and money up-front when it will create the greatest benefit and result in the most significant cost savings. The National Aeronautics and Space Administration (NASA) found that this premise is indeed true in its projects. Figure 3.shows the comparison between cost overrun versus up-front investment studies on a number of past NASA projects (Hooks, 1994).

The more spent early in a project life-cycle, the greater the opportunity for completing the project at, or near, the original cost. As shown in the figure, the optimum amount to allocate to early project definition studies appears to 10-15% of the project cost.

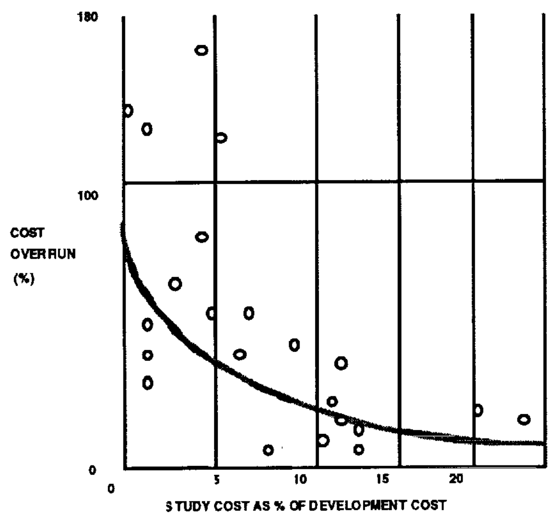

Figure 4. Benefit of Study Phase Investment

RESEARCH STUDY

A recent investigation into the management of some contemporary NASA projects explored just how the project managers deals with this early front end of the project cycle. It must be kept in mind that NASA products are generally unique one-of-a-kind items, and therefore have neither the opportunity for, nor benefit of, follow-on changes after the product is launched. All reasonable action must therefore be taken to ensure that the single product developed will perform as desired at its first and often only debut.

The management of complex projects is a tough job. As is evident from anecdotal evidence and in the literature (Gaddis 1959, Gadeken 1997), not everyone may have the necessary attributes to be a manager of complex projects. Much has been, and continues to be written about how product development projects *should be* managed, and *how to* manage them (Kerzner 1995, Wheelright & Clark 1992, Shtub et al. 1994). The use of interdisciplinary teams, team building, team dynamics and other managerial techniques is tremendously popular. The latest software, training courses, simulations, and other method-based tools are readily available, and of course useful. There continues to be however, a paucity of empirical information about what the project leader or manager brings to the project that results in a positive project outcome. This is especially true for complex, advanced technology projects where the project manager cannot, and probably must not, be the technical expert on the project. The review of ten recent, complex NASA projects provides some insight into the relevance and importance of how the project manager performs his/her role in complex NASA projects.

The research study included several different types of NASA projects in a variety of technical disciplines within the four NASA enterprises of Space Science, Space Flight, Earth Science, and Aero-Space Technology as shown in Figure 5. The projects included in the study involved the development of space and planetary mission equipment, biomedical-research equipment, an advanced aeronautics wind tunnel facility, a launch vehicle, and aeronautical flight equipment development and test.

AERO-SPACE TECHNOLOGY ENTERPRISE	**SPACE SCIENCE ENTERPRISE**
-Flight Test Demonstrator -Aircraft Development Test -Wind Tunnel Development	-Biomedical-Research Satellite -Biomedical-Research Hardware
SPACE FLIGHT ENTERPRISE	**EARTH SCIENCE ENTERPRISE**
-Rover Development - Spacecraft Launch Vehicle	-Satellite Instrument I -Satellite Instrument II -Satellite Instrument III

Figure 5. NASA Case-Study Projects

The portion of the study described here focuses on the initial part of the project life cycle where the most benefits are to be gained as mentioned earlier. The project managers were interviewed about their projects to obtain first-hand information on how they managed the project, the project team, and outside influences. The findings indicate similar methodologies of use that present consistent patterns for the way these project managers manage their projects. Although these methodologies are similar, they are also extremely flexible to fit both the situation and the individual project manager.

Establishing the Project. How the project is established is important. One of the key issues addressed by the study participants was in formulating the project itself. Although the projects were very complex, each project was formulated based on simple principles. The key issues for the project manager included being involved early in the project, structuring the project in ways that were comfortable to them, establishing and articulating the project goal and success factors, and in selecting the project team. Figure 6. shows the important factors derived from the interviews for establishing the project.

FACTORS	COMPONENTS	IMPORTANT ISSUES
Project Formulation	Project requirements	Detailed knowledge of requirements & project history
	Influence	Ability to influence technical, cost, and schedule constraints of the project
Project Goal	Deliverables	No ambiguity about what the project is to achieve
	Success Factors	Identifies minimum necessary to meet the project goal
Project Structure	Personal strengths & weaknesses	Fit to the project manager's strengths & weaknesses, & compatible with their preferred personal style for the project and situation
Project Team	Size	Small increases visibility Tight control with no slack (extraneous roles)
	Key Members & Deputy	Synergy with project manager's strengths and weaknesses

Figure 6. Establishing the Project

The particular requirements for each project defined the preferred project structure, and what the project managers chose to do themselves in structuring the project. The important technology areas involved and the driving forces of having to meet a fixed launch date or tight cost constraint focused the project manager's attention on the areas they felt were most important to the project outcome. They often chose to focus on particular items they were comfortable with such as the work-breakdown-structure (WBS), "I broke it down to the fourth level," or the budget, "I had a 300 element budget." Other approaches included innovating away from the standard practices of how-to-do project management, and organizing the projects in ways that mitigated risk; "I organized [my project] by [its] systems in a unique way." Whatever the choice of project structure that was chosen it was simple and fit the project manager's personal skill-set and their intuitive sense of what was needed in the particular situation they faced.

The goal of the project was made crystal clear to the project team. Early involvement by the project manager provided an opportunity to understand the project goal and articulate it to the team. The goal was succinctly defined and made clear about why it was important to the project manager personally, to the team, to NASA, and in many cases to the world. Each project also had simply defined success factors with the science to be delivered always as the main product.

The study participants were outspoken about the importance of choosing their key team members. Seven of the study project managers were able to choose their full-time team members, partly due to being involved in the early stages of the project's development, and partly because of their outright demand to do so.

Smaller project teams are also better. The project managers preferred as small a team of full time members as possible. The reasons appeared to be a dual issue of both visibility of the project, and control. These project teams had no extraneous members or as one project manager stated it, "It was a no slack zone." The team members were placed in the few key roles established earlier by the project structure. The number of key team members ranged from 4 to 25 as shown in Figure 7. There was considerable variability in the complexities and types of technologies involved in the different projects that sometimes required more, and more diverse, technical specialists in some cases than in others.

PROJECT VALUE ($ millions)	CORE TEAM SIZE (full-time)
450	22
350	25
150	12
135	5
110	5
49	8
30	11
25	15
22	6
21	4

Figure 7. Project Size Comparison

Managing the Project. Beyond establishing the project in ways that fit their characteristics, there were general methods used in managing the study projects that became the framework for day-to-day operations. Defining clear roles for the key team members ensured that there was no duplication of effort. The small size of the teams allowed the project manager the visibility to ensure that all work was directed toward the project goal. The project goal and success factors not only defined what would be worked on, but also what would not be worked on.

There were also few rules. Everyone on the project team knew his/her role. The project plan was to be followed and the minimum needed to accomplish the goal was the rule, but it would be done in a thorough and complete manner. It was made clear that the project manager was not the technical expert, and that the team specialists were both responsible and accountable for the technical issues. The project manager however,

COMPONENT	FACTORS	APPLICATIONS
Clear Roles	No duplication of effort or responsibility	All work is directed toward the project goal 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 is in charge of the project The project manager handles all non-technical external contact with the project
Few Rules	No ambiguity about how the project will operate	A few, simple rules are established how the project would be managed - 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 - Conflict is brought out and firmly dealt with

Figure 8. General Management Methods

ruled the budget and schedule. No technical changes were made that impacted these two, or that added risk to the project without involving his/her consent. The project manager handled all interactions outside of the project except for the technical issues that remained the responsibility of the technical specialist team members.

SUMMARY

Projects in NASA and in most of government and industry today need to move quickly from the functionality requirements to the reality of a product. Achieving good-and-fast decisions in the early phase of new product development demands the kind of project leadership that can make-it-happen. The managers of complex NASA projects provide that leadership and more. They recognize the need for early involvement in formulating the project through defining the project goal and success factors, careful structuring of the project, choosing the project team, and in establishing a few clear and simple guidelines for how the project will operate. They make-it-happen.

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BIOGRAPHY

Gerald M. Mulenburg is an Aerospace Engineer and Division Manager for aeronautics and spaceflight hardware development at the National Aeronautics and Space Administration (NASA), Ames Research Center. He has project management experience with the Air Force, industry, and NASA, where he participated in both ground-based and spaceflight research projects. He has served as Assistant Director of the University of California Lawrence Hall of Science, Executive Director of the California Math Science Task Force, and Assistant Chief of the Ames Life Sciences Division. His academic degrees include Mechanical Engineering, Aerospace Engineering, and Systems Management.