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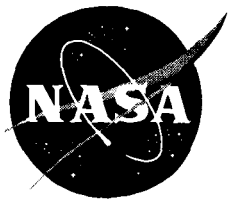

The Characteristics of Project Managers: An Exploration of Complex Projects in the National Aeronautics and Space Administration

Gerald M. Mulenburg

December 2000

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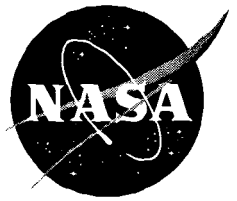

The Characteristics of Project Managers: An Exploration of Complex Projects in the National Aeronautics and Space Administration

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The Characteristics of Project Managers: An Exploration of Complex Projects in the National Aeronautics and Space Administration

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1. Introduction

Just as with leadership, much has been written about project management. There is also, however, as little agreement among theorists, academicians, and practitioners about exactly what it is that a good *project manager* has as there is about what a good *leader* has. In addition, just as good leaders are in high demand, so are good project managers as the field of project management expands to encompass a wide variety of fields formerly considered part of traditional management.

Archibald (1976) states that project management is the single most important management development in the second half of the 20th century. The 1970s and 1980s saw a continual increase in the use of project management in U.S. industry as the superior quality of foreign products eroded American market share, and U.S. companies fought for their corporate lives. Use of the concepts of project management has continued to expand throughout the world, and these concepts are now an integral part of global market competition. Following its evolution as a management discipline over the last 50 years, project management is now a pervasive and important part of the larger field of management.

> 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).

A general definition of project management is that it is an efficient and effective means for achieving a specific, one-time, usually unique requirement, within a strictly defined period of time. Although simple in concept, project management is "a fragile mechanism with many interactive parts" (Murphy, Baker & Fisher, 1974) that to be successful requires "...a combination of art, science, and ...logical thinking" (Shtub, Bard & Globerson, 1994). For NASA, the Department of Defense (DOD), and much of industry, project management is a systematically effective management technique for managing large and complex projects (Sayles & Chandler, 1971; Chapman, 1973; Archibald, 1976; Kezbom, Schilling & Edward, 1989; Gadeken, 1997).

Achieving project success requires a capable project manager. The importance of the project manager to project outcome is well recognized: "Project management starts with the project manager" (Roman, 1986). At the same time, however, an understanding of the role that the project manager plays in achieving the desired project outcome lacks a firm grounding in empirical data. The research described here involved a search for what, how, and why the project manager contributes to the project outcome. Although a topic of substantial current interest and relevance to the larger world of project management, this research focused on complex projects within the National Aeronautics and Space Administration (NASA), which is founded organizationally on and operates within a total project environment.

Chapter 1 provides a brief historical review of the background of project management and its relevance for research. The literature review of Chapter 2 provides insight into the problems being addressed that led to the specific research questions posed in the research design. A detailed methodology in Chapter 3 describes the research framework and strategies employed, and the data collection and analysis methods used. Chapter 4 describes the findings and analyses. Discussion of the findings for complex projects in NASA and other areas, and implications for future research, is provided in Chapter 5.

Historical Perspective of Project Management

Although the beginnings of project management can be said to derive from as far back in time as written history, or even to archaeological time, its modern practice comes from the period during and following World War II. Project management is unique in that it lies outside of the normal functional organization, and

is staffed by technical specialists working toward a common, specific project objective. The Manhattan Project, the Marshall Plan, and other major undertakings sprung from innovations in management to accomplish projects that "...were set up outside of existing academic and government structures" (Drucker, 1973). These projects comprised teams of academic specialists working toward common, specific goals, and were driven by urgent time requirements. These criteria remain as the basic definition of project management today, with the addition of finite resources being available to accomplish the desired project outcome.

In the 1950s, with the fears of World War II replaced by fears of the Cold War, the availability of electronic computing power provided a new paradigm for managing projects that extended and elaborated on the use of Gantt's original work-flow scheduling methods (Drucker, 1973). In 1958, the event-oriented Program Evaluation and Review Technique (PERT) was created to deal with the complexities involved in developing the Navy's Polaris Missile system (Levin & Kirkpatrick, 1966). At the same time, Dupont developed a valuable corollary, activity-oriented technique, called the critical path method (CPM), to aid in scheduling maintenance shutdowns of its chemical plants (Shtub, Bard, and Globerson, 1994). PERT, CPM, and other techniques soon became essential requirements for managing projects for the Department of Defense, NASA, and their contractors. These techniques are still in use today for developing complex space flight and military hardware (Kerzner, 1989), including the International Space Station. The most visible example of project management in the history of mankind began with the challenge to NASA by President Kennedy,

> ...before this decade is out of landing a man on the moon and returning him safely to earth (Bilstein, 1989).

The Apollo program began within this very specific project requirement and definite time frame, and this program institutionalized the use of project management in NASA for accomplishing all subsequent space and aeronautics objectives (Levine, 1982). To meet the new challenges of the space program, NASA became the first major organization to develop a complete organizational structure based on systems theory (Drucker, 1973). The resulting NASA organization gave project managers full authority for project technical direction and management. Located at one of the ten NASA field Centers, NASA project managers report to program managers outside the NASA Center's functional chain of command, and these program managers in turn report to Headquarters Assistant Administrators (Chapman, 1973; Levine, 1982). Although organizational changes have occurred over the years in NASA, the systems structure and the authority and reporting chains remain similar to the original organizational design. Within this organizational design lies a unique opportunity to explore the project manager's role as part of the larger field of management through numerous recent, complex, high-technology NASA projects that were studied in detail to examine the role of the project manager in their outcome.

Relevance for Research

If management can be considered the art of combining organizational design with the science of human behavior, then perhaps project management is an ideal experimental microcosm for testing this paradigm. Viewed as a *system*, the microcosm of project management lends itself to much closer scrutiny than the general field of management, especially for exploring the inner workings of the project, and particularly its manager. Based on the general systems theory of Bertalanffy (1972), the concept of systems management itself is said to have evolved from project management (Murphy, Baker, and Fisher, 1974).

The general definition of a system (Ackoff, 1974) accurately describes a project and its team:

> A system is a set of two or more interrelated elements of any kind.., it is *not* an ultimate *indivisible* element, but a whole that can be divided into parts...that form a system...[with] the following three properties:
>
> 1. The properties or behavior of each element of the set has an effect on the properties or behavior of the set taken as a whole.
>
> 2. The properties and behavior of each element, and the way they affect the whole, depend on the properties and behavior of at least one other element in the set.
>
> 3. Every possible subgroup of elements in the set has the first two properties: each has a non-independent effect on the whole (and) the whole cannot be decomposed into independent subsets...[or] subdivided into independent subsystems.
>
> Because of these three properties, a set of elements that forms a system always has some

characteristics, or can display some behavior, that none of its parts or subgroups can. *A system is more than the sum of its parts.*

The importance of recognizing projects as systems helps in managing the complexity involved in large projects. It follows then that the "... systems approach to a project—is of fundamental importance in establishing if the project will be a success" (Morris and Hough, 1974). The complexity of a project is determined by many factors, including its size, the time available to complete it, and the technological uncertainty involved (Kerzner, 1989; Kezbom, Schilling, and Edward, 1989).

For this research, the NASA projects of interest involve meeting a combination of three factors:

1. Developing a unique science or technology
2. Taking from 2 to 10 years to complete
3. Costing more than $20 million

This level of project complexity requires a project team of specialists and the skills and abilities of a systems approach to manage. The research builds on an existing body of evidence in the literature that suggests differences in the characteristics of project managers from functional managers that contribute to project outcome. The findings of this study extend that evidence to current managers of complex NASA advanced-technology projects.

2. Literature Review

The relevant project management literature overwhelmingly agrees that the role of the project manager is critical to project outcome (Gaddis, 1959; Sayles and Chandler, 1971; Roman, 1986; Struckenbruck, 1987; Kezbom, Schilling, and Edward, 1989; Kerzner, 1995; Anderson, 1992; Eisenhardt and Tabrizi, 1995; Center for Project Management, 1996). There remains, however, a paucity of empirical evidence about the makeup of this *critical* project manager (Anderson, 1992). What *is* reported, however, helps to define what is known, and also what is missing, about project managers. Three areas are prominent in the literature:

1. The personal characteristics of project managers are important.

2. These personal characteristics influence a project manager's actions.

3. The project manager's actions influence project outcome.

Characteristics of Project Managers

Project managers have identifiable personal characteristics that are important to project outcome. Gaddis (1959), an early writer who explored the question of specific characteristics needed in a project manager, asked, "What kind of a man [sic] must he be?" In answering this question, Gaddis claimed that the project manager is somewhere between a technologist and a manager. Being neither – yet some of both – "he [sic] provides an integrative function to accomplish what neither can do by themselves [sic]." Gaddis also stated that the processes of the project manager's mind were indefinable. However, these processes must include an ability to deal with intangible as well as tangible factors of the project, and the project manager must be intuitive in making judgments and decisions, including the capability for both conceptual analysis and integration. For managers in research-and-development-intensive organizations such as the National Aeronautics and Space Administration (NASA), the idea of project managers as integrators is supported by other authors (Lawrence and Lorsch, 1967; Dinsmore, 1990; Kezbom, 1989). Considering the project manager as the single point of integrative responsibility in managing a project infers that his/her effectiveness depends not only on skills and experience, but also on some personal characteristics necessary to achieving this integration (Archibald, 1976). These descriptions then imply that to be effective, a project manager requires something more than just the traditional management skills of planning, organizing, commanding, coordinating, and controlling (Fayol, 1949; Cleland and Kerzner, 1985).

One fundamental difference in project management versus general management noted in the literature lies in the unique position the project manager occupies on the boundaries of

1. His/her own organization

2. The functional organization that provides him/her with technical expertise

3. The customer or end user organization for the product of the project

This positioning creates problems for the project manager who must deal with the differing priorities and interrelationships of these three stakeholders (Kezbom, Schilling, and Edward, 1989), while exposing him/herself to significant risk and confrontation among the differing organizational goals and restraints of each:

> ...the project manager is the focal point in a constantly exposed organizational responsibility system (Wilemon and Cicero, 1970).

The complexity of project management supports the need for personal characteristics of the project manager as influencing factors of project outcome. Many reports in the literature use language that differentiates the project manager from the project leader in describing the need for certain characteristics (Eisenhardt, 1989a; Kezbom, 1994; Gadeken, 1997). The question of whether leaders' and managers' characteristics are substantially different is an unresolved and long-standing one in management. The literature shows a consensus that they are different, but not necessarily separate and complete opposites (Gardner, 1972; Kotter, 1990; Kouzes and Posner, 1993). For example, Barnard's (1938) description of leadership as executive functions, and his use of the metaphor of the human nervous system as "...directing those actions [of the body] which are necessary...to adjust to the environment," characterize the need for the project manager to be able to adapt to an ever-changing and demanding project environment. The general question of characteristics of effective managers was perhaps best asked and answered by Boyatzis (1982):

> What enables a person to demonstrate the 'specific actions' that lead to 'specific results?' Certain characteristics or abilities of the person enable him or her to demonstrate the appropriate special actions.

In a 20-year longitudinal study at AT&T, Bray and Howard (1983) found that the successful managers were more achievement oriented, less deferential toward authority, less nurturing toward others, more open minded, less authoritarian, had a higher energy level, and held a more positive attitude. A significant finding over the period of the AT&T study follows:

> ...the more successful men increased in their already better skills or motivations while the less successful men lost ground.

This finding parallels a more recent one for project managers in government agencies. Gadeken (1997) found that persons who were inexperienced in project management but possessed the difficult-to-develop personal characteristics needed in managing projects will quickly develop into more effective project managers than those persons who have much greater knowledge, skills, and experience in project management, but who lack these difficult-to-develop personal characteristics.

Table 2.1 summarizes a sampling from numerous authors of characteristics that are desirable in project managers, managers, leaders, and integrators. It is apparent that many of these characteristics are repeated in the different roles, many are personal traits, and some are desirable ways to act or behave under any circumstances.

Influences on the Project Manager's Actions

The most difficult management task for any manager may be that of managing human behavior. Although dealing with human behavior may be the most interesting part of management, it is certainly the most challenging as well. A complicating factor in managing projects not apparent in many other managerial roles is the dynamics of the project team, which is usually made up of technical specialists who are experts in their disciplines, but are borrowed from other organizations (Kezbom, Schilling, and Edward, 1989). Team members needed to accomplish a particular part of the project are usually assembled from functional organizations for the duration of the project. Recent literature on project management has focused on the increasing use of cross-functional matrixed teams, in addition to engineers who are the mainstay of project teams (Eisenhardt and Tabrizi, 1995; Iansiti, 1993; Patterson, 1993; Workman, 1995). This scenario has resulted in renewed interest in the human side of project management.

We are all a product of both our heritage (through genetics), and our experiences (environment) – nature versus nurture. Obviously both have some influence over our actions in a given situation. As with most theories, it is also reasonable to assume that the reason why a person behaves in a particular way at a particular time lies somewhere between the extremes of environmental influences on character (nurture) and inherent personal characteristics (nature). How then do the project manager's actions, which are influenced by his/her personal characteristics from both genetics and environment, contribute to his/her responses to needs in the project setting? Dinsmore (1990) devotes a chapter in his book to presenting several management experts' views about how human behavior affects the outcome in effectively managing projects. Beginning with the premise that behavior is relevant to the effectiveness of a project manager because it is s/he who accomplishes the work of the project through others, it is important to understand what causes the behavior that influences the project manager's actions in response to project needs. Dinsmore (1990) states the importance of the nature/nurture relationship as a basic premise:

> The project manager's search for the answer to what makes people act and react must begin at the very foundations of behavioral theory, set forth thousands of years ago by Plato and Aristotle.

For the project manager, the importance of this statement lies not only in understanding the source of human behavior, but in how to manage the day-to-day behavior of project team members to get them to contribute their maximum to project accomplishment. Modern motivation theory considers both environmental factors and inherent human instincts. For example, Maslow (1943) pointed out with his basic needs theory that the first two needs, physiological and safety, are instinctive. The remaining three needs of love, esteem, and self-actualization, although perhaps instinctively driven, are certainly subject to being managed or motivated by the external environment or project culture that can be influenced by the project manager.

Other sources have created related models. McGregor (1957), for example, defined X and Y managerial styles of a manager's behavior and their effects on employees' behavior. McGregor's theory X approach of tight control is most likely to be counterproductive in project management situations because of the self-motivated involvement required of project team member technical specialists. A more participative Y approach by the project manager is needed because

TABLE 2.1 DESIRED MANAGERIAL CHARACTERISTICS

Project Managers	**Project Managers**	**Project Managers**	**Competent Managers**	**Emotional Maturity**	**Integrators**	**Leaders**
ARCHIBALD (1976) Flexibility Adaptability Initiative Leadership Aggressiveness Confidence Persuasive Verbally fluent Ambitious Active Forceful Communicator Integrator Broad personal interests Poise Enthusiasm Imagination Spontaneity Balance Organized Disciplined Generalist Planner & controller Identifier of problems Decision maker **WILEMON & CICERO** (1970) Creativeness Entrepreneurial Communicator Mentor Influence Balance	**GRAHAM** (1989) PROBLEM SOLVING Diagnostic thinking Systematic thinking Conceptual thinking Monitoring information gathering MANAGERIAL Project Manager Identity Self-confidence Flexibility ACHIEVEMENT Concern for achievement Results orientation Initiative Business orientation INFLUENCE Organizational & interpersonal astuteness Skillful use of influence strategies Team building Developing others Client/user orientation Self-control	**LOWEREE** (1990) Take-charge attitude (need to manage) Achiever (results oriented) Thinking person (judgment & common sense) Relevancy of perfection (perfection is a fallacy) Time management [sees the pieces of a puzzle (how everything fits together)] Single-minded purpose in communications (conveyance of a message) High energy level **ROMAN** (1986) Leadership Strength Fairness Flexibility Innovativeness Adaptability Emotional stability Decisiveness Problem solving People-centered Motivating Extroversion	**BOYATZIS** (1982) (Competencies) Efficiency orientation Pro-activity Diagnostic use of concepts Concern with impact Self-confidence Use of oral presentations Conceptualizations Socialized power Managing group process Perceptual objectivity Self-control Stamina Adaptability (Threshold competencies) Unilateral power Accurate self-assessment Positive regard Spontaneity Logical thought Specialized knowledge Developing others (no or negative support) Concern with close relationships Stamina Logical thought Systems orientation	**GARDNER** (1972) Good self-image Not sensitive to criticism Tolerant of others Admits mistakes Accepts ideas from others Communicates well Confident Understands self Understands others Less need for approval Can easily give approval Learns from mistakes Comfortable with people Decisive Understands people' s motives Confident Remembers people Interested in others Has high energy & drive Works well on a team Has humility Objective Candid Positive Self-disciplined Persuasive Flexible Calm Considerate Nondefensive Relaxed Goal-oriented Responsible Patient	**LAWRENCE & LORSCH** (1967) Initiative Leadership Aggressive Confident Persuasive Verbally fluent Ambitious Active Forceful Effective in communication Personal scope Breadth of interests Social poise Clever Enthusiastic Imaginative Spontaneous Talkative Flexible Adventurous Humorous Assertive High achievement need High affiliation need Influence Competence Knowledge Balanced orientation & behavior Capacity for resolving conflicts by confrontation	**GARDNER** (1972) Ambition/enthusiasm Persistence Courage Faith (self-confidence) Integrity Creativity Sense of justice Objectivity Flexibility Self-discipline Decisiveness Ability to get along with people **KOUZES & POSNER** (1993) Honesty Forward looking Inspiring Competent Fair-minded Supportive Broad-minded Intelligent Straightforward Courageous Dependable Cooperative Imaginative Caring Mature Determined Ambitious Loyal Self-controlled Independent

s/he depends on the expertise, sense of responsibility, and willing cooperation of these project team members rather than on any formal authority over them.

Recognizing the importance of this influence, Herzberg (1984, 1968) built upon and applied Mazlow's ideas in work situations. He developed a theory of hygiene needs that relates the satisfaction of minimal or lower needs (physiological, safety) as necessary-but-not-sufficient *satisficers*. In addition, the higher needs (love, esteem, self-actualization) that motivate people to seek achievement, recognition, challenges, responsibility, and growth are *disatisfiers* if not present. To ensure project success, the project manager must, therefore, satisfy the lower needs of the project team as maintenance items, and satisfy the higher needs as motivators for the team. When responding to these and other project needs, the project manager takes certain actions to attend to these needs, and the results of these actions influence the outcome of the project.

Forming project teams using an organizational matrix is typical in NASA and much of industry, especially in research and development parts of major organizations. In NASA, team members may be matrixed into a project team from functional organizations at the Center where the project manager resides, but can come from other Centers if team members with the necessary expertise are not available at the home Center. These team members support the project manager in accomplishing the project goals, but remain administratively part of their parent functional organization, where they will return when the project (or their role in it) is completed. Some team members may be assigned to a project only part time, and have other projects they support as well.

Although such matrixing provides overall economies for the larger functional organization by making effective use of its most desired people, it creates difficulties for the project manager who has little, if any, formal authority over matrixed team members and must find innovative methods of motivating and managing them. The use of a project team, therefore, differentiates the project manager from a functional manager by the level of formal authority over their subordinates, and the limited time they will be working together. The functional manager has authority to hire, fire, and promote direct reports, while the project manager has little or no real, long-term formal authority or power over project team members during or following the project.

Influences of the Project Manager's Actions on Project Outcome

In responding to project needs, the actions taken by the project manager influence the project in either a positive, neutral, or negative manner, all of which affect the project outcome. The question then becomes, what identifiable responses by the project manager influence the project outcome positively, rather than neutrally or negatively? Several authors, including Murphy, Baker, and Fisher (1974), found that:

1. Multiple determinants affect project outcome.
2. Many of these determinants lie within the project manager's control.

Thamhain and Gemmill (1974) found that, of the five power bases identified by French and Raven (1959), a project manager's expert power (special knowledge or expertise) and referent power (a feeling of oneness with or attraction to the person in charge) played the major role in his/her ability to influence project team members. In addition, they found that legitimate power (formal authority) had a *negative* effect on the project manager's ability to influence team members.

Another premise from human motivation theory is one of expectations (Miller, 1978). The expectation of a favorable outcome for performing as requested creates a motivation to perform. The implication for the project manager is the need, therefore, to provide valid expectations for team members that allow them to make positive choices in favor of the project. This scenario includes clearly identifying the project manager's own value for the project. Expectancy theory also helps explain individual behavior in making choices about whether to comply with a request based on the probability s/he can expect to:

1. Overcome any difficulties that will be encountered
2. Achieve the desired level of outcome required

The need to manage both tasks and relationships based on situational considerations is described by Hersey and Blanchard (1982). The methods used by the project manager (concern for people versus concern for production) must also vary with the maturity level of the people, which continually changes over the project life cycle. The focus on entrepreneurship and creativity at the beginning of a project becomes subservient to the need for team members to stay within scope during design and development, versus the need to stick to the task during fabrication and test phases of the project. The

personal traits and preferred style of the project manager must be flexible to fit this changing requirement throughout the project life cycle.

Summary of Literature Review

The review of the relevant literature identified many supporting and interesting interpretations of the project manager's role as well as some contradictory issues. The critical importance of the project manager to project success can be succinctly summarized by a description of effective job performance (Boyatzis, 1982):

> The job demands ...reveal primarily *what* a person in the job is expected to do. The organizational environment ... reveals *how* a person is expected to respond to the job demands. The individual's competencies ... reveal *why* he or she may act in a certain way.

The job demands required of a project manager lead to three compelling research questions that this research attempts to answer by looking at numerous NASA projects of the complexity described earlier. The answers provide insight into how the project manager's responses to project needs contributed or did not contribute to the project's outcome.

1. ***What*** characteristics describe the NASA project manager?

2. ***How*** did the project manager respond to project needs?

3. ***Why*** did the project manager respond the way s/he did, and why was this response important to the project outcome?

Significant to answering these three questions is identification of links between the characteristics of the project manager that affect his/her responses to project needs, which in turn lead to project outcomes. It is not sufficient to simply ask the project manager why s/he responded in a certain way (or what of his/her characteristics were involved) because

> The existence and possession of these characteristics may or may not be known to the person. In this sense, the characteristics may be unconscious aspects of the person (i.e., he or she is not aware of them or is unable to articulate or describe them). (Boyatzis, 1982)

What characteristics the project managers possess is evaluated from demographic information, from a personality survey (Myers-Briggs Type Indicator), and by emotional maturity (ego-resilience) information.

How the project manager responded to project needs (actions taken) is substantiated from in-depth interviews with the project manager, his/her manager, and from project documentation.

Why the project manager responded in the way s/he did is derived from an evaluation of his/her personal characteristics, the situational demands of the project, and other influencing factors (internal and external) that might be involved. These factors are determined using an active interview process (Holstein and Gubrium, 1995) that reaches beyond simply questions and responses, and delves into the rich data carried in the minds and experiences of those involved.

The research questions drove the development of a methodology designed to find the answers through a rigorous research design of data collection, analysis, meaning making, and theory development.

3. Methodology

The basis for development of the research methodology described below is that the personal characteristics of project managers help to determine their actions in response to project needs. This research contributes to and responds to the paucity of information on this subject in the relevant project management literature. The research design is the outcome of a series of decisions taken in developing a research methodology that explores the personal role that the project manager plays in complex National Aeronautics and Space Administration (NASA) projects. The resulting conceptual framework became the guide for examining how these project managers responded to their project environment by the actions they took. It explores why their response was or was not a contribution to project outcome, and the personal characteristics that were involved in their responses. The goal of the study was to find the "theory in use" versus the "espoused theory" (Argyris and Schon, 1974) of NASA project management.

NASA Project Organizational Structure

The NASA organization imposes a certain management structure on project managers that affects the environment and methodology of how they go about managing their projects. Understanding how this organization affects the project manager's positioning in the structure helps to explain why they take certain

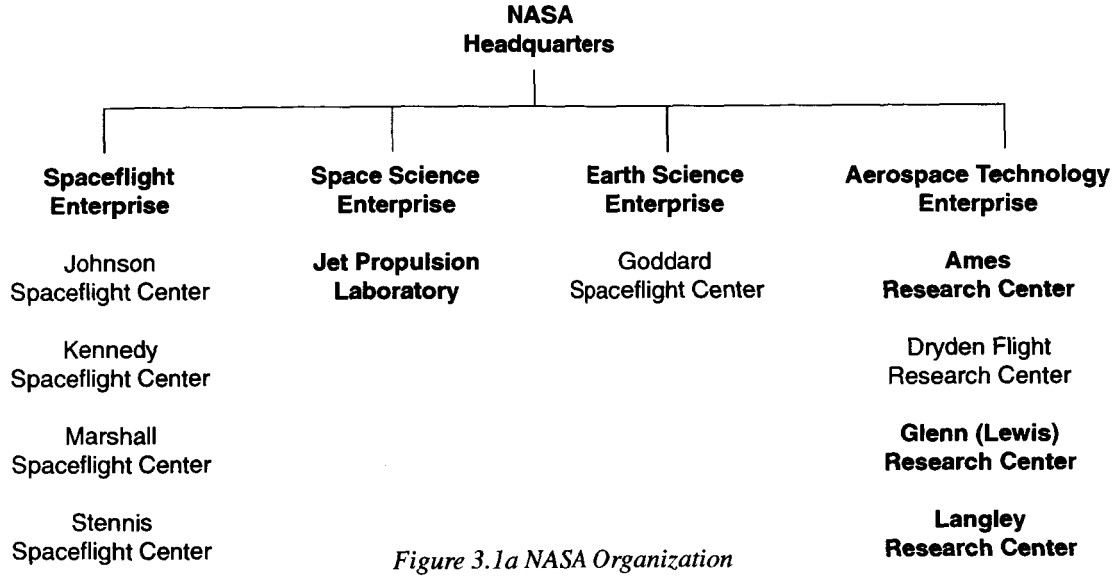

Figure 3.1a NASA Organization

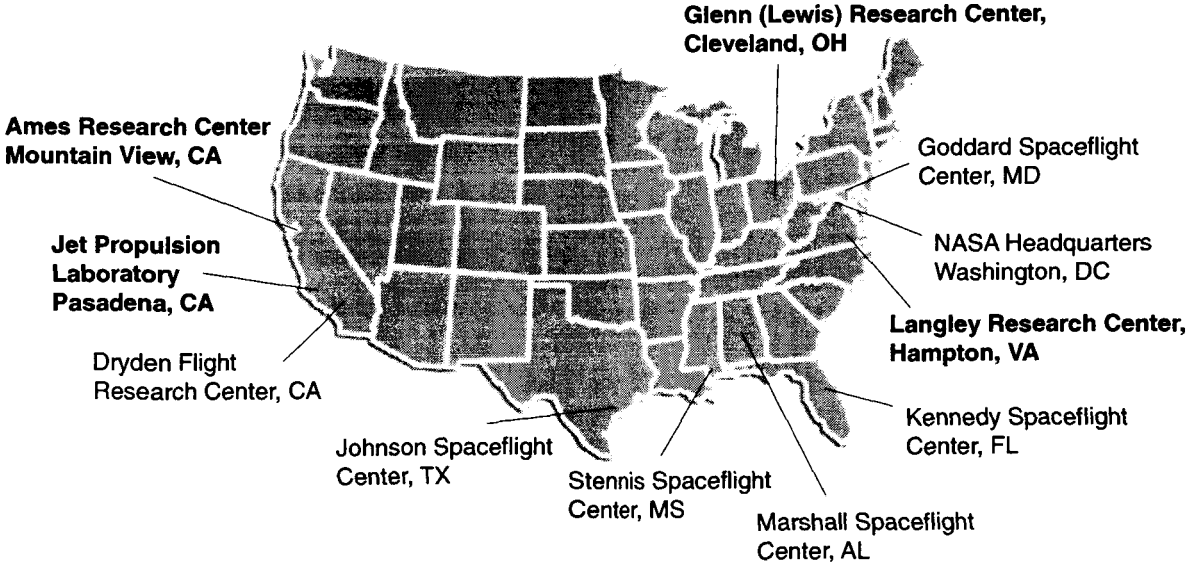

Figure 3.1b NASA Center Locations

actions in managing their projects. The NASA organization consists of four enterprises at its headquarters in Washington, D.C., that represent the major focus of its research and development activity (see Figure 3.1a). The projects in the study came from the Centers shown in bold in the figure.

These enterprises consist of a number of programs to achieve the enterprise objectives, and the programs are made up of numerous supporting projects to accomplish the program objectives. These programs and projects are located at any one of the ten different NASA Centers shown in Figure 3.1b. The program and project managers reside at one of the Centers, but not necessarily at the same Center. Both the program and project managers are administratively supported by the Center they are located at, but in different ways. Program managers report directly to an enterprise manager for all program issues, and only peripherally to the Center director where they reside (see Figure 3.2).

The project manager, however, actually belongs to a functional (line) organization at his/her Center that provides supervision, training, administrative support, and more importantly, the evaluation of his/her performance and promotions. The project manager is matrixed to the program manager and reports directly to him/her on all project matters. This arrangement puts the project manager in a boundary position, as shown in Figure 3.2, under the authority of two different managers who can influence how and why they manage their projects the way they do.

Two recent changes in NASA influenced some of the projects in the study, and they may have affected some of the data collected from these cases. The first change was a paradigm shift away from large, expensive, and long-term development projects such as for Apollo, the Space Shuttle, and others such as the Hubble telescope that had massive redundancies to reduce project risk. The shift was to smaller/better/

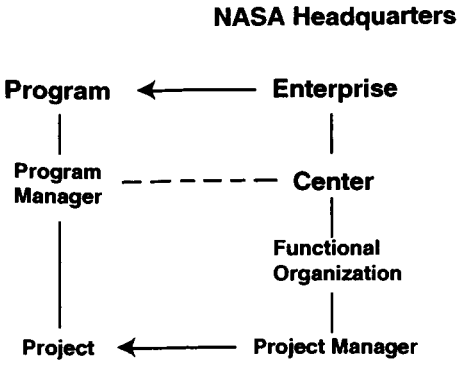

Figure 3.2 Boundary Position of Project Manager

faster projects such as the Mars Pathfinder, the Lunar Prospector, and a host of others with less redundancy and, therefore, significantly more risk. The second change was in the methodology of project management in NASA, involving a move away from the traditional A-B-C-D-E phase project life cycle to a four-tiered model of formulation, approval, implementation, and evaluation, shown in Table 3.1 and Figure 3.3.

The effect of the change to smaller projects resulted in five of the study projects being less than $100 million, and five of them greater than $100 million because of the lack of larger projects still in development at the time of the study.

The effects of the change in NASA project management methodology on the projects in the study appeared to be marginal. The larger-dollar-value projects in the study (>$100 million) were near completion or complete at the time of data collection. And, with one exception, the smaller projects (<$100 million) had been formulated, approved, and were well into the implementation phase at the time of the change in methodology. The one exception was a project in the study that was cancelled because of a lack of available funding after the formulation phase was complete. Data collection, however, was com-

TABLE 3.1 NASA PHASED PROJECT LIFE CYCLE

PREPHASE A Advanced Studies	**PHASE A** Preliminary Analysis	**PHASE B** Concept Definition	**PHASE C** Design	**PHASE D** Development	**PHASE E** Operations
Research & development in a broad spectrum of areas	Determine feasibility, desirability, & compatibility with needs (requirements)	Define initial baseline to meet needs	Detailed design of systems & subsystems	Build & test systems & subsystems	Meet identified needs

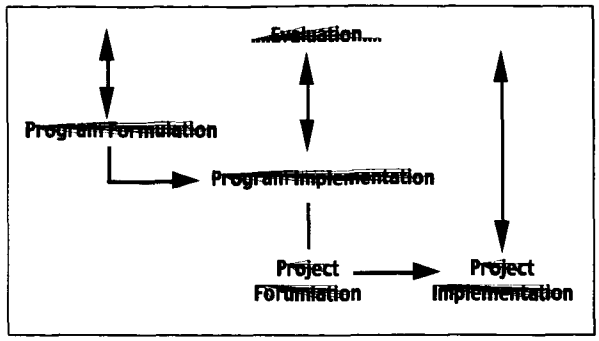

Figure 3.3 New NASA Project Cycle

plete at the time of cancellation and the project was retained in the study for comparison purposes.

Research Design

The over-arching research methodology selected for the study is based on a general framework for qualitative theory building (Eisenhardt, 1989b), shown in Table 3.2. The framework identifies a series of steps to be followed, the activity that is involved in each step, and the rationale for each activity. An additional column was added that specifies the results sought from each step of the framework.

An a priori theory was selected as an aid in focusing the development of the research methodology (Yin, 1994; Miles & Huberman, 1994; Marshall and Rossman, 1995). This theory is based on the traditional model of

STIMULUS —> RESPONSE —> OUTCOME

More specifically, it assumes that *the personal characteristics of project managers influence the actions they take in response to project needs.* The goal of this study, however, was not to provide proof of this a priori theory, but to develop a new theory across multiple cases. The a priori theory, however, helped to focus the research strategy and data collection in answering the three research questions that address both the depth and specificity of the research effort (Boyatzis, 1982). The research strategy chosen for each question (Yin, 1994) and what is to be made known by the answers help clarify the methodology and rationale.

Table 3.3 shows appropriate research strategies for different types of research questions (Yin, 1994). The form of the question (how, why, what, etc.), the researcher's control over behavioral events (e.g., experiment, observation, etc.), and whether these events are contemporary or historical determine the choice of strategy.

Research Questions

RESEARCH QUESTION 1. *What* characteristics describe the project manager of a complex NASA project?

This *what* form of question deals with events not controlled by the researcher because the events have already occurred during management of the project, and they are contemporary events of the projects selected. As indicated by Table 3.3, the appropriate strategy is one of using surveys to gather data to answer this question. Three surveys were chosen; they are imbedded in each project case study to inform the research about three different personal aspects of the project manager.

DEMOGRAPHIC SURVEY

Much of individuals' responses to life are influenced by their environment and how they respond to environmental influences they experience. A recent examination of characteristics of high achievers indicates that demographic characteristics (first born, only child, etc.), including age, play a role in people becoming high achievers (Simonton, 1994). It would be expected that similar characteristics should, therefore, also apply to project managers of complex NASA projects. A sample of the self-reporting demographic survey that was used to gather data about each project manager participant is shown in Appendix A. Additional questions were included to provide a database that might be called upon during the research, or for future research questions.

PERSONALITY SURVEY

People have certain personalities and ways they prefer to behave and act in their everyday world. The self-administered Myers-Briggs Type Indicator (MBTI) construct (Myers-Briggs & McCaulley, 1985) identifies four personal aspects about how people act in their environment.

1. How they maintain their personal energy (introversion/extraversion)

2. How they gather and respond to information (sensing/intuition)

3. What influences their decision-making (thinking-feeling)

4. How they structure their lives (judging-perceiving)

The MBTI was given to all the project manager participants, and the results were scored by a certified MBTI administrator. The project managers' actions

TABLE 3.2 THEORY-BUILDING FRAMEWORK

Steps	Activity	Rationale	Results
1. Getting Started	Define research questions Identify a priori constructs Neither theory or hypotheses	Focus efforts Provide grounded construct measures Provide theoretical flexibility	**Management Question** What role does the project manager play in project outcome? **Research Questions** 1. What characteristics describe the project manager of a complex NASA project? 2. How does the project manager respond to project needs? 3. Why did the project manager respond in the way s/he did, and why was the response important to project outcome?
2. Select Cases	Specify population Theoretical (not random) sampling	Constrain & sharpen external validity Focus on useful cases to replicate & extend theory	Limit to project managers of NASA complex projects Restrict to NASA complex projects
3. Identify Instruments & Protocols	Multiple data-collection methods Qualitative & quantitative techniques combined	Strengthen grounding of theory by triangulation of chain of evidence Develop a synergistic view of the evidence & foster divergent perspectives	Interview project manager and project manager's manager, plus prepare written material on projects Merge, compare, & contrast findings from constructs and interviews
4. Field Work	Overlap data collection & analysis Use flexible & opportunistic data-collection methods	Speed analysis & reveal helpful adjustments to data collection Take advantage of emergent themes and unique case features	Begin data analysis during and following each case and across cases Use coding techniques to identify common parameters & findings
5. Data Analysis	Within-case analysis Cross-case pattern search using divergent techniques	Gain familiarity with data & generate preliminary theory Force looking beyond initial impressions & seeing evidence through multiple lenses	Use each project as a separate case and analyze data within each case and across cases Search data for patterns, anomalies, and outliers
6. Shaping Hypotheses	Iterative tabulation of data for each construct Logical replication, not sampling, across cases Search evidence for "why" behind cases	Sharpen construct definition, validity, & measurability Confirm, extend, & sharpen theory Build internal validity	Document interviews and construct data analysis for each case Maintain global replication of data-collection techniques across cases but allow for flexibility in pursuing interesting features within cases Examine findings within cases and continually ask "why" of the results
7. Literature Enfolding	Comparison with conflicting literature Comparison with similar literature	Build internal validity, raise theoretical level, & sharpen construct definition Sharpen generalizability, improve construct definition, & raise theoretical level	Examine findings for conflicts with literature & seek explanations for deeper insights Examine findings for similarities with literature & seek explanations
8. Reaching Closure	Theoretical saturation when possible	End the process when marginal improvement becomes small	Continue revisiting within and across case data and findings until nothing new emerges

taken in response to project needs during management of their project are compared with the responses that might be expected of their personality types evidenced by the MBTI.

EGO-RESILIENCE SURVEY

How well people respond to ambiguity and uncertainty in their environment led to the development of a construct called ER89 (Block and Kremen, 1996) to evaluate an individual's ego-resilience as a measure of his/her response. Some people do not respond well to an ambiguous or changing environment, and their egos are easily shattered; these people's egos are not considered resilient. Others seem almost indifferent to change; these people have highly resilient egos that bounce back quickly, even in uncertain or ambiguous situations. The highly uncertain and ambiguous environment of a complex NASA project forces the project manager to continually respond to changes occurring both within the project and from the outside environment.

Rarely is there one "correct" way to respond to change, and how a project manager responds is an important element of his/her project management. The project manager's ego-resilience in experiencing and reacting to change can be a factor influencing his/her response to the project environment, in turn affecting the outcome of that project. A significant result occurs from any response at all, even a nonresponse. The self-administered ER89 construct identifies a project manager's tendency toward a resilient, or nonresilient, ego.

SUMMARY OF QUESTION 1:

Although a large number of survey methods of evaluation are available, the three described above (demographics, personality, ego-resilience) and the role these characteristics play in project outcome were chosen for this investigation of the characteristics of project managers. Theory developed from answers to question 1 forms a beginning to evaluate the role of these three and other characteristics of project managers in project outcome.

RESEARCH QUESTION 2. How does the project manager respond to project needs?

This *how* form of question fits a case study strategy, as shown in Table 3.3, requiring no researcher control over events occurring during the project, and the events of interest again are contemporary. Each case is a complex NASA project, and data collection for this strategy was from active interviews.

SELECTION OF PROJECT CASES

Ten projects were selected for use as cases from a list of complex NASA projects that meet the three criteria of developing a unique technological objective, a budget of more than $20 million, and a 2–10 year time frame. (One exception is a one-year-long project that was cancelled.) A list of the projects in the study is shown in Table 3.4.

ACTIVE INTERVIEWS

Active interviews (Holstein & Gubrium, 1995) were used for data collection from project managers and their managers who were knowledgeable about the project. These in-depth interviews provide a thorough base of qualitative data about each project case and the project manager's methods for establishing and managing his/her project. Also included are details of the project manager's problem solving, conflict resolution, and decision-making actions taken during the course of the project. The interviews took place over a period of several weeks, normally in an office setting, and lasted from one to a few hours each. Follow-up interviews reviewed transcripts for accuracy and collected any missing information. Data about individual respondents were not shared among the interviewees.

TABLE 3.3 RESEARCH STRATEGIES

Strategy	Form of Research Question	Requires Control Over Behavioral Events?	Focuses on Contemporary Events?
Survey	Who, what, where, how many, how much	No	Yes
Case Study	How, why	No	Yes
Archival Analysis	Who, what, where, how many, how much	No	Yes / No
History	How, why	No	No
Experiment	How, why	Yes	Yes

TABLE 3.4 NASA CASE STUDY PROJECTS

Ames Research Center	Jet Propulsion Laboratory	Langley Research Center	Glenn (Lewis) Research Center
1. Advanced Aerodynamics Windtunnel 2. Bio-Research Satellite 3. Advanced Technology Aircraft Flight Test 4. Space Station Bio-Research Project	5. Mars Rover	6. Satellite Instrument I 7. Satellite Instrument II 8. Satellite Instrument III 9. Advanced Aeronautics Technology Flight Demonstrator	10. Spacecraft Launch Vehicle

OTHER INTERVIEWS

Interviews with the manager of the project manager, and in some cases others familiar with the project, provided additional perspective about the project manager and how project managers are identified. The data collected during these additional interviews were used to compare and corroborate or contrast the data gathered on the project managers, and their descriptions of desirable characteristics in project managers.

SUMMARY OF QUESTION 2:

Data collected in response to question 2 provided information about the project manager's methods used in managing his/her project. Responses to issues that arose during the life of the project and how they were dealt with provide key information about the problem-solving, conflict resolution, and decision-making processes used by the project manager.

RESEARCH QUESTION 3. Why did the project manager respond in the way s/he did, and why was this response important to project outcome?

This *why* form of question also fits the case study strategy (Yin, 1994), with no researcher control over the contemporary events involved. An active interview approach again provided data within the case study strategy to supplement the data collected from questions 1 and 2. The difference in *how* the project manager responds to events, and *why* s/he responds in that way, is crucial to understanding his/her role in project outcome. The *why* and *how* are intimately linked to the survey data from question 1 about the characteristics of the project manager, and to the interview data collected for question 2, about how the project manager responds to project needs. Why project managers acted in one way instead of another is a key issue in understanding the importance of the project manager's role in project success. Particular attention was paid not only to *how* the project manager responded to a certain event or requirement (question 2), but to *why* s/he chose to respond in that way, and *what* that response contributed to project outcome (question 3). Because people are often not aware of why they respond in a certain way, it became the responsibility of the researcher to draw out this information during the interview, and in later analysis and review of the transcript and notes.

SUMMARY OF QUESTION 3:

The data from question 3 were the most difficult to link to the findings from the other two questions, but these data actually contribute most to the theory and meaning-building of the research. The answer to the *why* of question 3 helps in the understanding of the relationship among the project manager's characteristics identified from question 1, and how these characteristics influenced the way the project manager responded to project needs identified from question 2.

Conceptual Framework

Table 3.5 shows how the three research questions drove the research strategy development, and how the methodology was linked to the three questions within the conceptual framework of the research data collection and analysis.

Data collection and analysis followed that proposed by Yin (1994) and included five components. The first three components indicate the data to be collected as a result of the study's (1) questions, (2) propositions, and (3) units of analysis. The remaining two components indicate (4) how the data are linked to the propositions, and (5) the criteria for interpreting the data.

TABLE 3.5 RESEARCH CONCEPTUAL FRAMEWORK

I. General Theory		
Stimuli (Causes)	Reaction (Results in)	Outcomes
...	...	...
II. General Theory Extended to Project Management		
Stimuli (Causes)	Reaction (Results in)	Outcomes
Requirements	Project Definition	Design
Constraints	Limitations	Boundaries
External Factors	Changes	Schedule Slip
...	...	...
III. A priori "Ungrounded" Theory of Project Managers		
Project Stimuli (Causes)	Project Manager Reactions (Results in)	Project Outcomes
Requirement change	Revision	Delay
Schedule change	Ambiguity	Schedule Slip
Loss of team member	Uncertainity	Tension
Test failure	Redesign	Increased cost
...	...	...
IV. Search for Theory of Project Manager Influence on Project Outcome		
Project Stimuli (Causes)	Project Manager Reactions (Results in)	Project Outcomes
Delay	Analysis	Restructure tasks
Schedule slip	Problem solving	Process flow
Tension	Conflict resolution	Increased cooperation
Increase in cost	Team decision-making	Increased team effectiveness
...	...	...

Data Collection and Analysis

SURVEY DATA ANALYSIS

The ten NASA case study projects make up a small, nonrandom, stratified, convenience, and opportunity sample based on the criteria used for their selection. As a result, only limited quantitative descriptive statistical analysis of the survey data was possible. However, the value of the survey data also lies in the strength of the link of the *why* of question 3, back to the *what* and *how* findings from questions 1 and 2.

INTERVIEW DATA ANALYSIS

The interviews were tape-recorded and transcribed to provide a permanent database for comparison with research notes, and for qualitative analysis. Each interview was also documented using a summary guide shown in Appendix B. Using the summary guide provided a consistent procedure across the interviews without restricting opportunities to pursue interesting aspects that came up during an interview.

A project matrix checklist, shown in Appendix C (Miles & Huberman, 1994), provided a record within each case of the various project needs, the project manager's response to those needs, and the resulting outcomes of the actions taken.

Memoing (Miles & Huberman, 1994) is a technique used in the interview data analysis process. This technique creates a permanent record of key concepts and codes, as shown in Appendix D, beginning with the initial data collection and continuing during the research through preparation of the final written report. It also was a later aid in developing propositions that reflect the findings and implications. Data analysis of the interviews included coding the written narrative (Miles & Huberman, 1994). Emerging pattern codes were used in the analysis of each project case and across cases. A representative code list is shown in Appendix E. Techniques such as pattern analysis, content analysis, code summaries, clustering, and cross-case analysis helped to build meaning from the data (Yin, 1994; Marshall and Rossman,1995; Miles and Huberman, 1994).

LINKING QUANTITATIVE AND QUALITATIVE DATA

The interview qualitative data and the survey quantitative data were linked back to the research questions, and to each other, to develop a full understanding and meaning of the data (Miles & Huberman, 1994). This linking was a steady, continuous, and integrated effort during the entire data-collection process.

An interim case summary (Miles & Huberman, 1994) was used to synthesize what was known about each case and what was missing during periodic reviews of the findings. An example of the interim summary format is shown in Appendix F.

A data accounting collection form, as shown in Appendix G, was used as part of each interim summary to document the state of completion of the research data.

Findings and Conclusions

Conclusion drawing and verification were integral parts of the systematic data collection, reflection on meanings, evaluation of implications, and for proposing interpretations (Marshall and Rossman, 1995).

The data analyses provided findings and implications throughout the study as data were collected, reduced, and displayed within the research conceptual framework. The final analysis process included gathering evidence for testing and confirmation, generating meaning, searching for alternative explanations, and drawing conclusions to form a chain of evidence and causality supporting the findings and implications (Miles and Huberman, 1994).

Summary of the Methodology

The soundness of the described methodology is based upon its usefulness, its consistent application across cases, its neutrality, and its credibility established in other research programs, and as published in research guidelines (Eisenhardt, 1989a; Marshall and Rossman, 1995; Miles and Huberman, 1994; Yin, 1994). The use of both qualitative and quantitative data increases this credibility by providing a means to triangulate findings from one method with findings from the other, to develop increased meaning and understanding (Yin, 1994; Miles and Huberman, 1994). The results of this process provide soundness for the findings and implications through the evidence obtained within the limitations and constraints of the study's design.

4. Findings and Analysis

The research findings provide basic information gathered from the three surveys and the interviews with the project managers. The implications of these findings are discussed in Chapter 5.

For ease of reading and clarity, the timetable for all ten projects is shown in Figure 4.1 in the format of the A-B-C-D-E NASA project life cycle. Only one project, the pilot, had been completed at the time data collection began. Seven of the project managers were involved before, or at the start of their project, and the other three began as project manager after the project was established. In the first two projects shown, the project managers began at the start of the project but both left the project two years early, with no apparent effect on project completion. All the projects except one have now met their completion dates, although several had multiple deliveries phased out over many years, as shown by the lines after a star for the initial completion date.

Data Collection

A rigorous research protocol describing the research program was approved by the NASA Human Research Investigative Review Board before the study began (Appendix H). Each participant was provided a copy of the research protocol and signed a consent form prior to data collection. Anonymity was granted to the participants to help encourage candid, open responses about themselves and their projects.

Following approval of the research proposal, a pilot study was conducted using a completed project as a first case. The project pilot was chosen for a variety of reasons: the unique technology involved, it had an experienced project manager, convenience, and the project manager left the project before it was completed. The pilot project met all of the study criteria, and is included as one of the ten project cases in the study, but was the only project that was completed at the time data collection began. The goal of the study was to use ongoing projects in order to ensure that the memories of the participants were fresh and current. The pilot study helped to structure the format of the interviews and influenced some of the interview techniques for collecting data in answering research questions 2 and 3. The experience gained from the pilot study also helped to refine the other data-collection techniques and defined more precisely the demographic instrument questions. Analysis of the pilot data began as data collection of the other projects was occurring.

The interviews were accomplished at other NASA Centers and at the researcher's home Center, as projects were identified and cooperation of project manager participants was obtained. Each interview was tape-recorded for accuracy and later transcribed verbatim. A copy of the verbatim transcript of his/her interview was provided to each participant to review for accuracy and to add any additional information that (s)he wished to include. Immediately following each interview, the participants were asked to com-

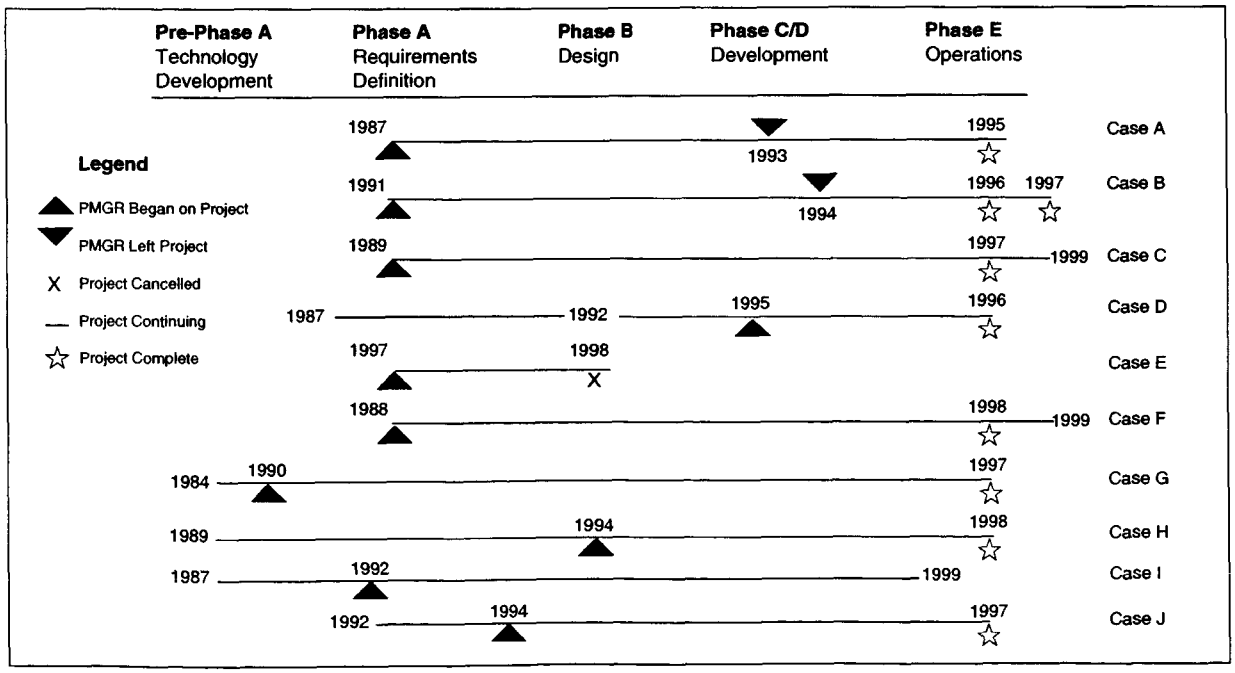

Figure 4.1 Case Study Project Data

plete the three surveys for research question 1. This sequence was chosen to ensure that the survey data did not influence the way the researcher conducted the interview because of previous knowledge about the participants; in addition, this scenario reduced the opportunity for bias in the interview data.

Secondary data were also obtained from each participant after the interviews. The data were collected in the form of project descriptions, organizational charts, technical papers, and press releases or similar public data, including Internet sites, as supporting background data on the projects.

Findings

The findings for the first two questions are presented for each survey in answer to research question 1, and the interview data in answer to research question 2. The results of each survey are presented individually and then discussed as a consolidated data set. The interview data in response to research question 2 are addressed by describing events that arose naturally during the analysis of how the project manager responded to project needs. The combined survey and interview data-set findings are then addressed in answering research question 3. A brief summary of the entire data set for all three of the research questions is provided. Additional findings are then addressed, including self-described characteristics of a project manager and a few outliers—identified in the data as significantly different in some way or they *lie outside* the pattern of the more frequent findings.

It should be noted that to ensure confidentiality in the discussion that follows, the author refers to all project managers as if they were men (when, in fact, two participants in the research were women).

RESEARCH QUESTION 1. *What* characteristics describe the project manager of complex NASA projects?

SURVEY DATA

The survey data characterize how the project managers responded to research question 1. As mentioned previously, all the surveys were self-reporting instruments that the project managers completed after the first interview. Because most of the interviews were at NASA Centers away from the researcher's home Center, interview opportunities had to coincide with other business travel to these Centers. It was, therefore, most efficient to ask the participants to complete the surveys at the time of the interview, rather than wait for them to be completed later and mailed.

Demographic Data—The demographic survey provided a baseline of information about the project manager participants in the research study. As shown in the consolidated demographics matrix, Table 4.1, there were two female and eight male project manager participants. Not shown is that nine were married at least once, three of them twice, and one was divorced at the time of the survey. Of the nine who married, eight had children.

Age and years of professional experience correlate positively, as expected, with some of the participants

TABLE 4.1 DEMOGRAPHIC DATA

Sex	Age	NASA Experience	Other Experience	Total Experience	Grade	Degree Area	College Degrees
M	63	38	0	38	GS-15	Physics	BS
M	61	36	0	36	GS-15	Elect	BS, MS Admin
F	56	32	3	36	GS-15	Aero	BS, MS
M	55	37	0	37	GS-15	Elect	BS, MS, MBA
M	54	33	0	33	GS-15	Elect	BS, MS
M	51	13	5	18	GS-14	Math	BS
M	49	10	19	29	GS-15	Aero	BS
M	46	18	6	24	GS-15	Elect	BS, MBA
F	41	15	3	18	GS-15	Mech	BS, MS, MBA
M	36	14	0	14	GS-14	Mech	BS

having professional experience outside of NASA. The participants' ages ranged from 36 to 63 years, with a midrange of 49.5 years, mean of 50.2 years, median of 52.5 years, and, assuming a normal distribution, a standard deviation of 9.67 years. Except for the two oldest and the one youngest, all the participants were within one standard deviation of the mean.

Eight of the participants were at the highest working level civil service grade of GS-15, the other two being at the next lowest level, GS-14. These grade levels compare to a senior engineer or researcher in positions without line-management responsibilities, both within and outside of the government. They are equal to or higher than functional line-management grade levels in NASA, without the supervisory responsibilities of a line manager. The next and highest grade level in government is the Senior Executive Service, comparable to Executive Vice President or Director positions in industry.

As expected from their role as managers of complex NASA technical projects, all participants had some type of technical degree. Eight had undergraduate degrees in various fields of engineering, one in physics, and one in mathematics. Six of the participants also had advanced degrees. Five had a second Master of Science degree and one a Master of Business Administration (MBA) degree. Two of the six with a second degree also had a third advanced degree (two MBAs), and one was pursuing a Doctorate at the time of the interview.

The participants' college grade point averages (GPAs) were unremarkable. Undergraduate GPAs ranged from 2.4 to 3.6, (one participant said he did not know). Graduate GPAs ranged from 3.0 to 4.0, with only two of the advanced-degree GPAs below 3.5, not unusual for masters programs that often require maintaining a minimum 3.0 to 3.5 GPA.

Summary of Demographic Findings—The demographic data helped characterize the participants within the above parameters as mature, experienced, and well educated in a variety of technical disciplines. Many had taken the initiative to pursue an advanced degree. Complementing the demographic data, the evaluation of personality types further helped to characterize the participants.

Personality Data—Personality data were collected using the self-reporting Myers-Briggs Type Indicator (MBTI) instrument (Appendix I), which was scored by a certified NASA MBTI administrator. The personality-type data helped describe the personality preferences of the project manager participants.

As discussed in Chapter 3, the MBTI is based on Carl Jung's theory of psychological types. Jung (1971) attributed much of the apparent randomness in individual behavior as actually an orderly and consistent way people perceive and operate in the world around them. The MBTI developed by Isabel Myers and Katharine Briggs operationalized Jung's theories in a structured, systematic way to aid in recognizing individual differences (Kirby, 1997).

> The MBTI is primarily concerned with the valuable differences in people that result from where they like to focus their attention and how they like to take in information, make decisions, and the lifestyle they adopt.

A detailed explanation of the theory behind the MBTI is described in Myers and Myers (1980). The MBTI was used in the 1970s as a tool for professionals in psychological analysis. The MBTI was refined in the 1980s for wider applications and is now in broad use for developing an improved understanding of personality preferences of managers (Blumenthal, 1994; Craig, Craig, and Slight, 1988; Fleenor, 1997; Furnham, 1992; McCaulley, 1990; Walck, 1997).

In order to clearly understand the terminology of the MBTI, a brief description of its construct and terms is provided. The scales and their meanings are shown in Table 4.2 (Hirsh & Kummerow, 1987). There are four scales, each having two descriptors, one for each opposing end of the scale.

A shorthand method used in identifying each preference is to represent each preference name by its first letter, capitalized, the exception being iNtuition, which uses the capital N because I is used for Introvert. With four opposing pairs of preferences, 16 individual types are possible as combinations of four-letter preferences. (See Table 4.3.)

The first letter of the four-letter type is for Extraversion or Introversion, the preference for focusing on the outer world of people and things (E), or the inner world of ideas and impressions (I). The second letter, Sensing or Intuition, is the preferred way of focusing on information, in the present and on concrete information (S), or on the future using a view of patterns and possibilities (N). The third letter, for Thinking or Feeling, is the preference for basing decisions on logic and objective analysis (T), or on values and subjective, person-centered concerns (F). The last letter is for Judging or Perceiving, the preference for a planned and organized approach to life (J), or a flexible and spontaneous approach by keeping options open (P). It is important to recognize

TABLE 4.2 MBTI SCALES

Characteristic	MBTI Scale	Meaning	
Energizing How a person is entergized	Extraversion/ Introversion	**Extraversion** Preference for drawing energy from the outside world of people activities, or things	**Introversion** Preference for drawing energy from one's internal world of ideas, emotions, or impressions
Attending What a person pays attention to	Sensing/ iNtuition	**Sensing** Preference for taking in information through the five senses and noticing what is actual	**iNtuition** Preference for taking in information through a "sixth sense" and noticing what might be
Deciding How a person decides	Thinking/ Feeling	**Thinking** Preference for organizing and structuring information to decide in a logical, objective way	**Feeling** Preference for organizing and structuring information to decide in a personal, value-oriented way
Living Life style a person adopts	Judgement/ Perception	**Judgement** Preference for living a planned and organized life	**Perception** Preference for living a spontaneous and flexible life

that all MBTI preferences are between a pair of choices from the same scale-pair such as EI, not across different scales. Also, in using dual letters to describe a scale such as EI, the meaning is E or I, not from E to I.

MBTI theory holds that the functions on each scale-pair of preferences are complementary, but that one is dominant. While the nondominant function remains as part of one's personality, it is subordinate in frequency of use to the dominant one. Therefore, although a four-letter code is used to describe each individual's type, the opposing types still exist, but are usually not the methods used. A measure of the strength of the dominance of each preference has also been developed using a numerical strength score for each of the letter scale-pairs.

TABLE 4.3 MBTI TYPES

ISTJ	ISFJ	INFJ	INTJ
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP	ENTP
ESTJ	ESFJ	ENFJ	ENTJ

In scoring the MBTI instrument, the preference on each scale is indicated by both a capital letter and a numerical score of the strength of that preference. Table 4.4 provides the approximate ranges used in estimating numerical strength. As an example, an E preference is for Extraversion and a numerical value of 45 is the strength of that preference on the EI scale, represented as E-45. However, low scores on any scale do not imply a comfortable relationship between dual preferences, but more likely indicates a tension between the opposite poles of the scale.

The MBTI data collected on the study participants provide descriptive information about the preferences of the participants in conducting their daily lives and, therefore, capture some of their uniqueness as individuals (Hirsh and Kummerow, 1987). In a completely heterogeneous world, one might expect to find an equal number of persons in each of the 16 MBTI categories. However, neither the world, the field of management, nor the practice of project management is completely heterogeneous.

TABLE 4.4 MBTI NUMERICAL STRENGTHS

41 or higher (31 or higher for F)	Very clear preference
21–39 29 or higher for F	Clear preference
11–19	Moderate preference
1-9	Slight preference

Table 4.5 shows the type preference of the ten project managers and their individual numerical scores on each scale. There are seven Extraverts and three Introverts, eight iNtuitives and two Sensors, nine Thinking and one Feeling, and six Judging and four Perceiving types. The predominant type for the group is ENT, with an almost equal JP preference. Another way to look at the data is by a numerical grouping on

TABLE 4.5 PARTICIPANT MBTI TYPES

MBTI	Extraversion/ Introversion	Sensing/ Intuition	Thinking/ Feeling	Judging/ Perceiving
ENFP	E-45	N-31	F-19	P-59
ENTP	E-35	N-17	T-33	P-1
ENTP	E-29	N-41	T-23	P-55
ENTP	E-21	N-19	T-25	P-33
ENTJ	E-19	N-23	T-45	J-33
ENTJ	E-17	N-47	T-5	J-37
ENTJ	E-11	N-35	T-19	J-7
ISTJ	I-51	S-43	T-29	J-19
ISTJ	I-47	S-61	T-35	J-55
INTJ	I-15	N-21	T-21	J-19

each scale-pair, as shown in Table 4.6. These data further indicate the preference of the participant group as being Extraverted, iNtuitive, Thinking types. However, is this grouping indicative of what might be expected as preferences in project managers, or even in more traditional managers' types?

Analysis of Personality Findings—Studies reported in the literature tend to support the MBTI type preference findings for the project manager participants in this study.

Although a predominance of S, T, and J appear when looking at all levels of management across all kinds of organizations, moving up the management chain in organizations results in a winnowing down to more select groups. Lower management is predominately populated by the INTJ preference, middle management by I and N, and at the executive level by E, N, and T (Walck, 1997). With six out of the ten study participants ENT types, and five of the six at the top GS-15 grade level, this finding appears to support ENT's moving to the top in project management responsibility. Extraverts also have a strong positive sense of well-being to better help manage executive stress than do Introverts (Walck, 1997).

With so many NTs among the study participants (seven), a more detailed description of the NT type helps in understanding the possible implications. The fact that iNtuitives self-select and appear more comfortable and favor less-structured and open environments such as found in project work in NASA compared to, say, a line organization (Walck, 1997), tends to support the above finding. However, in a negative way, NTs also show a preference for holistic information, and their nonlinear problem construction can lead to biases, including selective recall, and weighing confirming information heavier than negative information.

TABLE 4.6 MBTI NUMERICAL SCORE GROUPINGS

	–60	0	+60
EXTRAVERSION	45,35,29,21,19,17,11	15,47,51	INTROVERSION
SENSING	61,43	17,19,21,23,31,35,41,47	INTUITION
THINKING	45,35,33,29,25,23,21,19,5	19	FEELING
JUDGING	55,33,19,19,7,1	33,37,55,59	PERCEIVING

> NTs evaluate patterns in structured data that may lead to representativeness biases which (sic) highlight similarities between specific instances and categories, and miss nuances of other categories (Haley, 1997).

It is important to the analysis of the MBTI data to understand and respect a potential for personal bias of the researcher as an INTJ type personality. Typically NTs have a general preference for data that can create bias by assuming casual links between initial and subsequent (sometimes unconfirming) information. This bias can then result in ignoring cases or information that appear contrary to their beliefs (Haley, 1997). A conscious effort was made by the author to remain aware of this potential for bias, but not to such an extent that bias in the opposite direction would occur.

Summary of Personality Findings—It is clear from the MBTI data that patterns exist in the study findings that add meaning to the search for theory as the goal of this research study. The data for this set of cases show an Extravert/iNtuition/Thinking dominance (seven of the ten cases), with nearly equal preference for Judging (six) and Perceiving (four). Based on the literature, these findings do fit the project environment requiring close working relationships with a project team (Extravert), favoring less structure (iNtuition), and a preference for logical and objective analysis (Thinking).

A more thorough discussion of the implications of the personality findings is provided in Chapter 5. The final survey for research question 1 provides a measure of emotional maturity of the participants using the construct for ego-resiliency, ER89.

Emotional Maturity—Measurement of emotional maturity of the project manager participants for the study used the ego-resiliency construct described by Block and Kremen (1996) in research studies over many years. As used here, emotional maturity is defined as that characteristic in an individual that enables him to control his ego needs, or who is, in Block's terminology, ego-resilient. Those who do not possess this ego control are considered ego-brittle.

> ...ego-resilience implies the ability to change from and also return to the individual's characteristic level of ego control after [a] temporary, accommodation-requiring stressing influence is no longer acutely present. Thus, ego resilience is expected to predispose individuals not only to an absence of susceptibility to anxiety, but also to a positive engagement with the world...The ego-brittle individual, in contrast, is expected to frequently experience anxieties precipitated, inevitably, by existential uncertainties and difficulties (Block and Kremen, 1996).

In his original work in the area of ego control, Block (1950) states:

> Ego-control represents the individual's characteristic means of handling or mediating both his (sic) internal need-tensions and the demands imposed upon him by the external world.

He further defines three separate ego-control states as:

a. overcontrollers

b. appropriate controllers

c. undercontrollers

The emotionally mature individual as defined here would be an appropriate controller whose

> ...patterns of adaptation are both socially appropriate and consonant with internal motivations (Block, 1950).

The premise of emotional maturity, or the theory of ego-resilience, is then an individual's adaptability or ability to modulate control over his/her responses in situations of uncertainty or ambiguity. Adaptation or adaptability implies a level of *flexibility* to operate in a changing environment temporarily, not to be confused with adapted, which implies an *adjustment* to the surrounding environment as an equilibrium state with longer-term implications.

> Individuals vary widely in their effectiveness of adaptation, in their ability to equilibrate and reequilibrate in response to their ever-changing being and the ever-changing world (Block and Kremen, 1996).

A current popular term for emotional maturity is Emotional Intelligence, originally defined in a seminal paper by Salovey and Meyer (1990) as

> ...the ability to monitor one's own and others' feelings and emotions, to discriminate among them and to use this information to guide one's thinking and actions,...a subset of Gardner's personal intelligences.

Emotional intelligence includes emotional self-regulation, adaptive impulse control, a sense of self-efficacy, and social intelligence. According to Goleman (1995), ego resilience can be considered a surrogate of emotional intelligence, much like SAT scores are for IQ. Emotional intelligence is also reported to be a better predictor of success in the

world of work than other measures, including intelligence tests (Goleman, 1998). Thus emotional intelligence, as popularly used, is aligned with the definition of ego-resilience as the modulation of ego control, and is used here to indicate a level of emotional maturity measured through the construct of ego-resilience.

The ER-89 instrument consists of 14 questions on a four-point continuum scale, from (1) *does not apply at all*, to (4) *applies very strongly* (Block and Kremen, 1996). As recommended by Block and Kremen (1996), the ER-89 items were intermixed with 20 similar inventory items from the Jerrell/Slevin Management Instrument (Slevin and Pinto, 1988). The instrument was modified to a four-point scale to match the ER-89 scale, rather than the original Jerrell/Slevin five-point scale. The combined 34-question instrument, shown in Appendix J, was used for evaluating ego-resilience of the project manager participants; the intermixed ER-89 questions are shown in bold, and the Jerrell/Slevin questions in plain text. For the participants, all questions were in the same type face, with no indication of which were the ER-89 questions.

The ER-89 evaluated the relative strength of the emotional maturity of the project manager participants in this study (see Table 4.7).

The ER-89 scale is an ordinal rather than interval numerical measure, limiting meaningful statistical discussion to the median (3.36) and mode (3.43). The results, however, appear to be interesting, perhaps useful, and possibly important.

Summary of ER-89 Data—An ER-89 score above 3.0 for nine of the participants establishes the ego-resiliency range for the study participants. The fact that all except the highest and lowest ER-89 scores are within 10 percent of the mode and median provides a sense of centrality to this grouping within the 3.0 to 4.0 range. Possible implications of this centrality will be discussed further in Chapter 5. The information from all three surveys is summarized as follows.

SUMMARY OF FINDINGS FOR RESEARCH QUESTION 1

The survey data collected for answering research question 1 clearly establish characteristics of the individual project manager participants, and patterns for the group as a whole. As a group, they are mature, experienced, well-educated individuals in the highest civil service grades. They exhibit definite preferences for Extraversion, iNtuition, and Thinking. They are tightly clustered near the highest range of ego-resilience, with one exception. With this baseline of characteristics describing the project manager participants, the next research question used interview data to develop insight into *how* the participants responded to project needs.

TABLE 4.7 EGO-RESILIENCE (ER-89) SCORES

CASE	AVERAGE
A	3.79
B	3.64
C	3.43
D	3.43
E	3.43
F	3.29
G	3.28
H	3.14
I	3.07
J	2.86

RESEARCH QUESTION 2. *How* does the project manager respond to project needs?

The use of interviews in answering this question provided extensive data that established how the project managers acted in response to project needs. During the interviews, the participants described in detail how they established and structured their projects, managed their project teams, addressed project needs, and handled conflict and outside influences affecting the project. Using the active interview methodology of Holstein and Gubrium (1995), interaction between the researcher and interviewee was constant. Each participant was involved with the researcher in developing the meaning-making and reality-constructing of project activities.

The interviews followed a semi-structured approach so all would cover the same general interest areas shown in the interview contact guide sheet in Appendix B. This approach involved capturing similar data in each interview. It also allowed the researcher the flexibility to take side excursions to pursue interesting issues that arose during the interview, and to return to items that needed more depth of exploration. This back-and-forth process provided the opportunity to develop a rich base of data about how the project managers managed their project.

Typed, verbatim transcripts of the initial interviews varied from 5 to 13 single-spaced pages of data. These

verbatim transcripts were provided to the participants to review for accuracy and to add additional information if needed. Follow-up interviews provided opportunities to add to the data and to make clarifications. When follow-up interviews were not possible in person, changes to the transcripts were made using the telephone or e-mail.

For clarity and ease of discussion, the findings of how the project managers responded to project needs are presented in a chronological format following the A-B-C-D-E phases of the NASA project life cycle described earlier. This chronological format fits how the participants became involved with and managed their projects in both general and specific ways. Additional data include the characteristics needed in a NASA project manager based on the participants' personal descriptions, and how these characteristics might be identified in potential project manager candidates.

A finding of substantial importance was how early in the project the project managers assumed their role on the project. Seven of the participants assumed their role early in the pre-Phase A, or Phase A portion of the project life cycle, and had significant influence on how they managed their projects compared to the three participants who began their role as project manager after the project was already established. Those involved early often had participated in developing some of the technology used in the project. This early involvement increased their ability to influence the project formulation in positive ways related to the technical requirements, cost, and in some cases, the schedule. Early involvement also provided insight about how they would structure the project to match their personal strengths and weaknesses. One project that was cancelled at the end of Phase A but after data collection was already completed, is included in the data sample and analysis for completeness.

ESTABLISHING THE PROJECT

How the project was established is important. Although the projects were very complex, project formulation was based on simple principles. The key issues for the project managers in establishing their projects included being involved early with formulating the project, structuring the project in ways comfortable to them, establishing and articulating the project goal and success factors, and selecting the project team. Table 4.8 shows the characteristics described in the interviews that were important in establishing the project. One of the most important issues addressed by the study participants for their project was their need for involvement in establishing the project itself.

Project Structure—The particular requirements and situation faced by each project manager, such as the important technology areas involved, defined the preferred project structure and what the project managers chose to do themselves in structuring the project. The driving forces primarily included having to meet a fixed launch date or tight cost constraint. 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." Some focused on the budget: "I had a 300-element budget." Other approaches included innovating away from standard practices of how-to-do project management, and organizing their projects to mitigate the constraints of high risk: "I organized it by systems in a unique way." Whatever the choice of project structure created, it was simple and fit the project manager's personal skillset and intuitive sense of what was needed in the particular situation he faced.

Project Goal—Following structuring of the project, the goal of the project was clearly defined and articulated. Early involvement of the project manager provided him an opportunity to understand, and in some cases influence, the project goal. The project manager then succinctly articulated the goal to the project team and why it was important to the project manager personally, to the team, to NASA, and even to the world. Each of the projects also had simply defined success factors, with the science to be delivered as the main product.

Project Team—The 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 because they were involved in early stages of the project development, and partly because of their outright demand to do so. In some cases, team members had also been involved in the early technology development and became logical choices for the team. Two project managers had to accept a deputy selected for them, and in both cases the deputy became a problem for the project manager. Three of the project managers inherited an existing project team, or did not get to choose the key project team. Of these three, one said he would not have done anything differently in choosing the team. Another was able to choose only his deputy, who also took on the role of lead engineer for the project. In the third case, a team member replaced the original project manager, who left the project for medical reasons.

TABLE 4.8 ESTABLISHING THE PROJECT

Components	Factors	Impact on Outcome
Project Formulation	Project requirements	Detailed knowledge of requirements & project history
	Influence	Ability to influence technical, cost, & schedule constraints of the project
Project Structure	Personal strengths & weaknesses	Fit to the project manager's strengths & weaknesses, & compatible with his/her preferred personal style for the project & situation
Project Goal	Deliverables	No ambiguity about what the project is to achieve
	Success factors	Identifies minimum necessary to meet the project goal
Project Team	Size	Small size increases visibility Tight control with no slack (extraneous roles)
	Key members & deputy	Synergy with project manager's strengths & weaknesses

Project Team Size—Smaller project teams are also better. The project managers preferred as small a team of full-time members as possible. The reasons included both the issue of visibility of what was going on in the project and exercise of control. These project teams had no extraneous members or, as one project manager stated, "It was a no-slack zone." The team members were, as would be expected, in the few key roles established by the project structure. The number of key team members ranged from 4 to 25. Table 4.9 shows the comparison of project size in dollar value with the size of the project team. Projects over $100 million had dollar value to team size ratios of more than ten, and those less than $100 million had ratios less than ten. In addition to dollar value, however, there was also much variability in the complexities and types of technologies involved in the different projects that, in some cases, required more diverse technical specialists than in others.

Clear Role Definitions—Everyone knew his/her role. As shown in Table 4.10, clear role definition for each key team member ensured there was no duplication of effort, and the small team size allowed the project manager to see that all work was directed toward the project goal. The project goal and success factors defined what would be worked on, and what would not.

MANAGING THE PROJECT—GENERAL

Beyond establishing the project in beneficial ways, the interview data identified additional, general methods that the participants used in managing their projects. These methods were the framework for day-to-day operations in the project.

Rules—A few established rules were seldom violated. The project plan was followed. The minimum needed to accomplish the goal for the project was the rule, but it would be done in a thorough and complete manner. It was made clear that the project manager was not a technical expert on the project. The various specialist team-member experts were held both responsible and accountable for technical issues. The project manager, however, ruled the budget and schedule, and no technical changes were made that impacted these parameters, or that involved risk to the project, without his/her consent. The project manager handled all interactions outside the project except for technical issues that were the responsibility of the technical expert team members. Once the project was estab-

TABLE 4.9 PROJECT SIZE COMPARISON

Project Value (millions of dollars)	Core Team Size (full-time team members)	Ratio (dollar value/team size)
450	22	20.5
350	25	14
150	12	12.5
135	5	27
110	5	22
49	8	6.1
30	11	2.7
25	15	1.7
22	6	3.7
21	4	5.3

lished and the general structure formulated with a few rules, the specific day-to-day methods of how the project would operate were defined.

MANAGING THE PROJECT—SPECIFIC

A clear understanding of how the project would conduct its business on a day-to-day basis was clearly defined by each project manager participant (Table 4.11). The specific rules for operating the project were simple, and everyone knew them. How the team would communicate, find and solve problems, make decisions, and deal with conflict was clear and direct. Communications were done in real time; problem finding and solving used the method established; decisions were by consensus when possible and appropriate. The project manager made decisions when the team could not reach consensus in a reasonable period of time. As one project manager stated, "this is not a democracy, and it's not a debating society."

Communications—Communications were done in real time and in the simplest manner possible. A variety of methods were used to communicate among the team members. All of these methods had the goal of meeting the need to share information, but keeping it simple. Nothing important waited for a meeting. The underlying principle was to have open, continual communications with the team; "we meet in twos, threes, and fours as small groups." None of the methods used were highly sophisticated, and structure was kept to a minimum. Periodic meetings predominated among the methods used, with wide variations in how they were used. Weekly or biweekly meetings were common, and were normally held at the same time. However, they were held only when necessary, and not held at all if there was nothing to discuss. In some cases, the meetings involved external players through scheduled videoconferences or telephone conference calls.

E-mail was another primary method of communication. One project manager collected e-mails from key team members during the week and sent out a very extensive weekly e-mail status report that was later summarized for monthly and quarterly reviews. One participant got information in writing and distributed it quickly to preempt questions from external sources. Periodic briefings to management and program offices were a necessary part of all projects and were usually done by the project manager alone, or with a minimum number of key team members.

Problem-Finding—Problem-finding fit the project situation and was an important and sometimes difficult issue. One of the project managers said, "putting together the right information in the many technical issues we had was a very difficult task." As a nontechnical expert, the project managers needed, "a deep enough understanding of the engineering so I can tell if they're doing something dumb," or to "get technically educated enough to know when something was going wrong." Among the problem-finding techniques used were peer reviews for major changes, probes to bring out softness in the disciplines, and simple

TABLE 4.10 GENERAL MANAGEMENT METHODS

Components	Factors	Benefits
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 nontechnical external contact concerning the project.
Few Roles	No ambiguity about how the project will operate	A few simple rules are established as to how the project is 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 acknowledged and dealt with firmly.

information-gathering. As described by one participant, "you ask questions and just keep poking at it until you turn the rock over and find out what's underneath." A unique technique for problem-finding used by one project manager with an extremely tight schedule was described as a "shotgun" approach. The team members would sit in a circle and each would describe the problem, or an element of the problem as they saw it. Once everyone understood and agreed on the problem, they would backtrack to identify the most likely causes. Work then began on finding possible solutions.

In most cases, the projects in the study were driven by an inviolate schedule that forced the development of efficient problem-finding methodologies. These methodologies varied from evaluating what-if problem scenarios that explored and allowed them to be ready for potential problems that could occur, to creating specific real-time activities when something was not going right. One potential problem scenario identified significant launch risk for the project and resulted in an intensive study to evaluate the risk, and to develop possible alternatives. The outcome of this study was a major change in data telemetry launch strategy, from using several aircraft to using a single satellite at about the same cost, but with significantly reduced risk.

Problem-Solving—Problem-solving approaches also varied widely, but were effective for the situation particular to each project. Common techniques included asking questions, listening to arguments, putting the right information together, and using parallel or multitasking approaches to identify immediate, action-oriented solutions. The team using the shotgun approach to identify problems handled problem-solving the same way by implementing multiple solutions simultaneously. They prioritized the solutions to be implemented by what could be tried most quickly; "it was always the most important thing to try something; you've got to start implementing solutions."

Decision-Making—Decision-making was also kept simple. The project managers accepted their responsibility for decisions affecting the whole project. Most stated that they really preferred consensus in making decisions, but also made it clear they had no qualms about making a decision if there was no consensus. Schedule demands drove many of the decisions because of the need to meet a launch date or other inviolate time requirement. Cost growth exceeding 15

TABLE 4.11 SPECIFIC MANAGEMENT METHODS

Component	Factors	Description
Communications	Simple, real-time Periodic meetings Video & telephone conferencing E-mail	Methods of communicating met the needs of the project manager & team to access important information & provide it to others in real time.
Problem-Finding	Situational Adaptive	Problem-finding was important to quickly identify a problem so problem solution could begin. Multiple, simultaneous approaches were used to ensure all potential avenues were quickly evaluated.
Problem-Solving	Situational Adaptive	A defined problem-solving methodology was employed to attact a problem once identified.
Decision-Making	Simple Consensus, when possible	Technical experts made technical decisions. Project manger made decisions when consensus was not forthcoming. Project manager made all project decisions that affected schedule, cost, or risk.
Conflict Resolution	Quick, fair, firm	Internal conflict was acknowledged & dealt with. Project manager handled external conflicts.

percent of approved spending for the project would trigger a program review for possible project cancellation, and was a constant and visible factor in the decision-making process.

Conflict Resolution—Project managers faced two types of conflict: internal, involving the project team, and external, involving outside influences.

Internal Conflict: There was no luxury for any kind of ambiguity in resolving conflict. The project managers understood their role in dealing with conflict within their project, whether it was comfortable for them or not. They advocated a clear need to get conflict out in the open, deal with it, and move on. They appeared to have no trouble controlling their emotions in dealing with conflict with team members. The two who had a deputy imposed on them dealt appropriately with the conflict this situation caused. One identified specific tasks the deputy needed to accomplish, tracked the accomplishment, and was ready to take disciplinary action for nonperformance when the deputy chose to retire. The other project manager identified the problems the deputy was concerned with, and together they either reached agreement or made accommodations that did not adversely affect the project. This project manager had to be the bigger person; "I had to accommodate [the deputy's] psychology."

External Influences: Influences from outside the project were dealt with directly by the project manager; the project team was shielded from outside influence. Most of the project managers were strong advocates of handling all conflict outside the project to protect the team; "I think my main job is to protect the team; I take all the grief." One project manager described his methodology as "providing a membrane around the project team." Self-confidence in themselves and in their understanding of the project was a significant factor in the project managers' approach to handling external influences. Conflict with their own managers appeared to be a challenge they seemed to willingly accept and deal with routinely or, as one said, "I go toe-to-toe with them all the time." There were also more serious challenges to their projects.

One project manager went directly to the Center Director for relief from his Division Chief's attempts to micro-manage the project, and got it. This step was taken at potentially great risk to the project manager's future career. Another project manager simply refused to be influenced by his next-level manager's attempts at micro-management, and won the battle of wills. One other project manager went over the head of his program manager and yelled at the next-level manager because of a proposed budget cut, which was then reduced to an amount the project could absorb and still survive. One required all outside requests for

change to be put in writing, requiring an agreement from the requester to pay all costs involved and obtain appropriate approvals for changes in the schedule. And one project manager 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 then act as the arbitrator on the issue.

A significant problem for several of the projects was incorrect funds phasing over the life of the project. One project was going to receive more than half of its funding after the hardware was scheduled to be delivered. This situation created enormous problems early in the project because the funds to meet the early requirements were not available and work had to be pushed into later phases of the project. After continuous attempts by the project manager, over several years, the problem was finally resolved after the project manager formulated an outside review board that pointed out the "ridiculous funding profile of the project." Another project manager said that getting funding in a timely manner "is always the biggest concern."

MISCELLANEOUS FINDINGS

Several miscellaneous findings had less influence across all the projects than those mentioned. However, they were important to the projects involved and are discussed for completeness.

Team Building—Some project managers focused on finding team-building opportunities. Because one team was not co-located, they used meetings to talk about fishing or baseball. One team traveled together for weeks at a time; another would all go out together and "hoist a few pints" on a regular basis. Seemingly small things helped to provide a sense of camaraderie. Giving everyone on the team a dog name, such as bulldog for the project manager, or mounting a stuffed toy on top of the computer to identify whoever's system was currently holding up the project, fostered a sense of interdependency and togetherness.

International Partners—Some of the project cases involved international partners, with the related problems involved in working across different cultures, languages, and project goals. The deterioration of the Russian economy significantly impacted one project that depended on Russian-developed hardware. Another joint U.S./Russian project was based on uncertain Russian launch support. Merely having an international partner such as Japan, France, or Canada meant less visibility and control over the project interfaces and the hardware delivery schedules. Other projects involved worldwide visibility, and, therefore, careful scrutiny by Congress concerning safety and other issues.

Gender—Gender was not a significant issue for most of the project manager participants. Many of the projects included both males and females, and gender did not usually come up during the interviews. One project manager, however, felt that a more balanced gender team would have been beneficial. The comment referred to how team interactions changed positively when one female member was on the team for a short while. One of the female project managers mentioned that just getting to the position of project manager for a woman was a tremendous challenge. She felt that women always had to be better than their male counterparts just to participate as an equal team member, and significantly better than the men to be a project manager. Promotion of both female participants in the study, who were obviously outstanding individuals, to NASA Senior Executive Level positions, tends to support this premise.

Maintaining Balance—As noted in the discussion of how the project manager responds to project needs, it was important for them to maintain a balance among the critical factors of technical requirements, schedule, and cost. Maintaining this balance was a challenge the project managers dealt with effectively and efficiently. In most cases, the project schedule drove completion of technical requirements. One participant described it as being 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 about how to meet the schedule and stay within the approved cost constraints, meeting the technical requirements was always the most critical and inviolate of the requirements. Technical and schedule risk could be offset by manipulating cost, but in the NASA project paradigm, any cost increase greater than 15 percent could result in project cancellation, so there was not a lot of flexibility with cost, either. Balance, therefore, was a challenge the project manager participants dealt with consistently, but also effectively and efficiently.

SUMMARY OF FINDINGS FOR RESEARCH QUESTION 2

The role of the project manager in establishing the project, and in responding to project needs, is a complex one. It is one that the participants handled by framing the project in simple ways that fit their particular skill set. Early involvement gave them an opportunity to structure the project in ways that were comfortable for them, and that took advantage of their

strengths. Within this structure, they clearly defined the project goal and success factors in simple terms. They also built the project team with as few key members as possible, and with a deputy who complemented their strengths and supplemented their weaknesses. And finally, they used this structural framework in managing their project.

The participants also clearly defined their role and the roles of each of the project team members. They developed a set of rules for project operations, including how the team would communicate, find problems and solve them, make decisions, and handle conflict.

The next section discusses the implications of the combined findings for research questions 1 and 2 in addressing research question 3.

RESEARCH QUESTION 3. Why does the project manager respond in the way he does, and why is this response important to project outcome?

The remaining research question to be answered seeks an understanding of why the project manager chooses to do things the way he does, and why that choice is important to the project outcome. To better explain the rationale behind a particular response by a project manager, Appendix K includes a minicase for each of the project cases that describes a particular problem faced by each of the participants in managing his project. Each minicase uses some of the project manager's own statements about the problem and the approach taken. The minicases also allow the reader to experience more of the depth of the concern and anxiety experienced by the project managers in solving important problems for their projects.

Appendix L also summarizes and expands on the problems described in the minicases. It lists 6 different problem categories and 14 different problems that the participants specifically responded to in managing their projects. It also identifies each problem that stimulated a need for action, the action chosen, why the choice of that particular action, the outcome of the response, and an interpretation of the rationale for that response. It also includes some supporting data from other research findings. The six different problem areas are summarized in Table 4.12.

Because of the specificity of the problems that occurred in the project cases studied, linkage of the responses to these problems to the findings from research questions 1 and 2 was somewhat elusive. Many of the findings do, however, provide pertinent information in answering research question 3.

MANAGERS OF COMPLEX NASA PROJECTS

Are these managers of complex NASA projects unique? As a group, they are fairly similar demographically, and also close in their personality characteristics and their level of emotional maturity. They are, however, highly individualistic, and they use that individualism to take advantage of their strengths and compensate for their weaknesses. They also exhibit numerous similarities in how they approach projects through a structured framework for establishing and managing their project. The following discussion addresses these factors and describes some implications of them.

Why Do They Respond to Project Needs in the Way They Do?—The answers to research question 3 help to tell the story about why NASA project managers do what they do so well. NASA project management is challenging and complicated—just what these project managers want, and are best suited for. NASA project management is about developing things that do not currently exist, at least not at the level of complexity involved in the projects studied. The worth of a NASA project lies in capturing new science, developing new capability, or advancing technology. These worthwhile endeavors create inherent value for the project manager as he manages a NASA project.

A complex NASA project demands a project manager who is not relied on for his technical expertise as much as for his maturity and experience. It takes someone who can provide both the substance of leadership and the ability to manage complexity in the face of uncertainty and change to accomplish the goals of the project. It requires a person who is emotionally mature to counter the multiple influences affecting the project, including those of his own management.

The NASA project manager brings a passion to the project to excite and keep the project team motivated and on track toward the project goals. The project manager gains personal satisfaction by quietly accepting his own often-unrecognized contributions, and by celebrating the successes as a team.

Why the participants chose the actions they did is based on a mixture of complex factors identified in the findings, including the situation they faced with their project at the time a problem arose, and what may best be described as a "toughness" in their character. The problems they faced were not trivial. Their toughness is evident in their willingness to stand up to their managers and others who wanted to "meddle" in the project, or even remove them as project manager.

TABLE 4.12 PROBLEM CATEGORIES

Problem Categories in Complex NASA Projects
Funding/cost constraints
Micro-management
Risk
Personnel issues
Technical issues
International issues

They did not allow those situations to materialize. They did what they felt was necessary, and the right thing to do to ensure completion of the project, often at great personal risk to their careers. This toughness is what various authors, and the participants themselves, say a project manager needs to have. It is a characteristic of initiative, decisiveness, and the forcefulness to choose an action and make it happen. And the actions they chose were not just important, but were often critical, to the project outcomes.

Why Were Their Actions Important to Project Outcomes?—Getting funding rephased, fending off attempts at micro-management, reducing unacceptable risk, and a host of other actions were taken by the participants to ensure that their projects would, and did, meet the necessary technical goals within the constraints of cost and schedule that they had to work with. The one exception may be the project that was cancelled. Recognizing that the project would probably not meet its goals, based on early projections of the proposed technical approaches and cost estimates that the manager had not had an opportunity to influence, the project manager restructured the project with a new cost estimate that would meet the technical needs and schedule for the project. A program decision was then made to cancel the project at the new cost because of program budgetary constraints. This project manager accepted the risk of having the project cancelled over personal career risk to himself, because he recognized he would not be able to meet the project technical objectives within the unacceptable schedule and cost estimate he had been given.

SUMMARY OF FINDINGS FOR RESEARCH QUESTION 3

The findings for research question 3 explain in a general way why project managers do what they do and why this is important to project outcome. The complexity of their projects, coupled with the complexity of the project manager, does not provide a simple answer to research question 3. Project Managers do what they do because of who they are, and without the outcomes they obtained, many of the projects in the study would not have met one or more of their constraints.

Analysis of specific problems encountered by the participants in their projects showed, in individual ways, why the characteristics of the participants were important in making particular decisions. However, substantial evidence exists that indicates that the sum of the characteristics they exhibit strongly influences the actions they take in responding to project needs. Therefore, a complete answer to research question 3 remains obscure until additional approaches are devised to explore this area. The broader implications of the totality of the research findings, however, define the characteristics of the NASA manager of complex projects, and how these managers use these characteristics in managing their projects.

Additional relevant information that is not directly related to one of the research questions can be gained from the study. And, this information is important in providing a complete picture of NASA project management of complex projects. The participants provided information about what they felt were important characteristics of project managers, and they also offered some information in the findings that does not fit the earlier-mentioned patterns, but is both interesting and relevant to a complete understanding.

SELF-DESCRIBED CHARACTERISTICS

An embedded goal of the research was to determine if the participants knowingly, or unknowingly, follow their own advice and meet their own criteria for a project manager. The participants were asked what characteristics they thought a NASA project manager requires, and how they would identify that need in a prospective project manager.

The participants made numerous general observations about the characteristics that NASA project managers need to have, and how one could find out if these characteristics exist in any particular individual. One claim was that because the human is a biological system and there are no identical biological systems, "there is no recipe." Another was that project leadership is an "innate capability." Numerous repeated characteristics were, however, defined as being necessary. These characteristics were in some cases felt to be observable; one participant said that it would be "fairly obvious early in their career if they can't handle five things at once." Table 4.13 lists the

characteristics they identified as the factors involved and possible benefits they may have.

INTELLECTUAL CHARACTERISTICS

Several of the participants identified intelligence as a critical need; "number one in this business, you've got to be real (sic) smart. There is no place in this business for people who are not real (sic) smart. You've got to be a 120-IQ kind of person." One manager said, "I would look for an analytical mind who (sic) can process a lot of information from a lot of different places." There was also a stated need for a high level of intuition, logical thinking, and ability to handle complexity tempered by a need for common sense. Another intellectual need was described as the capability to learn.

PERSONALITY CHARACTERISTICS

Both a statement of the need for a "visionary" project manager and the implications of needing a view of the "big picture" were repeated across the interviews: "You need the project manager to be a visionary because those people usually delegate. You need your design engineers to be organized."

Another stated personality-related characteristic was for the project manager to be someone who was in charge, "not a wimp but not overly controlling, not a task master."

SELF-UNDERSTANDING

Some participants referenced "knowing who you are as a part of your tool kit." This factor included the need for the project manager to work within his strengths, and to fill in for his weaknesses. This solution often took the form of having a deputy who was strong in a critical area in which the project manager was weak. The willingness to delegate was repeated throughout the interviews with some reluctance: "I'm not comfortable with it, but I do it."

COMPETENCE

Both technical and managerial competencies were expressed as strong needs for NASA project managers. These characteristics were expressed as a combination of having enough "technical horsepower" to understand in a broad sense the technical issues, and then working interpersonal relationships "to get the people to get the job done."

The difficulty level in doing NASA project management ranged from "this stuff is really hard," to "none of this stuff is really hard." One comment was, "there is nowhere you can go to learn this stuff!" Another was, "you've got to be able to lead the team, to help them capture the vision, to see the problems and see the alternatives, to help them be objective." To develop the needed competence requires a willingness for continual learning; "I will learn anything from any source and if it rings true to me, I will make it part of myself." Decision-making was a strength that was recognized as essential: "He's got to be willing to make decisions."

TECHNICAL EXPERTISE

There was almost universal agreement on the nonrequirement for the project manager to be a technical expert on the team. The need for a good technical understanding without being a technical expert in any of the project areas was the most required trait; "someone with a broad experiential background." One stated it as, "number one, you've got to understand the technical things to be good enough to understand what's going on."

PROJECT MANAGEMENT TRAINING

Most of the participants had minimal, if any, project management training. For those with some project management training, it had often been many years prior, "in a one-week course." One had an advanced degree that included substantial project management coursework, and another had attended a nondegree project-management-focused study program. Some expressed no knowledge at all of the NASA project management system or any need for training.

FLEXIBILITY

To be "nimble and innovative" was expressed as a need to deal with the constant change that happens in a project because of the continuing evolution as the project moves along its life cycle. One concern related to the new faster/better/cheaper NASA paradigm was, "they keep telling you that you've got to take more risk, but as the project manager, you don't want to be the one who fails."

EXPERIENTIAL CHARACTERISTICS

Repeated references were made to project managers needing experience to be able to do the job: "It's just one of those things that comes with experience." Some of the terminology used to describe this experience included having a demonstrated track record of success, and the way to get that is to "just get in and find out how well you do."

INTERPERSONAL CHARACTERISTICS

A strong case was made in nearly all the interviews for the importance of good interpersonal skills: someone

TABLE 4.13 SELF-DESCRIBED CHARACTERISTICS OF PROJECT MANAGERS

Characteristics	Factors	Description
Intellect	Intuition Analytical mind Logical thinking Common sense	These characteristics provide abilities needed to absorb critical infomation, perform required analyses, draw correct conclusions, and make good decisions
Personality	Visionary Take-charge attitude Outgoing, people oriented	Visionaries have the ability to see the whole project at all times and are willing to delegate. A take-charge attitude ensures that there will be no ambiguity about who runs the project and makes key decisions. Managers are personable, and they enjoy working with the team
Self-Understanding	Personal tool kit	This person knows his own strengths and how to compensate for weaknesses.
Competence	Technical competence Management competence	This person is not a technical expert, but understands technical issues and knows how to manage interpersonal relationships.
Technical Expertise	Nontechnical expert	This person understands the general technical issues at all times and their importance to project outcomes.
Project Management Training	Project management methodology	This person places a weak value on formal project management training. This person gains valued training experientially by working on projects.
Flexibility	Innovative Nimble	Constant change drives the need for innovation and the ability to quickly move focus from one facet of the project to another.
Experience	Demonstrated experience	Actually doing project management is necessary to be able to do it well and goes beyond knowing how to do it.
Interpersonal	Personable Personally likeable	Interpersonal relationships and communications impact the entire project.
Willingness to Confront	Interference	Outside influences demand a willingness to confront and mitigate them at personal and professional career risk.
Work Ethic	Commitment	Project management requires a full-time commitment to hard work, and everything else is secondary.

who is "personable, personally likeable, comfortable with people in social situations." These skills ranged from the ability to listen and communicate to creating close interpersonal relationships with the team members.

WILLINGNESS TO CONFRONT

A strongly repeated theme was the willingness to confront anyone, especially management, who wanted to interfere with the project: "He's got to be able to stand up and tell his management what he thinks. You might lose, but you've got to be willing to say it." Some repeated terms were, "going toe-to-toe with them" and "just not letting them do it."

WORK ETHIC

A NASA project manager has a particular mentality regarding his work ethic: "It's a mentality where he's got to be willing to put his nose to the grindstone and work hard." Project managers also need to have the conviction to commit to "whatever it takes to get the job done." They have to put themselves second behind a lot of things, and be willing to commit themselves to their project: "Getting here from there is a very painful process. Project work is hard work and it's painful, and there are a lot of bad days." They often "work real (sic) hard" and, in some cases, endure incredible stress and fatigue. One stated, "It's not an easy job, it's a very demanding, full-time, grind-them-out thing. It takes a lot of patience and perseverance."

IDENTIFYING CANDIDATES

In describing how to identify the needed characteristics in someone who wants to become a NASA project manager, the responses ranged from developing "some kind of test like the Myers-Briggs Type Indicator," to talking with them or others who know them. Another suggestion was to work with them for a while in a small project situation to evaluate them.

SUMMARY OF SELF-DESCRIBED CHARACTERISTICS

During the interviews, each participant was asked to describe what he felt were the important characteristics for a project manager to have, and how he would identify those characteristics in a prospective project manager candidate. The goal of this question was to compare the survey findings to the participants' perspective of a project manager.

COMPARISON WITH MANAGERS' COMMENTS

In an attempt to triangulate the interview findings and the self-described characteristics provided by the project managers, the managers of the project managers were asked to describe both why they chose these particular project managers and the characteristics they looked for in prospective project managers. The following provides some of their comments.

PROJECT MANAGERS' MANAGER COMMENTS

Numerous candidates applied for the job of project manager for one of the projects. This project was larger than anything taken on by this office previously, and no one in the group was available who could do the job. In addition, many interfaces with the Air Force were involved with the project. The manager needed someone who "would go the extra mile," including 70- to 80-hour weeks and a lot of time away from home. Asked about characteristics desired in prospective project managers, this manager said he looked for the ability to lead and work well in a team. Potential prospects had to be able to delegate and let others be the technical experts, and they needed good planning and oral communication skills. The selected candidate had not been a project manager previously, but had demonstrated capability as a member on other project teams and knew the players involved from previous work with the Air Force. Observed in his present job as a functional Branch Manager, it was noted that this person interacted well with people, was well organized, and had the overall knowledge needed. The manager said, "it was an easy choice." When the manager providing these comments retired, this project manager was promoted into his job.

One manager looked for prospective candidates as project managers with "the ability to do constant assessment, planning, execution, and replanning." Making midcourse adjustments and not being overtaken by events was described as an important characteristic. He described it as "some come by it naturally. People can be trained, but some will never be [competent] project managers." It requires being "sensitive to technical issues and being able to pick up on people." They needed an ability to "pick good technical people and understand how they are working the technical issues." For this case, the project manager who was chosen "had been on three similar projects as a project engineer." The manager knew what was involved in the project from having been a previous project manager. The manager also knew the candidate from previous projects. The candidate had the international experience needed, and was the most experienced person available, "with the most chance to be successful." Although the project manager chosen was not an engineer, the manager felt that "being that project manager did not require an engineer, but someone with a technical background who would be less intimidated by technical issues."

Another manager said he looked for someone as a project manager who could "see the big picture but can get into the details without being buried." He also looked for "resilience and perseverance—being able to bounce back and forth from the details to the bigger picture." He chose the project manager for this project based on knowing his previous experience and the fact that he "did a great job." It was also important that the chosen candidate had been involved with the project early and, "had learned all the technical stuff," and was the most knowledgeable about it. The candidate was also known to be good at scheduling and meeting milestones and had built an advocacy for the project. The choice was described by the manager as, "a no-brainer," despite some resistance from higher management because of the candidate's youth. When the project later encountered problems, the project manager demonstrated that the problem was being addressed and, the manager said, exhibited tremendous "resilience."

Experience by the project manager was a major factor for one manager of three of the project managers in the study. He stated that, "apprenticeship is the only real way [to learn project management], and that technical experience is required for making the top-level decisions needed." Experience as a team player and team leader is also important; "teams always outperform a group of individuals." However, his final selection was a joint one with the Principal Investigator for the project; "science is the reason to fly and they must agree with my choice for project manager."

One of the three participants managed by this manager was a concern. Because of this project manager's style of "delegating everything," the manager felt that opportunities to prevent problems were missed rather than being solved after they were identified as problems. Despite the manager's concerns, the project met all of its technical requirements and its cost and schedule goals.

Another of his project managers was the one whose project was cancelled. The manager confirmed that the cancellation was in no way related to the management of the project, but simply was a matter of money available, and the need for certain science outcomes. The science of other projects was felt to be more important and this project was not approved for Phase B funding.

All three of his project managers in this study competed for their job against other candidates. All had had substantial involvement in the early phases of developing their project in the study, and had been project managers on earlier projects.

Both of the two GS-14 Project Managers were given temporary promotions to GS-15 at the time of their selection to their projects, which would become permanent promotions upon approval of the project for Phase C/D. Both projects were approved and the candidates submitted for their permanent promotions. One of these had been a Deputy on an earlier project under an outstanding project manager and there was some concern about whether he could do a project on his own. The manager had confidence in the candidate, however, because of the respect shown him by his teammates on earlier projects and for the diligence he paid to his work; "on a scale of 100, he would get 100."

OUTLIERS

The discussion to this point has focused on the most repeated or common findings among, and across, the cases studied. This section looks at what can be called outliers, or as mentioned earlier, those findings that are significantly different in some way or *lie outside* the pattern of the more frequent findings. They are included to avoid overgeneralization, or omission of any possibly important information in the findings. Table 4.14 displays some of the more obvious outliers from the findings of the study.

PERSONALITY

Because there was only one MBTI Feeling personality type among the participants, this project manager is different from the other participants. From the interview data, this Feeling preference expresses itself through a strong concern for and desire to help the project team. This project manager felt like more of "a coach than a manager," and his goal was to keep the team "happy." A stated measure of the success of this participant would be the future career success of the project team members.

The ten participants included three Introverts. The one INTJ type was responsible for an engineering project, and this manager had neither engineering training nor any advanced degree. He did, however, have extensive project work experience, and seemed to have no serious problems managing the project, even though he was one of only two participants at the GS-14 grade level. This project manager expressed concern about having to commit to the project manager role, and "everything else comes second." Everything else in this case included his family.

Of the two ISTJ types, the one labeled A in Table 4.14 was working in a different engineering specialty than that of his professional training. His MBTI Sensing and Judging scores were also higher than any of the

other participants. An expressed concern of this individual was in not being able to "trust people to do what they say." This lack of trust consumed much of his time in carefully checking details; "I usually have a fine enough detail in the schedule so I can tell if something is going wrong." The other ISTJ, labeled B in Table 4.14, had the highest Introversion score, and he preferred that his deputy handle interactions with the technical staff on the project.

The Introvert project managers appeared as effective as the extravert project managers, although they approached their jobs differently. Some of their comments during the interviews, however, indicated that they worked much harder and did not appear to have as much fun at their job as the Extravert participants.

CANCELLED PROJECT

The manager of the project that was cancelled had the highest iNtuition score of the iNutuitives. Coming onto the project late, and recognizing deficiencies in its structuring, the project manager restructured the project at the risk of project cancellation, rather than accepting the deficiencies and risking failure of the project. This step was taken at some risk to the project manager's professional career.

FEMALE PROJECT MANAGERS

The two female participants managed their projects no differently than the male participants. They were similar to the majority in both their characteristics and their project management approaches. What made them outliers is that they were the only participants to leave their projects during the study, and they both left for promotions to higher-level positions. Neither of their projects appeared to have suffered any problems because of their leaving.

SUMMARY OF FINDINGS

Research questions 1 and 2 provided answers about who the project managers of complex NASA projects are, and how they manage. The findings describe a pattern of characteristics that show each of the participants as a unique individual, although as a group they display many similarities. These similarities fit their environment in ways that make them well suited to what they do. Project managers use their characteristics when they structure their projects within a simple framework that helps them to manage using a system of a few simple rules. Looking within this framework, the challenge was to find links between their characteristics and how they manage. These links help explain why they take the actions they take in responding to project needs, and provide supporting evidence for why their responses were important to the project outcomes.

The findings for research question 3 address these links about why the project manager's characteristics are important in taking actions to meet project needs, and why these actions are important to project outcomes. These findings include specific instances of linkage to the participants' characteristics in addressing project needs. As Extraverts, they prefer to be with people; as iNtuitives, they prefer unstructured environments; as Thinking types, they prefer to use objectivity and logic in solving problems encountered in their projects. Having strong ego-resilience, they easily handle the ambiguity and uncertainty involved in complex NASA projects. They use these characteristics in systematically structuring, managing, and solving problems for their projects. They also use them in protecting the project team by providing a tough exterior against outside influences and willingly confronting these influences themselves.

The findings identify a natural grouping of characteristics among this set of project managers that corresponds to how they take actions in establishing and managing their projects. An evaluation of what the participants believe are important characteristics for NASA project managers showed that these characteristics closely represent those identified from the survey data and from the managers of the project managers. Many outliers among the findings show that gender does not appear to be a factor in project manager characteristics, and Introverts can be excellent project managers, but it may be more difficult for ISTJ types who appeared to combine with lower ego-resilience. Chapter 5 discusses these findings with implications for meaning, theory, and future research.

TABLE 4.14 OUTLIERS

Outliers		Demographics	Personality Type	Emotional Maturity	Comments
MBTI Feeling Type (ENFP)		Advanced Degrees (MS,MBA) GS-15	E(15) N(31) F(19) P(59)	3.43	-Choosey about team members -Concerned for their careers & keeping team happy -Confrontational to outsiders -Deputy was arbitrator
Introverts					
INTJ		No Advanced Degree GS-14	I(15) N(21) T(21) J(19)	3.29	-Nonengineer working out of speciality -Arbitrator vs. Confrontational
ISTJ	A	Advanced Degree (MBA) GS-15	I(47) S(61) T(35) J(55)	2.86	-Entered late on project -Working out of technical speciality
	B	No Advanced Degree GS-15	I(51) S(43) T(29) J(19)	3.07	-Entered late on project -Nonengineer -Inherited existing project team -Oldest participant -Strong -Deputy handled key technical staff
Cancelled Project		No Advanced Degree GS-15	E(17) N(47) T(5) P(37)	3.43	-Entered late on project -Requirements, budget, schedule, all defined -Did not get to choose project team -Saw problem with project & risked project cancellation over failure
Female	A	Advanced Degree (MBA) GS-15	E(19) N(23) T(45) J(33)	3.64	-Strong -Left project early for promotion -Project met all requirements
	B	Advanced Degree (MS) GS-15	E(29) N(41) T(23) P(55)	3.28	-Strong -Left project early for promotion -Project met all requirements

5. DISCUSSION AND IMPLICATIONS FOR FUTURE RESEARCH

Summary

This study was undertaken to address a question that either has been overlooked, has been of little interest, or perhaps has been considered too difficult to answer by those involved in or interested in project management theory. The question concerns the importance of the project manager's role in project outcomes. The intuitive answer is, of course, that the project manager is important to project outcome. However, when probed a bit deeper as to why the project manager is important, the answer no longer appears to be so intuitive or easy to answer.

The job demands on the project manager identified in Chapter 2 led to the three research questions in this study. These questions were posed to explore in some depth the importance of the project manager in the limited arena of managing complex projects in the National Aeronautics and Space Administration (NASA).

It should be noted that in the discussion that follows the author refers to all project managers as if they were men (when, in fact, two participants in the research were women) to ensure confidentiality.

RESEARCH QUESTIONS

1. What characteristics describe the manager of a complex NASA project?
2. How does the project manager respond to project needs?
3. Why does the project manager respond in the way he does, and why is this response important to the project outcome?

These questions are of interest both because they address an area neither well researched nor discussed in the literature, and because the answers may have significant importance to the field of project management. The findings presented in Chapter 4 provided detailed information in answering the three research questions. The emergent themes and unique features that led to the implications drawn from the findings are the subject of this chapter.

The methods used to address the research questions were derived from an a priori conceptual construct used to help focus the research as a theory-building process. A qualitative research framework (Eisenhardt, 1989b) was used in the collection and analysis of the data, and for developing meaning and shaping hypotheses from the data. The research is, therefore, not based on existing theory or hypotheses, but contains the essential theoretical flexibility needed in a quest for theory and meaning-making that evolves from qualitative data.

DATA COLLECTION

The data collection methods used were based on research strategies described by Yin (1994). They include surveys to obtain data for answering the *what* of research question 1, and case studies using active interviews (Holstein and Gubrium, 1995) to obtain data to answer the *how* and *why* of research questions 2 and 3. Each of the ten projects in the study was treated as a separate case, with the project manager as the source of project data. This method was used because the project manager was the only person who had the depth of information about what stimuli drove the actions taken in managing the project, and was, therefore, the focal point of not only *how*, but the only one who could address *why* a particular decision was made.

As the data collection and analyses proceeded, patterns were sought looking within and beyond the individual cases at cross-case data. The search was constant for the *why* behind the cases as themes began to emerge. *Why* was a certain approach to a project need taken, and *why* was this approach important to the project outcome? As replications of evidence in the different cases began to appear, they were tested against other cases to validate and sharpen the theory. Links across cases were explored, and outliers examined. Finally, theoretical saturation occurred as marginal improvement became less and less with each additional review of the data showing little new information.

RESEARCH CREDIBILITY

The credibility of qualitative research such as the study reported here is not based on statistical analyses as in quantitative research. The validity of qualitative research such as reported here, however, is addressed through numerous well-recognized qualitative methods (Miles and Huberman, 1994; Marshall and Rossman, 1995; Yin, 1994).

Transferability of the findings to a larger NASA population, or to other populations, is enhanced by the use of multiple cases and informants. Additional credibility considerations include the mixed data collection methods used, which helped to triangulate

the findings of both the survey and interview data across the cases. This methodology includes the use of the researcher as an instrument of data collection and analysis. The dependability of the results appears to be as reliable as it could be within the conditions of the study, and the probability the findings would be confirmed if replicated in another study under the same conditions is high. A contrast with other studies in the literature and studies of NASA project managers, and NASA engineers and scientists as managers, is provided in the next section, Literature Comparisons.

BIAS CONSIDERATIONS

The potential bias of the researcher was recognized and acknowledged, and conscious efforts were made to reduce or mitigate this bias as much as possible. Attempts were also made to mitigate bias in the data from the three survey instruments, and in the interviews. The value of the interview data lies in the accuracy and honesty of the interviewees' describing their reality, or what they feel is their reality, and also of the interviewer in correctly hearing and interpreting that reality. To reduce interview errors as much as possible, anonymity was offered to the participants in order to obtain candid and complete answers to the surveys and interview questions. Audio tape recordings of the interviews were transcribed verbatim, and the transcripts reviewed by the participants to ensure accuracy, as well as to provide an opportunity for them to add information for clarity if needed. To ensure ethical responsibility of the research, a request for approval of human research was submitted to and approved by the NASA Human Research Investigation Review Board. Each participant for each case signed a consent form that outlined the research protocol and offered anonymity. The NASA authorization and a sample consent form are provided in Appendix H.

Using multiple cases helped reduce the effects of bias in the data from all sources. The ten projects in the study represent an opportunistic, but broadly distributed, collection of cases. Consideration was given to include a wide distribution of active projects across the four NASA enterprises, representing many diverse technical areas, located at different NASA Centers, and involving project managers with educational backgrounds from many different technical disciplines. This diversity was necessarily tempered by the opportunity of the researcher to travel to the various Centers on business, and to include both the time and opportunity for interview sessions with the volunteer participants.

NUMBER OF CASES

The question of whether the number of cases used was sufficient was examined; data from the second five cases added little new to the findings of the first five cases. The first five interviews included the two female participants, one of the oldest participants, the participants with the highest and lowest ego-resiliency scores, the participant with the MBTI Feeling personality, and one Introvert. They also included participants with a wide range of educational backgrounds and project disciplines, and participants who were involved in a mixture of projects from two different NASA enterprises, managed at four different NASA Centers. All except one of the first five case participants were involved with early technology development for their project, and/or began early in the process as the project manager. The one who began latest as project manager was also assigned to a project completely outside his technical field. All of the first five were able to pick their key team members except one, who was assigned a deputy who caused problems for him.

The three longest interviews were with the two female and the one Myers-Briggs Type Indicator (MBTI) Feeling participant. The shortest of both the first set of five and second set of five interviews was with the oldest participant in each group. The one interview conducted using e-mail was in the second set of five cases, and that interview had the shortest transcript but the most precise interview data. This interview, however, lacked the richness of the personal experiences expressed in the face-to-face interviews because of the lack of opportunities to pursue interesting meanders from the core interview questions. Both of the female participants left their projects early for promotions to line management positions.

In a retrospective summary, the data from the second five interviews did not result in any new perspectives different from the first five for answering the research questions. How the project was established and structured, how the team was selected, and how the few rules and specific methods were used to manage the projects were all identified in the first five cases. However, the second five cases were valuable in adding clarity and support to the more subtle findings of the first five cases.

Literature Comparisons

As the process of determining meaningful conclusions evolved, and theory was developed from the findings

and analysis of the data, the literature was consulted for conflicting or corroborative findings. There is a paucity of literature conflicting with the findings, possibly because of either the lack of interest or difficulty in researching this area, as mentioned earlier. Some relevant corroboration does exist in the literature, however, especially as to the complexity of the project manger's job and what it requires in the way of personality, emotional maturity, and methods of completing the project. For example,

> Successful project managers meet their leadership challenges in large part through unraveling the complexity and uncertainties of their situations by focusing on key principles and actions. In the technical arena, it is especially true that most people who know how, end up working for those who know why (Caldwell and Posner, 1998).

The initial comparison is between the findings reported here and those identified from the various authors in the literature search shown in Table 2.1 (see Chapter 2). This comparison indicates that, while many desired characteristics for project managers, competent managers, integrators, leaders, and identifiers of emotional maturity fall under the demographic, personality, and ego-resiliency categories used in the study, some do not. Those that do not can be categorized as desired leadership and managerial characteristics. The following discussion contrasts the desired characteristics espoused by various authors from Table 2.1 with the findings of this study, and groups the remaining author-identified desirable characteristics into Leadership and Managerial competencies.

MBTI PERSONALITY CHARACTERISTICS

The combined personality characteristics listed in Table 2.1 support the identified personality profile of Extraversion, iNtuition, and Thinking for project managers identified as dominant in this study. Although they show no Introversion or Sensing preference, they do include substantial Feeling and Judging characteristics, with almost no Perceiving (Table 5.1).

EMOTIONAL MATURITY

The various characteristics described by the authors in Table 2.1 also show a distinct pattern of emotional maturity. Although the author's listing includes more terms than are contained in the definition of ego-resiliency, they can grouped into the broader definition of emotional maturity, defined as the capability for handling day-to-day situations (see Table 5.2).

OTHER CHARACTERISTICS

An additional set of characteristics from Table 2.1 identified by the various authors parallels some of the data found in this study. Major categories included as parallels are leadership, strength or toughness, moral and ethical values, and control (see Table 5.3).

A final set of characteristics that completes the list of remaining items from Table 2.1 fit into a category of managerial and technical competencies (see Table 5.4).

These characteristics describe in general terms the manager's role and what the individual brings to that role separate from demographics, personality, and emotional maturity described earlier. Many of these competencies were also self-described by the participants as desirable in a project manager (Table 4.13).

The major groupings include what can be considered some of the traditional descriptors of a manager, plus many desirable and/or necessary characteristics, including intellect, competence, skills-training, and work ethic.

SUMMARY OF COMPARISONS

In summary, the various characteristics identified by the authors in Table 2.1 as being desirable in project managers, competent managers, leaders, and integrators were found to a large degree in the NASA project manager participants in this study. The various authors' desirable personality characteristics include but go beyond the Myers-Briggs ENT type preference found for the managers of complex NASA projects. A noticeable preference for Feeling was identified in the authors' listing but was found in only one of the study's participants. Also, Introversion and Sensing are nearly absent in Table 5.1, while a Judgment preference strongly predominates over Perception.

The emotional maturity characteristics listed by the authors in Table 2.1 closely match those found for the project managers in this study. These could be interpreted, therefore, to be desirable in all NASA engineer and scientist managers, not just those managing complex projects. Similarly, the characteristics for leadership and managerial/technical competence closely fit those identified by the participants in this study as being important for project managers.

Relevant NASA and Literature Studies

In addition to the above comparison between this study's findings and those of the various authors in

TABLE 5.1 COMPARISON OF PERSONALITY CHARACTERISTICS

MBTI Preference	Identified Characteristics	
Extraversion	Extraversion Talkative Comfortable with people Ability to get along with people	High affiliation need People centered Interested in others
Introversion	(No preference identified by the various authors)	
INtuition	High need for achievement Sees how things fit together Clever Problem identifier Problem solver	Creative Initiative Imaginative Forward-looking
Sensing	(No preference identified by the various authors)	
Thinking	Entrepreneurial Logical thinker Systematic thinker Diagnostic use of concepts	Conceptualizer Diagnostic thinker Conceptual thinker Objective
Feeling	Remembers people Patient Inspiring Concerned with close relationships Team builder Sense of justice/fair-minded	Considerate Motivating Supportive Works well on a team Develops others
Judgment	Organized Take-charge attitude Decisive Results oriented Shows good judement	Planner & controller Single-minded purpose Achievement oriented Goal oriented
Perception	Perfection relevancy	Perceptual objectivity

TABLE 5.2 COMPARISON OF EMOTIONAL MATURITY CHARACTERISTICS

Ego-Resilience Characteristics		
Adaptability	**Flexibility**	
Emotional stability	Tolerant of others	
Confident	Accepts ideas from others	
Less need for approval	Understands others	
	Understands people's motives	
Self-knowledge	Can easily give approval	
Good self-image		
Positive regard for others	**Self-controlled/disciplined/calm**	
Understands self	Mature	Poised	Relaxed
Accurate self-assessment	Balanced	Disciplined	Humble
Personal scope & astuteness	Nondefensive		
Admits mistakes	Not sensitive to criticism		
Learns from mistakes			

TABLE 5.3. COMPARISON OF LEADERSHIP CHARACTERISTICS

Leadership Characteristics	
Leadership	**Strength/Toughness**
Adventurous	Capacity for resolving conflicts by confrontation
Spontaneous	High energy level
Enthusiastic	Ambitious
Assertive	Active
Persuasive	Forceful
Persistent	Aggressive
Courageous	Strong
Common sense	Stamina
Determined	
Independent	**Moral/Ethical**
Control	Honesty
Managing group process	Integrity
Socialized power	Straightforward
Unilateral power	Fair
	Loyal

TABLE 5.4 COMPARISON OF DESCRIBED COMPETENCIES

Managerial and Technical Competence	
Traditional	**Intellect**
Generalist	Intelligent
Communicator	Broad-minded
Integrator	
Mentor	**Work Ethic**
Influencer	Responsible/dependable
	Proactive/active
Competence	Ambitious
Specialized knowledge	Cooperative
Business orientation	Concerned with impact
Organizational astuteness	
Client/user orientation	**Skills/Training**
Efficiency orientation	Time manager
Systems orientation	Uses oral presentations
	Verbally fluent

Table 2.1, there are other relevant findings from previous NASA studies, and some that concern, in particular, MBTI preference findings from the literature. A NASA study of engineer and scientist managers identified characteristics of highly effective versus typical managers from these disciplines (Dreyfus, 1991). Two other NASA studies looked at project managers, but these studies were conducted more than two decades apart (Chapman, 1973; Leonard, Fambrough, and Boyatzis, 1995). One ongoing NASA study with partial findings is looking at project teams.

NASA ENGINEERS AND SCIENTISTS AS MANAGERS—DREYFUS

In a study of NASA engineers and scientists as managers conducted by Dreyfus (1991), highly effective managers were identified based on a combined rating by the participants' managers, peers, and subordinates. The findings share numerous parallel findings with this study.

Of the demographic data collected in comparison with this study, a contrast of the means presented in Table 5.5 shows a close relationship between the project

TABLE 5.5 DEMOGRAPHIC COMPARISONS

	Age	Education	Marital Status	Children	NASA Years
Dreyfus p.29	49.84	16.1	89%	3.26	24.11
This Study	50.2	17.6	90%	1.6	24.6
Difference	0.36	1.5	1.5	1.66	0.49

TABLE 5.6 DREYFUS MBTI MEAN STRENGTH COMPARISONS

	Dreyfus Study	This Study	Ratio
Extraversion	12.5	25.3	0.49
Sensing	12.5	52	0.41
Thinking	14.9	23.7	**0.62**
Judging	18.1	22.3	**0.81**

	Dreyfus Study	This Study	Ratio
Introversion	15	37.6	0.40
Intuition	12.3	29.3	0.41
Feeling	5.6	19	0.29
Perceiving	10.1	46	0.22

manager engineers and scientists in this study, and that of engineers and scientists in functional manager roles described by Dreyfus. This similarity of demographic findings lends credence that the participants of both studies derive from the same basic NASA engineer and scientist population.

In comparing the MBTI type preferences found in the Dreyfus study, both the highly effective and typical managers exhibited a slight preference for Extraversion, Sensing, Thinking, and Judging (ESTJ) compared with the predominance of ENTJ/P found for the project managers in this study. In addition, the reported MBTI mean numerical strength scores for the highly effective NASA engineer and scientist managers are noticeably lower than the MBTI mean scores for the participants of this study, as shown in Table 5.6. The mean values reported by Dreyfus were lower by more than half of this study's mean values, except for Thinking and Judging, which had reported values higher than half (see ratios in bold), but were still noticeably less for the NASA engineer and scientist managers than for the NASA engineer and scientist project managers.

These data indicate an MBTI preference of ESTJ for the more general population of NASA scientists and engineers who become managers. In addition, their mean MBTI numerical preference strengths are substantially less than for the engineer and scientist project managers of this study. These lower means for MBTI numerical strength indicate a less-pronounced set of personality characteristics for NASA engineer and scientist managers, in general, than for NASA managers of complex projects.

Among other characteristics exhibited by the highly efficient NASA engineer and scientist managers, they were high in self-confidence, pro-activity, adapting, setting and managing goals, and in managing group processes (helping and delegating). These findings compare closely with those of managers of complex NASA projects.

ADDITIONAL MBTI PREFERENCE COMPARISONS

In addition to the Table 2.1 and the Dreyfus study comparisons discussed above, other relevant research data provide comparison with MBTI preferences for populations of managers outside of NASA. Some of this evidence shows a commonality of TJ type preference among a large number of managers who participated in training at the Center for Creative Leadership from 1985 to 1993, as shown in the matrix of Table 5.7 (Fleenor, 1997). The fact that nearly 60 percent of the participants in this training were TJs who appear in the corners of the type matrix would seem to indicate that, in general, a majority of management types would be somewhat similar.

This "cornering" for TJ preference was indeed found to be true in another study of 361 managers (Sundstrom and Busby, 1997), with more than 70 percent of the participants' preferences in the TJ corners of the matrix (see Table 5.8).

Although the sample of ten NASA project managers from the current study is inadequate for meaningful comparison with the larger manager studies mentioned above, it is interesting to note that half (50 percent) of the ten NASA case project managers also fit into the TJ profile found in the larger studies. They did not, however, include the strong ESTJ preference found in these two studies and in the Dreyfus study. The remaining half of this study's participants were the four ENTPs and one ENFP (see Table 5.9).

Table 5.9 also shows that among the 16 possible types, all the NASA participants represent only 5 of the possible types. Also, except for the two ISTJs and one ENFP, the remaining seven participants are NTs, and all except one of these are ENTs.

The MBTI Guide to the Development and Use of the Myers-Briggs Type Indicator (Briggs Myers and McCaulley, 1993) provides additional data and interpretation of the characteristics of various groupings of type categories.

Among other information, this source of data includes some interesting trends in age- and gender-related data. These data show that the E preference decreases with increasing age faster than the I preference increases. Also, both the S and N preferences increase with increasing age, but S increases faster, and both T and F preferences increase at about the same rate.

The J preference increases with increasing age faster than the P preference decreases. Taken literally, one might therefore expect with older populations to find an MBTI preference with more IST/FJ, a scenario that contradicts the findings for project managers in this study. Also, with male versus female populations, social pressures tend to push men toward T and women toward F activities that may influence their preference scores if they answer the MBTI questions in a "socially acceptable manner" (Briggs Myers and McCaulley, 1993).

TABLE 5.7 PSYCHOLOGICAL TYPES IN MANAGEMENT TRAINING (n = 26,477)

ISTJ 18.2%	ISFJ	INFJ	INTJ 10.5%
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP	ENTP
ESTJ 16%	ESFJ	ENFJ	ENTJ 13.1%

TABLE 5.8 MANAGER TYPE IN A MANUFACTURING ORGANIZATION (n = 361)

ISTJ 30%	ISFJ	INFJ	INTJ 14%
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP	ENTP
ESTJ 18%	ESFJ	ENFJ	ENTJ 10%

TABLE 5.9 DISTRIBUTION OF TEN NASA PROJECT MANAGER TYPES

ISTJ 20%	ISFJ	INFJ	INTJ 10%
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP 10%	ENTP 40%
ESTJ	ESFJ	ENFJ	ENTJ 20%

TABLE 5.10 COMPOSITE MBTI DATA FOR SELECTED ENGINEERING FIELDS

Population Percentages	**E**	**I**	**S**	**N**	**T**	**F**	**J**	**P**
Engineering (all fields)	48	**52**	**53**	47	**64**	36	**60**	40
Electrical/ Electronic	37	**63**	**52**	48	**67**	33	**63**	37
Mechanical	47	**53**	**58**	42	**70**	30	**62**	38
Aeronautical/ Aerospace	**50**	**50**	43	**57**	41	**59**	**54**	46

The temptation when viewing these data, of course, is to want to decide before a project begins what kind of project manager a particular MBTI type will be.

The stated purpose of the MBTI however, is not to predict type, but it is primarily to be used by respondents to understand how they fit within their own world and how they might respond to other people of similar, or different, types. It is important to remember that in this research study the MBTI is used to help inform the study about just one characteristic of the individual project manager participant—his or her personality type.

However, the extensive data bank of MBTI types *does exist*, and does show MBTI preferences accumulated over many years for several populations. Data for the three engineering fields that represent a majority (eight) of the engineering project manager participants in this study are shown in Table 5.10 and compared with composite preferences found for all engineering fields.

The composite data in Table 5.10 (note the predominate preferences shown in bold for all engineering fields) seem to indicate that the majority of the participants in this study would be ISTJ. Similarly from these data, it may also seem reasonable to expect an ISTJ preference for the electrical/electronic and the mechanical engineers, and an E/INFJ preference for the aeronautical/aerospace engineers. The findings described earlier for the NASA engineer project manager participants, however, do not fit these engineering population preferences, except for the two ISTJs (see Table 5.11).

Neither of the two mechanical engineers in the study and only one of the four electrical/electronic engineer participants is an ISTJ. The participants do show several groupings, but are not a close match to the data from the population database. This disparity tends to indicate again the uniqueness of the individuals managing complex NASA projects compared to their professional counterparts.

TABLE 5.11 MBTI PREFERENCES FOR MANAGERS OF COMPLEX NASA PROJECTS

ISTJ (2)	ISFJ	INFJ	INTJ (1)
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP (1)	ENTP (4)
ESTJ	ESFJ	ENFJ	ENTJ (2)

NASA LEWIS STUDY OF PROJECT MANAGERS—LEONARD

A recent research study for the NASA Lewis Research Center (currently named Glenn Research Center) developed a model of performance competencies and behavior-specific skills and abilities of superior project managers. The purpose of this study was to "identify the skills and abilities necessary for [superior] project management" (Leonard, Fambrough, and Boyatzis, 1995). Although the purpose was somewhat different from that of the research reported here, many parallels are evident. An initial pool of all project managers was sorted into superior and average performers based on input from supervisors, peers, and subordinates of the participants. Major differences were identified between the superior and average performers.

> ...it is clear that superior project management requires more achievement oriented and action taking skills than quantitative and technical ability.

TABLE 5.12 LEONARD STUDY DEMOGRAPHICS COMPARISON

Source	Age (years)	Education (years)	Work Years	NASA Years	GS Level	Sample Size
Leonard Study (superior project managers)	44.4	17.2	24	21.3	13.8	n = 14
This Study (managers of complex projects)	50.2	17.6	28	24.6	14.8	n = 10
Difference	5.8	0.4	4	3.3	1.0	4

> This is an intuitive but not always obvious distinction. As project managers move from the highly technical and theoretical demands...to the larger domain of project management, achievement and outcome oriented skills become increasingly important (Leonard, Fambrough, and Boyatzis, 1995).

One specific comparison between the Leonard study and this research is seen in the demographic findings (Table 5.12). The demographics for the Leonard study participants show nearly equal mean values for participants with about the same amount of education, but they are younger, less experienced, and one grade level lower than participants in this study.

This result is not unexpected, however, because the Leonard-study participant pool included all project managers at Lewis rather than just those who were managing complex projects, as in this study. Additional overall comparisons with the Leonard study are shown in Table 5.13.

Three specific Superior outcomes presented in Table 5.13 that were identified by both the project managers and their bosses in the Leonard study include Efficiency Orientation, Planning, and Initiative. These are compared with findings from this study in Table 5.14.

STUDY OF NASA PROJECT MANAGERS—CHAPMAN

Another much earlier study of NASA project managers by Chapman (1973) identified findings not unlike the Leonard study.

The Chapman study was, for example, similar to the Leonard study in looking for superior versus average project managers. Although separated by more than two decades, some of the findings from the two studies indicate that the characteristics of project managers in NASA do not change much with time, and/or with advancing technology. Neither of the studies considered the complexity of the project being managed, and the participants came from a similar pool of engineers and scientists with two to three years of project management experience. The average age of the project managers in both of these studies was in the mid 40s, with 15 to 20 years of experience, and the managers were near the highest GS grade levels (although the Lewis participants were again a grade or two lower).

A contrast of the findings in Table 5.15 shows that although there are wide differences in the terminology used in the two studies, a case can be made that substantial similarities exist between the two. For example, the important functions of planning and attending to the project team are clearly identified in both studies. Similarly, important human skills are characterized in working with others and communicating, management skills are characterized in organizing effectively and efficiently, and conceptual skills are characterized in evaluating and understanding problems and what to do about them.

Technical skills are identified as unimportant in the Leonard study for superior project managers, but these skills are important for the average performers. Technical skills, therefore, do not appear separately for the superior performers because it was assumed that these skills were common within this group. The study found, however, that technical skills were used far less by superior performers in managing their projects than by the average performers, who used them extensively. A fundamental knowledge of the applications of technical skills for all project managers, however, is certainly implied in the Leonard study and matches the Chapman study findings.

The Chapman study concludes that the most important NASA project manager functions involve dealing with

1. the project team
2. control of critical factors in the project

TABLE 5.13 LEONARD-STUDY OVERALL COMPARISON

Identified Abilities	Behavior Indicators	Comparison to This Study's Findings
Goals & Action Efficiency Orientation	Expresses a concern with doing something better or accomplishing something unique	Minimum necessary to accomplish goal Few rules—No duplication of effort Simple decision-making Real-time communications Shields project from outside influences
Planning	Sets goals or objectives in measurable terms Outlines a series of actions toward achieving a goal	Early involvement Project formulation—Goal setting Establishes success factors No ambiguity
Initiative	Takes action different from anyone else or what others expect	Constant but thin oversight What-if risk analysis Problem finding/problem solving Takes action when no consensus
Analytic Reasoning Pattern Recognition	Identifies patterns to explain/interpret Reduces large amounts of information through previously unapplied concepts	Myers-Briggs NT personality type Working with less than complete data Pattern searching
People Management Group Management	Acts to promote commitment through friendly, personal contact	Clear role definition, little ambiguity Balances own strengths & weaknesses Deals with conflict quickly & firmly
Empathy	Accurately reads or interprets the moods, feelings, or behaviors of others	Not specifically identified, but implied in team relationship, especially with team-building activities
Persuasiveness	Attempts to convince others by anticipating reaction & developing appropriate communication Uses questions or other techniques explicitly to result in a feeling and acceptance of ownership of ideas, projects	Implied in having few key team members
Developing Others	Provides others with information, tools, resources, or opportunities Explicitly tells another that s/he can accomplish an objective and provides encouragement and support	Not specifically identified, but implied in team relationship and having a few key team members

It identifies the project manager as "the key man in the system [who] symbolizes the project team and represents its collective capacities" (Chapman, 1973). Qualities for selecting project managers include having

1. a strong technical background
2. the ability to build a cohesive team
3. demonstrated management capability

The most useful indicators for identifying project managers include

1. a past record of extraordinary achievement in managing technical projects
2. a well-developed sense of engineering judgment or "intuition"
3. a mature sense of risk-taking

NASA PROJECT TEAMS STUDY

A separate NASA study that is currently ongoing examines the characteristics of superior project teams and looks at project leader competencies (Hoffman, 1999).

Preliminary findings of this Teams study indicate that internal assessment of a project team's and project manager's performance correlates positively with external assessments by stakeholders, customers, and evaluators. Numerous early findings from the Teams study identify the importance of the project manager to the team in achieving the desired project outcome. Other characteristics identified for the best teams are also similar to findings from this study (see Table 5.16).

The Teams-study goals parallel those of both this research and that of the Leonard and earlier Chapman studies. All attempt, through empirical findings, to better define what it is that results in desired project outcomes. In developing a better understanding of NASA project management, the Superior Teams study focus is to identify superior project teams and, specifically, to build a descriptive model of their processes and characteristics. Although the Teams study focuses on the team itself and not just the project manager, the similarity of the findings strongly emphasizes the role of the project manager found in complex projects in this study.

1. There is almost total agreement that the role of the project manager determines how well projects develop as teams.
2. There is general agreement across projects about the characteristics that are associated with superior project teams.
3. There is general agreement across projects about the specific functions performed by project managers in developing the project team.
4. The competencies most frequently mentioned that should be the object of [project] management training programs are not technical.

SUMMARY OF STUDY COMPARISONS

From the above comparisons with other NASA and non-NASA studies, a pattern of project manager characteristics appears to transcend wide variations of different methods of looking at project management in NASA over both short and long periods of time. All of these research efforts, including the one undertaken for this study, are an attempt to better define what it is that results in desired project outcomes.

Limitations of the Research

Complex projects in other industries have similar characteristics to those found in NASA projects (Kerzner, 1995). However, the situational factors identified in the NASA projects studied may have an overriding influence on how project managers manage them. Most notably, the rigid constraint of project schedule may not be as significant in other industries, allowing more flexibility for the project manager to balance the project. The lack of the threat of project cancellation if expenditures exceed 15 percent of authorization may also reduce pressure on different types of projects that would not be cancelled regardless of cost overrun. Examples might be an important bridge, military requirement, tunnel, airport, or others (Archibald, 1976; Kerzner, 1995; Morris and Hough, 1987). Finally, the technical constraints in many areas of project management are different from those in NASA, where the whole world watches to see the success of another new adventure in science development or application—or watches the spectacular failure.

Considerations for Theory

Several constants in the findings appear to apply to a multitude of project management situations. One is the advantage gained by early involvement of the project manager. This early involvement allows project managers to influence and establish the project in

TABLE 5.14 LEONARD-STUDY MAJOR CHARACTERISTICS COMPARISON

Characteristics of Superior Project Managers	Superior Project Managers	Managers of Complex Projects
Efficiency Orientation	Doing things better or accomplishing something unique	Structuring project to personal strengths, clear role definition, few rules
Planning	Setting goals or objectives in measurable terms	Establishing project goal and success factors
Initiative	Taking action different from anyone else or the expectations of others	Using unique methods of managing, take-charge attitude

TABLE 5.15 CONTRASTING FINDINGS OVER MORE THAN TWO DECADES

Chapman Study	Leonard Study
Important Personal Characteristics Dominance (directs others, assumes responsibility, persuades) Intraception (understands & appreciates others' problems) Change (flexible, adapts to change) Order (organizes & plans without difficulty) Endurance (sticks to problem until solved) **Important Functions** Planning Project team **Important Personal Skills** Human skills Communication Works with others Managerial skills Organization Conceptual skills Decision-making Evaluation Technical skills Applications Fundamentals	**Important Personal Characteristics** Self-confidence (assured, forceful, capable) Persuasiveness Initiative (takes action different from others) Action orientation **Important Functions** Planning Group management **Important Personal Skills** Human skills Empathy (accurately interprets feelings or nonverbal behavior of others) Developing others (acts to promote commitment to team or goal) Written communications Managerial skills Efficiency orientation (doing things better, unique accomplishments) Conceptual skills Pattern recognition (identifies patterns or information not used by others) Systems thinking Technical skills Important for average performers

TABLE 5.16 SUPERIOR TEAMS-STUDY COMPARISON

Superior NASA Project Teams Characteristics	Parallels to NASA Managers of Complex Projects
Functional Work Structure - Know boundaries of their jobs & how jobs are connected - Know process for making changes affecting schedule, requirements, interfaces - Team focus keeps members' responsibilities from becoming rigid - Freedom to contact anyone within the project	**Project Structure** — Requirements & influence - Fit to the project manager's strengths & weaknesses, & compatible with preferred style for the project & situation Few Rules - No ambiguity about how the project will operate
Team Focus - Focus on what constitutes project success - Team revisits goals & schedules regularly - Clear about the difference between "nice to have" and "must have" - Clear understanding of project schedule	**Project Goal** - No ambiguity about what the project is to achieve - Identifies minimum necessary to meet project goal
Empowerment - Members can influence everything that goes on in the project - Influence is balanced with competence - Empowered members have freedom to and do influence through competence	**Project Team** - Synergy with project manager's strengths & weaknesses - Fewer members increases visibility - Tight control with no slack (extraneous roles) - Clear roles - No duplication of effort or responsibility
Communications - Commitment to honest & open communication - Members listen & learn from one another	**Communications** - Simple, real-time - Periodic meetings - Video, teleconferences, e-mail
Commitment - Problems addressed until they are solved - Refusal to fail - Put the project first & make personal sacrifices to ensure success	**Work Ethic — Commitment** - Project management requires a full-time commitment to hard work, and everything else comes second
Recognition, Reward, Celebration - Assume responsibility to recognize own successes & individual contributions - A portion of most meetings emphasizes achievements & contributions - Celebrations with outings & social events	**Team-Building** - Finding team-building opportunities (time in meetings to talk about fishing; traveling together; going out together & "hoisting a few;" names for team & individuals)

ways that take advantage of their strengths in establishing the project goal, in identifying the success factors, and in structuring the project. Other important factors include the opportunity to select key members of the project team, especially a deputy to offset self-known weaknesses, and establishment of a few rules for project operation.

A second and most likely more important consideration appears in the make-up of the project manager him/herself. The findings of this research appear to justify the position that certain personality characteristics add to the strength of a project manager, especially the characteristics of Extraversion, iNtuition, and Thinking.

These characteristics are based on preferences of wanting to work with others (Extraversion), being able to work with patterns in data rather than having complete information (iNtuition), and basing decisions on logic and objective analysis (Thinking).

The major strength identified in the participants, however, is in having high levels of emotional maturity or ego-resilience, expressed by self-understanding, self-confidence, self-control, flexibility, and adaptability. The centrality of the ego-resilience findings in the 3.0 to 4.0 range for all ER89 scores (except one of the participants) could be interpreted as spanning the definition from being ego-resilient, to the definition of being *appropriate controllers* (Block, 1950). The two end-scores for this group imply that there may be a tendency in these individuals toward *overcontrolling* (3.79, the highest score), or *undercontrolling* (2.86, the lowest score).

The need for project managers to have a strong ego is aptly stated by one of the current management authors:

> Project managers must have phenomenal ego involvement. They are faced with a most daunting and complex task. To succeed, they must be consumed by it; the best 'become' their projects...But project managers must [also] have no ego at all. They deal with numerous outsiders and insiders, whom they can hardly 'command' (Peters, 1992).

In a similar vein, Gardner (1997) discusses how an individual achieves this kind of resilience by describing the building blocks for excellence in people:

> ...humans come equipped...with strong proclivities to focus on certain experiences, to draw certain inferences, and to pass through certain cognitive, affective, and physiological stages.

This point of view is supported by Simonton (1994), who drew his conclusions from research into the ego strength of great leaders and great talents in many fields and across long spans of time, to identify what is involved in greatness.

> It is imperative that a strong ego unify the personality into a tenacious whole.

And finally, Cooper and Sawat (1996) describe how this strong ego presents itself in leadership:

> While there are many situations in which we can't control what is happening, we can always change how we are relating to it. This is adaptability, which in turn promotes resilience.

Project leaders certainly have ample opportunities to build upon whatever ego strength they bring to a particular project while they manage it.

DEVELOPMENT OF THEORY

Among the demographic characteristics identified in this study, maturity—in the sense of experience working on projects in some capacity—appears to be an advantage, but not essential if many of the other characteristics mentioned also exist. The findings of Gadeken (1997) corroborate this theory by indicating that the existence of a few essential characteristics is a greater indicator of performance in project management than long experience in the field by those not possessing those essential characteristics.

A question that underlies the findings of the research is why would someone want to become a project manager? Why, considering the difficult environment involved, the ambiguous authority provided, and the lack of a defined career after completion of a project, would anyone want to be a project manager in NASA? The reasons given by the participants were simple and clear, but they lacked a depth of understanding about how the project managers found themselves in the position of being project managers. They claimed that the challenge was rewarding, and even fun in some cases, but often countered with descriptions of the difficulties of the job, including the feelings of frustration they had for not being acknowledged for their contributions. The following comments from some of the participants describe their feelings.

COMMENTS FROM PARTICIPANTS

The ten participants were asked to comment on the discussion and model developed from the findings. Comments from those who responded follow.

One participant generally agreed with the findings about NASA project managers and addressed why someone would want to be a project manager: "Psychologically [it's] difficult to return to a technical niche after having seen the bigger picture and having developed a new technology from infancy to practical application."

Another participant came from a line management position prior to being a project manager. He addressed why someone would want to be a project manager: "The feeling of having accomplished something after years of hard work on a significant project offers greater rewards than the feeling I have had after years of hard work on mundane organizational matters." He added, "I agree with your profile of a project manager and think that many of those characteristics are needed. Emotional maturity and ego-resilience are necessary traits." In addressing the project management model developed from the study, this manager stated, "I also like your model. Things did not always work out [that way], but we did try to operate that way."

One participant found the results of the study "very interesting," and said the conclusions reached were "excellent." In discussing the project management model developed, this manager said it "hit the nail on the head." He also made a comment about his philosophy of managing the project team: "If you make it possible for the team to do their job in 40 hours a week, they'll work 60. If you make it a 60-hour-a-week job, they won't like it."

Although it is difficult to point to specifics in the study data to support the position, a different possibility for the participants becoming project managers that repeatedly presented itself is intriguing. With the ever-increasing availability of new knowledge, the participants' technical expertise had waned, despite going back to school for an advanced degree, and participants universally acknowledged that they were not technical experts on their project.

This does not imply any lack of technical competence, which the participants obviously must have exhibited to rise to the role of project manager. It may, however, indicate a high level of comfort with the mature level of technical competence that they have reached. As in most professions, many engineers and scientists achieve a point in their careers where they no longer need to prove their competence; it is well recognized by others as well as themselves. It may be that many of the new start-up and spin-off companies are created by such individuals, who often begin their new venture as a project to create a new or better product.

Project management also fits into an unusual organizational niche. Even in a technical organization such as NASA, the project manager is outside of both line management and research positions in the traditional organizational management structure. A possible theory evolving from these considerations is that the characteristics identified in this study do, however, fit what might otherwise be considered a misfit position in the traditional organizational structure. For example, multiple reporting paths are involved, and although the position is considered nonsupervisory in the traditional sense, managing people is an integral element of the job. The responsibility is great without commensurate authority, and rewards and recognition often go to others, while the assignment of responsibility for failure is singularly that of the project manager.

A corollary to the project manager's role may possibly be found in the ambiguity faced by a college president and described by Cohen and March (1996) as an organized anarchy: ambiguity of purpose, ambiguity of power, and ambiguity of experience. This closely describes the NASA project management environment involved in developing something unique, with no authority over those who will do it, with only general rules established for how to do it, and little helpful training available outside of experience on the job. The project manager must understand the requirements, define the goal, identify the success factors, structure the project, and create the project team and operating rules to get it done. In this ambiguous role they need the self-knowledge, self-confidence, and ego-resilience to do the job with little or no outside help, and in many cases substantial interference that they must, and may even desire, to confront.

In this unique position, NASA project managers survive on the boundary of the organization by creating their own organization and the rules for operating in it. They are comfortable in this role, supported in most cases by their Extraverted/iNtuitive/Thinking personalities that prefer an open, unstructured environment where they work with incomplete information and can apply their talents to challenging problems using logical and objective analysis. They control their project organization by developing very specific guidelines to meet the technical requirements, cost, and schedule demands. Rather than seeing their role as simply a difficult one, they use their technical understanding, experience, unique personality, and strong emotional maturity to achieve challenging – and often unbelievable – results. They see project management in NASA as an opportunity to do something they are well suited to, enjoy, and do well.

These individuals do not seem to be like those who strive to lead organizations such as Jack Welch, Thomas Watson, and other top performers in industry, but appear to be more like leaders of expeditions into unknown or uncharted areas. They are more like the modern equivalent of people like Lewis and Clark, Daniel Boone, and others who prefer to take on challenging projects because these opportunities suit their personal preferences while meeting their professional needs.

They do not do it for personal recognition or rewards; they do it because they are good at it, and have risen to a level of competence where they do not fit well, and perhaps are not comfortable and have no place in, more standard organizational roles.

Implications for Practice

Summarizing the research findings leads to two outcomes to consider as implications for practice. One is the profile of a project manager of complex projects that may fit well, whether in a NASA or other arenas with similar projects (see Table 5.17). A caveat is that all components of the profile may be necessary but not sufficient. Many more components than could be identified in this study are involved in managing complex projects.

A second outcome of this research is a framework for how these managers of complex projects construct their environment and manage their projects. Using this framework simplifies the unstructured environment and provides them with a boundary they can comfortably operate within. A visual depiction of the framework in Figure 5.1 shows a model bounded by a tough, flexible, but porous periphery. The project manager provides the toughness of the boundary as a protective shield to the project team. This shield resists outside influences that must first directly confront the project manager if they are to affect the project. The porosity of this boundary, however, allows technical information to flow freely across it to and from the project technical experts. Additional porous inner boundaries contain the project structure and rules, and enclose the processes for how the project operates. Communications about project activity flow freely across these inner boundaries but are limited to a single path through the outer boundary, which is controlled by the project manager. The day-to-day processes for communications, problem finding and solving, decision-making, and conflict resolution all reside nested within the innermost boundary.

TABLE 5.17 PROJECT MANAGER PROFILE

Characteristics	Components
Demographics	Mature Educated Experienced Competent
Personality	Extraverted iNtuitive Thinking
Emotional Maturity	Self-understanding Self-confident Flexibility Willingness to confront

Any model must be general enough to fit a large number of situations, yet be specific enough to be useful in a given situation. This model fits the findings of this study and may have potential for use in other project management arenas. Application of this model in other project management situations will help to identify its limitations and hopefully improve on it.

Implications for Future Research

The research results reported here, of course, represent only a small step in an incremental process of developing a useful understanding of the project manager, if indeed it is possible to do so. Follow-on studies may wish to consider additional research of complex projects to corroborate or disprove these findings. It seems reasonable to perform another study, or even to continuously study numerous similar current and future projects. A secondary but longer-term effort would be to review the characteristics of, and methods used by, project managers on projects that met all or most of their technical, cost, and schedule constraints. This has been done to some degree by others (Archibald, 1976; Chapman, 1973), but they focused on *how* the projects were managed, not *why* they were managed the way they were. A final consideration would be to incorporate some of the findings of this research into project management training, and project manager assignment processes, to test their validity and to add refinements. This could include opportunities for early involvement of project managers during project formulation, and for evaluation of the project managers doing project work as part of a career path to determine whether they have the characteristics and capabilities needed in managers of complex projects.

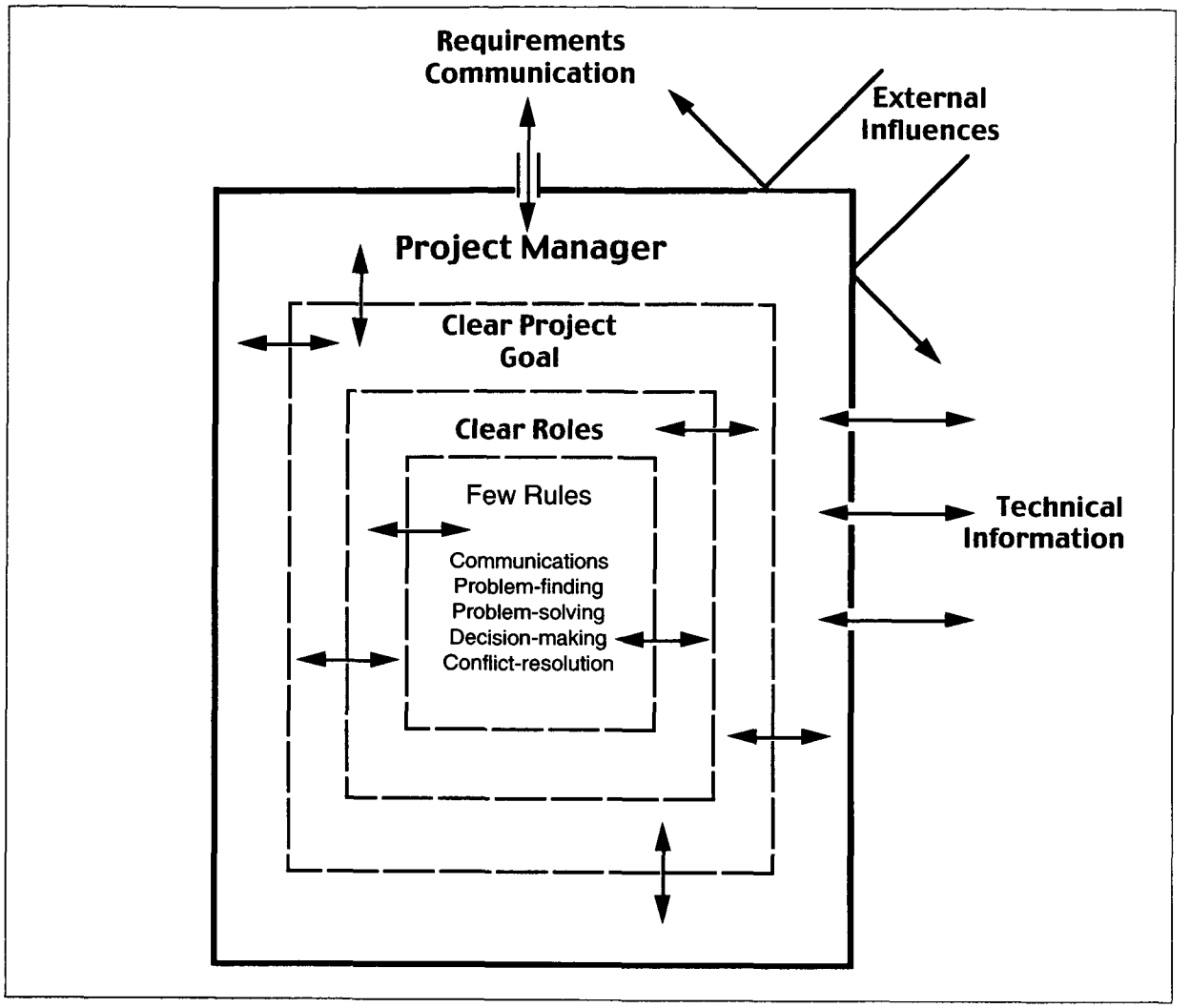

Figure 5.1 Project Management Model

Future research using similar limited, tightly defined cases such as examined in this study may further clarify these findings, and illuminate other information that may have been overlooked or did not exist in the NASA setting. Based on the similarity of the data found across the cases involved in this study, and the comparisons with other studies, it is expected that findings for cases outside of NASA but based on the same types of project complexity would replicate the results of this study.

Appendices

APPENDIX A: DEMOGRAPHIC SURVEY FORM

DEMOGRAPHIC SURVEY Date _____

YOUR NAME_____
CURRENT NASA INSTALLATION _____
MAILING ADDRESS_____
TELEPHONE NUMBER_____
FAX NUMBER _____
EMAIL ADDRESS _____

EDUCATION AND TRAINING
Undergraduate degree discipline _____
Year graduated _____ GPA _____
Highest degree earned _____
Graduate degree and discipline _____
Year graduated _____ GPA _____
Your formal Project Management training_____
Year of training _____
Type of training _____
(repeat as necessary)

PERSONAL DATA
Your gender_____M _____F
Your age _____Years
Number of times married _____
Number of children_____
Main hobby outside of work_____

PROFESSIONAL SERVICE
Your total years of civilian Federal Government service _____
Your years of professional work in Industry _____
Your years of supervisory experience _____
The Federal Government agencies you have worked in_____
Your years of military service _____
Your years at NASA _____
Your current grade level _____
Date of your last promotion_____
Years in your current position_____
Your current functional field (e.g., engineering, physics,...) _____

CURRENT OR LAST PROJECT MANAGED
Project title _____
Project dollar value $_____
Year project funded _____
Project length (from funding to scheduled completion) _____Years
Date you were selected for this project (after project was funded) _____
Date you were selected as this project's manager _____
OTHER PROJECT MANAGEMENT EXPERIENCE

APPENDIX B: INTERVIEW CONTACT GUIDE

INTERVIEW CONTACT SUMMARY GUIDE **Date** _____

Participant _____
Site _____
Interview Number _____
Initial Contact Date _____

I. MAIN ISSUES-THEMES NOTICEABLE IN THE INTERVIEW
II. SUMMARY INFORMATION OBTAINED (NOT) ON TARGET QUESTIONS
Question:
1. Tell me a little about the project **(Loosens up participant and develops background information)**
Title:
Dollar Value
Length (years)
Project Team **(Supplements data collected on the demographic form.)**

2. What were some difficulties encountered during or when the project was getting under way?
(delays, changes, failures, conflicts,...)
How were they solved? What actions were taken? By whom?
Why was that action chosen over another that might have been considered?
(Provides information about project manager behaviors involved in handling different situations and [hopefully] how and why that behavior occurred.)
Was the outcome(s) positive? **(Links behavior to outcomes and influence on project.)**
For you?
For the project?
For the project team?
For others?
How much did the outcome(s) contribute to the completion of the project?

3. Describe the approach used in managing the project.
How would you describe your (the project manager's) personality?
What is (was his/her) management style? (Authoritative, participative, etc.)
How do/did you (project manager) handle: conflict, problem solving, decision making, the outside environment (management, politics, etc.), communications...
(Provides information to triangulate with the MBTI survey results, the literature, and the general manager ability used in managing the project.)
How would you describe your (project manager's) temperament?
- In a normal project management situation?
- In a crisis situation?
- In an example situation?
(Provides information to triangulate with the ER89 survey results and compare with the literature.)

4. What is your personal definition of project success?
Do you feel you are (the project manager is) a successful project manager? Can you give me an example of why?
What do you see as differences between a successful and an effective project manager?
(Provides information to base a definition of project manager success and contrast with the literature.)

5. What are the most important measurements of project outcome?
Which is most important... second, third, ...?
If these added up to 100 percent, what percentage of importance would you assign to each?
(Provides a basis of project outcome to contrast with the literature.)

APPENDIX C: MATRIX CHECKLIST

STIMULI (Change arena & factor)	BEHAVIOR RESPONSES (Response to stimuli)	PROJECT OUTCOMES (Results of responses)
Schedule		
Cost		
Implementation Process		
Integration		
Technological Conceptual Technical Definition Risk		
Organizational Factors Political Support Structural Influence Administrative		
Outside Influence Political Ambiguity		
Project Team Communication Conflict Power Judgment Personality Education/Training Competence Skill Motivation Responsibility Growth Understanding Participation Empowerment		

APPENDIX D: MEMOING FORM

CASE _____

DATE _____

COMMENTS

KEY CONCEPTS

NOTE LOCATION

PATTERN CODES

APPENDIX E: REPRESENTATIVE CODE LIST

CODES	ASSOCIATED MEANINGS
BEHAV	Behavior
PMGR	Project Manager
PTEAM	Project Team
PSUCC	Project Success
PROB	Problem
CNFLT	Conflict
DLAY	Delay
CNCRN	Concern

APPENDIX F: INTERIM CASE SUMMARY FORMAT

Interim Case Summary Report

Case: _____

Date: _____

Table of Contents

A. Project
   1. Title
   2. Brief description of the project's objective and scope
   3. Project manager and other key players

B. Project Management Chronology
   1. Problems encountered during the project
   2. Actions taken in addressing the problems
   3. Outcome of the actions taken

C. Current Status of the Research Questions
   1. Status of data collection completion
   2. Status of data analysis completion
   3. Status of linking of qualitative and quantitative data
   4. Level of completion of this case
   5. Remaining actions required on the case

D. Causal Network
   1. Graphic relationship of the known variables and processes
   2. Narrative discussion of the graphic, describing ties to a priori theory, conceptual understandings, and missing elements

E. Brief Methodological Notes

   How the analysis was done, problems found, solutions, confidence in results, suggestions for next summary, etc.

APPENDIX G: DATA ACCOUNTING COLLECTION FORM

	INTERVIEW 1	INTERVIEW 2	INTERVIEW 3	INTERVIEW 4	INTERVIEW 5	DEMOGRAPHICS			MBTI			EGO RESILENCY		
PARTICIPANTS						SENT	RECEIVED	REVIEWED	SENT	RECEIVED	SCORED	SENT	RECEIVED	SCORED
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
MANAGERS														
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														

APPENDIX H: APPROVAL OF HUMAN RESEARCH FORM

NASA
Ames Research Center

APPROVAL OF HUMAN RESEARCH

Principal Investigator _____ Code _____ Date _____

J.O. Number _____ Ext. _____ Mail Stop _____

P.I. – Complete sections 1 and 2 only.

1. Study Title and Summary: Attach a 1-2 page description of research proposal (or full protocol) including: purpose, number/type subjects, subject hours, procedures, risks. (see AMI 7170.1)

2. ARC Investigators only: Complete 2a, 2b (Note: see reverse side for definitions of *Exemption* and *Minimal Risk*)

If PI, Branch and Division (below) all agree that the proposed research qualifies for exemption and does not impose greater then minimal risk, the work may proceed without further reference to AMI 7170.1. **However, an information copy of this form and summary should be sent to Human Research Coordinator (HRC), Mail Stop 218-2.** If one or more individuals disagree on exemption status, this form should be sent (after approval by Branch and Division) to HRC for Research Category assignment.

2a. Exemption Requested		2b. Minimal Risk		
yes*	no	yes	no	Date
☐	☐	☐	☐	_____ Principal Investigator _____
☐	☐	☐	☐	_____ Branch/Office Approval _____
☐	☐	☐	☐	_____ Division Approval _____

*Reason _____

3. **Human Research Category Assignment** (to be completed by the HRC and by the Medical Services Officer)

Category I	Category II	Date
☐	☐	_____ Human Research Coordinator _____
☐	☐	_____ Medical Services Officer _____

Assigned human research number: HR I _____ HR II _____

4. **Category I Research** requires approval by the Director (Determination, Findings and Authorization Form) after full HRIRB review and approval of:

_____ Organization Director Date _____

_____ Human Research Coordinator Date _____

_____ Legal Office Date _____

_____ Medical Services Officer Date _____

Category I Research requires 14 copies of all review materials: 11 copies for the HRIRB, plus retention copies for Division, Directorate and HRC.

(Continued on back)

5. An expedited review of HR II _____

Title: _____

_____

has been conducted and has been ☐ approved ☐ disapproved.

_____ Date _____
Chairman, HRIRB

HR Category II Research may proceed after approval by the Chairman, HRIRB and signature of the PI assuring conformance to AMI 7170.1.

_____ Date _____
Principal Investigator*

* After signing, retain copy and return origninal. **Research cannot begin until original is returned to HRIRB, Mail Stop 243-2.**

DEFINITIONS

The following definitions are abstracted from the "Federal Policy for the Protection of Human Subjects," also referred to as the "common rule," effective August 19, 1991. They have been added to NASA regulations at 14 CFR 1230.101 and 1230.1.2.

Human Research means any test, experiment, or other evaluative procedure involving a "living individual" about whom an investigator (whether professional or student) conducting the research, obtains:

(1) data through intervention or interaction with individual,
or,
(2) identifiable private information

Intervention includes both physical procedures by which data are gathered (for example, venipuncture) and manipulations of the subject or the subject's environment that are performed for research purposes.

Interaction includes communication or interpersonal contact between investigator and subject.

Minimal Risk means that the probability and magnitude of harm or discomfort anticipated in the research are not greater in

EXEMPTIONS

The following categories are exempt from this policy:

- Research involving the use of education tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview and of themselves then those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.

procedures or observations of public behavior, unless:

- Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if

(i) Information obtained is recorded in such a manner that human subjects can be identified, directly or through indentifiers linked to the subjects.

(ii) Any disclosures of human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

these sources are publicly available; or if the information is recorded by the investigator in such manner that subjects cannot be identified, directly or though indentifiers linked to the subjects.

APPENDIX I: MYERS-BRIGGS FORM G BOOKLET COVER

MYERS-BRIGGS
TYPE INDICATOR

FORM G BOOKLET

Katharine C. Briggs
Isabel Briggs Myers

DIRECTIONS

There are no "right" or "wrong" answers to these questions. Your answers will help show how you like to look at things and how you like to go about deciding things. Knowing your own preferences and learning about other people's can help you understand where your special strengths are, what kinds of work you might enjoy and be successful doing, and how people with different preferences can relate to each other and be valuable to society.

Read each question carefully and mark your answer on the separate answer sheet. *Make no marks on the question booklet.* Do not think too long about any question. If you cannot decide on a question, skip it but be careful that the *next* space you mark on the answer sheet has the same number as the question you are then answering.

Read the directions on your answer sheet, fill in your name and any other facts asked for and, unless you are told to stop at some point, work through until you have answered all the questions you can.

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APPENDIX J: EGO-RESILIENCE QUESTIONS

(ER89 questions shown in **bold**)
Please answer the following questions and indicate your choise of 1, 2, 3, or 4 by a check mark in the appropriate box.
1. Does not apply at all. 2. Applies slightly, if at all. 3. Applies somewhat. 4. Applies very strongly.

	1	2	3	4
1 I am very generous with my friends .				
2 Once I make up my mind I stick to it.				
3 I quickly get over and recover from being startled.				
4 I enjoy giving orders.				
5 I enjoy dealing with new and unusual situations.				
6 I like working in a group situation.				
7 I often ask for information from subordinates.				
8 I usually succeed in making a favorable impression on people.				
9 I feel comfortable being placed in a powerful position.				
10 No one else can know as much about the problem as I do.				
11 I enjoy trying new foods I have never tasted before.				
12 I feel the work group should determine its own work schedule.				
13 I feel groups give a deeper analysis of a problem.				
14 It is easier to make a decision in a group.				
15 I am regarded as a very energetic person.				
16 I have a strong ego.				
17 I like to take different paths to familiar places.				
18 A group is no better than its best member.				
19 I am more curious than most people.				
20 I like quick results.				
21 Most of the people I meet are likable.				
22 I don't like it when others disagree with me.				
23 I feel groups usually take up more time than they are worth.				
24 I usually think carefully about something before acting.				
25 I find it hard to accept others decisions.				
26 I like to do new and different things.				
27 I feel the work group should determine its own vacation schedule.				
28 My daily life is full of things that keep me interested.				
29 I usually make my decision before calling a staff meeting.				
30 I would be willing to describe myself as a pretty "strong" personality.				
31 I feel group decisions are the best.				
32 I get over my anger at someone reasonably quickly.				
33 I often use what subordinates have to say.				
34 Better decisions are made in group situations.				

APPENDIX K: MINICASES

Minicase 1

Case one involved the design and rebuilding of a major aeronautical research test facility. The original facility could no longer perform its function because of a major crack in the pressure shell. The driving force behind the project was a national need for aeronautical testing at the unique conditions the facility provided for NASA, the military, and for the U.S. industrial community. The project requirements included getting the new facility built and operating as quickly as possible to ensure continuing U.S. aircraft development superiority. To accomplish this task, accelerated funding approval was provided, also creating high visibility of the project from the Center Director all the way to Congress.

The final project included a budget of $110 million, with a scheduled project completion in seven years. Unique requirements of the project were to provide a computer-automated replacement for the previously manually operated facility, with a pressure shell capability that would be the highest in the world (6 atmospheres).

The project manager became involved early with the original investigation that discovered the crack, and then participated in establishing the requirements, estimating funding needed, and planning the schedule for the project. An engineer, but not a technical expert in aeronautical research, nor in civil engineering construction, the project manager was selected for this project based on his knowledge of the problem and previous success in managing other large and complex projects. Projects at this Center fall under the responsibility of one of the functional organizations.

In choosing the project team, the project manager selected the deputy and one other key person. The three of them then chose a core mix of other people from within the organization. Some of the team "had been sterling workers and stars, but [there were] also some who didn't shine in their careers." Willing to work with people who had "some difficulties," they ended up with the people requested and "some who may have been considered subpar actually, turned out to be quite over par." One member in particular had experienced "interaction problems previously," but was chosen because of his needed technical capabilities. One team member later left the project because he wanted to "stay technical," and one member was removed who could not handle the increasing responsibility of his role in the project.

A conflict encountered early in the project involved attempts at micro-management by the project manager's functional manager. Accepting a great risk to his own career, the project manager brought this concern to the Center Director, who removed the project from the functional organization and established the project as a new division reporting directly to the Center Director. This process ruined both the personal and business relationship between the project manager and his functional manager. For the project manager, "it was extremely tough." The relationship of the project team members and the functional organization also changed, but "they were grateful for the change."

An additional significant problem occurred during the project when bids for design and construction exceeded the project team's estimates. Described by the project manager as, "this is an important point in your career to have the bid come in 2 1/2 times greater, and to deal with it." The team had carefully estimated and had high confidence in their estimates, so were shocked at the difference amounts proposed in the bids. The project manager "had the deputy on a plane in an hour" to discuss the problem with industry representatives who had assisted in developing the estimates and, "was in the Center Director's office every day."

The problem turned out to be caused by the way the project was packaged as one contract, with the bidders adding considerable contingency to cover risk involved in the project in disciplines with which they were unfamiliar. A new formulation of the bid package by the team broke the job into separate contracts, actually adding work content. This scenario resulted in minimal schedule impact, "including having to go back to Headquarters and say phenomenal things!" The outcome was a team effort in "beating the revised estimate from that point on, and [resulted in] actually returning money to the government."

In describing the role and needs of managing a complex NASA project such as this one, the project manager stated, "from my standpoint I think project managers are generalists. That is essentially where I was on this job. I had to judge whether a structural engineering problem and solution were correct, and to probe and ask the questions that bring out 'softness' in the other disciplines. My management style is to give someone something so they know we are going to

stand together, but they also know they have a responsibility. It's sort of a very narrow line to walk in terms of managing somebody but also making them (sic) feel like they (sic) are part of what I view for the project. "

Minicase 2

Case 2 is a space project that was part of a larger project sharing the same launch vehicle and deployment activity. However, it involved the most complex portion of the total project. The requirements were generated as a set of specific standards to be met in terms of what the project was to accomplish, including the scope of activity, the data to be collected, and the expected operational life of the device. There was some concern about the project manager's ability to manage the project: "I can understand what they're telling me. I've had no experience in (this area) myself. My job is to have a deep enough understanding of the engineering to be intelligent about managing the people so I can tell if they're doing something really dumb." Managing this type of project required meeting a launch date years in advance of actual operations, but that could not change. The project approach, responsibilities, and accountabilities were developed by the project manager and involved significant up-front analysis, planning, and structuring of the project before project team selection could begin.

Projects at this Center begin with the assignment of a project manager, who then solicits staff from the functional organizations. The project manager describes this process as, "you go and negotiate to get the people you want and you scream and shout and carry on, just like any other negotiation." Able to obtain all the team members requested, the project manager organized the team in a unique way around the elements of the system they were to develop. Internal problems were handled by consensus as much as possible.

One major problem for the project manager of this project was an incorrect funding profile over the development life cycle of the project. Although the total funds to be provided were correct, the program manager "phased it so we were way short up front and had half our money after we'd delivered the hardware. My struggle for two years was to get the money rephased so we could meet a schedule. I was able to convince an outside review board that my reserve position was ridiculous, and convinced them to move money." Before achieving this solution, this problem had created other problems for the project manager, who had to rearrange expenditures and make schedule changes.

Another major problem faced by this project manager was attempts at micro-management from the manager of the larger project, who actually tried to both get the project manager removed and the project taken off the launch. Others wanted to change the hardware. The project manager "spent a lot of time fending off attacks and making sure the money flowed in."

The project manager left the project for a higher-level management job before the project was completed. The project exceeded all its established goals.

Minicase 3

Case 3 is a traditional NASA satellite project with multiple deliveries due for launch over multiple years. It is one of many projects that are part of the Earth Observing System (EOS), and was developed as a traditional NASA project in the $100 million or greater range prior to the faster/better/cheaper paradigm shift. The mission to be accomplished was a unique application of a technology to study atmospheric effects on Earth never previously attempted. The project manager was involved in the project from the beginning through the entire project life cycle to launch.

With the next-level manager's support, the project manager chose the deputy and a couple of the key people for the project team from the functional organizations, and "knew several key people well." The project manager professed not to be a technical expert: "I'm not an expert in any area—I got the degree and got the hell away from it. I'm not a technical expert, but I have a real (sic) good technical understanding—I have a good project management understanding of what needs to be done."

The major problem faced by this project manager was one of interference from managers in the functional organizations, and from the project manager's management chain. "Until the end of the project, there were a lot of management changes—everyone had a new thought on the project. I told them that if you want me to do [something], put it in writing, directing me to make the change. I always say, good idea, just write a short note as to what we ought to do, what

we're going to gain from it, what we need to get the project office to agree to, and I'll change it."

A seasoned project manager with experience on similar complex NASA projects and involvement throughout the entire project life cycle on this project, the project manager did not relate any major problems. The biggest problem was, "people keep changing and you spend a lot of time retelling what is happening on the project—they don't know the history; that has been frustrating [but] I feel very confident in the story and can defend it, I've been with it since the beginning." This project is now complete, and it met all its objectives for development, delivery, and operations in space within the cost and schedule constraints originally defined with the project Manager's involvement.

Minicase 4

Case 4 was an aeronautics flight project to evaluate design alternatives during flight as part of a joint NASA/industry new technology demonstration program. The goal of the project was to demonstrate the efficacy of the new technology in actual flight for comparison to computational fluid dynamics and wind tunnel test results. If proven feasible, the impact of the technology could significantly reduce aircraft drag at high speeds and result in the ability to fly longer because of lower fuel consumption, and/or reduce operating cost because less energy (fuel) would be needed to fly the aircraft. The scope of the project involved the combined efforts of three major aircraft manufacturers as well as the joint efforts and personnel involvement from two different NASA centers. The goal began as a technology demonstration effort four years before the team was formed for the flight research. During this period, numerous concepts were developed during Phase A. Designs were completed during Phase B, and the actual development work for the flight program was done in Phase C/D. The project manager entered the project late in the project life cycle: "in this project, Phase C/D was pretty much done." This scenario resulted in fewer project development problems for the project manager, but this statement is not meant to imply that the remaining project activity was not complex. The risks associated with flight test created a situation wherein even small potential problems could result in the aircraft crashing.

Having previously been a project manager in industry before coming to work for NASA, this project manager had encountered problems relevant to his approach to project problems. One such problem was inheriting a member for a project team: "I had never met anybody who was harder to get along with. That was really rough—I couldn't get rid of him—I finally did—we were able to shuffle him off, but it wasn't easy." Another example of a problem experienced by this project manager while in industry was a situation of not getting the people needed for the project: "I took very personally what happened and it's the closest I've ever come to a nervous breakdown. Since that happened, I've taken a different attitude. It's not as important as I made it out to be in the very first part of my project management career. It's good I had to go through one of these experiences where things weren't happening, and it was somewhat beyond my control, but it was not a fun situation to be in."

In managing projects, this project manager's self-described style is to "try to get myself technically educated. Often I've been put on a project where I'm not the technical expert—this project is a case in point. I try to get myself educated enough to understand all of the technical rationale for the decisions people are making. I tend to be pretty detailed with my schedules and tend to break things down fine enough so that I know when something's going wrong. At the beginning, I'm a completely trusting person as long as they do what they said they were going to do. I heard somebody use a phrase recently that I've keyed into, 'trust and verify.' I've just been burned too many times not to. I can't really trust too many people to do what they said they were going to do—on time, on schedule, and within budget."

The necessary data needed from the flight test program was obtained and the project completed as planned. Following the completion of this project, which was the largest project managed to date, this project manager chose to move out of project management and become involved with analysis work related to NASA research programs and projects.

Minicase 5

The project of Case 5 began after implementation of the faster/better/cheaper paradigm shift in NASA. It was a demonstration of how a needed capability in Earth orbit could be obtained outside the traditional NASA methodology using a NASA launch vehicle, satellite, and instruments. The project manager became involved soon after the decision to attempt this new scenario. The goal was to develop the NASA hardware so it could be launched on a commercial launch vehicle, using excess available power from the

commercial satellite for the NASA mission. There was both a unique technology to be developed for the proposed mission and a unique opportunity to participate in someone else's launch. The project challenges, although substantial, were clearly understood.

Experienced with project management in another government agency, and with program management experience in NASA, this project manager had been assigned to the project just one month previous to the interview. The project was in the Phase A stage at the time of the interview, and the manager was very enthusiastic: "We've been established as a project for about a month now, so we're still in that wonderful stage known as where a lot of things are happening at one time. We're trying to get schedules pulled together that are well integrated and complete and that match the budget profile."

The project team was formed prior to the project manager's selection, and collocation of everyone had occurred just a week earlier: "A large part of the team was already pulled together, but I know how the team came together and I wouldn't have done anything differently. The team we've got is a very good team—they're a young team but a good team." The project manager's academic training in engineering was not in the technical area of this project, but included additional training in project management and business administration, and some graduate work in the sciences. "The dimension that I bring to the team as value added is in the project management world and in the external communication. The other dimension I bring to it is many years of looking at the interdisciplinary aspects of the problem and being sure we're focusing."

A focus of the project manager's approach was networking to meet the needs of the project: "I think a project manager has got to have a sufficient amount of contacts to bring resources onto the problem that may not necessarily be within the project—who you know that knows somebody else, that you can leverage." Although the team worked together for over a year on the Phase A design effort, the necessary funding for future development was not approved because of budget pressures. Changes in the NASA management structure nullified the previous management's position, and the project was not accepted for continuation into Phase B. The project was then cancelled, and the project team members were reassigned. The project manager began working on proposals for future projects, hoping to be successful and again assume a project management role.

Minicase 6

The Case 6 project is an international cooperative project with two other countries that provide the launch vehicle and some of the science hardware. The project is managed at one Center with program management direction at another Center. Following approval to proceed into Phase C/D after four years of Phase B, the first of multiple hardware deliveries was scheduled for launch four years later. At the time of the interview, the first mission launch was one year away and the project was well into Phase C/D development.

The project manager was involved early in the project in the selection of the project team and in developing the project budget during Phase B: "You've got to do your homework on budgeting, which is really important. The two things I'm most proud of are the team members that I picked, and the budget that I did in Phase B, because I budgeted really well." This project manager's management style is one of hands-off. "My philosophy is that you select the very best people that you can get for your team and you delegate everything. That's basically what I've done and if things don't work out, I know when people are not performing—I get them replaced. I think of myself as a coach, not a manager."

Among the problems encountered by the project manager early in the project, one involved a nonperformance issue with the deputy of the project, who was an "inherited" team member. Given specific requirements in the form of deliverables to be met, and not meeting them, the deputy chose to retire early. Another team problem involved a person who was extremely technically capable, but confrontational; the project manager went to the functional manager to replace him and explained, "he's a great engineer but he just doesn't fit this team." This project met its delivery dates for launch, but the foreign partners were unable to meet their schedules, resulting in several delays of the planned launches. Budgeted costs were also met for the project.

Minicase 7

Case 7 involves a joint international, biological space project for the launch and evaluation of biomedical science effects on specimens carried on the flight. The program office was at NASA Headquarters and the project manager at one of the Centers, with visibility of the project all the way to the congressional level. In addition to the uniqueness of the science and interna-

tional cooperative agreement requirements, this was a first for U.S. participation in integrating the U.S. and foreign hardware into the launch vehicle, with the foreign partners participating in both the launch and science aspects of the project.

The project manager had been involved with earlier similar projects, and began as project manager during the development stages of the project (Phase A) and continued through the flight and recovery portion of the flight. This project manager's technical degree is in a nonscience area, and he has a history of project participation on similar biospace projects, but none as project manager: "I had to know enough about the program to be able to respond to challenges, or to queries. I've been around the project, and I was project engineer for the two flights before." The project team members also moved to this project from earlier projects and were familiar to the project manager. Although not directly chosen by him, they had participated together on previous projects: "I think the key for me on this project really was that I had people that I could delegate to who (sic) I could trust."

A major problem for this project was its high visibility: "I think probably the biggest [problem] was because this was [international], and because it was reviewed by Congress, this became a very public flight. We had major congressional scrutiny, and we had three separate reviews of the science. I'd say that was one of the major challenges...the whole political backdrop—how to deal with that. It required days, or weeks, or months of negotiation. You just had to do whatever would work at the time—flexibility [to] change when the situation requires it. There was also a problem during post-flight data collection: "when this recording didn't happen—it was one of our principal investigators and he didn't get the...recordings he needed—I went in and asked that it be redone. They were not happy with me at the time and, as it turned out, we never would get anything else. Actually, the project is still ongoing to some extent because the product is the science."

Minicase 8

Case 8 was a joint NASA/industry flight demonstration project to test the flight worthiness of individual aeronautics technology advances developed over many years. The unique aspects of the project included never-before-flight-tested aspects of a radical aircraft design concept that, if proven in flight test, could change the very basics of aircraft design. The project had been completed at the time of the interview.

This was the first project that the project manager, an engineer trained in a related field with previous participation on projects as a member of a project team, had managed. As part of the earlier technology development, the project manager was on the team that defined the flight requirements, and was involved throughout the flight test program with continuous involvement from Pre-Phase A development through Phase E, flight operations.

The project manager chose all the project team members except for the deputy. The project manager did not play a technical role on the project: "I didn't perform any analysis per se, but when a decision had to be made, it was made based on technical information. I had a breadth of knowledge of the other technologies and was asked to become the project manager."

A significant problem for the project occurred during a flight test when communications contact with the aircraft was lost; this situation could have proven disastrous: "It was the most gut-wrenching experience all of us had on the program—everyone was just sweating bullets." The cause of the failure was difficult to diagnose. "It was a sneaky little fail. It was [in] an old piece of equipment and was very hard to find because of the intermittent nature [of the failure]." A feature that had been put into the earlier design saved the flight: "It was the thinking of many years prior, to include that particular feature that saved the aircraft."

Because of the sensitive nature of the project, it was limited in access to only those closely involved, and, therefore, did not suffer from micro-management. "We didn't have to have n+1 reviews all the time, and the limited visibility gave us the ability to keep people out of our shorts. The greatest thing we did was having a standalone facility—we did everything in one facility, and that really made our turnaround time for modifications and software a lot faster."

"This (project) was a local high point in my career—things can't work out much better than they did on this project. You really feel like you've accomplished something when you start with basic constituent technologies and end up with a validated system that demonstrates a new capability." After completion of

this project, the project manager was selected to manage another project.

Minicase 9

The Case 9 project is an international cooperative biological-research project to evaluate numerous effects of spaceflight on living specimens. Its uniqueness derives from the research objectives not having been previously performed in space, and the unique hardware necessary to accomplish these objectives. The scientists originally defined the requirements, and the project ensured that these were translated correctly into engineering requirements to build the hardware to.

Located at a different center than the program manager, the project manager began on the project several years ago in Phase B, and the project was in Phase C/D at the time of the interview. The project manager, therefore, "inherited" the existing project team, and was also affected by a major reorganization that put some people on the project team who did not fit well. Some of these members left of their own volition and of others the project manager said, "I sort of told their supervisor they weren't doing me any good, and let them take care of it." Having a technical degree in a related field and previous experience with spaceflight projects, the project manager was "not a technical expert in anything, but [I] understand the basic principles and reasoning to ask questions and understand if they make sense. The name of the game is the stuff has got to work when you fly it."

A major problem for the project manager was to get approval for Phase C/D—it was cancelled twice just before it was to be approved. This setback, of course, delayed the project and was terribly upsetting for the project team: "You've got this goal out there, and you're going to build a bunch of hardware—and it damm well is going to work when you get it built. It's terribly upsetting to your life, but you say ok, I'm going to figure out how to get it done, and you go ahead."

Another later problem involved a proposed budget cut of more than 50 percent one year, with the potential to devastate the project schedule and significantly impact the overall cost. The project manager's frustration was overwhelming: "I yelled over the phone because I really lost my cool. We went and defended all the cuts in various areas point-by-point and when we got done they only cut us 15 percent, so we put up a pretty good defense. You have to be willing to stand up to something like that and say, no guys, you're not right—it won't work and this is why. You have to have good logic. I don't have any problem standing up to anybody if I'm really convinced I am right." At the time of the interview, the project was continuing to experience out-year budget cuts and related slips in the schedule.

Minicase 10

The Case 10 project included development of a launch vehicle launch operations profile for a major space mission. The project manager from one NASA Center supported the main-mission hardware development effort at another Center, with the actual launch services provided by a third Center. The mission operations stage of the project, Phase E, was under way at the time of the interview.

The uniqueness of the project involved special launch requirements not previously dealt with. The project involved participation with other government agencies and a support contractor for launch services, plus managing the mission-peculiar hardware modifications and independent verification and validation of the contractor supporting the project manager.

The project manager was assigned two years after the project began, in Phase B, with the launch scheduled for three years later. The project was already well established at the time the project manager came on board: "I did not get to pick the team except for one individual who I worked with closely; he served as my backup and primarily as our lead engineer." This project manager was in a line-management role when selected for this project: "I did not have the technical knowledge to make all the decisions by myself. Putting together the right information to make the right decision in the many complex technical issues we had was very difficult. I try to remain active, enthusiastic, and focus on the task at hand, and to be respectful of management's responsibility and authority—friendly and courteous."

A major problem faced by the project manager was that a high-risk arrangement already established used aircraft telemetry support for the launch. Any unavailability of the aircraft caused by problems or weather would jeopardize launch: "In this mission, schedule was of the essence. We had a narrow window to make the launch or risk a tremendous cost increase and mission delays. Schedule drove most of the deci-

sions." The solution developed by the project manager involved changing the basic launch telemetry paradigm to an existing satellite system that could "provide, theoretically, all the coverage required for any of our various launch azimuths, and for any launch on any day of the opportunity. We looked at the technical requirements and, very importantly, we did a risk assessment—including a gut-feel assessment. We presented the results, and obtained buy-in to proceed with the required design and development activity.

The project met all of its technical and schedule requirements, and returned funding back to the government at the end. The only problem during launch was a human error at one of the ground stations, but no data was lost due to (sic) the use of the satellite system." The project manager was subsequently promoted into a higher management position at his Center, and was recognized for exceptional service on the project: "I have been given a very meaningful job."

APPENDIX L: SPECIFIC PROBLEMS ADDRESSED

Project Stimuli	Project Manager Response	Why that Action?	Outcome	Rationale	Supporting Data
Funding/Cost Problems					
1-Bids were 21/2 times project estimates	Sent deputy immediately on a plane to discuss bids with proposers & identify problem	Deputy was the technical expert. Project manager had high confidence in team's estimates & needed to understand problem	Restructured bid request, succeeded in obtaining additional funding & met original project schedule	Self-confidence to admit original error and to accept risk of requesting additional funding	High ego-resilience (3.64) ENTJ with strong Thinking and Judging Intelligent— high grade point averages Early involvement on project & picked team
2-Phasing of funding would not allow completing project on schedule	Project manager used personal influence to convene an outside review board	Local management and program office repeatedly unresponsive to requests for help	Successfully got funds rephased	Self-confidence and willingness to risk career advancement	Ego-resilient (3.28) ENTP - strong Intuition and Perceiving Mature (56 years) & experienced (32 years) Early involvement on project & picked team
6- Phase B estimates were unrealistic & had insufficient contingency to meet project goals	Changed project scope to meet goals & increased project cost estimate to meet new goals	Risked project cancellation rather than accept inadequately scoped and funded project	Project cancelled for lack of available funding	Self confidence and awareness that project requirements could not be accomplished without changes	Ego-resilient (3.43) ENTJ — strong Intuition Not involved early on project Did not pick project team
7-Hq person made extra work for project manager	Project manager maintained a file of notes of difficulties	Anticipation there would be a big shoot-out with that person	The problem person retired and was not replaced	Confident but wanted supporting information to back up position	Ego-resilient (3.43) ENFP — strong Extravert, Intuition, and Perceiving Early involvement on project and picked team
10-Budget cuts	Refused to accept and fought back	Knew it was not right to cut so much — project may have died because of inability to meet goals	Reduced a 60 percent budget cut to a 15 percent cut	Self confidence in project knowledge plus experience and passion for project	Lower ego-resilience (3.04) ISTJ — strong Introvert & Sensing Mature (63) with long experience on projects Assigned as project manager after project was ongoing

Project Stimuli	Project Manager Response	Why that Action?	Outcome	Rationale	Supporting Data
Micro-Management Problems					
1-Attempts by manager to control project	1-Sought assistance from Center Director	Center Director was next level of management above the problem.	Center Director created a new, temporary Division for the project with the project manager as Division Chief. (This method now standard for large projects at this Center)	Confidence and willingness to fight for what is right and say what is really going on to stimulate action	High ego-resilience (3.64) ENTJ with strong Thinking and Judging Intelligent — high grade point averages Early involvement on project & picked team
2-Manager wanted to cancel project and/or replace project manager	Refused to quit and fought all attempts	Recognized need to have to " go it alone" without management support	Project manager stayed on project until near the end when promoted to a high-level position at Center	Willingness to be fired if necessary	Ego-resilient (3.28) ENTP — strong Intuition and Perceiving Mature (56 year) & experienced (32 years) Early involvement on project & picked team
3-Attempts to make changes in project	Refused to accept changes without a written request and agreement to pay additional costs incurred	Placed responsibility on the proposer of change	Requests withdrawn and project met goals without changes	Strong ego-resilience and recognition of role as project manager	Very strong ego-resilience (3.79) ENTP — strong Extravert & Thinking Mature (61) and experienced on projects Early involvement on project & picked team
7-Attempts to influence project team over the project manager	Confronted and went toe-to-toe with them	Accepted risk to personal career and replacement as project manager	Interference stopped and project completed without incident	Self-confidence and desire to protect project and team from outside influence	Ego-resilient (3.43) ENFP — strong Extravert, Intuition and Perceiving Mature (55) & experienced on projects Early involvement on project and picked team
Risk					
11- Project plan looked high risk and cost-prohibitive	Initiated study to validate " gut-feel" risk assessment that showed less risk for alternative at about same cost	Understood that the risk was real and needed support to argue for the change	Sold project change to HQ with significantly reduced risk	Confidence and conviction that decision was correct	Ego-resilient (3.14) ENTJ — strong Intuition Mature (54) and experienced in the project area but first time on a project Only picked Deputy on team

Project Stimuli	Project Manager Response	Why that Action?	Outcome	Rationale	Supporting Data
Personnel					
7-Problems with non-performing Deputy assigned without project manager' s approval	Forced retirement of Deputy because of nonperformance	Understood impact of nonperformance of Deputy on rest of team	Appointed project team member as Deputy	Willing to do whatever was necessary to get Deputy to perform or leave the project	Ego-resilient (3.43) ENFP — strong Extravert, Intuition, and Perceiving Mature (55) & experienced on projects Early involvement on project and picked team
9-Problems with Deputy assigned at a grade level higher than the project manager	Project manager worked with Deputy to identify source of problems & mitigated them	Did not know about the grade imbalance until later but understood the value of the Deputy to the project	Project completed and met all goals	Emotional maturity of first time project manager provided capability to understand and deal effectively with problem	Ego-Resilient (3.43) ENTP — strong Perceiving Young (36) and first-time project manager Early involvement in project and picked team, except Deputy
Technical					
4-Project manager came from a different technical background	Educated self in the technical areas needed to understand and be able to manage the project	Did not have confidence to trust that others on the team would do the right thing	Project met all goals	Confidence in self to learn necessary technical issues and to manage project	Weak ego-resilience (2.86) ISTJ — strong Introvert, very strong Sensing and Judging Long-time project manager, also in industry Picked key team members
International					
8-Launch problem attributed to project design problem	Project manager refused to accept problem existed and requested launch anyway	Knowledge, emotional maturity, and confidence in project hardware and team	Project launched on schedule and met all goals	Understood project well enough to accept risk involved	Ego-resilient (3.29) INTJ — no strong scores Mature (55) with long experience on similar projects but first-time project manager Early involvement in project and picked team

REFERENCES

Ackoff, R. L.: Redesigning the Future. A systems approach to Societal Problems. John Wiley & Sons, New York, 1974.

Anderson, S. D.: Project Quality and Project Managers. International J. of Project Management, vol. 10, no. 3, 1992, pp. 138–144.

Archibald, R. D.: Managing High-Technology Programs and Projects. John Wiley & Sons, New York, 1976.

Argyris, C.; and Schon, D. A.: Theory in Practice: Increasing Professional Effectiveness. Jossey-Bass, San Francisco, 1974.

Barnard, C. I.: The Economy of Incentives. In Classics of Organization Theory, 4th ed. J. M. Shafritz and J. S. Ott, eds., Wadsworth Publishing, Belmont, Calif., 1996.

Bertalanffy, L. V.: General System Theory: Foundations, Development, Applications. G. Braziller, New York, 1972.

Bilstein, R. E.: Orders of Magnitude: A History of the NACA and NASA, 1915–1990. NASA SP-4406, 1989.

Block, J.: An Experimental Investigation of the Construct of Ego-Control. Unpublished doctoral dissertation, Stanford University, Calif., 1950.

Block, J.; and Kremen, A. M.: IQ and Ego-Resiliency: Conceptual and Empirical Connections and Separateness. J. of Personality and Social Psychology, vol. 70, no. 2, 1996.

Blumenthal, R. A.: Winners and Losers: Types that Found Businesses and that Succeed or Fail in Their Businesses. In Proceedings from the Meyers-Briggs Type Indicator and Leadership: An International Research Conference. C. Fitzgerald ed., University of Maryland, College Park, Md., 1994.

Boyatzis, R. E.: The Competent Manager: A Model for Effective Performance. John Wiley & Sons, New York, 1982.

Bray, D. W.; and Howard, A.: The AT&T Longitudinal Studies of Managers. In Longitudinal Studies of Adult Development, K. W. Schaie, ed., The Guilford Press, London, 1983.

Caldwell, D. F.; and Posner, B. Z.: Project Leadership. In The Project Management Institute: Project Management Handbook, Jeffery K. Pinto, ed., Jossey Bass, San Francisco, 1998.

Center for Project Management Provides Software Development Process. PM Network, July 1996.

Chapman, R. L.: Project Management in NASA: The System and the Men. NASA SP-324, 1973.

Cleland, D. I.; and Kerzner, H.: A Project Management Dictionary of Terms. Van Nostrand Reinhold, New York, 1985.

Cohen, M. D. and March, J. G.: Leadership in an Organized Anarchy. In Classics of Organization Theory, 4th ed. Jay M. Shafritz and J. Steven Ott, eds., Wadsworth Publishing Co., Belmont, Calif., 1996.

Cooper, R. K.; and Sawaf, A.: Executive EQ: Emotional Intelligence in Leadership and Organization. Grosset/Putnam, New York, 1997.

Craig, D. L.; Craig, C. H.; and Slight, C. C.: Type Preferences of Decision Makers: Corporate and Clinical. J. of Psychological Type, vol. 16, 1988, pp. 33-37.

Dinsmore, P. C.: Human Factors in Project Management. American Management Association (AMACOM), New York, 1990.

Dreyfus, C. R.: Scientists and Engineers as Effective Managers: A Study of the Development of Interpersonal Abilities. Unpublished doctoral dissertation, Case Western Reserve University, Cleveland, Ohio, 1991.

Drucker, P. F.: Management: Tasks, Responsibilities, Practices. Harper & Row, New York, 1973.

Eisenhardt, K. M.: Making Fast Strategic Decisions in High Velocity Environments. Academy of Management J., vol. 32, no. 5, 1989a.

Eisenhardt, K. M.: Building Theories from Case Study Research. Academy of Management Review, vol. 14, no. 4, 1989b.

Eisenhardt, K. M.; and Tabrizi, B. N.: Accelerating Adaptive Processes: Product Innovation in the Global Computer Industry. Administrative Science Quarterly, vol. 40, 1995, p. 84–110.

Fayol, H.: General Principles of Management. In Classics of Organization Theory, 4th ed., J. M. Shafritz and J. S. Ott, eds., Belmont, Calif., Wadsworth Publishing, 1996.

Fleenor, J. W.: The Relationship Between the MBTI and Measures of Personality and Performance in Management Groups. In Developing Leaders, C. Fitzgerald and L. R. Kirby, eds., Davies-Black, Palo Alto, Calif., 1997.

French, J. R. P., Jr.; and Raven, B.: The Bases of Social Power. In Classics of Organization Theory, 4th ed., J. M. Shafritz and J. S. Ott, eds., Wadsworth Publishing. Belmont, Calif., 1996.

Furnham, A.: Personality at Work: The Role of Individual Differences in the Workplace. Routledge, New York, 1994.

Gaddis P. O.: The Project Manager, Harvard Business Review, May-June, 1959.

Gadeken, O. C.: Project Managers as Leaders, Army R&DA, Jan.-Feb., 1997.

Gardner, J.: The Leader Himself. American Management Association (AMACOM), New York, 1972.

Gardner, H.: Extraordinary Minds. Basic Books, Harper Collins, Inc., New York, 1997.

Goleman, D.: Emotional Intelligence. Bantam Books, New York, 1995.

Goleman, D.: Success Secret: A High Emotional IQ. Fortune Magazine, Oct. 26, 1998.

Graham, R. J.: Project Management: As if People Mattered. Primavera Press, Bala Cynwyd, Penn., 1989.

Haley, U. C. V.: The MBTI and Decision-Making Styles: Identifying and Managing Cognitive Trials in Strategic Decision Making. In Developing Leaders, C. Fitzgerald and L. R. Kirby, eds., Davies-Black, Palo Alto, Calif., 1997.

Hersey, P.; and Blanchard, K. H.: Management of Organizational Behavior, 4th ed. Prentice Hall, Englewood Cliffs, New Jersey, 1982.

Herzberg, F.: One More Time: How Do You Motivate Employees? In Classic Readings in Organizational Behavior, 2nd ed. J. Steven Ott, ed., Wadsworth, Belmont, Calif., 1968.

Herzberg, F.; Mausner, B.; and Snyderman, B.: The Motivation to Work. In Human Factors in Project Management. P. C. Dinsmore, ed., American Management Association, New York, 1984.

Hirsh, S. K.; and Kummerow, J. M.: Introduction to Type in Organizations, 2nd ed. Consulting Psychologists Press, Palo Alto, Calif., 1987.

Hoffman, E. J.: Project Teams Study Presentation. National Aeronautics and Space Administration, Washington D.C., 1999.

Holstein, J. A.; and Gubrium, J. F.: The Active Interview. Sage Publications, Thousand Oaks, Calif., 1995.

Iansiti, M.: Real-World R&D: Jumping the Product Innovation Gap, Harvard Business Review, May–June, 1993.

Jung, C. J.: In The Portable Jung, Introduction by Joseph Campbell. Viking Press, New York, 1971.

Kerzner, H.: Project Management: A Systems Approach to Planning, Scheduling and Controlling. 3rd ed. Van Nostrand, New York, 1989.

Kerzner, H. Project Management. Van Nostrand, New York, 1995.

Kezbom, D. S.: Team-Based Organizations and the Changing Role of the Project Manager. AACE Transactions, 1994.

Kezbom, D. S.; Schilling, D. L.; and Edward, K. A.: Dynamic Project Management: A Practical Guide for Managers and Engineers. John Wiley & Sons, New York, 1989.

Kirby, L. K.: Psychological Type and the Myers-Brigg Indicator. In Developing Leaders, Catherine Fitzgerald and Linda Kirby, eds. Davies-Black Publishing, Palo Alto, Calif., 1997.

Kotter, J. P.: A Force for Change: How Leadership Differs from Management. The Free Press, London, 1990.

Kouzes, J. M.; and Posner, B. Z.: Credibility: How Leaders Gain It and Lose It, Why People Demand It. Jossey-Bass, San Francisco, 1993.

Lawrence, P. R.; and Lorsch, J. W.: New Management Job: The Integrator. Harvard Business Review, Nov-Dec., 1967.

Leonard, D.; Fambrough, M.; and Boyatzis, R.: Project Management at NASA's Lewis Research Center: Identifying a Model of Superior Performance. (NASA Grant: NCC-3-90, LSN: 10414.) National Aeronautics and Space Administration, Washington, D.C., 1995.

Levin, R. I.; and Kirkpatrick, C. A.: Planning and control with PERT/CPM. McGraw-Hill, New York, 1966.

Levine, A. S.: Managing NASA in the Apollo Era. NASA SP-4102, 1982.

Loweree, J. H.: The Superior Project Manager. In Project Management: A Reference for Professionals. R. L. Kimmons and J. H. Loweree, eds., Marcel Dekker, Inc., New York, 1990.

Marshall, C.; and Rossman, G. B.: Designing Qualitative Research. Sage Publications, Inc., Thousand Oaks, Calif., 1995.

Maslow, A. H.: A Theory of Human Motivation. In Classics of Organization Theory, 4th ed. J. M. Shafritz and J. S. Ott, eds., Wadsworth Publishing, Belmont, Calif., 1996.

McCaulley, M. H.: The Myers-Briggs Type Indicator and Leadership. In Measures of leadership. K. E. Clark and M. B. Clark, eds., Leadership Library of America, West Orange, N.J., 1990.

McGregor, D. M.: The Human Side of Enterprise. In Developing Leaders. C. Fitzgerald and L. R. Kirby, eds., Davies-Black, Palo Alto, Calif., 1957.

Myers-Briggs, I.; and McCaulley, M. H.: A Guide to the Development and Use of the Myers-Briggs Type Indicator. Consulting Psychologists Press, Palo Alto, Calif., 1985.

Myers, I. B.; and Meyers, P. B.: Gifts Differing: Understanding Personality Type. Davies-Black, Palo Alto Calif., 1980.

Miles, M. B.; and Huberman, A.: Qualitative Data Analysis: An Expanded Sourcebook. Sage Publications, Inc., Thousand Oaks Calif., 1994.

Miller, L. M.: Behavior Management. In Human Factors in Project Management. P.C. Dinsmore, ed., American Management Association, John Wiley & Sons, New York, 1978.

Morris, P. W. G.; and Hough, G. H.: The Anatomy of Major Projects: A Study of the Reality of Project Management. John Wiley & Sons, New York, 1987.

Murphy, D. C.; Baker, B. N.; and Fisher, D.: Determinants of Project Success. NASA CR-139407, N74-30392, Boston College School of Management, Chestnut Hill, Mass., 1974.

Patterson, M. L.: Accelerating Innovation: Improving the Process of Product Development. Van Nostrand Reinhold, New York, 1993.

Peters, T. J.: (1992). Liberation Management: Necessary Disorganization for the Nanosecond Nineties. A. A. Knopf, New York, 1992.

Roman, D. D.: Managing Projects: A Systems Approach. Elsevier, New York, 1986.

Salovey P.; and Mayer J. D.: Emotional Intelligence. J. of Imagination, Cognition, and Personality, vol. 9, no. 3, 1990.

Sayles, L. R.; and Chandler, M. K.: Managing Large Systems: Organizations for the Future. Harper & Row, New York, 1971.

Shtub, A.; Bard, J. F.; and Globerson, S.: Project Management: Engineering, Technology and Implementation. Prentice Hall, Englewood Cliffs, N.J., 1994.

Simonton, D. K.: Greatness: Who Makes History and Why. The Guilford Press, New York, 1994.

Slevin, D. P.; and Pinto, J. K.: Leadership, Motivation, and the Project Manager. In Handbook of Project Management, D. I. Cleveland and W. R. King, eds., Van Nostrand Reinhold, New York, 1988.

Sundstrom, E.; and Busby, P. L.: Co-workers' Perceptions of Eight MBTI Leader Types: Comparative Analysis of Managers' SYMLOG Profiles. In Developing Leaders, C. Fitzgerald and L. R. Kirby, eds., Davies-Black, Palo Alto, Calif., 1997.

Struckenbruck, L. C.: The Implementation of Project Management: The Professionals Handbook. Addison Wesley, Reading, Mass., 1987.

Thamhain, H. J.; and Gemmill, G. R.: Influence Styles of Project Managers: Some Project Correlates, Academy of Management J., vol. 17, no. 2, 1974.

Walck, C. L.: Using the MBI in Management and Leadership: A Review of the Literature. In Developing Leaders, C. Fitzgerald and L. R. Kirby, eds., Davies-Black, Palo Alto, Calif., 1997.

Wilemon, D. L.; and Cicero, J. P.: The Project Manager: Anomalies and Ambiguities. Academy of Management J. vol. 13, 1970, pp. 269–282.

Workman, J. P.: Engineering's Interactions with Marketing Groups in an Engineering-Driven Organization. IEEE Trans. on Engineering Management, vol. 42, no. 2, 1995.

Yin, R .K.: Case Study Research: Design and Methods. 2nd ed. Sage Publications, Inc., Thousand Oaks, Calif., 1994.

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13. ABSTRACT ***(Maximum 200 words)***

Study of characteristics and relationships of project managers of complex projects in the National Aeronautics and Space Administration. Study is based on Research Design, Data Collection, Interviews, Case Studies, and Data Analysis across varying disciplines such as biological research, space research, advanced aeronautical test facilities, aeronautic flight demonstrations, and projects at different NASA centers to ensure that findings were not endemic to one type of project management, or to one Center's management philosophies. Each project is treated as a separate case with the primary data collected during semi-structured interviews with the project manager responsible for the overall project. Results of the various efforts show some definite similarities of characteristics and relationships among the project managers in the study. A model for how the project managers formulated and managed their projects is included.

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