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The Relationship of Project Team Attributes to Project Interim Performance

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TO PROJECT INTERIM PERFORMANCE

by

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ABSTRACT

THE RELATIONSHIP OF PROJECT TEAM ATTRIBUTES
TO PROJECT INTERIM PERFORMANCE

Vickie S. Parsons
Old Dominion University, 2004
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The factors associated with project success, or failure, have not been conclusively resolved in the project management literature. The purpose of this research was to investigate the relationship of project team attributes and interim project performance using a statistical research design. An abundance of research has focused solely on the importance of technical project components as they relate to cost, schedule, or technical performance. However, research into internal team attributes has been sporadic and, generally, associated with subjective measures of project performance or less than optimal statistical techniques. Prior assessment of project performance has also been concentrated at project completion. In contrast, this research developed an objective measure for interim project performance, based on identified deficiencies documented by independent reviewers at critical project control gates. A validated survey instrument completed by team members from National Aeronautics and Space Administration (NASA) aerospace projects, during the project formulation phase, provided data on team attributes. Using statistical analyses, appropriate to the level of data and data collection methodology, along with validating semi-structured interviews, the relationships between interim project performance and seven team attribute variables were investigated. The

team attribute variables were focus, empowerment, structure, cohesion, recognition, interdependence, and intra-team communication. Rho and gamma statistics indicated a highly significant relationship between team member interdependence and interim project performance. Weaker relationships between the interim performance metric and communication, cohesion, and empowerment were found. In contrast, no relationship was supported with focus, structure, or recognition. For the early project lifecycle, this research substantiated through quantitative empirical means, the theoretical premise that project team member interdependence is associated with high interim project performance. The establishment of an interim project performance metric contributed to both practice and methodology. The utilization of statistics mathematically appropriate to the level of data and collection methodology was significant to a field where rigorous statistical research is difficult and scarce. The emphasis on early project lifecycle performance contributed to theory. From a practical viewpoint, the results provide evidence to support the need for early project lifecycle emphasis on the purposeful building of team effectiveness by concentration on specific attributes related to project performance.

ACKNOWLEDGMENTS

I would like to thank my advisor, Chuck Keating, for his guidance and direction during my journey through PhD studies as well as the research and documentation of this dissertation. I would also like to thank the other members of my committee for their expert judgments during the process. This effort was made easier by the tireless support of the NASA Langley Research Center technical library staff in locating often obscure references. Also, Scott Harrison at Old Dominion University facilitated this effort by posting my survey and collecting the responses. For their support, I will remain grateful.

I would also like to thank the NASA project managers who graciously agreed to provide the results of their independent reviews and request their team members complete the survey. I am grateful to those project team members who took time from their busy schedules to answer my survey. And I extend a special thanks to my three experts who agreed to rank review findings and the experts who contributed to the ranking definitions.

The tolerance of my sons during this journey, when I always seemed to have a book, article, or laptop in hand, is also appreciated. But most of all I wish to thank my husband, Larry, for his encouragement and understanding which allowed me to reach this personal goal. His companionship and love sustained me throughout this endeavor, as always.

PREFACE

The project environment is an intense activity, requiring total commitment from members of the team. With a concrete goal of developing an instrument, a spacecraft, or aircraft improvements, NASA aerospace projects can inspire outstanding performance by the right team. The missions are too important to allow easily corrected impediments to prevent success. While certain things such as politics, funding, and schedule constraints cannot be controlled, selecting the right team is within the power of NASA. However, the technical challenges are often thought to eclipse the human ones. Having experienced successful project teams and others that never coalesced, the author became interested in researching whether or not project team dynamics related significantly to project performance. While a poor team can be emotionally, mentally, and physically draining to the members suffering the experience, does it statistically relate to the project outcome?

Furthermore, the author realizes the importance of the early life cycle phases of a project. Good planning is often the key to ultimate success. While challenges later in the project can cause failure, projects without a strong early foundation are doomed from the beginning. Therefore, this research concentrated on projects as they were progressing through the planning process.

Chapter I summarizes the focus and significance of this research, including the hypotheses to be investigated. To set the context for this effort, the limitations and delimitations are detailed in the first chapter. Definitions of the

key concepts and variables are also provided in *Chapter I*. *Chapter II* summarizes the insight from an extensive literature review of theories and empirical research into team dynamics and project performance metrics. The literature synopsis is categorized as opinion or philosophical, project professional survey results, meta-analyses, and empirical research. In *Chapter II*, it becomes painfully obvious that the previous research has neglected interim measures of project performance. In fact, most previous researchers concentrated on subjective measures of performance when the project results were known.

The statistical methodology and research design are described in *Chapter III*. The controversy surrounding surveys, the aggregation of data, and the interpretation of various statistics are discussed. In addition, the precautions, employed by this research effort to eliminate potential biases from data collection and statistical interpretation, are explained. The research design includes the validity testing of the team dynamics survey instrument employed, a description of the population from which the sample projects were drawn, and the rationale for the sample selection. *Chapter III* also describes the analysis plans, challenges, and additional validation performed for this research.

Hypotheses results, along with supporting information, are detailed in *Chapter IV*. Finally, *Chapter V* documents concluding remarks, including the contributions of this research to theory, methodology, and practice. Future research suggestions are also found in *Chapter V*. An additional value to future researchers is the extensive consolidated reference list.

This research contributes to the body of knowledge relating to project management. It is also hoped that this research will assist project managers in heeding the importance of their team functions in addition to focusing on the technical performance aspects of the project. By focusing on the early project lifecycle, this work should serve to emphasize its importance. The creation of an objective measure for interim project performance adds significantly to available metrics for evaluating projects early in their lifecycle when corrective action is technically and financially feasible. Furthermore, this document is intended to inspire other researchers to continue the investigation.

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CHAPTER I

INTRODUCTION

As the National Aeronautics and Space Administration (NASA) continues to develop cutting edge technology, instruments, and missions for the study of the planet Earth and the Universe, a project methodology is employed to accomplish these tasks. Why does one project succeed while another apparently equally promising one fails? As the extensive literature on project management reveals, this question has not been conclusively and universally resolved. NASA projects have specific goals, limited resources, and firm timetables for their completion. Yet, projects don't mysteriously happen; it takes people to make them successful. These people form the project team. While the literature is replete with research and investigations focusing on the technical aspects of NASA projects, the relationship between the project team and project performance has not been extensively studied. This research focused on attributes of the project team and investigated their concomitance with interim project performance.

This chapter sets the stage upon which this research was conducted. The following sections answer the critical questions: (1) Why study project teams? and (2) Why be concerned with project performance early in the project's lifecycle? Some background on project executions within NASA is also provided. This chapter clearly states the research question and the hypotheses that form

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· Style conforms to the *Engineering Management Journal* model.

the foundation for this work. There is a high level snapshot of the research design in the purpose section. The variables are operationally defined in the definitions section. Finally, as all research has boundaries, this chapter describes the limitations and delimitations to this work.

SIGNIFICANCE

Projects are socio-technical systems where the people element is significant. In their classical management handbook, Peters and Waterman (1982, p. 39) emphasized the importance of people to successful ventures: "Treating people - not money, machines, or minds - as the natural resource may be the key to it all." According to Tippett and Peters (1995, p. 29), "Top project managers have long known that building a cohesive, motivated project team is a key step toward the ultimate accomplishment of project goals." Because project environments are more difficult than routine work or sports environments, a conscious effort is required to build an excellent project team (Frame, 2002). The literature contains a profusion of references on the significance of people management to project success. However, comprehensive research to support theories concerning the socio variables and their interrelationships to project performance is severely limited. Among the prior research completed, "... studies often point to interpersonal and behavioral problems as root causes for project failure" (Heerkens, 2002, p. 18). Even so, only 4% of project management research between 1960 and 1999 deals with the socio aspects of projects (Kloppenborg and Opfer, 2002). Thus, the goal of this research is to fulfill a gap in the body of knowledge resulting from a shortage of empirical

studies to support the widespread belief that project success is affected by the attributes of the project team (Hoffman et al., 2002).

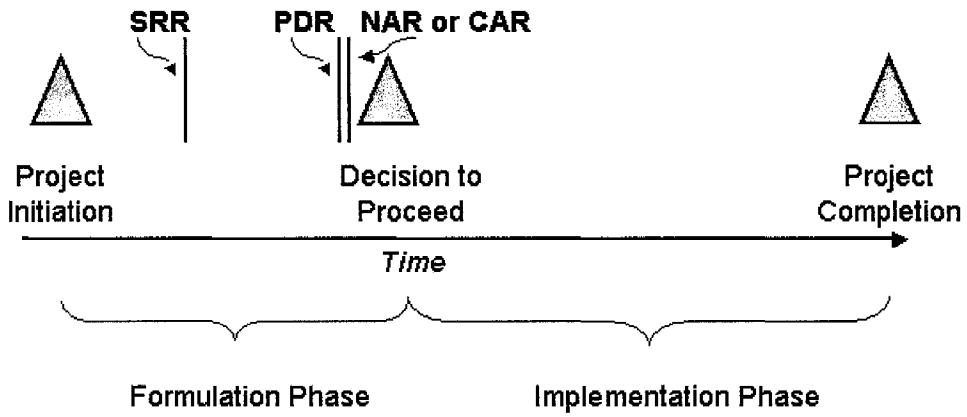
Also, while others have investigated the relationship of different variables to the perceived final success of projects, the literature reveals no studies on the relationship between team attributes and an objective interim measure of project performance. In fact, the literature is silent on suggested appropriate metrics to measure interim project performance. The key scheduled lifecycle events, that are common to all NASA aerospace projects, are required independent reviews. At the conclusion of each review, the review team presents the project with requests for action where deficiencies have been identified. From action items generated by independent reviewers, this research developed a technique for assessing the interim performance of NASA aerospace projects. In this manner, this research also contributes to NASA project metrics.

In concurrence with the author's observations, Lencioni (2002, p. vii-viii) stated, "The fact remains that teams, because they are made up of imperfect human beings, are inherently dysfunctional .... Building a strong team is both possible and remarkably simple. But it is painfully difficult." Therefore, any research into project team variables that can be modified or controlled, and potentially relate to team building and project performance, is valuable. Finally, this research further substantiates the claim made by the US Advisory Committee on the Future of the US Space Program (1990, p. 16), "There is no more important task for managers at all levels of NASA and its contractors than to nurture a culture of excellence ... to total teamwork in achieving that goal."

BACKGROUND

With years of experience in project management and project controls at NASA Langley Research Center, the author has observed both successful and unsuccessful projects. NASA has emphasized management tools that are employed by project managers to evaluate the health of their projects, particularly in the areas of schedule, cost, and risk controls (NASA NPG 7120.5B and NPG 8000.4, 2002). In addition, NASA has consistently employed control gates and independent reviews before a project is authorized to progress from one phase to another (NASA NPG 7120.5B, 2002). A project team must successfully demonstrate an understanding of science and technical requirements with their interdependencies at a Systems Requirements Review (SRR). Following preliminary design, the project must convince an independent review board that their design plans will meet those requirements and their management processes are adequate to sustain the project throughout it's lifecycle. These criteria are judged at the Preliminary Design Review (PDR), and a Non Advocate Review (NAR) or Confirmation Assessment Review (CAR), usually held jointly. Historically, NASA has used the terms NAR and CAR to identify the same review. According to NASA Procedures and Guidelines NPG 7120.5B, NASA Program and Project Management Processes and Requirements (2002), both assess identical aspects of the project. Segments from NASA NPG 7120.5B (2002), which detail the criteria evaluated and purpose of these NASA project reviews, are provided in *Appendix G*.

Exhibit 1. NASA project approval process



The sequence of these reviews with reference to the project lifecycle is shown in *Exhibit 1*. NASA projects progress through the formulation phase where the project requirements are definitized at SRR and the instruments are preliminarily designed by PDR. Once the project receives a favorable decision to proceed, the implementation phase begins. During implementation the project completes instrument designs, fabrication, and the remaining parts of the mission. However, even with advanced management tools and control gates, some projects "... often cost more than estimated, frequently do not meet schedules, and sometimes perform at lower levels than originally forecast" (Gansler, 1992, p. 10). This trend continues as "almost daily we are made aware of projects that have failed or not met customer expectations ... project success is too often dependent on the specific team" (Forsberg, et al., 2000, p. 4). In an effort to elucidate this phenomenon, this research investigated a set of project team

variables to determine their variability with project performance during the formulation phase.

RESEARCH QUESTION

Since teams execute projects, and teams are composed of people, the socio attributes of the project team have been frequently cited as important to ultimate project success. For example, according to Frame (1999, p. 137), "... an important determinant of project success ... is the effective functioning of teams." After a careful search of previous research, which is documented in *Chapter II*, seven unique team attributes were identified: focus, empowerment, structure, cohesion, recognition, interdependence, and communication. These attributes are characteristics of the team and measure the dynamics of the team's operating processes. Much of the previous research focused on subjective measures of performance at the end of the project lifecycle. However, project performance needs to be evaluated at interim periods during the project lifecycle. By the end of a project, the opportunity to affect team variables that may relate to project success has passed. To facilitate investigation into project performance early in the project lifecycle, a metric for measuring interim project performance was developed from review team action items as described in *Chapter III*. Therefore, this research focused on the question: Does a relationship exist between project team attributes and interim project performance?

PURPOSE

As stated previously, major accomplishments only occur through people. Rigorous investigation of the relationship between team attributes and project performance is a worthwhile goal. Therefore, the purpose of this research was to investigate the relationship between project team attributes and interim NASA project performance using a statistical analysis. Correlational statistics provided the best analytical technique to determine the strength of the relationship. As described in *Chapter III*, the particular statistics were dictated by the data collection methodology and the numerical characteristics of the actual data. Team attributes were captured through project members' self-assessment of seven key team variables, selected based on a careful review of theory, expert opinions, and empirical research. In addition, little attention has been previously given to criteria for determining the status of projects early in their lifecycles. To fill this void and facilitate the research effort, a methodology for measuring interim NASA project performance was also developed. This process for assessing interim project performance from independent review results is also detailed in *Chapter III*. This research should benefit team dynamics and project theorists as well as organizations who accomplish tasks through the employment of project teams.

RESEARCH HYPOTHESES

The team attributes of interest, identified in the literature search and defined in the next section, were team focus, team empowerment, internal team

structure, team member cohesion, group recognition, team interdependence, and intra-team communication. The following null hypotheses were investigated:

1. There is no statistically significant correlation between the strength of team focus and interim project performance.
2. There is no statistically significant correlation between team empowerment and interim project performance.
3. There is no statistically significant correlation between the level of structure within the team and interim project performance.
4. There is no statistically significant correlation between team cohesion and interim project performance.
5. There is no statistically significant correlation between team recognition and interim project performance.
6. There is no statistically significant correlation between the level of interdependence within the team and interim project performance.
7. There is no statistically significant correlation between intra-team communication and interim project performance.

Further investigation into the existence of relationships among the team attributes (focus, empowerment, structure, cohesion, recognition, interdependence, and communication) themselves was also pursued.

DEFINITION OF KEY CONCEPTS AND VARIABLES

While there are many different definitions and applications for the word team, this research focused exclusively on project teams. "A team is a small group of people with complementary skills committed to a common purpose and set of specific performance goals" (Katzenbach and Smith, 1999, p. 21). Specifically, a project team is composed of the individuals assigned to accomplish a specific goal within a limited timeframe and with the consumption of limited resources: the people working a project. In the case of NASA projects, the team consists of government, industry, and academia employees who are engaged full-time in the project activities.

Project performance is a measure of the progress being made at a particular point in the project life cycle. The life cycle extends from project conception and authorization to completion with accomplishment of goals or to cancellation.

All NASA independent critical milestone reviews, including the Systems Requirements Review (SRR) and the Preliminary Design Review (PDR) in combination with either a Confirmation Assessment Review (CAR) or Non-Advocate Review (NAR), "... assess the technical and programmatic health of a program, project, or major element of a project with respect to the success criteria and acceptable risk" (NASA NPG 7120.5B, 2002, p. 125). The content reviewed is mandated by NASA NPG 7120.5B (2002). Each criteria to be analyzed is specifically itemized in NASA NPG 7120.5B (2002) with additional detail in subordinate NASA management procedures, thus ensuring that all

SRR's evaluate the same project components. Likewise, all PDR/CAR's and PDR/NAR's, despite the different names, assess identical project components. All facets of the project are addressed including technical, programmatic, workforce, cost, and schedule. The checklists for these reviews, along with their reference sources, are provided in *Appendix G*.

For NASA projects, these "... reviews provide the opportunity to ... communicate progress and risks toward meeting the success criteria" (NASA NPB 7120.5B, 2002, p. 122). Review team members document these identified risks by submitting requests for actions (RFAs) to the project team. As the name implies, the project members must respond to each RFA by describing how the potential risk will be mitigated. For this research, interim project performance was operationalized as the relative percentage of a formulation-phase project's RFAs written at its latest formal project review. The percentage was determined by comparing each project's weighted RFA count to the average (mean) weighted RFA count (for the same review) of the projects within this sample. The weighting of an RFA that was included in the project's count depended on its criticality evaluated by three independent experts. This process is described in detail in *Chapter III*.

During the development of the *TeamMates* (Hoffman et al., 2002) survey instrument, described in *Chapter III*, Dennis Kinlaw, with the assistance of project personnel, defined the variables each set of survey questions was designed to measure. The original definitions were verbose and most included references to examples of good project management practices. For instance, structure was

expanded to include specifics such as knowledge of how requirements are managed and schedules changed. Unclear modifiers were also included such as describing communications as honest and open. Therefore, the original definitions were slightly modified to the following operational definitions, for this research effort, to ensure that each concept was succinctly represented.

Team focus is measured by the degree to which individuals on the project team understand the team goals.

Team empowerment is the extent to which the project team members perceive they have the freedom to accomplish the project in the best possible manner.

Internal team structure is the degree that individuals within the project team express a clear understanding of their responsibilities.

Team cohesion is defined as the degree that project team members express loyalty to each other.

Group recognition is defined as team member rewards for team accomplishments.

Interdependence within the team is the extent to which members of the project team rely on other team member competencies.

Intra-team communications measures the perceived quality of both aspects of good communications: transmitting and listening.

In summary, each of the team attributes was narrowly defined to insure measurement remained confined to a single variable. The project performance during formulation phase was also explicitly operationalized. In addition, the

universe of consideration was limited to NASA aerospace project teams, during the formulation phase when data was captured.

STUDY LIMITATIONS AND DELIMITATIONS

There is a wealth of theories and studies pertaining to projects. Projects are a frequently chosen method to accomplish significant outcomes in all arenas – industrial, governmental, academic, and personal. Every researcher must narrow that broad spectrum to the key elements under investigation. Previous sections have set the stage for this research by describing the purpose, significance, and details related to the hypotheses that were tested. This section explains the boundaries for this specific work.

Because the research sample was composed of NASA project teams, no applicability for the results of this research beyond NASA project situations (within the framework of project types selected) can be directly claimed. Caution should be used in attempting to generalize the findings to other situations. Since this research was a correlation analysis, no statistical inference can logically be made as to the cause and effect where relationships were shown. Therefore, this research was not intended to provide a prediction mechanism for project performance.

The values for team attribute variables were gathered through team member perceptions, which could result in a tendency for over-optimism among the collected responses. In fact, social identity theory confirms that people tend to rate their groups positively (Messick and Mackie, 1989). This phenomenon resulted in team attribute values ranging from three to five on a scale of one to

five with five being the most positive. Despite this unavoidable limitation, enough discrimination existed between teams to achieve valid results as described in Chapter *IV*. In addition, most team research contains an additional bias, resulting from data collection after the project outcome is known (Brown et al., 1990). With the collection of all data during project formulation, this second potential shortfall was eliminated.

This research did not investigate variables, external to the project team, which could affect project success. Numerous characteristics, programmatic and technical, controllable or random, can affect a project's success. As Parsons et al. (2002) noted, the complexity of a project has multiple dimensions, which they categorized as technical, environmental, social, and cost/schedule complexities. The variables examined in this research are a subset of the social category. This does not imply that variables within the other complexity areas are related less significantly to a project's outcome. The other complexity areas were excluded because they are not relevant to the hypotheses tested in this research.

Also, the number of team variables was intentionally restricted to seven even though other team aspects may be strongly related to project performance. The focus for this effort was the dynamics within the team (the interactions or forces operating between team members) rather than individual team member attributes. This research also did not delve into the project manager characteristics that conceivably influence the other variables being investigated. The potential effect of team member personalities on the other team variables was also not addressed. Finally, no comparison between team variable effects in

different types of tasks (construction, etc.) was studied, since the sample was exclusively NASA aerospace projects.

Research efforts must balance a manageable subset of all possible variables, while remaining focused on making a significant contribution to the subject of study. The socio variables that were studied are a critical component for the numerous project endeavors attempted by teams of individuals. In addition, a quantifiable measurement technique was optimal for project performance. Also, relationships among concurrently measured variables were best determined through the statistical correlation employed in this research design as described in *Chapter III*. The author's goal was to contribute valid empirical research in the area of team dynamics and interim project performance measures. Despite the recognized limitations and delimitations identified, this research accomplished the initial goal.

SUMMARY

Even with the universally accepted belief that somehow a project team is related to project performance, little empirical research exists to substantiate this claim. "No general theory on human behavior in project management has evolved; however, studies have spotlighted some areas of behavior management that seem to be particularly applicable for running projects" (Dinsmore, 1984, p. 43). In fact, no one has empirically studied the relationship between team attributes and interim project performance. This research devised a method for measuring interim NASA project performance. Then, the relationship between team attributes (focus, empowerment, structure, cohesion, recognition,

interdependence, and communication) and interim project performance was rigorously investigated with the appropriate statistical techniques.

This chapter has summarized the focus and significance of this research, including the hypotheses to be investigated. A general introduction into the thought processes for selecting the research design has been provided. The boundaries of the research have also been explained. The reasons for studying team attributes and interim project performance have been expounded. *Chapter II* provides insight from an extensive literature review of theories and empirical research into teams and project performance. Additionally, the specific knowledge gap filled by this research is identified.

CHAPTER II

LITERATURE REVIEW

Teams can be found in many different situations. Human beings are social animals; therefore, we tend to live, work, and play as groups. The management literature, described in the project team attributes section below, contains a plethora of theories and references to the benefits of teamwork. Even old aphorisms praise the outcomes from teams: two heads are better than one. Any time people gather to accomplish a task, the relationships among those individuals have a bearing on the accomplishments of the team. And since teams are everywhere, it is important to identify those attributes of a team, which relate to the performance of that team. Only in this manner can these factors be handled in a way to maximize the potential for the team's successful accomplishment of its mission. "Top managers ... need to understand that they cannot simply decree that a group of people become a team and then demand a high level of performance from them. Human behavior is not that simple." (O'Conner, 1993, p. 67)

This chapter systematically navigates through the literature applicable to this research. Since this work focuses on team attributes and project performance, the two major threads follow those themes. Generally, the literature can be classified into opinions and empirical research. The theories, concerning project teams and performance, are found within the opinion works, but special attention was paid to the empirical work to identify the gap filled by

this research. The topics covered within this chapter are succinctly presented in *Exhibit 2*.

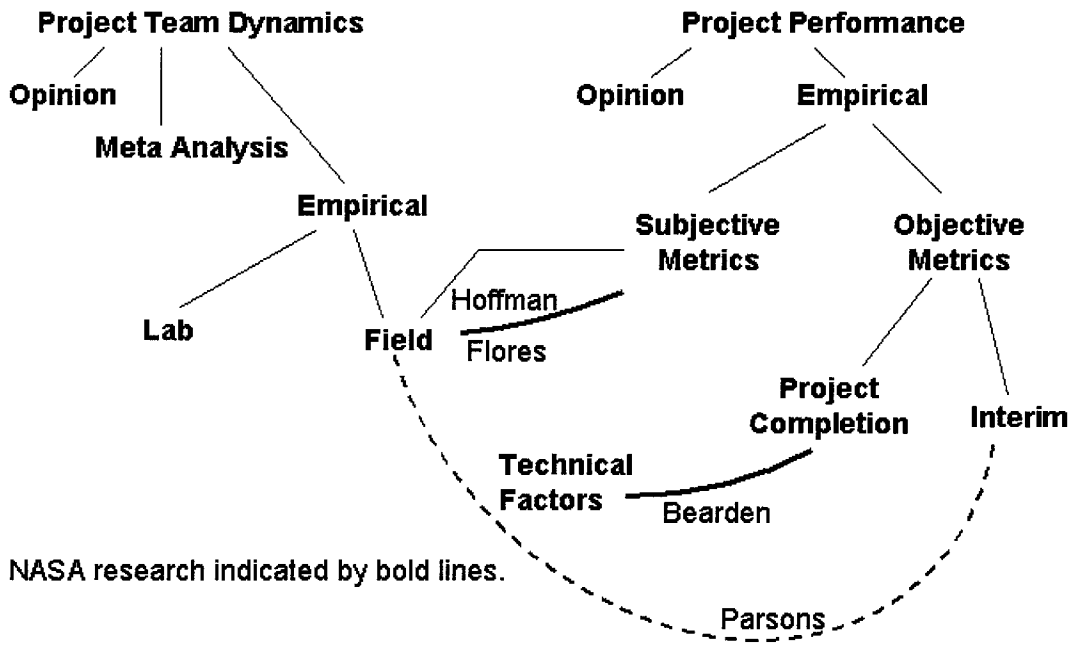
PROJECT TEAMS

The literature contains numerous opinions and studies regarding the impact of technology, task difficulty, limited schedules, resource constraints, and other external factors on project success. The 1980 NASA Colloquium Proceedings on Project Management emphasized technical areas as major concerns for project managers; however, there was mention of several team variables including lack of trust (empowerment), lack of esprit de corps (cohesion), need for better communications, and incongruent structures. Bearden (2000) listed programmatics and social drivers but chose to concentrate entirely on technical parameters in classifying NASA project complexity for risk assessments. In contrast, Parsons et al.'s (2002) work supported the importance of social characteristics in team member classifications of project complexity. As Kinlaw (1991) proposed, the development of superior teams is not a function of the environment; it is a function of the team members' decision to become a team. Therefore, this literature review focused on the relevant available information concerning team attributes and team performance, as summarized in *Exhibit 2*.

As stated in *Chapter I*, the research question studied is whether or not a relationship exists between project team attributes and interim project performance. The team attributes identified in the hypotheses in *Chapter I* pertain to the dynamics among members of the project team. Therefore, the

literature review began with project team dynamics and project performance. Within the literature pertaining to project team dynamics, the articles were classified as opinion, meta-analyses, or empirical as shown in *Exhibit 2*.

Exhibit 2. Streams of literature



Similarly, project performance literature was subdivided into opinion or empirical. No articles were found documenting meta-analyses of other research into project performance. As indicated by the bold lines in *Exhibit 2*, only three applicable significant research efforts into NASA projects were identified. Following the paths in *Exhibit 2*, the literature review continued to drill down to where the dotted line indicates the gap filled by this research.

PROJECT TEAM DYNAMICS

The literature includes numerous, sometimes confirming but often conflicting, opinions of which team attributes relate to project success or failure. The Task Group Effectiveness Model of team performance postulated that focus, empowerment, structure, recognition, interdependence, and communication affect the team's success (Gladstein, 1984). Peters (1987) mentioned focus, recognition, structure, empowerment, and good communications as necessary for team success. Cleland (1996) identified characteristics of an effective team to include focus, cohesion, trust, communications, and interdependence. A review of the literature conducted by Bishop (1999) revealed that focus, communication, empowerment, cohesion, and recognition are among the key variables thought to be necessary for project success. Lewis (1998) postulated that good project teams are characterized by trust, open communication, team pride, enthusiasm, focus on goals, and interdependence. Communication, empowerment, recognition, and goal focus were also identified by Slevin and Pinto (1986) and Pinto and Slevin (1987) as key factors in their Project Implementation Profile. In a philosophical article, Sundstrom et al. (1990) proposed that collective performance is influenced by team focus, empowerment, recognition, cohesion, and structure. Team success was thought to be enabled by recognition, empowerment, focus, and cohesion (Katzenbach and Smith, 1999). The outcomes of projects were believed to be influenced by team member focus, interdependence, cohesion, structure, communication, and recognition (Forsberg et al., 2002). Thus, the opinion literature pointed to the

criticality of team attributes in the ultimate accomplishment of the team objective. Thamhain emphasized the importance of these team attributes by stating their effect on the more traditional aspects of good project management in Cleland and King (1988, p. 843): "... the greater the team spirit, trust, and quality of information exchange among team members, the more likely the team will be able to develop effective decision-making processes, make individual and group commitment, focus on problem solving, and develop self-forcing, self-correcting project controls. These are the characteristics of an effective and productive project team." Based on the theoretical and opinion literature reviewed, the Task Group Effectiveness Model's (Gladstein, 1984) identification of project team attributes related to project success was expanded to include cohesion. Thus, the seven project team attributes chosen for this research were supported by the theoretical literature reviewed.

In addition to the expert opinion literature, several authors canvassed project managers to determine their thoughts on variables that affect team performance. A survey of 32 management teams identified lack of focus, communication, cohesion, and recognition as likely team problems (Larson and LaFasto, 1989). A survey of 90 project managers by Thamhain and Wilemon (1983) yielded poor focus, incongruent structure, missing recognition, and poor communication as among the key obstacles to effective project teams. In subsequent field work, empowerment and cohesion were included in the variables believed to contribute to project performance, as measured by subjective means (Kerzner and Thamhaim, 1984). Pinto and Slevin (1987)

asked 52 MBA students, who worked full time, what would affect project success; focus, structure, and communications were identified. Although they claimed this was empirical support for theoretical literature, in reality it was merely an opinion survey; no attempt was made to determine the strength of relationships between attributes and success. Kezsborn's (1992) survey of 285 project managers in technical Fortune 500 companies considered focus, cohesion, communication, and structure to be important to project success. A survey of 123 project managers by Dugan et al. (1977) sought to distinguish important variables during each phase of a project lifecycle. During the formulation phase, communication, recognition, focus, and cohesion were considered important. In all cases, the surveyed managers believed that team variables were the most important forces affecting project performance.

As shown in the previous summary of opinion literature, both scholarly experts and project management professionals speculate that team dynamics have relationships with project accomplishments. Both theoretical works and surveys of project managers from the late 1970's to the present consistently attribute project success in part to various combinations of the team attributes studied in this research. However, opinion surveys do not provide justification for accepting theory; empirical research is necessary. Thus, while suppositions are interesting, further literature searches, described in the following sections, uncovered the level of effort expended in attempts to support these postulates.

META-ANALYSES

The literature is satiated with meta-analyses of previous team studies by other researchers, with mixed conclusions. Cohen and Bailey (1997) summarized empirical team research between January 1990 and April 1996. They found little research on project team internal processes; however, empowerment was specifically mentioned as not being significantly correlated with achievement. Yet, in a contradictory meta-analysis by Miller and Monge (1986), a review of 47 studies concluded that empowerment strongly related to team member satisfaction and, by inference, to team performance. Guzzo and Dickson (1996) and Johnson et al. (1981) summarized others' research to show focus, cohesion, structure, and interdependence each positively correlating with performance. Poor structure related negatively to performance and cohesion correlated positively to success in Forsyth's (1990) review of 42 studies. Gully et al.'s (1995) meta-analysis of 44 studies on cohesion vs. team effectiveness concluded that there is a correlation between group cohesion and performance with task interdependence as a moderator. A correlation of 0.419 was obtained between team cohesion and team success by Evans and Dion (1991) from their meta-analysis of 16 studies (a total of 372 groups). Mullen et al.'s (1994) review of 17 studies concluded that cohesion had a positive correlation with project performance only when the cohesion was task-based rather than personal. Yet, after reviewing 250 studies, Bettenhausen (1991) concurred with Levine and Moreland's (1990) observations that confusion still exists over the conceptualization and measurement of cohesion among researchers in small

group dynamics. Sometimes other authors referred to the seven team variables by different labels, but their operational definitions roughly matched those provided in *Chapter I*. Based on the translation to the labels identified in this research, the various team attributes reviewed in these meta-analyses are summarized in *Exhibit 3*. The individual team attributes reviewed by each meta-analysis are indicated by X's in the matrix.

Exhibit 3. Team attributes investigated with subjective performance measures in meta-analyses

Authors	Focus	Empow-erment	Struc-ture	Cohe-sion	Recog-nition	Interde-pendence	Commu-nication
Cohen & Bailey, 1997		X					
Evans & Dion, 1991				X			
Forsyth, 1990			X	X			
Gully et al., 1995				X		X	
Guzzo & Dickson, 1996	X		X	X			
Johnson et al., 1981				X		X	
Miller & Monge, 1986		X					
Mullen & Copper, 1994				X			
Mullen et al., 1994				X			

The team attribute most often emphasized in these meta-analyses was cohesion and, in general, the results were inconclusive. In fact, of the nine meta-analyses in *Exhibit 3*, seven performed analyses of studies that investigated cohesion. By contrast, no meta-analysis reviewed research into recognition or communication. Meta-analyses provide a convenient summary of historical research. However, meta-analyses, by design, can only compare and analyze

the work of others. Thus, the methodological and statistical errors in the original research are propagated into the meta-analysis. In some instances, the processes originally employed are not documented well enough for the meta-analysis to evaluate their appropriateness and validity. Therefore, only through the actual review of individual studies can the full rigor of empirical research be determined. The next section explores individual empirical research as documented in the literature.

EMPIRICAL RESEARCH

While secondary dictionary definitions exclude the scientific method from empirical research, primarily empirical studies derive knowledge of phenomena from observations and measurements according to the scientific method. In order to be valuable, a meticulous methodology must be followed in empirical research. Numerous so-called research activities employ questionable methodologies and therefore, the results are subject to criticism. After reviewing 49 studies, Mullen and Copper (1994) identified a higher significance for cohesion vs. productivity in real groups than experiments. Since there are unsolved issues concerning the applicability of laboratory results to real teams, laboratory studies are summarized in *Exhibit 4*, but detailed descriptions are not provided. Also, research pertaining to team attributes of real world teams or groups are summarized in *Exhibit 4*, but, in general, details are expanded in this section for only those that are project specific. The empirical research into project team attributes and project performance are the most applicable to this research. Therefore, details of the results in those studies are provided below.

Other than Hoffman et al.'s work (2002) described in *Chapter IV*, the only empirical research, that was identified through an exhaustive review of literature, pertaining to team attributes of NASA projects, is the case study effort by Flores (2001). His work solicited opinions through eight interviews and compared one successful and one unsuccessful NASA project. Cohesion, focus, empowerment, recognition, and communication were identified as discriminating factors between the two projects.

Other authors have addressed non-NASA technical projects. Baker et al. (1986) discovered a lack of focus correlated with failure in a survey of 211 research and development (R&D) projects. McComb et al. (1999) found a correlation of 0.21 ($\alpha < 0.10$) between focus and performance of 67 project teams. Might and Fischer (1985) found only limited support that team structure related to project success.

Ancona and Caldwell (1992), Keller (1986), and Dailey (1978) studied multiple project teams in different organizations. Ancona and Caldwell determined the correlation between cohesion and subjective evaluation of performance to be 0.89 ($\alpha < 0.01$); Dailey's result was 0.73 ($\alpha < 0.001$). Keller's results ranged from 0.44 to 0.51 ($\alpha < 0.01$). While these results are statistically significant, the discrepancy would indicate that survey mechanisms, subjective evaluations of performance, and situational differences could have an impact on results. In contrast, Kim and Lee (1995) studied 80 R&D teams in Korea and found a correlation of –0.07 between cohesion and subjective measures of performance. They also discovered empowerment to be correlated weakly with

Exhibit 4. Empirical research summary

Authors	Projects	Focus	Empowerment	Structure	Cohesion	Recognition	Interdependence	Communication	Interim Performance	Subjective Performance	Objective Performance
Allen et al., 1980	X							X		X	
Ancona & Caldwell, 1992	X				X					X	
Baker et al., 1986	X	X								X	
Campion et al., 1993		X	X	X	X	X	X	X		X	X
Dailey, 1978	X				X		X			X	
George et al., 1990		X	X		X	X		X		X	
Gladstein, 1984				X		X	X	X		X	X
Greene, 1989		X			X					X	
Griffin & Gibson, 1997	X	X			X	X		X			X
Hoegl & Gemuenden, 2001				X	X		X	X		X	
Hoffman et al., 2002	X	X	X	X	X	X	X	X		X	
Jones & Harrison, 1996	X				X					X	
Keller, 1986	X				X					X	
Kim & Lee, 1995	X		X		X					X	
Levi & Slem, 1995					X	X				X	
Lewis, 2000	X	X	X		X					X	
Lynn & Akgun, 2000	X	X	X		X		X	X		X	
McComb et al., 1999	X	X								X	
Might & Fischer, 1985	X			X						X	
Murphy et al., 1974	X	X	X	X	X					X	X
Olson et al., 1995				X						X	
Proehl, 1996		X		X		X		X		X	
Sethi, 1995		X	X		X		X			X	
Shaw, 1975		X			X			X			X
Trent & Monczka, 1994			X		X	X		X		X	
Tushman, 1988	X							X		X	
Wagemon, 1995 & 1997		X	X			X	X			X	
Weldon et al., 1991		X									X
Zaccaro & McCoy, 1988					X						X
This Research	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**		**X**

performance at –0.27. In this case, the Korean culture was speculated to affect the correlations achieved. However, Jones and Harrison (1996) also concluded

that cohesion was not significantly related to perceived team performance among 131 information specialists from a Fortune 500 service firm in the United States.

Allen et al. (1980) documented a longitudinal study of 58 projects within one R&D facility over 15 weeks. There was no significant correlation between communication quantity and team performance. This supports the logical assumption that quality, not quantity, is the important variant in communications. However, Tushman (1988) found communication type and quantity were positively related to performance in 61 R&D projects.

Others investigated a larger number of team attribute variables in their empirical research. Lynn and Akgun (2000) collected data from 117 projects with questionnaires. Their regression analysis resulted in teamwork, communication, focus, and market niche predicting subjective measures of success with r^2 = 0.32. The successful vs. unsuccessful project results were statistically significant at $\alpha < 0.05$ for empowerment, focus, and teamwork, which was a composite variable including descriptions of cohesion and interdependence. Murphy et al. (1974) collected 646 Likert-style surveys from government, manufacturing, construction, and service project members. The emphasis was on non-NASA projects despite the fact that the research was NASA-funded. The 177 variables addressed were varied; the results applicable to this research were correlations with a combined subjective and objective measure of success for focus (r = 0.41), empowerment (r = 0.28), cohesion (r = 0.37), and structure (r = 0.29). A regression analysis of 650 projects resulted in r^2 = 0.77 using focus, empowerment, and cohesion to predict a subjective rating of success (Lewis,

2000). Griffin and Gibson (1997) discovered relationships between a weighted objective project success metric and poor communications ($r = -0.54$, $\alpha < 0.02$) and incompatible recognition processes ($r = -0.47$, $\alpha < 0.05$) for a sample of 20 construction efforts.

Campion et al. (1993) investigated 19 group characteristics in 80 financial workgroups performing routine tasks. The characteristics studied represented a hybrid of the theories of Gladstein (1984), Hackman and Morris (1975), and Guzzo and Shea (1992). These were not project teams; but, this research is applicable because among the 19 characteristics were the seven team dynamic variables being studied in this research. The characteristics were correlated with two subjective and one objective performance measures. Empowerment (0.23), interdependence (0.20), cohesion (0.20), and communication (0.18) correlated with an objective measure of performance at a statistically significant level of $\alpha < 0.05$. Correlations with the subjective performance measures only resulted in two greater than 0.17: empowerment at 0.28 ($\alpha < 0.05$) and communication at 0.18 ($\alpha < 0.10$). This highlights the difference in findings depending on the method used to measure performance.

Tippett and Peters (1995) subjectively studied 1667 people within 134 teams at 88 companies and organizations. The government organizations had the poorest ratings on variables thought to lead to success, including communication, recognition, and goals. This lends significance to this NASA-specific research, since NASA is a government agency.

In summary, each of the seven team attributes considered in this research has been the subject of some previous empirical work. Of these, cohesion has been studied most frequently. While the results were varied, at least one prior research indicated a positive relationship between each team attribute and some measure of performance. However, interpretations of the individual results are dependent upon the validity of data collection, research designs, and the appropriateness of statistical analyses used in the empirical studies. Therefore, each research effort must be reviewed and the results tempered according to the rigor of the methodology utilized. The most common flaws in these research works were the use of subjective measures where objective ones were available and the use of statistics incompatible with the data level. This literature search supports Shaw's (1981, p. 450) conclusion that "... a tremendous amount of information has been amassed through empirical investigations. Much of this information is unreliable and lacking in validation; theoretical integration (in the field of group dynamics) is practically nonexistent."

While this summary indicates a significant amount of empirical research into team attributes, only Hoffman et al. (2002) studied projects and all seven of the variables being addressed by this research. However, these team attributes were a subset of a much larger variable assessment. Also, their emphasis was placed solely on subjective performance measures in the statistical analyses. This led to further literature searches into project success measures.

PROJECT SUCCESS

According to Pinto and Slevin, "there are few topics in the field of project management that are so frequently discussed and yet so rarely agreed upon as the notion of project success." (Dvir, 1998, p. 917) Experts provide various similar but slightly different definitions. Hackman and Morris (1975) measured team effectiveness by their current performance and their ability to continue functioning as a team in the future. Kerzner's (1989) more comprehensive definition equated project success to completion on schedule, within budget, to specifications, with customer acceptance, with minimal scope changes, without disrupting the organization, and without changing corporate culture. Gladstein (1984) defined team effectiveness as the performance of the team plus member satisfaction in addition to the ability of the team to continue its existence. According to Liu and Walker (1998, p. 213), "The concept of project success has remained ambiguously defined." While ultimate project success has varying definitions, each exemplarily research activity operationally defined success and determined metrics for measuring it that were appropriate for that specific definition.

PROJECT SUCCESS METRICS

Liu and Walker (1998) reviewed studies and concluded that research does not support a strong correlation between satisfaction and performance. Yet, this review of empirical team research revealed that project success is typically measured by subjective opinions, which can be influenced by satisfaction. In fact, in Cohen and Bailey's (1997) review of empirical team research, no study

used an objective measure of project performance; all used opinions, either internal or external to the team. As noted in *Chapter III*, self-reporting should only be used to gather data when no alternative is possible. This is further supported by a meta-analysis of fifty field studies, in which Bommer et al. (1995) only found a fair correlation of 0.39 between subjective and objective performance measures; therefore, they concluded that the measures were not interchangeable. In addition, Messick and Mackie (1989) noted that social identity theory asseverates that people tend to rate their groups positively. And within teams, Kolb (1995) found the leader's rating was more positive than other team members' assessments in 12 of 13 categories. In general, the literature questions the validity of results where subjective project performance metrics have been employed.

While Olson et al. (1995) used perceptions as measures of project performance, they acknowledged the inherent bias and recommended more objective measures for future research. Where the subject has been investigated empirically, the results are conclusive – subjective and objective measures of performance are not equal. The most valid measure is the objective one. This led to the development of an objective measure of project performance for this research. Also, much of the empirical research has measured team attributes and performance at the end of the project life cycle when perceived results could further subjectively influence the ratings of other variables. Therefore, this research design, described in *Chapter III*, concentrated on the early project life cycle.

TEAM-PERFORMANCE RELATIONSHIP

Teams are recognized as extremely important in the accomplishment of project goals, as indicated by the following quotes. "Top project managers have long known that building a cohesive, motivated project team is a key step toward the ultimate accomplishment of project goals." (Tippett and Peters, 1995, p. 29) NASA project manager Robert Shaw stated, "Project success depends on successful teamwork." (Laufer and Hoffman, 2000, p. 125) Since projects are accomplished by teams, "an important determinant of project success ... is the effective functioning of teams." (Frame, 1999, p. 137) "People are a project's most important asset ... Unfortunately, this is often forgotten by many of us who write project management textbooks and offer project management seminars. Rather than focus on people, we focus on techniques." (Frame, 1995, p. 54) "Today we realize that team building, interpersonal relationships, conflict management, and other aspects of managing people are just as vital to successful project management as the use of scientific tools for planning and control." (Cleland in Dinsmore, 1984, p. ii) And, as another NASA project manager, Linda Abbott, succinctly stated, "the rule is very simple. No teamwork – no success. Period." (Laufer and Hoffman, 2000, p. 162)

NASA's regulations and documents also recognize the importance of the people, who make accomplishments possible. "The manager must view the program/project team as the most essential attribute for mission success" (NASA NPG 7120.5B, 2002, p. 61). "People are our greatest asset in ensuring exceptional performance, therefore the development and management of our

'human capital' is as critical to the success of the project or program as the management of any other resources" (NASA NPG 7120.5B, 2002, p. 61). In addition, NASA also recognizes elements of effective teams. The "... behaviors associated with effective teaming include open communication, recognition of superior performance, team development ..." (NASA NPG 7120.5B, 2002, p. 61).

However, despite all the literature on team variables, there is still confusion over what is critical for team success. The previous empirical research is "... clearly insufficient to understand fully the features or characteristics of effectively functioning teams." (Larson and LaFasto, 1989, p. 19). Hackman and Morris (1975) concluded that, even after thousands of studies, the knowledge of why some projects are more successful than others is still inconclusive. Each author's research is cross-referenced in *Exhibit 4* as to whether or not they studied project teams as well as which of the seven team attributes (focus, empowerment, structure, cohesion, recognition, interdependence, or communication) were included. *Exhibit 4* also indicates whether each author utilized an objective or subjective performance measure. As shown, three studies actually used a combination of performance measures and no previous research utilized an interim performance metric. Therefore, *Exhibit 4* provides a summary, in matrix form, of the empirical research reviewed and identifies where this research fulfills a gap.

SUMMARY

As shown in this chapter, the existing literature investigates some team attributes and their relationships to team success. Overall, empirical studies and

meta-analyses expand upon Gladstein's Task Group Effectiveness Model (1984) by including cohesion. But, as shown in *Exhibit 4*, rarely are all seven team attributes studied simultaneously. Furthermore, conflicting results have contributed to the perceived inconclusiveness of various theories concerning how socio variables relate to project performance. In addition, the statistical methodologies employed are often questionable, which reduces the recognized validity of any conclusions. Despite the discrepancies identified between subjective and objective performance measures, and the acknowledged subjective biases, the majority of research continues to employ subjective evaluations of project performance. This subjective bias is exacerbated by collecting data on team variables in conjunction with subjective performance, usually when the project is close to completion. As a result, the biasing effect between team attributes and subjective performance values may be reciprocal. Little research has focused on NASA project teams and no prior research has been identified that considered a metric for measuring interim project performance. This research fulfills a gap in the body of knowledge while following a rigorous methodology, described in *Chapter III*, to minimize potential biases and facilitate defensible results.

CHAPTER III

RESEARCH METHODOLOGY

Since this research investigated the existence of relationships between team attributes and interim performance of project teams, a quantitative statistical methodology for analyses was determined to be the most appropriate. Values for the variables were collected simultaneously, providing a snapshot of the team attributes. No causal relationship was implied; so, simple correlation analysis provided the desired quantitative results for interpretation. However, the statistical analysis was used inductively to build the foundation for theory development concerning the relationship between team attributes and interim performance of NASA projects.

This chapter specifies, in detail, the research methodology that was employed during this research. In addition, the reasoning and justification for this design are documented. The research design is outlined followed by sections explaining the survey instrument decisions, the sample selection, data analysis plans, and data interpretation criteria. Each section describes the basis for choices made in that area. Finally, the barriers to this research and their mitigations are discussed.

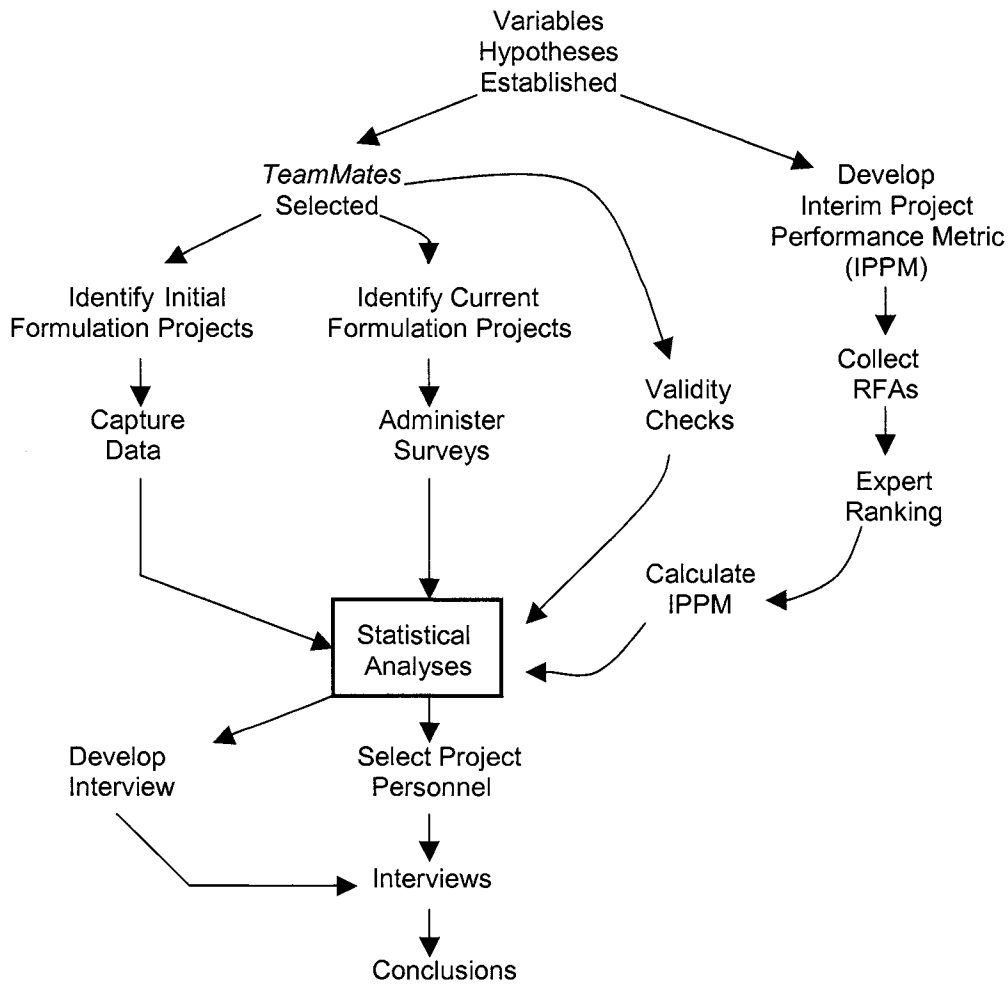
RESEARCH DESIGN

This research evaluated the relationship of seven intra-team variables (focus, empowerment, structure, cohesion, recognition, interdependence, and communication) with an objective measure of project performance early in the

project life cycle. In addition, the relationships among the seven team variables were explored. Each step, following the formation of the hypotheses to be investigated, is shown in *Exhibit 5* and described below.

The *TeamMates* (Hoffman et al., 2002) survey, described in the next section, was selected to measure the seven intra-team variables. Three NASA projects included in the *TeamMates* survey, which was administered between April 2000 and June 2001, met the selection criteria, described in later sections of this chapter. Data for those three projects were used as the team variable

Exhibit 5. Research design



values associated with the research hypotheses. Between March 2003 and November 2003, additional NASA project teams participated in the *TeamMates* survey and were included in this research effort. The validity of the *TeamMates* survey questions was assessed, as described in the *Data Analysis Plan for Team Attributes* section below. An objective methodology for evaluating NASA interim project performance, described in the *Data Analysis Plan for Interim Performance* section of this chapter, was developed and used to measure the common performance variable for the seven research hypotheses. Statistical analysis, using *SPSS for Windows* ® software (SPSS, 2000), was performed to determine whether or not the team attribute variables correlated with the interim project performance variable. In addition, the interactions among team variables were statistically evaluated. Finally, interviews with selected project personnel were conducted to assist interpretation of statistical results.

TEAM VARIABLES SURVEY INSTRUMENT

A search of potential survey instruments to capture the team attributes data led to discovery of *TeamMates* (Hoffman et al., 2002). Further investigation revealed the systematic creation of the survey summarized here. Initially, a study of 250 teams in 25 organizations was used by Dr. Dennis Kinlaw to develop his model of team dynamics. Interviews, responses from more than 3000 attendees at team workshops, and 20 years of published studies were used to develop a survey instrument designed to measure team attributes (Kinlaw, 1991). NASA-sponsored research resulted in the refinement of this survey instrument into the NASA Project Team Development Survey, nicknamed

TeamMates. As part of this effort, 150 statements from the initial generic inventory of team attributes were rated by 2012 NASA project and management personnel. Through factor analysis, focus, interdependence, and cohesion were identified among factors with the largest variation in responses. The participants in two NASA Advanced Project Management (APM) training sessions reviewed the survey items to improve their clarity and validity. An early version of the *TeamMates* survey resulted from this initial effort, additional interviews, independent expert evaluation, and correlational statistical analyses. Next, the survey was pilot-tested on the members of eleven projects at six different NASA centers. These responses were analyzed by four researchers and the final *TeamMates* survey, parts of which were used in this research, was the result of their consensus. After revision, it was further validated by five additional NASA projects. In an effort to further improve internal and content validity for this research, the key concept definitions described by Hoffman, et al. (2002) were compared to the *TeamMates* survey questions. Also, relational statistics described in *Chapter IV* were calculated on the APM database of *TeamMates* responses (178 projects) to determine if questions within a category were measuring a single concept. This method of assessing the consistency among survey questions, in order to determine which questions should be retained, was supported by Nunally and Bernstein (1994) as well as Nachmias and Nachmias (1976). As documented in *Appendix C,* permission to use the NASA *TeamMates* was obtained from Dr. Claire Kinlaw, one of the originators of the survey.

TeamMates has been incorporated into previous research concerning NASA project teams. Hoffman et al. (2002) used regression analysis and discriminant analysis to relate the *TeamMates* survey results to team members' subjective evaluation of project performance. The relationship was greater than 0.74. When statistically regressing subjective assessments of performance over all *TeamMates* variables (the team attributes included in this research plus other individual characteristics), 81% of the delta was explained. Furthermore, external subjective perceptions of project performance correlated with team member opinions. While this tends to add to the perceived validity of the survey instrument and the potential relationship between the team attribute variables and project performance, this effort is susceptible to the biases introduced from subjective self-evaluation of performance. Also, the methodology employed by Hoffman does not justify the use of regression analysis since no causation between variables can be assumed without a time delay between independent and dependent data collections. In addition, Dr. Hoffman's statistical analytical techniques directly assumed numerical data, which would require individuals to perceive equitable gaps between the Likert-scale values (1 - 5). This research design was contrived to correct these statistical errors and reduce potential biases in order to incontrovertibly evaluate the significance of resulting relationships between team attributes and interim project performance.

Shenhar et al. (1997) studied the relative importance of various factors on project performance and concluded internal variables were most important in the early lifecycle phases. Because this research focused on projects during their

formulation phase, a subset of the team attribute variables from the original *TeamMates* survey was employed. In addition to variables that deal with the interactions among team members, the *TeamMates* survey, in its original form, measured personal and project performance elements. For reasons discussed in the *Surveys* section, this research did not utilized the subjective performance aspects of the survey. Similarly, the three personal element variables were excluded because they were measures of individual attributes and this research focused exclusively on team attributes that measure the forces acting among team members. The portions of the survey being utilized for the seven intra-team variables in this research are provided in *Appendix B*.

In summary, the *TeamMates* survey was selected to capture data on team attributes because it was well-validated by the original creators and measures the team attributes of interest in this research. However, only the parts directly applicable to this research were utilized. The next section answers the question of why this research employed a survey instrument to collect team attribute data.

SURVEYS

Statisticians and social/psychological researchers support multiple methods for data gathering in research. Each technique has specific benefits and weaknesses. For group research, Bowen (1995) maintains that surveys result in poor casual determination, high external validity, and good sample sizes. This research made no attempt to assign causality in the discovered relationships, therefore, the potential flaws identified by Bowen were not a consideration. According to Forsyth (1990), the fact that some variables cannot

be accessed, in certain research settings, without the use of surveys outweighs the problems generally associated with surveys. The team attribute data of interest in this research could not be reliably gathered with observations, as the true dynamics within a project team are not readily identifiable to outsiders. The survey employed in this research is considered a self-reporting mechanism, which is the most popular data collection methodology for the behavioral and social sciences. As McGrath (1984) and Spector (1994) report, self-reporting is the only way to get information on attitudes and feelings such as these team attribute variables. Therefore, a self-reporting survey methodology for collecting the data on focus, empowerment, structure, cohesion, recognition, interdependence, and communication was chosen.

It is generally accepted that a Likert-type scale for survey instruments produces good results. While the interpretation of each level may vary from one individual to another, the data does provide the trends necessary for this level of analysis. Theoretical analyses, supported by empirical research, indicate that Likert-type scales are acceptable for most traditional statistical analyses (Cohen and Cohen, 1983). While social science surveys have experimented with response scales from three to nine options, Likert himself favored the 5-point scale (Likert, 1961). For the team attributes in this research, a 3-point scale would not have provided the opportunity for adequately dispersed responses. In contrast, a larger scale would have provided more choices than were necessary for this level of analysis and would most likely have diluted results. Through empirical research, McKelvie (1978) investigated 5, 7, and 11-point scales for

survey questions and determined that 5-point scales were the most reliable. Therefore, as explained in the previous section, this research solicited question responses utilizing a 5-point Likert scale.

Another determination in survey design is the optimal number of questions per variable being measured. A larger number of questions could result in a survey that requires too long to complete while one question per variable does not allow a check on internal consistency. Hatcher (1994) maintained that surveys should include at least five questions per variable in order to increase the probability of retaining at least three after verification of internal consistency. The optimal number of survey questions per variable is between three and five (Nunally and Bernstein, 1994). By beginning with five questions per team variable, the *TeamMates* survey meets this paradigm.

McGrath (in Goodman et al., 1986) contends that serious research should stop relying on self-evaluation surveys where other options are available. While the team attributes prohibited an alternative data collection technique, other options were available for interim project performance. Therefore, for the interim performance of the project teams, this research designed and utilized an objective measure rather than subjective ratings by the project personnel and/or organization management. This measure, described in the *Data Analysis Plan for Interim Performance* section, was also ordinal because deltas among categories were not absolute equalities.

In summary, this section provided justification for a survey instrument to collect team attribute data. The optimization provided by the *TeamMates* five-

point scale and five questions per variable design is explained. The logic for not using a survey to gather interim project performance values was also discussed. The next two sections drill down the process from population identification to sample selection for this research.

POPULATION

The population for this research was the universe of NASA aerospace projects at any of the multiple NASA centers, including the Jet Propulsion Laboratory. More specifically, the population was limited to those projects that were in a formulation phase at some point during the 2000 - 2003 timeframe. To be included in this research, the project had to be recognized by NASA as a valid project that was subject to the processes described in the NASA Policy Directive (NPD) 7120.5 (2002) and NASA Procedures and Guidelines (NPG) 7120.5B (2002). For inclusion, these projects were also required to have a recognized project manager, to develop a formal project plan, and to endure independent reviews during their lifecycle. Project team size was not a selection criteria because group size is not critical to group theories (Guzzo and Shea, 1992). For concomitance, the *TeamMates* survey had to be completed by project personnel within 60 days of the independent review, which was used for the interim performance variable. The technical specifics, dollar value, and schedule duration for these projects were not relevant to this research effort; therefore, no further limitations on project selection were made.

PROJECT AND PARTICIPANT SELECTION CRITERIA

The sample of projects for this research was the result of a judgmental purposive selection, based on the highest chance of providing a representative sample (Emory, 1976). Due to the small population of NASA projects in formulation (thirty in 2003) and the need for concurrent data, no other sampling technique was feasible. As a starting point, the surveys completed by project team members working with NASA personnel attending an Advanced Project Management (APM) class, offered by the NASA Headquarters training office between April 2000 and June 2001, were reviewed. Since NASA attempts to select attendees for these classes from a cross-section of project participants, this selection methodology did not bias the sample; it was representative of the population of NASA projects as identified above. Only projects within the initial database that were in the formulation phase or had just completed the formulation phase (within the previous two months) when the survey was completed were considered for inclusion in this research. In order to capture the data during the actual formulation phase, no effort was made to retroactively gather data for NASA projects that had completed formulation prior to 2003. Three projects from the initial database met the criteria to be included in the sample and provided the additional data required to calculate their interim performance metrics.

To complete the sample, members of NASA project teams that were currently in the formulation phase and belonged to programs subject to independent assessment reviews were also solicited to complete the survey.

The sample size was necessarily bounded by the number of projects where team attribute data could be collected during the formulation phase through administration of the *TeamMates* survey and where interim project performance data was available. During 2003, of the thirty NASA projects in formulation, only thirteen projects met the criteria outlined above and were subject to either a SRR or PDR. Of those, eleven agreed to participate in this research for a response rate of 84.6%. Based on this large response rate, this sample clearly represented the targeted population during the timeframe of this research effort. Thus, the combined sample for this research consisted of fourteen projects.

The number of individual responses per project to the *TeamMates* survey varied from four to 52. This reflected the typical variation to survey responses and introduced no additional biases to the research (Nachmias and Nachmias, 1976). The number of personnel actively involved full-time varied with each project and current activities within individual projects. Each person completing the *TeamMates* survey was considered a key member of the project's team by the project manager.

The last two sections described the criteria and methodology for sample selection employed in this research. The framework from which this sample was selected was also explained. The plan for analysis of team attribute data is developed in the next section.

DATA ANALYSIS PLAN FOR TEAM ATTRIBUTES

In order to maintain the rigor of this research, strict guidelines were followed for data analysis. Within the survey responses, if an individual did not

answer all the questions in a particular team variable category, all of that individual's responses for that particular category were excluded. For instance, the empowerment variable required responses to questions 2, 10, 18, 26, and 34. If a particular person answered questions 2, 10, 26, and 34 but did not answer question 18, the responses from that person for empowerment were not included in the analyses. This method was chosen to preclude dilution of the data by using a median response to the missing question, which is another acceptable statistical technique (Emory, 1976).

Even though the *TeamMates* survey had been refined and validated as described above, the initial analysis included further statistics to verify that all survey questions within a variable grouping were related. The APM database, provided by Dr. Kinlaw, was populated with responses from NASA personnel working projects during 2000 – 2002. All NASA project teams are composed of college-educated engineers and scientists operating within the aerospace research environment. Federal personnel and acquisition regulations mandate the selection process, which creates a homogeneous environment. As such, the education and culture of initial respondents (during 2000-2002) is consistent with the personnel who completed the survey specifically for this research (during 2003). The projects were also comparable to the projects in this sample because NASA's mission has remained constant between 2000 and 2003: "To understand and protect our home planet, To explore the universe and search for life, To inspire the next generation of explorers … as only NASA can" (NASA NP-2003-01-298-HQ, 2003, p. ii). The projects initiated to accomplish these goals

have similar technical, schedule, and cost challenges because NASA only undertakes challenging aerospace projects that are outside the charters of other organizations. Therefore, utilizing the initial database for analysis of questions and their applicability to a team attribute variable did not introduce any biases. For each of the 178 projects within the initial database, there were between one and 31 individual responses to the survey questions. Every question received the full possible range of responses (1 – 5). For this internal consistency analysis, individual responses across the original database for the five questions within each team attribute variable category were correlated. Based on the ordinal data level, the gamma statistic was employed to determine which questions should be retained for each of the seven team attribute variables. Following the data interpretation and correlations criteria at the end of this chapter, only questions with a very strong (gamma > +0.50) relationship to other questions were retained for further analysis.

Care must be taken to insure that variables are measured at their natural level. When data is collected about individuals, the analysis must be consistent and focus on individuals. Only where aggregation to a higher level is justified can the data be considered representative of the team itself. In a meta-analysis of studies investigating cohesion and team performance, Gully et al. (1995) pointed out that rarely was an individual consensus determined prior to using the mean to represent group cohesion. As a result, the conclusions of those research efforts could be invalid. As emphasized by James et al. (1980), Mossholder and Bedeian (1983a, 1983b), Ostroff (1993), and George and James

(1993), the legitimate aggregation of individual characteristics to a group level variable depends on agreement within the group. To guard against analytical errors, the individual values of variables in this study were aggregated into team attributes only after evaluating the within-group agreement. In order to justify aggregation of the individual answers into team-level variables, the responses needed to vary more between projects than within single projects. Again, the initial database was used for these tests due to the larger sample size. The initial database contained a wide range of number of responses per project team (one to 31). To calculate between-team vs. within-team variance of responses, each team is required to have the same number. Since the majority of teams had three to twelve responses (85%), only those projects were selected for comparison. Data results are available in *Chapter IV*. Because the missing values were filled with the medians, using all data and a larger percentage of medians may have produced false results. Several other subsets of projects were tested including teams with six to ten responses, five to twelve responses, six to twelve responses, and exactly ten responses. In all cases, the between-team variance substantially exceeded the within-team variance at a significance far exceeding $\alpha = 0.001$. Only because the aggregation was justified could the results developed by this research be interpreted as a relationship between team attribute variables and interim performance. This provided the quantitative justification for the aggregation of individual responses into team attribute values in this research.

Also, aggregation to team level values was qualitatively appropriate prior to statistical analyses since this research concentrated on group-level theory (Klein et al., 1994). As explained by Van De Ven and Ferry (1980), data collected through individual surveys can be combined mathematically where the individuals are members of the group being studied. When the survey questions solicit opinions about the team relationships, as this research does, they produce group-level information. The wording of survey questions also led respondents to consider the team by the use of the plural pronoun, we. Therefore, aggregation of the team attributes was qualitatively valid as well.

To summarize, this data analysis plan for team attributes included additional validation of the *TeamMates* survey instrument. Specifically, the required statistical calculations were explained to quantitatively justify survey question inclusion and aggregation to team level variables. Finally, the qualitative justification for data aggregation was described. As this section focused on the team attribute data, the next section provides the plan for the interim project performance variable.

DATA ANALYSIS PLAN FOR INTERIM PERFORMANCE

NASA does not have a specific measure for rating interim project performance. The critical milestone and control gate reviews, such as the SRR and PDR/NAR (or PDR/CAR), evaluate all aspects of the project at a particular time. "The reviews provide topdown systematic evaluations of the derivation and functional allocation of requirements, the engineering implementation to address the requirements, the validation and verification of the requirements, the

preparation for operations and data analysis, and the system management processes that tie it all together" (NPG 7120.5B, 2002, p. 125). The method utilized by NASA review panels to capture the status of project elements is the preparation of Requests for Action (RFAs), which must be answered by the project team in order to continue into the next lifecycle phase. Examples of RFAs are provided in *Appendix F*. Other independent ratings of NASA projects at this early lifecycle phase do not exist. Therefore, the author decided that RFAs were the best available objective measures of interim project performance.

For each project considered, the actual action requests (RFAs) from the review process were solicited. The review chosen was the SRR, or the combined NAR (or CAR) and PDR, whichever was the most recent review for the project. These are the major reviews required of NASA projects during the formulation phase. The RFAs were written by technical and management experts on the independent review panels. Since these panel members have no vested interest in the project being reviewed, the RFAs were not biased to favor the projects.

These RFAs represent potential risks to the project if not mitigated in a timely manner. The NASA Risk Management Procedures and Guidelines, NPG 8000.4 (2002) recommends classifying risks before assessing their severity. The RFA content determined whether the RFA addressed a technical, programmatic, cost, or schedule risk. According to Pinto (2002), the simplest method for categorizing project risks is a matrix based on severity vs. likelihood of occurrence. But, MIL-STD 882D (2000) indicated that severity only ratings are

sufficient during early project phases. Therefore, no attempt was made to estimate the likelihood of these RFAs not being mitigated. NPG 8000.4 (2002) provided suggestions for criticality rankings but clearly stated that the methodology should be tailored. Five options for ranking RFAs were chosen based on the current NASA convention. A NASA risk management group recommended the use of five severity categories and received endorsement from NASA's Program Management Council for general risk assessments within the Agency. Five also represents the optimal number of responses, as discussed in the *Surveys* section above. Therefore, each RFA was ranked as 1, 2, 3, 4, or 5 based on its perceived level of severity, matched with the descriptions in the potential risk matrix (*Exhibit 6*).

The category definitions were developed by the author with consideration of the typical project knowledge available during the formulation phase. The author's initial definitions for categories one through five were patterned after the general risk matrix severity definitions used by independent review teams (*Appendix G*) and the broad severity explanations proposed by Carbone and Tippett (2003). These were refined to the definitions in *Exhibit 6* based on consensus of three project manager experts with a combined 82 years experience in project execution and review. In addition, cost and schedule analysts with a combined 84 years experience concurred in the cost and schedule definitions.

A survey of empirical studies by Rantilla and Budescu (1999) concluded that the use of three experts achieves the most benefit and a simple mean is the

appropriate methodology for aggregating their responses. For this research, three experienced NASA project reviewers separately assessed each RFA and assigned its criticality. Each expert was chosen based on their experience as a

Exhibit 6. Potential risk matrix

Severity	Technical	Programmatics	Schedule	Cost
5	Complete technical failure and/or loss of vehicle	Key workforce, facilities, management plans, and/or mitigation of critical risks needed to complete the effort will not be available	Missed Level 1 milestone and/or >20% delay in critical path	Cost overrun > 20%
4	Missed full success criteria and/or technical margins exceeded	Missing management plans, mitigation of critical risks, skills, facilities, and/or workforce needed to meet minimum success criteria	Missed Level 2 milestone and/or 10 – 20% delay in critical path	15 - 20% cost overrun
3	>50% technical margins will be required to meet minimum mission success criteria and/or requirements are inconsistent	Moderate problems with management, workforce, risk mitigation, facilities, and/or procurement approach leading to problems in meeting full success criteria	5 – 10% delay in critical path which can be handled by schedule reserves	10 – 15% cost overrun
2	<50% technical margins will be required to meet full mission success criteria	Minor problems with management, workforce, risk mitigation, facilities, and/or procurement approach leading to increase risk of missing full success criteria	<5% delay in critical path and/or schedules that are not integrated	5 – 10% cost overrun
1	Minimal or no impact and/or only minor changes needed to enhance performance	Minimal or no impact	Minimal or not impact and/or no required use of reserves	< 5% cost overrun

project manager and review team member. Collectively, the three experts had 81 years experience with NASA and Department of Defense projects. An acceptable agreement among the experts was required to develop the final rating of RFA's for each project. The Nominal Group Technique (NGT) was empirically shown to be the best group consensus process among several options by Gustafson et al. (1973). In this application of NGT, each expert independently ranked the project RFAs. For each expert's input, the author calculated the individual project's interim performance metric, according to the formula provided later in this section. Because the deltas between severity levels in *Exhibit 6* are not equal, these interim performance metrics were based on ordinal level data. Therefore, the gamma statistic was utilized, for reasons documented in the *Data Interpretation and Correlations* section, to measure agreement among expert rankings. Additional modifications to individual RFA rankings were unnecessary because the performance metrics calculated for each expert's initial rankings were in excellent agreement as described in *Chapter IV*.

Since the details of a project reviewed at the PDR/NAR (or PDR/CAR) are more extensive than those evaluated at the SRR, projects having completed PDR/NAR (or PDR/CAR) had the potential for a larger number of RFAs. The number of NASA projects in formulation at any given time is limited by federal funding. Therefore, in order to increase the sample size for this research, projects at both points of formulation were used. However, to generate a measure of interim project performance that was equitable across projects, the absolute number of RFAs was converted to a weighted percentage of the mean

RFAs from that review for the projects within this sample. Those RFAs rated as a severity of 5 have the potential of more negative effect than those rated as 4, 4's are more adverse than 3's, and so forth. As a result, a simple arithmetic sum would not discriminate among projects' performance levels. Therefore, this research used a weighted sum:

$$\textit{Weighted RFA Count} = (N_5 * 5) + (N_4 * 4) + (N_3 * 3) + (N_2 * 2) + (N_1 * 1)$$

$$\textit{Interim Project Performance Value} = \textit{Weighted RFA Count} / M * 100$$

where N_x = *Number of RFAs rated as X, for X = 1 to 5*

M = Mean Weighted RFA Count for projects within sample for that particular review

With ordinal level data, the important characteristic is the order of the data values, not their absolute magnitude. Therefore, weighting factors equal to the severity levels in *Exhibit 6* were sufficient to distinguish between the potential risk levels in calculating the interim performance metric because only ordinal level statistics were used for testing these research hypotheses. The arithmetic distributive property can be used to prove that multiples of these factors would yield the same data order. For example:

If $(N_5 * 5) + (N_4 * 4) + (N_3 * 3) + (N_2 * 2) + (N_1 * 1) > (M_5 * 5) + (M_4 * 4) + (M_3 * 3) + (M_2 * 2) + (M_1 * 1)$

Then $(N_5 * 10) + (N_4 * 8) + (N_3 * 6) + (N_2 * 4) + (N_1 * 2) = 2 * [(N_5 * 5) + (N_4 * 4) + (N_3 * 3) + (N_2 * 2) + (N_1 * 1)] > 2 * [(M_5 * 5) + (M_4 * 4) + (M_3 * 3) + (M_2 * 2) + (M_1 * 1)] = (M_5 * 10) + (M_4 * 8) + (M_3 * 6) + (M_2 * 4) + (M_1 * 2)$

The data analyses recorded in *Chapter IV* indicate that other weighting factors also preserve the order of interim performance metrics in this

sample. As an illustration of the process used for this research, a hypothetical calculation for four projects is given in *Exhibit 7 and described below.*

Exhibit 7. Calculation of interim project performance for hypothetical projects

Project	5's	4's	3's	2's	1's	Wt'ed Count	Interim Project Perf
SRR's							
A	3	1	2	2	1	30	130.4
B							
C	1	0	2	0	5	16	69.6
D							
Mean						23	
PDR's							
	5	0	7	0	4	50	106.4
	2	0	10	0	4	44	93.6
Mean						47	

Hypothetical projects A and C were evaluated based on the RFAs written during an SRR. Project A's nine RFAs were combined according to the formula above (3*5+1*4+2*3+2*2+1*1) for a weighted count of 30. Similarly Project C's weighted count was 16. Since only two projects are included in this hypothetical example at SRR, the mean weighted count is (30+16)/2 or 23. To develop interim project performance values: A = 30/23*100 = 130.4 and B = 16/23*100 = 69.6. Similar calculations for hypothetical projects B and D, evaluated based on

the RFAs written during PDR, resulted in interim project performance metrics of 106.4 and 93.6, respectively.

Following the collection of data, gamma and Spearman's Rank Order correlation analyses between the project interim performance variable and team-level attributes were conducted. Also, the interactions between team variables were studied. The results were subject to the correlation criteria set forth in the next section.

In summary, this section described the plan for derivation of interim project performance values for the projects within this research sample. The methodology, including risk ranking of action requests by three experts, was supported by previous research. The next section sets the criteria for data interpretation.

DATA INTERPRETATION AND CORRELATIONS

Evidence supported the premise that raters assume a normal distribution across options within a Likert-type scale (Ramsey, 1973). However, since there is no method to verify that individuals consider the differences between adjacent numbers on the scale to be uniform, the raw survey data was considered ordinal and not numerical. "When only the rank order of scores is known, means ... are in error or misleading ... and do not have substantive meaning" (Siegel and Castellan, 1988, p. 33). Therefore, for this research, medians rather than means were utilized as the aggregate for group values.

This is a statistically conservative approach because numerous classical statistical texts emphasize the inappropriateness of different statistics for less

than numeric levels of data. However, Knoke and Bohrnstedt (1982) distinguished only between discrete and continuous variables when choosing the proper statistical calculation. They maintained that correlations are appropriate "where there is clearly an underlying continuous variable, even if it is measured only at a discrete level" (Knoke and Bohrnstedt, 1982, p. 304), such as Likert-scale surveys. While various statistics were considered, the Spearman's Rank Order correlation (rho) and gamma were chosen as appropriate for this ordinal level data. These measures of association also provided a conservative estimate of the relationship between the variables since normalcy is not a pre-requisite for non-parametric statistics and the variable distribution is not strictly linear (Hatcher, 1994). Furthermore, this statistical technique produces accurate analyses for small sample sizes such as this research entailed (Siegel and Castellan, 1988).

In analyzing the data, this research followed Fink's (1995) suggestions for interpretation of correlation results. If correlations were between –0.25 and +0.25, little or no relationship between the variables was considered to exist. Correlations between –0.50 and –0.26 or between +0.26 and +0.50 were rated as an indication of a fair degree of relationship. The range between |0.51| and |0.75| represented a moderate to good relationship; |0.76| to |1.00| values indicated a very good to excellent relationship. While Fink was establishing criteria for Pearson's correlation, these levels apply to Spearman's Rank Order correlations as well (Siegel and Castellan, 1988). The level of significance sought was 0.05, which is considered the social psychology standard by

Buchanan (1974). Gamma is another statistic that non-parametrically measures relationships between ordinal variables. Where the data contains numerous tied values, gamma is considered a more accurate depiction of relationships (Siegel and Castellan, 1988). Gamma values < |0.20| were considered weak, values > |0.50| provided evidence of a very strong relationship, and gammas between |0.20| and |0.50| represented some relationship (Buchanan, 1974). However, a gamma value of ± 1.0 does not indicate a perfect correlation (Nachmias and Nachmias, 1976). The level of significance sought for gammas was also 0.05.

This section has provided evidence supporting the data interpretation standards chosen for this research. The non-parametric gamma and rho statistics selected were appropriate for the level of data collected. Care was taken to always select the most conservative approach; so, any results achieved would be incontrovertible. The next section describes the final step in this research design – the interviews of project personnel to collaborate statistical findings.

VALIDATION PLAN

As a final validation of this research, a subset of project team members was selected and personally interviewed to determine to what extent the analysis results were supported by their project experiences. The interviews conformed to the characteristics of focused, nonscheduled-semi-structured interviews: all interviewees were known to have experienced the project team, the team attributes were analyzed prior to conducting the interviews, an interview guide was followed (*Appendix D*), and the interviews focused on subjective

experiences. This interview style was recommended for non-experimental research designs such as employed in this effort (Nachmias and Nachmias, 1976). The interview questions, listed in *Appendix D*, were developed based on the results of the statistical analyses following data collection. Recording responses in predetermined categories is the most common interview technique for hypotheses testing (Nachmias and Nachmias, 1976). As recommended by Emory (1976), the categories, documented in *Appendix D*, were selected to be orthogonal, exhaustive, and appropriate to this research effort. In addition, responses to some questions were recorded in more detail to capture the full complexity of behavioral opinions. These open-ended questions served to provide supporting information as recommended by Leedy and Ormrod (2001).

The author conducted all interviews, using a semi-structured guide to maximize consistency, and prepared the interviewer notes in *Appendix D*. Each person interviewed concurred on the notes from their interview prior to further analysis. At least one member of a project for each of the NASA enterprises represented in this sample was selected, based on availability for interviews. Those interviewed also represented the sample demographics of job type, time with project, and age. This selection method, though not random, guarded against the introduction of biases. Their agreement or objection to the assessment of their project on team variables was recorded following the semi-structured interviews and is summarized in *Chapter IV*.

The purpose of these interviews was to add additional data to this quantitative research. As such, the data coding scheme was a frequency count

of agreement to the research statistical findings. No further statistical or qualitative data analyses were performed.

This section described the process for selecting persons to be interviewed, the purpose of the interviews, and the interview structure and type. The actual details of the interview questions and responses are provided in *Appendix D*. The plan for analyzing responses was recorded in this section while the analysis results are in *Chapter IV*. The next section explains how this research plan guarded against barriers and overcame challenges to insure accurate results.

ISSUES, CHALLENGES, AND BARRIERS TO RESEARCH

Anytime a researcher attempts to delve into the social aspects of the socio-technical system that is a project, there may be resistance from the project team members. The general participation of NASA project team members in the team attribute survey was never a concern, since most NASA employees are accustomed to research and are willing to participate in such efforts. The major concern was the willingness of the project managers to provide the actual action requests (RFAs) from their reviews. That data is only maintained by the project and review teams and does not reside within a common NASA database. Therefore, the sample size was not only a function of the number of aerospace projects in formulation phases within NASA, which is limited at any given time, but also of the cooperation of those project managers. Fortunately, 84.6% of project managers, whose projects met the sample criteria, agreed to participate.

Another issue was the adherence to confidentiality while presenting the data and results in a usable format. This was accomplished by coding the project teams; only the author has knowledge of their true identities.

Also, the temptation to use inappropriate statistics had to be avoided. Since the lowest individual data form was ordinal, care was exercised to use only statistics that are valid with ordinal or nominal data. The near simultaneous collection of all data precluded statistics that imply causation. Therefore, regression analyses were inappropriate since "such procedures are designed to detect and interpret stochastic relationships between a dependent (response) variable and one or more independent (predictor) variables" (Hollander and Wolfe, 1999, p. 415). According to Fink (1995), statistical regression is equivalent to prediction, which is not justified by this research design. Also, the aggregation of individual responses into team-level variables had to be statistically justified. By carefully outlining the statistical and research methodologies, the author ensured that data assumptions matched the statistical methods employed. In addition, potential research biases were minimized by utilizing appropriate data collection techniques.

SUMMARY

As mentioned in *Chapter II*, there is no conclusive justification for extrapolating empirical research results from laboratory studies to the world of real project teams. Therefore, the only logical scenario for this research was the collection of information on real project teams. This particular approach, combining self-reporting of team variables with an objective measure of interim

performance, further guarded against procedural flaws explained in this chapter. Historical precedents and conservative statistical considerations support the selection of a non-parametric correlation analysis between the aggregated team attribute variables, obtained through individual surveys, and the weighted interim project performance variable in order to test the null hypotheses stated in *Chapter I*.

The author's personal observations, supported by an extensive literature review, justified the need for research into the relationship between team dynamics and project performance. The criticality of the initial phase of a project's life cycle, as documented by Shenhar et al., (1997), justified the design choice of formulation phase projects. The requirement to capture performance concurrently with team data and the lack of such a measure for early phase NASA projects required the creation of a measure for interim project performance.

This chapter has systematically explained the research design. The rationale for selection of the *TeamMates* survey for capture of team attribute data was described along with the survey originators' development process. The development of a metric to measure interim project performance was also explained. Several sections were devoted to the prescription for analyzing team attributes and interim project performance, as well as interpreting the data. The population sample and interview plans were documented. Finally, the last section described issues and challenges associated with this research. This

chapter summarized the design; *Chapter IV* provides the results of this research, including statistics and analyses.

CHAPTER IV

RESULTS

This chapter provides a summary and an analysis of the data collected for this research. The actual raw data is presented in *Appendix E*. The research design, as described in *Chapter III*, was meticulously followed to preclude contamination of data and false results. Dissection of the data into several relevant categories further added to the validity of the results obtained. The data resulting from each step in the research design, including their validation, is summarized in the following sections.

Chapter III provided the template and justification for conducting this analysis of the collected data. This chapter begins with verification of the team attribute data and the calculations to justify retention of all survey questions and aggregation into team level variables. Next, calculations to generate interim project performance values are explained. This preliminary work leads to the documentation of the hypotheses testing, which is the focus of this research. This chapter concludes with a summation of the interviews conducted to assess whether statistical results were acknowledged by project team members.

DEMOGRAPHICS

Demographics were not available for the persons completing the *TeamMates* survey in the Advanced Project Management (APM) classes (three projects within this research sample). Therefore, no demographic information is available for projects C, D, and F. The limited demographic information required

in the survey administered during 2003, for the sole purpose of this research, provided the opportunity for additional external validity checks. However, NASA does not have a central repository for the demographics of personnel working projects. In addition, project team members include employees of industrial and academic partners where NASA would not have access to this information. However, the age range of current NASA employees, in general, was available for comparison with this sample. The age range completing the survey for this research is representative of the entire NASA civil service employment with a correlation of 0.886 ($\alpha < 0.02$). For those who completed the survey in 2003, the time with their project ranged from zero months to 125 months. The age of those completing the survey fell between 20 and greater than 69. The jobs were predominantly engineers and managers, while scientists, administrative professionals, and other skills were also represented. Overall the respondents were distributed as shown in *Exhibit 8*.

Exhibit 8. Distribution of demographics within sample (11 projects)

Age	Count	Skill	Count	Time with Project	Count
20's	8	Manager	39	0 – 12 months	58
30's	31	Engineer	63	13 – 24 months	54
40's	61	Scientist	8	25 – 36 months	11
50's	21	Admin	10	37 – 48 months	1
60's	6	Other	8	> 48 months	4
> 69	1				

To ascertain whether these demographics affected responses to the team attribute questions, gamma statistics were calculated for the question responses

compared with each of three identifying data points. The results are provided in *Exhibit 9*.

Exhibit 9. Relationships between team attribute questions and demographics

	Gamma				Gamma		
Question	**Age**	**Project Time**	**Skill**	**Question**	**Age**	**Project Time**	**Skill**
Q1	.112	.022	.093	Q20	-.007	-.174	.217
Q2	.029	.080	.193	Q21	.149	.030	-.013
Q3	-.003	-.075	.081	Q22	-.002	-.119	.134
Q4	-.123	-.146	.068	Q23	.060	-.066	.032
Q5	-.074	-.118	.001	Q25	.031	-.042	.051
Q6	.038	-.126	-.005	Q26	.011	-.117	.138
Q7	.107	-.021	.192	Q27	.028	.089	.279
Q9	-.120	.136	.076	Q28	-.088	-.147	.041
Q10	-.099	.050	.041	Q29	-.026	-.048	.156
Q11	.011	-.033	-.013	Q30	.102	-.116	.262
Q12	-.030	-.170	.072	Q31	.012	-.097	.102
Q13	-.028	.054	-.052	Q33	.093	.047	.159
Q14	.054	.017	.252	Q34	.265	.041	.279
Q15	.114	-.051	.108	Q35	.050	-.003	.160
Q17	.015	-.026	.061	Q36	-.005	.036	-.005
Q18	-.042	.001	.292	Q37	.054	-.060	.147
Q19	.094	.050	.186	Q38	-.016	-.111	.220
				Q39	.092	-.165	.109

Only one question (Q34) had a moderate gamma value when compared to respondent age. The project results for the total empowerment variable were not affected by this relationship. In fact, Project K had more respondents in the age categories with higher Q34 responses than those with lower values, yet Project K had the lowest overall empowerment median. When comparing respondent time with the project to question values, all the gamma values were weak. This

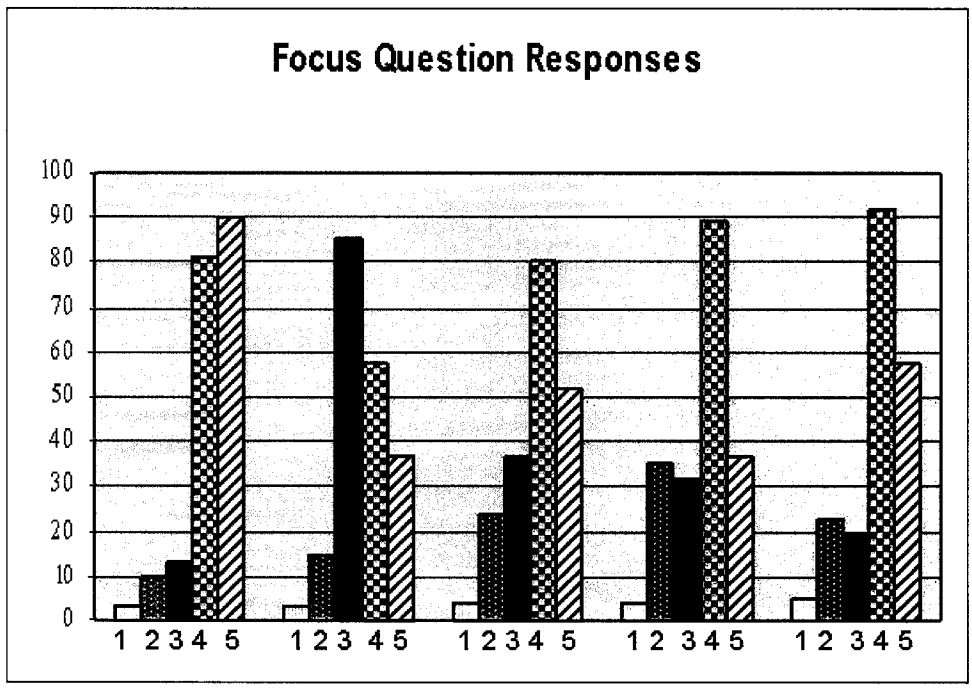
provided evidence that time on a project was unrelated to the way a respondent answered the survey questions. In seven cases, questions had a moderate relationship to skill category as shown by the gamma values in *Exhibit 9*. These questions fit into the empowerment (Q18 and Q34), cohesion (Q20), structure (Q27), and interdependence (Q14, Q30, and Q38) variables. With the exception of Q20, all of these relationships to skill were significant at the $\alpha < 0.05$ level. However, by comparing individual project skill mixes with project median values for those variables, none appeared to be influenced by these moderate gammas on individual questions. Therefore, based on these weak to moderate values for gamma, the demographics of respondents to the *TeamMates* survey did not significantly affect responses to the team attribute variables.

TEAM ATTRIBUTE VARIABLES

In testing for question validity, each question in the survey of team attributes recorded the full range of possible responses (1 – 5) in both the Kinlaw APM database and the data used specifically for this research. The actual survey responses are provided in *Appendix E*. Also in *Appendix E* are graphs of the frequencies of responses per question; an example of the distribution of responses for the focus attribute is shown in *Exhibit 10*. The horizontal axis values represent the question answers; the bars are grouped by question. Considering all seven attributes, the majority of responses to 24 questions were four (somewhat agree) and five (strongly agree) while ten questions had the most responses in the three (neither agree or disagree) and four categories with only one question (structure Q11) maximizing two (somewhat disagree) and four.

Every attribute had at least three questions with the concentration of response values as four or five. The largest number of responses fell at three for two questions (focus Q9 and cohesion Q12) and at five for six questions (focus Q1, cohesion Q20, structure Q27, recognition Q5, interdependence Q14, and communication Q15). Each attribute with the exception of empowerment had one question with the majority of responses in the five category. This confirms the natural bias of team members to positively rate their team (Messick and Mackie, 1989), as described in *Chapter I*. Despite this positive bias, the discrimination between teams was sufficient to test the hypotheses.

Exhibit 10. Distribution of question responses



As justified in *Chapter III*, the Kinlaw APM database (178 projects) was used to determine whether any of the five questions within a category did not measure the team variable under study. Gamma statistics, as described in *Chapter III*, were calculated to determine whether a question should be retained for the hypothesis testing. As shown in *Appendix E*, each question within a team variable category was very strongly related (gamma > 0.50) to other questions in that category. For example, the first interdependence question (Q6) is related to the other interdependence questions with gammas of 0.612 (Q14), 0.591 (Q22), 0.577 (Q30), and 0.601 (Q38). All gamma values were significant to $\alpha < 0.001$. Therefore, according to the criteria set forth in *Chapter III*, it was decided to retain all questions for the hypotheses testing.

In addition, gamma statistics were calculated to compare each question to all others to determine whether or not a particular question related more strongly to another outside of its variable set. As shown in *Exhibit 11*, in all cases, the question's strongest relationship was to another question within its variable set. In fact, the relationships outside a particular team attribute variable set ranged from 0.000 between focus Q3 and empowerment Q10 to 0.455 between recognition Q29 and structure Q35. For focus, empowerment, recognition, interdependence, and communication team attributes, the weakest relationship among questions within their variable set was greater than the strongest relationship with a question outside their variable set. While structure Q35 related to recognition Q29 with a gamma of 0.455, Q35 related more strongly to other structure questions (gamma = 0.537, 0.611, 0.679, and 0.752) and

recognition Q29 related more strongly to other recognition questions (gamma = 0.490, 0.680, 0.717. and 0.746). Similarly even though cohesion Q20 related to empowerment Q26 with a gamma of 0.433, Q20 related more strongly to other cohesion questions (gamma = 0.577, 0.599, and 0.672) and Q26 related more strongly to other empowerment questions (gamma = 0.589, 0.591, 0.599, and 0.635). Therefore, the consistency criterion was met in these instances as well. The full data set is provided in *Appendix E*. As an additional test to determine whether or not the questions in each variable set measured a single construct, Cronbach's alpha was calculated. The results were 0.789 for the focus questions, 0.828 for empowerment, 0.787 for structure, 0.709 for cohesion, 0.802 for recognition, 0.823 for interdependence, and 0.764 for communication. The evidence in support of each variable set representing one construct was incontrovertible.

Exhibit 11. Question relationships

Attribute	Strongest gamma within set	Weakest gamma within set	Strongest gamma outside set
Focus	.771	.434	.176
Empowerment	.635	.464	.433
Structure	.752	.433	.455
Cohesion	.672	.315	.433
Recognition	.746	.490	.455
Interdependence	.747	.577	.175
Communication	.728	.510	.337

To determine whether or not these individual responses could be aggregated into team level variables, the variance within and between teams was

Exhibit 12. Comparison within and between teams

Variable	Question	Within Team	Between Teams	Significance
Focus	Q1	0.52	2.62	5.79E-59
	Q9	0.64	3.48	8.71E-66
	Q17	0.67	2.92	4.70E-47
	Q25	0.70	3.98	2.83E-69
	Q33	0.63	5.05	4.60E-107
Empowerment	Q2	0.59	1.88	4.80E-30
	Q10	0.79	4.29	6.83E-70
	Q18	0.51	1.84	1.44E-36
	Q26	0.62	3.18	1.01E-63
	Q34	0.75	3.93	1.15E-65
Structure	Q3	0.67	3.43	1.06E-64
	Q11	0.85	5.28	8.54E-84
	Q19	0.86	4.69	8.76E-70
	Q27	0.51	1.89	7.49E-39
	Q35	0.69	3.35	2.54E-59
Cohesion	Q4	0.79	3.99	1.03E-62
	Q12	0.64	3.10	1.27E-58
	Q20	0.52	2.94	1.99E-72
	Q28	0.61	2.78	1.39E-53
	Q36	0.86	7.02	2.40E-115
Recognition	Q5	0.69	2.33	4.14E-33
	Q13	0.71	5.66	4.60E-113
	Q21	0.71	3.72	2.39E-66
	Q29	0.66	2.19	7.79E-32
	Q37	0.73	4.35	2.08E-78
Interdependence	Q6	0.53	2.41	4.58E-54
	Q14	0.40	1.56	2.44E-42
	Q22	0.56	2.21	7.41E-43
	Q30	0.64	2.59	1.06E-44
	Q38	0.58	3.09	9.66E-69
Communication	Q7	0.58	2.71	3.23E-57
	Q15	0.68	2.87	1.40E-48
	Q23	0.70	2.88	3.90E-47
	Q31	0.58	2.60	2.26E-53
	Q39	0.70	4.24	2.61E-82

calculated as described in *Chapter III* and documented in *Exhibit 12.* The deltas within teams were very significantly less than the deltas between teams. This

provided strong quantitative support for the aggregation of responses into team level variables. In addition, the question wording qualitatively identified each attribute as a team variable. Therefore, aggregation of individual responses into team attribute values was justified both quantitatively and qualitatively, according to the criteria set forth in *Chapter III*.

In conclusion, all questions were considered valid for the team variable being measured. Also, aggregation to team level variables was justified. As specified in *Chapter III*, the median of the question median values was the appropriate value to use for the team attributes. The summary of team data are included in *Appendix E*; *Exhibit 13* provides the calculated medians, which were used as the team attribute variable values in the hypothesis testing. For all team

Exhibit 13. Project survey data

Project ID	Medians						
	Focus	Empower	Struct	Cohesion	Recog	Interdep	Comm
A	4	4	4	4	5	4	4
B	4	4	4	4	4	4	4
C	4	4	4	4	4	4	4
D	4	4	4	5	4	5	4
E	4	4	4	4	4	4	4
F	3	4	3	4	4	4	4
G	4	5	4	4	5	4	4
H	4	4	4	4	4	4	4
I	4	4	4	4	4	5	4.5
J	4	4	4	3.5	4	4	4
K	3.5	3.5	4	3.5	4	4	4
N	4	4	4	4	4	4	4
Q	4	4	4	4	4	4	4
R	4	4	3	3	4	4	4

attributes, response four (somewhat agree) was the most frequent median value. Focus, empowerment, structure, and cohesion had projects with team values less than four. Of those, Project K was less than four on three of the team attributes. Project F and Project R were below four on two team attributes. In contrast, empowerment, cohesion, recognition, and interdependence had projects with team values of five, and communication had one team with a 4.5 median value. Project G, Project D, and Project I displayed two attributes greater than four. Values for the projects' interim performance variable are included in the next section. These team attribute and interim project performance values were used in the hypotheses testing described later in this chapter.

INTERIM PERFORMANCE VARIABLE

As described in *Chapter III*, three experts independently ranked each RFA from each project's review. The descriptions of severity levels used in the rankings are provided in *Exhibit 6*. To determine whether or not additional consideration was necessary to reach a consensus, gammas were calculated comparing each expert's rankings. The results were 0.517, 0.488, and 0.450, with $\alpha < 0.001$ for all three pairs, indicating there was strong to very strong agreement on individual RFA's among the three experts. In a review of the rankings in *Appendix E*, it was apparent that Expert 2 was more lenient than the others. However, this did not have an adverse effect on the data because he was consistently more lenient as evident from the strong gamma values cited above. Therefore, a more meaningful comparison, which negated the natural

tendency of some to be more lenient than others, was to compare the project interim performance scores among experts.

The formula, for calculation of interim project performance, provided in *Chapter III*, was applied to the project rankings. For each expert, the number of RFAs ranked as 1, 2, 3, 4, and 5 for each project were tallied. That expert's weighted RFA count was calculated using the formula provided in *Chapter III*. Then the *Chapter III* formula for interim project performance value was used to develop the scores provided in *Exhibit 14* for each expert's ranking of the projects' RFAs.

Exhibit 14. Project interim performance scores

Project	Expert 1	Expert 2	Expert 3	Mean
A	109.96	112.08	117.36	113.13
B	102.59	114.12	113.91	110.21
C	238.06	240.47	213.31	230.61
D	31.17	21.4	28.99	27.19
E	66.88	71.32	64.89	67.70
F	91.14	94.59	92.72	92.82
G	37.53	42.2	38.42	39.39
H	78.88	91.68	74.34	81.64
I	38.29	37.84	37.59	37.91
J	327.02	320.17	329.12	325.44
K	83.48	72.77	90.21	82.15
N	109.39	104.95	108.38	107.57
Q	43.65	40.75	37.59	40.66
R	41.94	35.66	53.16	43.59

To further test that the chosen weighting factors, as described in *Chapter III*, did not affect the research results, two additional sets of factors were assigned and the project interim performance scores were calculated. If the

weights were multiples of the 5,4,3,2,1 used in *Exhibit 14*, the project order was proven to be maintained in *Chapter III*. Therefore, the chosen test cases purposely used weighting factors that were not multiples of the 5,4,3,2,1 but still maintained the order of severity. In particular, the weighting factors were 100,75,50,25,10 and 120,70,40,30,10. The project interim performance scores for these two test cases related to the scores in *Exhibit 14* with gamma values of 0.978 and 1.000 and rho values of 0.996 and 1.000 ($\alpha < 0.001$). In addition, when these test scores were used in lieu of those shown in *Exhibit 14*, the hypotheses test results were identical to those described in this chapter's *Summary*. Therefore, the weighting factors chosen for this research did not bias the research results.

Gamma statistics were calculated between the project performance scores of each expert. The results were 0.846, 0.889, and 0.911 ($\alpha < 0.001$), indicating very strong agreement. The Spearman's rho values were also significant to $\alpha < 0.001$; results were 0.952, 0.970, and 0.964, indicating excellent agreement among the three experts. Therefore, according to the research design described in *Chapter III*, utilization of the means in *Exhibit 14* as the interim project performance values during hypotheses testing was justified.

HYPOTHESIS TEST RESULTS

Each team variable and the interim project performance values were calculated as described in the previous sections. Then, according to the research design described in *Chapter III*, Spearman's Rank Order correlation (rho) and gamma statistics were calculated to test the hypotheses set forth in

Chapter I. As the variables were defined, a larger team attribute value would indicate a more positive response to the team attributes being studied. In contrast, the larger interim performance scores can be interpreted as a more problematic project performance. Therefore, the Spearman's rho and gamma values for these hypotheses tests were expected to be negative, if relationships existed.

Exhibit 15 provides the statistical results associated with the hypotheses testing, in order of the hypotheses tested. The gamma and Spearman Rank Order correlation values for focus and interim project performance supported Hypothesis 1 as stated; there was not a significant relationship between those variables. Similarly, the statistics supported Hypothesis 3; there was not a significant relationship between team structure and interim project performance. While the Spearman correlation statistic indicated there is little relationship between empowerment and interim project performance, there was moderate support for rejecting the null Hypothesis 2 due to a gamma of -0.360, indicating there was evidence of some relationship. Also, moderate support was found for

Exhibit 15. Statistical results of hypotheses testing

With Interim Performance	Spearman	Gamma
Focus	-.105	-.200
Empowerment	-.234	-.360
Structure	.051	.083
Cohesion	-.325	-.378
Recognition	.000	.000
Interdependence	-.608	-1.000
Communication	-.378	-.846

the rejection of null Hypothesis 4 by a gamma of -0.378 and a Spearman correlation of -0.325 between team cohesion and interim project performance. However, based on the significance of these relationships, the evaluation of Hypothesis 2 and Hypothesis 4 is inconclusive.

At the extremes, two team variables appeared very strongly related to interim project performance while one, recognition, had absolutely zero relationship to interim project performance within this research sample. The gamma value of -0.846 for communication and interim performance supported rejection of Hypothesis 7 (there is no statistically significant correlation between intra-team communication and interim project performance), since this is considered a very strong relationship between the variables, as specified in *Chapter III*. Even the Spearman correlation statistic of -0.378 indicated a fair relationship. However, this result was not statistically significant according to the alpha criteria set forth in *Chapter III*. More notably, the gamma of –1.000 between interdependence and interim project performance strongly supported rejection of null Hypothesis 6 (there is no statistically significant correlation between the level of interdependence within the team and interim project performance). The Spearman correlation statistic of -0.608 also indicated a good relationship between those variables. In fact, the Spearman rho between interdependence and interim project performance was the only relationship significant at $\alpha < 0.05$. In contrast, Hypothesis 5 was supported since no relationship was found between recognition and interim project performance with this sample.

To summarize, the only team attribute which met the criteria for a significant relationship with interim project performance, as specified in *Chapter III*, was interdependence. The perfect absence of any relationship between recognition and interim project performance was an unexpected result. The other five team attributes displayed different non-significant levels of relationships. Based on the criteria set forth in *Chapter III*, only null Hypotheses 6 (there is no statistically significant correlation between the level of interdependence within the team and interim project performance) was rejected.

RELATIONSHIPS AMONG TEAM VARIABLES

Most often, multiple variable regression analysis is used to study the relationships among variables when they are jointly believed to impact a dependent variable. As described in *Chapter III*, the data is ordinal and interval level data is necessary for traditional regression analyses. Also, for this research, as explained in *Chapter III*, even non-parametric regression analysis was inappropriate (Hollander and Wolfe, 1999, and Fink, 1995), because the interim performance variable was collected at relatively the same time frame as the team variables; so, there is no dependent variable in the classical sense. Therefore, the most appropriate manner to investigate the relationship between team attribute values is by Spearman's rho. The median team values for each variable were statistically compared using SPSS for Windows ® software (SPSS, 2000). The results of Spearman's rho calculations among the team attributes are shown in *Exhibit 16*.

Exhibit 16. Project team attribute relationships

	Focus	Emp	Str	Coh	Recog	Inter	Comm
Focus	1.000	.500	.457	.226	.166	.166	.113
Empowerment	.500	1.000	.000	.353	.540	.000	.000
Structure	.457	.000	1.000	.349	.167	.167	.113
Cohesion	.226	.353	.349	1.000	.127	.477	.086
Recognition	.166	.540	.167	.127	1.000	-.167	-.113
Interdependence	.166	.000	.167	.477	-.167	1.000	.679
Communication	.113	.000	.113	.086	-.113	.679	1.000

Empowerment and recognition were significantly related with a rho value of 0.540 ($\alpha < 0.05$). Similarly, the relationship between communication and interdependence was significant with a rho value of 0.679 ($\alpha < 0.01$). No other attributes related to each other at the significance level required in *Chapter III*. In fact, interdependence, communication, and structure had no relationship with empowerment.

INTERVIEW RESULTS

Following the initial analyses of the statistical data as described above, the questions provided in *Appendix D* were developed. Five interviews were conducted with personnel from five different projects within this purposive selected sample (Emory, 1976) to ascertain if their project experiences supported the statistical results. The five projects were chosen to ensure that projects were included from each of the three NASA enterprises represented in the sample for this research. In addition, an attempt was made to represent different skill, age, and time with project ranges by the personnel interviewed. While several different demographic categories were represented by the persons interviewed,

the majority were engineers between 40 and 49 years of age. Following each interview, the person interviewed concurred with the record of their interview that is included in *Appendix D*.

In general, the interviews provided face validity for the statistical results. The overall consensus was that the individual's project experience confirmed the statistical results. For the interdependence team attribute, five of the five interviews (100%) confirmed the very strong statistical relationship with interim project performance. Five of the five interviews (100%) confirmed the statistical results for the communication team attribute. Five of the five interviews (100%) also confirmed the statistical results for the cohesion team attribute. For the recognition team attribute, three of the five interviews (60%) agreed with the lack of relationship with interim project performance that was found in the statistical results. One declined to comment on this attribute and another's personal experience disagreed with the statistical finding. Therefore, only the lack of a relationship between recognition and interim project performance was questionable according to those interviewed.

Each of those interviewed was asked to rate their project (scale of 1 - 5) on each of the four team attributes (interdependence, communication, cohesion, and recognition.) This ranking produced interesting results, provided in *Exhibit 17*. The interview rating of their project team attributes agreed with the median survey values in only five cases. In one instance, the person interviewed gave their team a higher value on cohesion than resulted from the survey. Most of the interviews rated their projects lower on communication, cohesion, and

Exhibit 17. Comparison interviews vs. surveys

Variable	Interview ID	Survey	Interview
Interdependence	1	4	3
	2	4	4
	3	4	4
	4	4	4
	5	4	3.5
Communication	1	4	2
	2	4	3
	3	4	4
	4	4	3.5
	5	4	3
Cohesion	1	4	2
	2	3.5	3
	3	4	3
	4	3.5	4
	5	4	4
Recognition	1	4	1
	2	4	3
	3	4	
	4	4	2.5
	5	4	

recognition than the survey results. Since the survey values were medians from a range of responses, this phenomenon was not a concern. The interdependence attribute was in the closest agreement, with three of the five interviews rating their team equal to the survey medians. In summary, while the persons interviewed differed in the individual values assigned to their team attributes, they generally agreed with the statistical findings of this research.

SUMMARY

In conclusion, this research resulted in substantial evidence of a strong relationship between interdependence within a NASA project team and the

project's interim performance as objectively measured. A relationship between intra-team communication and interim project performance was also demonstrated, although the strength of that relationship was not statistically significant according to the criteria set forth in *Chapter III*. In addition, there was inconclusive support for rejecting the null hypotheses, which claimed no relationship between either cohesion or empowerment and the operational definition of interim project performance. By contrast, the team dynamics involving focus, structure, and recognition were found to be unrelated to interim project performance in this sample. The hypotheses are restated and the final results are summarized in *Exhibit 18*.

The processes employed in following *Chapter III*'s reseach design were described in this chapter. The values of team attribute questions were statistically compared to the demographics of the respondents with a conclusion that skill mix, age, and time with the project were unrelated to their responses. Appropriate tests were conducted to justify retention of all five survey questions for each team attribute variable and aggregation of individual responses into team level variables. In addition, statistics validated that each survey question belonged with the variable set to which it was assigned. Expert rankings of independent review team requests for action were combined according to the formula in *Chapter III* to form the interim project performance metric. Only numerically justified statistics were employed to test the hypotheses with the results provided in *Exhibit 18*. Both Spearman's Rank Order correlation (rho) and gamma were used for hypotheses testing. Where gamma values provided

Exhibit 18. Hypotheses results summary

Hypothesis	Result
1. There is no statistically significant correlation between the strength of team focus and interim project performance.	Supported
2. There is no statistically significant correlation between team empowerment and interim project performance.	Inconclusive
3. There is no statistically significant correlation between the level of structure within the team and interim project performance.	Supported
4. There is no statistically significant correlation between team cohesion and interim project performance.	Inconclusive
5. There is no statistically significant correlation between team recognition and interim project performance.	Supported
6. There is no statistically significant correlation between the level of interdependence within the team and interim project performance.	Rejected
7. There is no statistically significant correlation between intra-team communication and interim project performance.	Inconclusive

evidence of some level of a relationship to a strong relationship as described in *Chapter III* but did not meet the statistical significance level, the hypothesis results are shown as inconclusive in *Exhibit 18*. Where both rho and gamma indicated a statistically significant result according to the criteria set forth in Chapter III, *Exhibit 18* indicates the hypothesis was rejected. By rejecting Hypothesis 6, this research provided empirical support to the theory that interdependence is related to interim project performance. *Chapter V* provides the conclusions that can be drawn from this research along with the significant contributions and suggestions for further work.

CHAPTER V

CONCLUSION

Just as research typically begins with the identification of a puzzle to be solved, this dissertation began with the identification of the research question and the purpose of this work in *Chapter I*. A record of the literature investigation, aimed at determining whether someone else had answered the question, followed in *Chapter II*. The justification and specifics for the research methodology were documented in *Chapter III*, and *Chapter IV* provided the results and analysis of this work. This final chapter begins with a summary of the research results and ends with suggestions for future research to further improve the knowledge into project management. This chapter also includes a discussion of the significance of this work as well as contributions to theory, methodology, and practice from the author's worldview.

This research investigated the following seven hypotheses, through the rigorous methodology detailed in *Chapter III*.

1. There is no statistically significant correlation between the strength of team focus and interim project performance.
2. There is no statistically significant correlation between team empowerment and interim project performance.
3. There is no statistically significant correlation between the level of structure within the team and interim project performance.

4. There is no statistically significant correlation between team cohesion and interim project performance.

5. There is no statistically significant correlation between team recognition and interim project performance.

6. There is no statistically significant correlation between the level of interdependence within the team and interim project performance.

7. There is no statistically significant correlation between intra-team communication and interim project performance.

As described in *Chapter IV*, the statistical correlation (both gamma and rho > 0.50) was highly significant ($\alpha < 0.05$) and enabled rejection of Hypothesis 6. There was also evidence of a fair correlation (between –0.26 and –0.50) and a very strong gamma (> 0.50) to indicate some relationship between communication and interim project performance. Gamma values of –0.360 and –0.378 and rho values (-0.234 and –0.325) indicated some level of relationships between cohesion, as well as empowerment, and interim project performance. However, the relationships for Hypotheses 2, 4, and 7 were not statistically significant, and they could not be conclusively rejected. The relationships between interim project performance and focus, structure, and recognition were weak. Therefore, Hypotheses 1, 3, and 5 also could not be rejected. The overall significance of this research is summarized in the next section.

SIGNIFICANCE

As evident from the literature review presented in *Chapter II*, several flaws were systemic to the preponderance of prior research dealing with project teams. The most glaring was the use of subjective metrics for measuring performance. The assertion that subjective measures should only be used when objective ones are not possible (Goodman, et al., 1986) was supported by a meta-analysis indicating no significant correlation between objective and subjective performance measures (Bommer, et al., 1995). In contrast to previous research, this research developed and utilized a technique for objectively capturing the performance of NASA aerospace projects early within their lifecycles. Thus, this work affects project management research by providing emphasis on the importance of choosing appropriate metrics to measure interim project performance.

Also, the prior literature addressed project team attributes sporadically and with conflicting results. This research systematically evaluated seven team attribute variables, with the aid of a validated survey instrument, during the formulation phase of NASA projects within the sample. The research investigated, for the first time, the existence of correlations between those team attribute traits and the interim project performance metric. The results provided evidence, through quantitative empirical means, to substantiate the theoretical belief that effective project teams are associated with higher project interim performance. In particular, the team attribute associated with interdependence of team members produced strong statistical results in relationship to interim project

performance. In contrast, the recognition of team members for project accomplishments was found to be unrelated to interim project performance. Therefore, this research identified a need to investigate team variables independently. In addition, recognition of the need to research project performance and project teams early in their lifecycle was a significant contribution resulting from this work. By focusing on the early project lifecycle, this research added to the project management body of knowledge. The following sections document the contribution of this research to theory, methodology, and practice.

THEORETICAL CONTRIBUTION

While the theory of effective project teams relating to successful projects was well documented as early as the Task Group Effectiveness Model (Gladstein, 1984), the literature in support of this theory is saturated with unsubstantiated speculation. This research strengthened the existing theory by collecting data from actual project teams and following strict guidelines in statistical analysis. Therefore, the results, that several aspects of team dynamics are somewhat related to interim project performance with interdependence being significantly related, add credence to the theory. At the same time, the team attributes that were found to be unrelated to interim project performance for this sample failed to add support for the theory concerning their ultimate significance to project success. The discrepancies of hypotheses test results among the seven team attributes add emphasis to the need for separating the general term

team dynamics into components prior to conducting empirical research into project teams.

Most previous research into the relationship between team dynamics and project performance used subjective measures of performance, which are fraught with biases as described in *Chapter III*. This research was more rigorous in its contribution to theory by developing and utilizing an objective performance measure. Furthermore, even though some research emphasized the importance of different project life cycle phases (Dugan et al., 1977), no previous work had studied the relationship of team attributes to an interim project performance metric. As a result, a significant theoretical contribution from this research was the statistical results indicating that specific team attributes are important early in a project's lifecycle. These theoretical contributions were more significant because the research process was well designed and provided methodological contributions as described in the next section.

METHODOLOGICAL CONTRIBUTION

Often articles are written describing the results of studies that claim to be research but fail to follow rigorous methodological processes. *Chapter II* described several key examples of this phenomenon. Among the most significant of these was research that utilized statistical methods only mathematically appropriate for interval level data when the collected data was ordinal. Another statistical error with some previous research was the employment of regression analyses when all data was collected simultaneously. By definition, regression is the statistical technique used to test whether or not

one variable can predict another; therefore, the predictor data must be collected prior to the predicted variable (Fink, 1995). While not advancing a new methodology, this research meticulously followed the design described in *Chapter III*. This research produced credible results by utilizing the most conservative interpretation of data levels and applicable statistics. Therefore, one methodological contribution is the emphasis on rigorous data collection and utilization of statistics appropriate to the lowest data level.

The majority of previous research into project teams used subjective performance measures where objective metrics were possible. Also, even though some researchers considered the different phases of the project, most measured performance only at project completion. In contrast, this research created and utilized an objective interim project performance metric. This is a significant contribution to methodology by establishing a criterion to calculate mathematically a measure of project performance early in the project's lifecycle. While contributions to theory and methodology advance the project management body of knowledge and provide a sound basis for future research, the more immediate practical contributions are described in the next section.

CONTRIBUTION TO PRACTICE

A major practical implication resulted from the significant relationship discovered between interdependence and interim project performance. Interdependence is defined as the extent to which members of the project team rely on other team member competencies. Since the overall purpose for the project team approach to tasks is to join together individuals with the

complementary skills required for successful accomplishment of the task, logical theory and practical experience would indicate that performance levels are related to the degree project team members understand and rely on individual diverse competencies. In particular, these research results indicated interdependence that is established early in a project's lifecycle has a positive relationship with the early project performance. This emphasizes the need for closer attention to team development during the early project lifecycle. These research findings indicate that different aspects of team dynamics have varying levels of relationships with interim project performance. For instance, at least in the sample for this research, recognition was irrelevant to project interim performance. Recognition is defined as team member rewards for team accomplishments. As referenced in *Chapter II*, given that many theoretical works and empirical studies have concluded recognition is important to performance, this result was surprising. As detailed in *Chapter III*, this research methodology did not include processes for investigating the reasons that certain results were statistically achieved. However, the author's experience supports the absolute dedication of NASA engineers and scientists when assigned to a project for which they are impassioned. Considering that phenomenon, the reduced importance of recognition may be a function dependent on the project task and individual team members. Of the seven dynamics variables studied, interdependence and communication statistically displayed the strongest relationships with interim project performance with only interdependence meeting the strict criteria set forth in *Chapter III*. Cohesion and empowerment were

somewhat related to interim project performance while focus and structure had very little relationship to interim project performance. The structure and focus attributes are more internal to the individuals within the project team; they are expressions of their understanding of individual responsibilities and the team goal. In contrast, the other team attributes are measures of more interactive phenomena. The stronger results for the more collective attributes, with the exception of recognition, indicate that emphasis is warranted on those aspects of team dynamics. In addition, earlier research (Parsons, 2003) concluded that other project personnel factors can overshadow the effect of team focus on performance. "Project management is itself a complex system, and only when so considered can optimal management techniques be developed and utilized effectively." (Murphy et al., 1974, p. 128) So, evidence discriminating between team attribute variables that are most significantly related to project performance assists in the determination of which management techniques to emphasize. The first practical application is closer attention to the various components of project team development at the beginning of the project lifecycle.

Previous to this research there was no documented metric for measuring interim project performance that incorporated the four dimensions of a project (technical, programmatics, schedule, and cost.) Earned value management, schedule analysis, cost performance, risk management, and technical milestone evaluations each measure a particular aspect of the project performance. The development of a metric to measure overall project performance, by ranking independent review action items during the early life cycle, is a significant

contribution of this research. Therefore, another practical application is a mechanism for evaluating a projects' overall performance prior to decisions to continue into implementation. The difficulty level for resolution of problems within a project is proportional to the elapsed schedule of the project. Determining project variables that can be adjusted early in the project lifecycle and positively relate to performance provides the best return on investment. Therefore, a measure of project performance early in the lifecycle is critical to the ability to evaluate the project when cost effective adjustments can be made. The previous sections have identified the significance of this research. Contributions to theory, methodology, and practice have been identified. Even though this research has contributed to the field of the team aspects of projects, this investigation has also generated new questions. The next section identifies opportunities for future research to attempt to empirically answer these new questions.

FUTURE RESEARCH SUGGESTIONS

These results are conclusive and support rejection of null Hypothesis 6, by determining a strong relationship between team interdependence and interim project performance. However, since this research was based on a sample of fourteen NASA aerospace projects, a future application of this research to other NASA projects as they reach the appropriate lifecycle phase would increase the credence associated with this work should similar results be achieved. In addition, the replication of this work in other project environments would serve to support a more universal application of the results or emphasize its limitation to NASA projects.

Additional interesting research would be similar data collection for NASA projects at each major review to investigate whether or not the team attributes of a given project team change over time. That would also require investigation into factors that may have precipitated any changes that are discovered. This could include identification of interventions to improve teams and the evaluation of which ones have the most significant effect on project interim performance. Such a structured longitudinal study would also determine whether or not the team attributes correlate more significantly to interim project performance at different reviews during a project lifecycle. The research would provide insight into whether the relative importance among the seven team attributes change as a project progresses through its lifecycle. Similar longitudinal research could also be conducted for non-NASA projects where independent progress reviews occur.

Within this research sample, relationships were significant between recognition and empowerment as well as between communication and interdependence. Further research into the relationship among team attributes would either support or refute these findings. Why these pairs were related and empowerment was unrelated to communication, interdependence, and structure requires further research. An investigation into the potential catalyst effect of each combination of team variables on project performance is also warranted.

This research design did not include methodologies to collect data to answer several questions that can be posed from the results. Most significant would be investigation into why recognition was deemed irrelevant to interim project performance among the NASA projects in this sample. The effect of the

work ethic, enthusiasm, and natural inquisitiveness for personnel assigned to NASA projects needs further investigation. Could the importance of recognition be dependent upon the nature of the project activity or individual characteristics of project team members? Other questions to be investigated include why focus and structure were not highly related to interim project performance in this sample. With different projects are these attributes related to performance? If so, why are they related in one sample of projects and not another? Finally, further research into the complex phenomenon of project teams may illuminate additional team attributes that have a strong influence on project performance. In addition, a search for variables external to the project team that might affect team attributes would be worthwhile. The socio aspects of a project are clearly important enough to project success to warrant emphasis within the larger framework of project management research. This research provided significant contributions as described earlier in this chapter and potential areas for future research have been identified in this section; a final summary follows.

SUMMARY

In summary, these research results indicated a significant relationship between team member interdependence and interim project performance. Some lesser relationships were also found between intra-team communication, cohesion, and empowerment and the interim project performance metric. However, no evidence supported relationships between interim project performance and focus, structure, or recognition. Future research suggestions to continue this exploration were provided in the previous section. These included

longitudinal studies of NASA projects to determine how these results change over the project lifecycle, as well as exploration into the applicability of these research findings to other projects and the analyses into why these results were found.

This research design, including safeguards against procedural errors made by previous investigations, added to the credibility of these research conclusions. Specifically, only the team attribute values were collected through subjective surveys. An objective metric to measure project performance during the early project lifecycle was developed. This interim project performance metric was used in the statistical analyses to investigate relationships with seven team attributes (focus, empowerment, structure, cohesion, recognition, interdependence, and communication). This research also followed conservative statistical procedures compatible with the level of data and collection methodology.

This chapter described contributions of this research to theory, methodology, and practice. While extensive prior theory existed concerning the relationship of team attributes to project success, this work expanded the theory to indicate the importance of team attributes early in the project lifecycle. In the areas of methodology and practice, this research developed a metric for objectively measuring interim project performance where none had been previously used in empirical research. The rigorous attention to appropriate statistical methods also enhanced the tenability of results, thereby contributing to overall methodology. Finally, the research serves to emphasize the need for

project managers to be concerned with team development of interdependence. Frame (1999) emphasized the significance of this research by quoting a project manager, with 25 years experience, who never saw a project fail because of a system crash but saw many fail due to people problems. "It is the poorly developed team which is likely to run aground when storms appear" (Wilemon and Thamhain, 1979, p. 379). Project teams are composed of people, and projects do not succeed without them. The results of this research empirically supported the importance of certain team attributes (most significantly, team interdependence) in relationship to interim project performance.

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APPENDIX A

GLOSSARY OF TERMS

APM – Advanced Project Management

APPL – Academy for Program and Project Leadership

CAR – Confirmation Assessment Review

CDR – Critical Design Review

FRR – Flight Readiness Review

IIR – Independent Implementation Review

IRR – Independent Readiness Review

MBA – Masters of Business Administration

MIL-STD – Military Standard

NASA – National Aeronautics and Space Administration

NAR – Non Advocate Review

NGT – Nominal Group Technique

NPD – NASA Policy Directive

NPG - NASA Procedures and Guidelines

ORR – Operational Readiness Review

PDR – Preliminary Design Review

Pre-NAR – Preliminary Non Advocate Review

Q - Question

RFA – Request For Action

R&D – Research and Development

SPSS – Statistical Package for the Social Sciences

SRR – Systems Requirements Review

US – United States

APPENDIX B

SURVEY INSTRUMENT (GROUPED BY VARIABLE)

Focus: In my project,
Q1: We always remain clear about what constitutes the success of the project.
Q9: We always reward team success more than individual success.
Q17: We always make full use of the competencies of each other.
Q25: We always involve others in all decisions that might affect them.
Q33: We always remain clear about the project priorities.

Empowerment: In my project,
Q2: We frequently make it possible for members to become more competent.
Q10: We frequently get feedback from each other on our performance as team members.
Q18: We are routinely given the freedom to learn from our mistakes.
Q26: We routinely make it easy for members to present ways to improve the project's performance.
Q34: We always push authority to act down to the lowest possible levels.

Structure: In my project,
Q3: We are all very clear about our own work responsibilities.
Q11: We are all very clear about how decisions are made.
Q19: We never let our formal organization get in the way of getting the job done.
Q27: We can easily get in touch with each other when we need to.
Q35: We are all very clear about our responsibilities to each other.

Cohesion: In my project,
Q4: We always include everyone in the project as equal members of the team.
Q12: We make sure that no member ever fails.
Q20: We consistently show respect to each other.
Q28: We consistently demonstrate our concern for each other – on and off the job.
Q36: We frequently socialize as a team.

Recognition: In my project,
Q5: We are quick to recognize publicly the contributions of team members.
Q13: We routinely celebrate reaching major project milestones and similar achievements.

Q21: We always ensure that the performance of team members is visible to senior management.
Q29: We always ensure that the persons who do the work get credit for the work.
Q37: We always ensure that members who perform the less glamorous jobs are appreciated as much as those who perform the more glamorous ones.

Interdependence: In my project,
Q6: We can always count on members doing what they say they will do.
Q14: We freely give help to each other when asked for it.
Q22: We frequently anticipate ways to help each other.
Q30: We always treat each other's jobs as important as our own.
Q38: We always trust the good intentions of each other.

Communication: In my project,
Q7: We always give straight answers to each other's questions.
Q15: We quickly share anything we know that could possibly affect each other's jobs.
Q23: We ensure that all members participate fully in project meetings.
Q31: We always listen carefully to each other to ensure understanding.
Q39: We always solve conflicts among us that might interfere with our communication.

APPENDIX C

PERMISSION FOR SURVEY USE

Date: Wed, 24 Apr 2002 20:09:05 -0700
From: clairek <clairek@team-zone.com>
Subject: Re: Your survey
To: Vickie Parsons <v.s.parsons@larc.nasa.gov>
X-Mailer: Mozilla 4.75C-CCK-MCD {C-UDP; EBM-APPLE} (Macintosh; U; PPC)
X-Accept-Language: en,pdf

Vickie,

I thought I had responded to this message, but can't find in my sent file. My apologies if this is a repeat.

I'm delighted that you will be using the data from TeamMates for your dissertation work. As we acquire more data, we'll send to you.

Please keep me posted on progress and let me know if you need further information or help with your work. I look forward to seeing your results and to writing a paper together for the APPL web page and perhaps for conference/journal.

Attached is short description of what TeamMates assesses and a list of the items. I look forward to working with you to use TeamMates in your new position with Integrated Program Analysis Office, if this opportunity becomes possible.

Claire

APPENDIX D

INTERVIEW TEMPLATE AND INTERVIEW NOTES

This interview is part of my research to fulfill requirements for a PhD in Engineering Management from Old Dominion University.

(1) Which NASA Enterprise has responsibility for your current project?
R ____ Y ____ S ____

(2) What is your age range?
20's ____ 30's ____ 40's ____ 50's ____

(3) What duties do you perform for your project?
Administrative ____ Engineering ____ Scientist ____ Manager ____

(4) How many months have you been with your current project?
0-12 ____ 13-24 ____ 25-36 ____ >36 ____

(5) Statistics from my research suggest a very strong relationship between interdependence (the degree that team members rely on each other) and performance (measure of progress) during the early project life cycle. Does your personal experience support that finding? Yes ____ No ____

Please provide an example of how interdependence may have affected your project performance either negatively or positively.

_____

_____

_____

How would you rate your current project on interdependence (the degree that team members rely on each other) on a scale of 1 to 5 with 5 being the best?

____

(6) Statistics from my research suggest a strong relationship between communication within the project team and performance during the early project life cycle. Does your personal experience support that finding?
Yes ____ No ____

Please provide an example of how communication within your project team may have affected your project performance either negatively or positively.

_____

_____

_____

How would you rate your current project on internal team communication on a scale of 1 to 5 with 5 being the best?

____

(7) Statistics from my research suggest some relationship between cohesion within the project team (loyalty to other team members) and performance during the early project life cycle. Does your personal experience support that finding?
Yes ____ No ____

Please provide an example of how cohesion within your project team may have affected your project performance either negatively or positively.

_____

_____

_____

How would you rate your current project on cohesion on a scale of 1 to 5 with 5 being the best?

____

(8) Statistics from my research suggest no relationship between recognition through team member rewards and performance during the early project life cycle. Does your personal experience support that finding?
Yes ____ No ____

Please provide an example of how team recognition may have affected your project performance either negatively or positively.

_____

_____

_____

How would you rate your current project on recognition on a scale of 1 to 5 with 5 being the best?

____

Thanks for your time. I will provide a record of this interview for your concurrence as to accuracy within the next two days.

INTERVIEW – 1

(1) Which NASA Enterprise has responsibility for your current project?
R ____ Y _*x*___ S ____

(2) What is your age range?
20's ____ 30's ____ 40's ____ 50's _*x*___

(3) What duties do you perform for your project?
Administrative ____ Engineering __*x*__ Scientist ____ Manager ____

(4) How many months have you been with your current project?
0-12 ____ 13-24 ____ 25-36 ____ >36 __*x*__

(5) Statistics from my research suggest a very strong relationship between interdependence (the degree that team members rely on each other) and performance (measure of progress) during the early project life cycle. Does your personal experience support that finding? Yes _*x*__ No ___

Please provide an example of how interdependence may have affected your project performance either negatively or positively.

Inaccessibility of contractor for day-to-day design issues has led to a negative effect on schedule.

How would you rate your current project on interdependence (the degree that team members rely on each other) on a scale of 1 to 5 with 5 being the best?
__*3*__

(6) Statistics from my research suggest a strong relationship between communication (transmitting and listening) within the project team and performance during the early project life cycle. Does your personal experience support that finding? Yes _*x*__ No ___

Please provide an example of how communication within your project team may have affected your project performance either negatively or positively.

Project Manager was never big on communications and left a lot to the imagination of individuals. This led to a poor understanding of requirements, resulting in a negative effect on schedule.

How would you rate your current project on internal team communication on a scale of 1 to 5 with 5 being the best?
_*2*___

(7) Statistics from my research suggest some relationship between cohesion within the project team (loyalty to other team members) and performance during the early project life cycle. Does your personal experience support that finding? Yes _***x***__ No ___

Please provide an example of how cohesion within your project team may have affected your project performance either negatively or positively.

Early on in the project, the project manager effectively killed any team formation as it started to emerge; he wanted to make sure that all things were focused to him. This limited project forward progress.

How would you rate your current project on cohesion on a scale of 1 to 5 with 5 being the best?
_***2***___

(8) Statistics from my research suggest no relationship between recognition through team member rewards and performance during the early project life cycle. Does your personal experience support that finding? Yes _***x***__ No ___

Please provide an example of how team recognition may have affected your project performance either negatively or positively.

After PDR, project received a team award; there was no effect on teamwork.

How would you rate your current project on recognition on a scale of 1 to 5 with 5 being the best?
__***1***_

INTERVIEW – 2

(1) Which NASA Enterprise has responsibility for your current project?
R ____ Y ____ S __*X*__

(2) What is your age range?
20's ____ 30's ____ 40's ____ 50's ____ 60's __*X*__

(3) What duties do you perform for your project?
Administrative ____ Engineering ____ Scientist ____ Manager _*X*___

(4) How many months have you been with your current project?
0-12 ____ 13-24 ____ 25-36 _*X*___ >36 ____

(5) Statistics from my research suggest a very strong relationship between interdependence (the degree that team members rely on each other) and performance (measure of progress) during the early project life cycle. Does your personal experience support that finding? Yes _*X*__ No ___

Please provide an example of how interdependence may have affected your project performance either negatively or positively.

At weekly status meetings, each person was asked to give a 3 minute status of their activity. In one, there was a weight problem & one subsystem manager offered relief to the thermal system at the expense of their own subsystem. This helped solve the problem.

How would you rate your current project on interdependence (the degree that team members rely on each other) on a scale of 1 to 5 with 5 being the best?
__*4*__

(6) Statistics from my research suggest a strong relationship between communication (transmitting and listening) within the project team and performance during the early project life cycle. Does your personal experience support that finding? Yes _*X*__ No ___

Please provide an example of how communication within your project team may have affected your project performance either negatively or positively.

Standard telcons for management, systems engineering, instrument, etc. with participants from across the country provided a positive influence.

How would you rate your current project on internal team communication on a scale of 1 to 5 with 5 being the best?
_***3***___

(7) Statistics from my research suggest some relationship between cohesion within the project team (loyalty to other team members) and performance during the early project life cycle. Does your personal experience support that finding? Yes _***X***__ No ___

Please provide an example of how cohesion within your project team may have affected your project performance either negatively or positively.

At the weekly status meetings, team members offered to accommodate other subsystems even when it made their subsystem less optimal. This was very positive for the project results.

How would you rate your current project on cohesion on a scale of 1 to 5 with 5 being the best?
_***3***___

(8) Statistics from my research suggest no relationship between recognition through team member rewards and performance during the early project life cycle. Does your personal experience support that finding?
Yes ___ No _***X***__

Please provide an example of how team recognition may have affected your project performance either negatively or positively.

Special achievement awards were given twice to particular outstanding contributors. Provided contributions to performance plans for team members in the matrix organizations. Not sure whether these positively affected performance.

How would you rate your current project on recognition on a scale of 1 to 5 with 5 being the best?
__***3***__

INTERVIEW – 3

(1) What NASA Enterprise has responsibility for your current project?
R _**X**___ Y ____ S ____

(2) What is your age range?
20's ____ 30's ____ 40's _**X**___ 50's ____

(3) What duties do you perform for your project?
Administrative ____ Engineering ____ Scientist ____ Manager __**X**

(4) How many have you been with your current project?
0-12 _**X**___ 13-24 ____ 25-36 ____ >36 ____

(5) Statistics from my research suggest a very strong relationship between interdependence (the degree that team members rely on each other) and performance (measure of progress) during the early project life cycle. Does your personal experience support that finding? Yes _**X**__ No ___

Please provide an example of how interdependence may have affected your project performance either negatively or positively.

Project requires a high degree of interdependence. The project office has responsibility for facilitating this interdependence & works to accomplish this through weekly staff meetings & risk management meetings. This has been a positive effect because all but one milestone have been met on time.

How would you rate your current project on interdependence (the degree that team members rely on each other) on a scale of 1 to 5 with 5 being the best?
__***4***__

(6) Statistics from my research suggest a strong relationship between communication (transmitting and listening) within the project team and performance during the early project life cycle. Does your personal experience support that finding? Yes _**X**__ No ___

Please provide an example of how communication within your project team may have affected your project performance either negatively or positively.

During early review cycles, the entire staff helped prepare materials which resulted in better presentations & had a positive effect on the project. In some cases, limited communication has resulted in an information flow breakdown with negative effect on the project.

How would you rate your current project on internal team communication on a scale of 1 to 5 with 5 being the best?
__***4***__

(7) Statistics from my research suggest some relationship between cohesion within the project team (loyalty to other team members) and performance during the early project life cycle. Does your personal experience support that finding? Yes _***X***__ No ___

Please provide an example of how cohesion within your project team may have affected your project performance either negatively or positively.

Through the matrix organization, supporting line managers provide resources to the project. Sometimes the guarded loyalty resulting from efforts to insure that the resources are not overcommitted has led to performance issues.

How would you rate your current project on cohesion on a scale of 1 to 5 with 5 being the best?
__***3***__

(8) Statistics from my research suggest no relationship between recognition through team member rewards and performance during the early project life cycle. Does your personal experience support that finding?
Yes ___ No ___

Please provide an example of how team recognition may have affected your project performance either negatively or positively.

Due to limited time with the project, this set of questions was not answered.

How would you rate your current project on recognition on a scale of 1 to 5 with 5 being the best?

____

INTERVIEW – 4

(1) What NASA Enterprise responsibility for your current project?
R ____ Y __***X***__ S _ ___

(2) What is your age range?
20's ____ 30's ____ 40's _***X***___ 50's ____

(3) What duties do you perform for your project?
Administrative ____ Engineering _***X***___ Scientist ____ Manager ____

(4) How many have you been with your current project?
0-12 _ ___ 13-24 ____ 25-36 ____ >36 _***X***___

(5) Statistics from my research suggest a very strong relationship between interdependence (the degree that team members rely on each other) and performance (measure of progress) during the early project life cycle. Does your personal experience support that finding? Yes _***X***__ No ___

Please provide an example of how interdependence may have affected your project performance either negatively or positively.

In the past dividing lines between responsibilities have caused partnerships between agencies working a project to fail. This project has made sure that interdependence was understood early through team building activities.

How would you rate your current project on interdependence (the degree that team members rely on each other) on a scale of 1 to 5 with 5 being the best?
_***4***___

(6) Statistics from my research suggest a strong relationship between communication (transmitting and listening) within the project team and performance during the early project life cycle. Does your personal experience support that finding? Yes _***X***__ No ___

Please provide an example of how communication within your project team may have affected your project performance either negatively or positively.

A strong effort was made to understand other agencies cultures (i.e., the different interpretations of acronyms, and different acquisition approaches) on this multi-agency project. One of the most positive findings at the recent requirements review was how well the entire team was "on the same page".

How would you rate your current project on internal team communication on a scale of 1 to 5 with 5 being the best?
__***3.5***__

(7) Statistics from my research suggest some relationship between cohesion within the project team (loyalty to other team members) and performance during the early project life cycle. Does your personal experience support that finding? Yes _***X***__ No ___

Please provide an example of how cohesion within your project team may have affected your project performance either negatively or positively.

When times are difficult such as funding issues, the team members present support for each other when their budget needs are questioned. Also, when one segment of the project has technical difficulty, the expertise from other areas offer support.

How would you rate your current project on cohesion on a scale of 1 to 5 with 5 being the best?
_***4***___

(8) Statistics from my research suggest no relationship between recognition through team member rewards and performance during the early project life cycle. Does your personal experience support that finding?
Yes _***X***__ No ___

Please provide an example of how team recognition may have affected your project performance either negatively or positively.

After the requirements review, a team award was given. This was affirmation of the job the team had been doing. Without the award, the team performance would not have decreased.

How would you rate your current project on recognition on a scale of 1 to 5 with 5 being the best?
__***2.5***__

INTERVIEW – 5

(1) What NASA Enterprise responsibility for your current project?
R ____ Y ____ S _***X***___

(2) What is your age range?
20's ____ 30's ____ 40's _***X***___ 50's ____

(3) What duties do you perform for your project?
Administrative ____ Engineering _***X***___ Scientist ____ Manager ____

(4) How many have you been with your current project?
0-12 _***X***___ 13-24 ____ 25-36 ____ >36 ____

(5) Statistics from my research suggest a very strong relationship between interdependence (the degree that team members rely on each other) and performance (measure of progress) during the early project life cycle. Does your personal experience support that finding? Yes _***X***__ No ___

Please provide an example of how interdependence may have affected your project performance either negatively or positively.

The high level designs receive support from all lower level systems engineers, including ground & flight. This process recognizes the individual roles & results in a strong process.

How would you rate your current project on interdependence (the degree that team members rely on each other) on a scale of 1 to 5 with 5 being the best?
_***3.5***___

(6) Statistics from my research suggest a strong relationship between communication (transmitting and listening) within the project team and performance during the early project life cycle. Does your personal experience support that finding? Yes _***X***__ No ___

Please provide an example of how communication within your project team may have affected your project performance either negatively or positively.

Good flowdown of requirements to spacecraft manufacturer has resulted in better spacecraft design.

How would you rate your current project on internal team communication on a scale of 1 to 5 with 5 being the best?
__***3***__

(7) Statistics from my research suggest some relationship between cohesion within the project team (loyalty to other team members) and performance during the early project life cycle. Does your personal experience support that finding? Yes _***X***__ No ___

Please provide an example of how cohesion within your project team may have affected your project performance either negatively or positively.

Project in early phases is just bonding now; probably more important later on. However, in recent peer reviews, team members protected each other by providing answers when someone else was presenting.

How would you rate your current project on cohesion on a scale of 1 to 5 with 5 being the best?
_***4***___

(8) Statistics from my research suggest no relationship between recognition through team member rewards and performance during the early project life cycle. Does your personal experience support that finding?
Yes _***X***__ No ___

Please provide an example of how team recognition may have affected your project performance either negatively or positively.

There have been no team rewards yet.

How would you rate your current project on recognition on a scale of 1 to 5 with 5 being the best?
__***N/A***__

APPENDIX E

DATA AND DATA SUMMARIES

For the following tables of survey team attribute data, where an individual failed to answer all the questions within a particular variable, all their responses for that variable's questions have been deleted.

Communication and demographics survey data

Project ID	Q7	Q15	Q23	Q31	Q39	Communication Median	Months with Project	Age	Job Title
A	4	5	4	5	5	5	17	40's	M
	5	5	3	4	4	4	13	40's	S
	4	3	3	3	3	3	12	40's	E
	4	4	4	4	4	4	13	30's	E
	4	4	4	4	4	4	11	40's	E
							18	40's	M
	4	3	5	4	4	4	14	30's	E
	5	5	5	5	5	5	4	60's	E
	5	4	5	5	4	5	15	40's	O
	4	4	5	4	4	4	24	30's	E
	5	5	5	5	5	5	10	40's	E
	5	5	5	5	5	5	6	30's	A
	5	5	4	5	5	5	4	30's	E
	4	2	4	2	1	2	15	40's	E
	5	5	4	5	4	5	13	40's	M
	3	3	5	4	3	3	13	30's	E
	4	4	4	5	4	4	12	30's	A
	5	5	5	4	4	5	12	40's	E
	4	5	4	4	5	4	9	40's	E
	4	5	5	5	5	5	15	40's	E
	5	4	5	4	4	4	36	30's	S
	5	5	4	4	5	5	7	50's	M
	4	3	2	3	4	3	3	30's	E
	5	5	5	5	5	5	16	40's	M
	4	5	4	4	4	4	8	40's	S
	5	4	4	5	5	5	9	30's	E
B	5	5	4	5	2	5	6	40's	M
	4	4	5	4	3	4	17	40's	M
	4	5	5	5	4	5	12	40's	M
	5	5	4	5	4	5	15	40's	M
	4	4	4	5	5	4	6	40's	M
	3	3	2	4	3	3	2	20's	A
	4	4	1	1	4	4	10	40's	E
	4	4	3	4	2	4	24	40's	M
C	4	5	4	4	4	4			
	3	2	4	3	4	3			
	5	2	4	5	4	4			

Communication and demographics survey data (continued)

Project ID	Q7	Q15	Q23	Q31	Q39	Communication Median	Months with Project	Age	Job Title
C	5	5	5	4	5	5			
	4	5	5	5	4	5			
	4	4	5	5	4	4			
	5	5	4	5	5	5			
	2	3	2	3	4	3			
	5	5	5	5	5	5			
D	5	5	5	4	5	5			
	4	5	4	5	4	4			
	5	5	5	4	4	5			
	4	4	4	4	4	4			
	4	5	4	4	4	4			
	4	5	5	4	4	4			
	5	5	5	4	4	5			
	4	4	5	4	4	4			
	2	5	5	4	4	4			
	4	4	4	4	4	4			
	5	4	4	5	4	4			
	4	5	5	3	4	4			
	5	5	4	5	5	5			
	3	1	3	1	1	1			
	2	2	3	4	5	3			
	4	4	4	2	3	4			
	5	5	4	5	4	5			
	5	5	5	5	4	5			
	5	4	4	4	4	4			
	5	5	4	5	5	5			
E	3	5	3	4	3	3	0	40's	M
	5	5	5	5	5	5	12	60's	M
	4	4	4	4	3	4	8	40's	O
	5	4	4	4	4	4	24	60's	E
	3	3	2	3	3	3	26	40's	A
	4	4	5	5	4	4	6	30's	E
	4	4	5	4	3	4	16	40's	E
	4	5	5	4	2	4	4	20's	E
	5	5	5	5	5	5	24	40's	O
	5	4	4	4	5	4	2	50's	E
	3	3	3	3	3	3	12	40's	E
	5	4	5	5	4	5	9	40's	E
	4	4	5	2	2	4	18	40's	M
	4	3	3	5	3	3	18	30's	O
	4	4	4	4	3	4	14	30's	E
	4	4	4	4	3	4	8	40's	E
	4	4	3	4	3	4	14	40's	E
	4	4	4	4	4	4	8	30's	E
	5	2	3	3	3	3	20	40's	O
	2	4	4	3	4	4	17	40's	E
	5	3	5	4	4	4	7	30's	E
	5	5	4	5	4	5	36	50's	E

Communication and demographics survey data (continued)

Project ID	Q7	Q15	Q23	Q31	Q39	Communication Median	Months with Project	Age	Job Title
E	5	5	5	5	5	5	12	20's	A
	2	5	5	4	3	4	20	40's	E
	2	1	2	3	1	2	16	30's	E
	5	5	2	4	5	5	12	40's	E
	3	5	2	2	3	3	10	20's	A
	1	5	2	2	3	2	10	20's	E
	4	4	3	4	4	4	2	30's	M
	3	3	3	3	3	3	12	30's	E
	4	5	3	4	4	4	11	20's	E
	5	5	4	5	5	5	7	50's	E
	3	4	4	2	2	3	18	60's	M
							8	30's	E
	5	4	4	5	4	4	30	40's	E
	5	4	3	4	2	4	12	30's	A
	2	3	2	2	3	2	16	30's	E
	3	4	3	3	3	3	17	40's	E
	5	4	2	4	4	4	7	50's	E
	4	4	4	4	3	4	18	30's	E
	2	2	2	2	2	2	21	50's	M
	4	3	3	3	4	3	6	30's	E
	4	3	4	4	3	4	24	60's	E
	5	4	5	4	4	4	24	40's	A
	3	2	3	2	3	3	12	50's	E
	4	3	4	4	2	4	16	40's	E
	4	5	5	4	3	4	18	30's	E
	3	5	3	3	3	3	16	40's	E
	4	4	4	4	4	4	13	50's	A
	4	4	3	4	4	4	24	30's	S
F	1	1	5	1	1	1			
	4	2	5	3	3	3			
	4	5	4	4	3	4			
	5	4	5	5	3	5			
	4	3	4	4	3	4			
	4	4	5	4	4	4			
	4	3	2	2	3	3			
	3	5	4	4	3	4			
	4	5	5	4	4	4			
	4	5	5	5	4	5			
	2	4	5	5	3	4			
	5	2	2	5	4	4			
	4	4	5	4	2	4			
G	5	5	4	5	5	5	0	40's	M
	5	5	4	4	4	4	36	40's	S
	5	5	4	5	5	5	12	50's	E
	3	4	4	2	4	4	6	40's	M
	1	5	5	2	4	4	22	40's	E
H	5	4	4	4	3	4	24	40's	M
	4	3	4	4	3	4	11	30's	M

Communication and demographics survey data (continued)

Project ID	Q7	Q15	Q23	Q31	Q39	Communication Median	Months with Project	Age	Job Title
H	4	3	2	4	3	3	3	50's	M
	5	5	4	4	4	4	6	40's	M
	4	5	4	4	4	4	4	50's	M
	4	4	4	4	3	4	22	40's	E
	3	4	4	3	2	3	14	50's	M
I	5	5	4	5	4	5	20	30's	M
	5	5	2	4	5	5	30	40's	O
	5	5	4	4	5	5	14	50's	S
							12	50's	S
	4	4	5	4	4	4	24	20's	M
J	5	4	4	3	3	4	14	40's	E
	4	4	5	4	2	4	0	40's	E
	5	5	5	5	5	5	32	40's	E
	2	4	4	3	4	4	12	40's	E
	4	4	3	4	4	4	20	20's	E
	4	5	3	4	3	4	32	40's	E
	5	4	2	4	5	4	22	30's	E
	4	4	2	4	3	4	18	40's	E
K	3	2	2	3	3	3	40	50's	M
	5	4	4	4	5	4	5	30's	M
	4	4	2	4	5	4	7	50's	M
	5	5	4	4	4	4	36	40's	E
N	5	5	5	5	4	5	84	50's	M
	4	4	2	2	3	3	18	50's	M
	4	5	2	4	2	4	84	40's	E
	4	5	5	4	5	5	0	60's	M
	4	3	2	4	3	3	120	40's	E
Q	5	5	5	4	4	5	24	40's	M
	3	3	2	3	2	3	24	50's	O
							36	40's	M
	4	5	4	4	4	4	24	30's	M
	4	4	5	4	4	4	2	40's	M
R	4	4	4	4	5	4	125	50's	M
	4	3	3	4	4	4	24	30's	S
	4	4	3	3	3	3	35	40's	M
	4	2	4	3	3	3	6	>69	A
	4	3	5	4	3	4	11	50's	O
	4	2	5	5	5	5			
	2	1	4	5	2	2			
	3	5	2	3	3	3			
	5	3	4	4	4	4			
	4	1	1	4	4	4			
	2	2	4	4	4	4			
	5	4	4	5	5	5			
	4	2	5	5	2	4			
	4	2	4	4	2	4			
	5	2	5	4	4	4			

Focus and empowerment survey data

Project ID	Q1	Q9	Q17	Q25	Q33	Focus Median	Q2	Q10	Q18	Q26	Q34	Empowerment Median
A	4	5	5	5	5	5	4	4	5	5	4	4
	4	3	3	3	4	3	4	3	3	4	3	3
	5	3	3	3	4	3	4	3	3	3	3	3
	4	5	4	4	5	4	5	5	5	4	4	5
	4	3	4	4	3	4	4	3	4	4	4	4
	5	4	5	5	5	5	5	5	4	4	5	5
	4	3	3	3	3	3	4	4	4	4	3	4
	5	5	5	4	5	5	5	5	5	5	5	5
	5	4	4	4	5	4	5	5	4	4	3	4
	5	4	4	4	4	4	4	4	4	5	2	4
	5	3	5	4	5	5	5	4	5	4	4	4
	5	5	5	5	5	5	1	5	5	5	3	5
	5	5	5	3	4	5	5	5	5	5	5	5
	4	2	3	3	3	3	3	4	4	2	3	3
	5	5	4	4	5	5	5	4	5	4	4	4
	4	3	3	4	4	4	4	4	4	4	3	4
	5	3	4	4	4	4	5	4	4	4	3	4
	5	3	5	5	4	5	4	4	3	4	3	4
	5	4	5	4	4	4	4	3	4	5	3	4
	5	4	5	5	5	5	5	4	5	5	4	5
	5	5	5	5	5	5	5	4	5	4	5	5
	5	3	4	5	4	4	5	5	4	5	3	5
	4	3	3	2	4	3	4	3	4	3	2	3
	5	5	5	5	5	5	5	5	5	5	5	5
	4	3	4	4	4	4	4	3	4	3	3	3
	4	4	4	2	4	4	3	4	4	4	3	4
B	5	2	4	4	5	4	4	5	4	4	4	4
	4	4	4	4	2	4	3	3	4	4	4	4
	3	3	5	5	4	4	5	5	4	5	3	5
	1	4	5	2	2	2	3	4	4	4	4	4
	5	3	4	4	5	4	4	4	4	5	4	4
	4	3	4	3	4	4	3	2	3	3	3	3
	2	5	1	4	2	2	2	3	2	2	2	2
	4	3	2	2	2	2	4	2	3	3	4	3
C	4	4	4	4	5	4	5	5	5	5	5	5
	4	3	4	3	4	4	3	4	3	3	4	3
	5	1	4	2	5	4	2	4	2	2	4	2
	5	3	5	4	5	5	5	5	5	4	5	5
	5	3	4	4	4	4	4	3	4	4	4	4
	5	5	4	4	5	5	4	4	2	5	5	4
	5	5	5	5	5	5	5	4	5	5	3	5
	5	3	3	2	4	3	3	3	4	4	3	3
	4	3	5	4	4	4	5	3	4	4	3	4
D	4	4	5	4	4	4	4	4	5	4	2	4
	5	4	4	4	4	4	4	3	4	4	4	4
	4	4	4	4	4	4	4	4	5	4	4	4
	5	3	2	3	5	3	4	4	3	3	3	3
	4	4	5	4	4	4	4	3	4	4	4	4

Focus and empowerment survey data (continued)

Project ID	Q1	Q9	Q17	Q25	Q33	Focus Median	Q2	Q10	Q18	Q26	Q34	Empowerment Median
D	1	1	1	1	1	1	1	1	1	1	1	1
	5	5	5	4	5	5	4	4	5	4	5	4
	4	4	4	4	4	4	5	4	4	4	3	4
	4	4	4	4	2	4	4	2	4	3	3	3
	4	3	4	4	4	4	5	4	4	5	5	5
	5	4	3	4	5	4	5	5	5	4	4	5
	4	4	5	4	4	4	5	2	4	2	4	4
	4	5	4	4	5	4	3	4	4	4	4	4
	5	5	5	4	5	5	5	4	5	5	4	5
	1	3	1	1	1	1	1	1	1	1	1	1
	3	4	2	2	2	2	4	3	4	2	4	4
	4	5	2	4	4	4	4	4	5	4	5	4
	5	4	5	5	5	5	5	5	5	5	4	5
	5	4	5	5	4	5	5	4	5	5	5	5
	5	4	2	4	5	4	4	4	4	4	3	4
	5	3	5	5	5	5	4	4	5	5	3	4
E	5	3	4	4	4	4	4	4	5	4	5	4
	5	5	5	5	4	5	4	4	4	4	4	4
	4	3	4	4	4	4	5	3	5	5	4	5
	4	3	3	3	4	3	4	2	4	4	3	4
	4	3	2	3	4	3	4	4	3	3	3	3
	4	3	3	5	4	4	4	4	3	3	3	3
	3	3	4	4	4	4	3	3	3	3	3	3
	5	2	2	4	5	4	4	2	3	4	2	3
							4	4	5	5	5	5
	4	3	3	5	4	4	3	3	3	4	4	3
	3	3	3	2	3	3	3	2	3	2	3	3
	5	4	5	5	5	5	4	4	4	5	4	4
	5	2	4	5	5	5	4	4	3	5	5	4
	5	4	4	3	4	4	4	3	5	3	4	4
	2	2	4	4	4	4	5	3	4	5	3	4
	3	3	4	4	4	4	5	3	4	4	4	4
	5	4	4	4	3	4	4	3	4	3	3	3
	4	4	4	4	4	4	4	4	4	4	3	4
	5	3	3	3	4	3	4	3	3	3	3	3
	3	4	4	4	2	4	3	2	2	4	3	3
	4	4	4	4	3	4	4	3	4	4	3	4
	5	3	5	4	5	5	4	4	5	3	4	4
	5	5	5	5	5	5	5	5	5	5	5	5
	5	3	2	4	4	4	3	3	3	5	3	3
	2	3	2	1	1	2	2	2	3	2	2	2
	4	3	4	4	4	4	5	4	3	4	4	4
	4	4	4	2	2	4	5	4	4	4	3	4
	4	3	2	2	2	2	3	3	2	4	2	3
	4	3	3	3	4	3	4	3	4	3	3	3
	4	2	3	3	2	3	4	3	4	4	3	4
	4	5	3	5	3	4	3	5	5	4	5	5
	5	4	5	5	5	5	5	5	5	5	4	5

Focus and empowerment survey data (continued)

Project ID	Q1	Q9	Q17	Q25	Q33	Focus Median	Q2	Q10	Q18	Q26	Q34	Empowerment Median
E	5	3	1	2	4	3	4	3	4	3	4	4
	5	5	5	4	4	5	5	3	4	4	3	4
	4	4	4	4	4	4	4	4	4	3	4	4
	4	4	5	4	4	4	4	3	4	4	3	4
	4	3	2	2	3	3	4	3	3	3	2	3
	2	4	4	4	3	4	4	4	3	3	4	4
	5	4	4	2	4	4	5	3	3	4	3	3
	4	3	4	3	4	4	4	3	3	4	3	3
	4	4	2	2	4	4	2	2	2	2	2	2
	4	3	3	3	3	3	3	3	3	3	3	3
	4	3	2	3	2	3	3	2	3	3	2	3
	4	4	5	2	5	4	4	2	5	2	2	2
	2	3	2	2	3	2	2	2	3	2	3	2
	5	3	4	3	4	4	4	2	3	4	3	3
	5	4	3	3	3	3	5	3	3	3	3	3
	5	3	3	2	3	3	4	2	4	3	1	3
	5	3	5	5	5	5	5	4	3	5	4	4
	5	4	4	4	4	4	5	4	4	4	4	4
F	2	1	3	1	1	1	1	1	1	1	1	1
	4	3	3	3	3	3	4	2	5	5	1	4
	4	4	4	5	3	4	4	3	4	4	2	4
	4	4	3	4	2	4	5	3	5	5	4	5
	4	3	3	4	2	3	4	4	4	4	3	4
	4	3	2	2	2	2	4	1	4	2	4	4
	3	3	2	3	3	3	2	2	1	3	1	2
	3	3	4	4	4	4	4	4	5	4	4	4
	4	3	4	4	4	4	5	3	4	4	2	4
	4	5	4	4	2	4	4	5	3	4	2	4
	3	3	2	5	3	3	3	2	3	3	3	3
	4	4	4	4	4	4	5	4	5	4	4	4
	4	4	4	4	4	4	5	2	4	4	2	4
G	4	5	4	5	4	4	5	2	5	4	5	5
	4	5	2	4	4	4	5	4	5	4	2	4
	5	5	5	5	4	5	5	3	5	5	5	5
	3	3	2	2	3	3	3	2	4	3	4	3
	5	3	5	5	4	5	5	5	5	5	5	5
H	5	3	4	5	4	4	4	4	2	3	4	4
	4	3	3	4	4	4	3	3	4	4	4	4
	4	3	3	2	4	3	3	2	3	3	2	3
	5	4	4	5	4	4	4	3	4	4	4	4
	4	3	4	4	4	4	4	4	4	4	4	4
	5	3	3	4	4	4	4	3	4	3	3	3
	4	3	4	4	4	4	3	2	2	3	2	2
I	5	3	5	5	5	5	4	4	5	4	4	4
	4	4	3	2	4	4	4	2	3	4	4	4
	5	3	4	4	4	4	4	2	3	5	5	4
							5	5	5	5	5	5
	5	3	4	4	4	5	5	3	5	4	3	4

Focus and empowerment survey data (continued)

Project ID	Q1	Q9	Q17	Q25	Q33	Focus Median	Q2	Q10	Q18	Q26	Q34	Empowerment Median
J	5	3	2	4	4	4	4	5	4	3	2	4
	4	5	3	4	5	4	5	4	4	4	4	4
	5	5	5	4	5	5	5	4	5	4	5	5
	5	3	3	3	5	3	4	3	2	4	3	3
	4	5	5	3	4	4	4	5	4	5	4	4
	5	3	4	4	5	4	5	3	3	4	4	4
	5	3	4	5	4	4	3	2	4	4	5	4
	4	2	2	4	4	4	2	2	4	2	2	2
K	5	3	3	2	4	3	5	3	4	3	3	3
	5	3	5	4	4	4	5	4	5	5	5	5
	5	2	3	2	2	2	2	2	4	3	2	2
	5	3	4	4	4	4	5	4	4	4	4	4
N	5	4	4	5	5	5	5	4	5	5	5	5
	4	3	4	2	4	4	4	3	4	3	4	4
	4	3	4	2	4	4	5	4	4	5	5	5
	5	3	5	4	5	5	4	3	5	5	4	4
	4	4	3	4	4	4	3	1	3	2	3	3
Q	5	4	4	4	5	4	4	5	4	4	4	4
	2	3	3	3	2	3	3	2	3	3	3	3
	2	5	4	2	2	2	5	4	5	4	4	4
	4	5	5	4	4	4	4	4	5	4	4	4
	4	3	4	3	4	4	5	4	5	5	5	5
R	5	3	5	4	4	4	4	4	5	4	4	4
	5	3	4	3	5	4	5	3	4	4	3	4
	4	5	4	3	5	4	5	4	4	3	4	4
	4	3	2	3	3	3	4	2	3	4	3	3
	4	3	3	3	2	3	5	1	4	4	4	4
	5	5	4	2	5	5	4	5	5	2	2	4
	5	2	4	2	5	4	3	2	2	4	3	3
	3	2	3	3	2	3	3	2	3	3	3	3
	5	4	4	4	5	4	4	5	4	4	4	4
	5	2	4	2	4	4	4	2	4	4	3	4
	2	2	2	2	2	2	4	2	2	2	2	2
	5	4	5	5	5	5	5	4	5	4	4	4
	5	4	5	3	4	4	4	3	4	3	4	4
	2	2	5	4	2	2	4	2	4	4	1	4
	4	5	5	4	5	5	4	4	5	5	4	4

Structure and cohesion survey data

Project ID	Q3	Q11	Q19	Q27	Q35	Structure Median	Q4	Q12	Q20	Q28	Q36	Cohesion Median
A	3	4	4	5	4	4	5	3	5	4	5	5
	5	3	3	5	2	3	2	3	5	2	1	2
	3	3	4	3	3	3	3	2	4	2	3	3
	5	4	4	5	4	4	4	5	5	5	4	5
	3	2	4	4	4	4	4	3	4	4	3	4
	5	4	4	5	5	5						
	3	4	3	4	4	4	2	2	4	3	3	3
	5	5	5	5	5	5	5	5	5	5	4	5
	5	4	4	5	5	5	5	4	5	4	4	4
	3	4	4	3	4	4	4	4	4	4	3	4
	5	5	4	4	4	4	5	5	5	5	4	5
	5	5	5	5	5	5	5	5	5	5	1	5
	5	2	4	5	5	5	4	4	5	5	4	4
	2	2	2	2	2	2	4	3	4	2	2	3
	5	5	5	5	5	5	5	5	5	3	2	5
	4	3	3	5	4	4	3	3	4	5	4	4
	4	4	3	4	4	4	5	3	4	5	5	5
	5	4	5	5	4	5	4	4	5	3	3	4
	5	4	3	5	4	4						
	4	4	4	5	5	4	5	4	5	5	4	5
	4	5	5	5	4	5	5	4	5	5	4	5
	4	4	5	5	4	4	4	4	4	5	4	4
	4	3	2	3	2	3	4	3	4	4	2	4
	5	5	5	5	5	5	5	4	5	5	5	5
	4	3	3	5	4	4	4	4	5	4	2	4
	4	2	4	2	4	4	4	5	4	4	4	4
B	5	2	2	5	5	5	4	4	4	5	4	4
	5	2	3	5	4	4	4	3	5	4	3	4
	4	3	4	5	4	4	4	4	5	3	3	4
	5	5	4	4	5	5	4	3	5	5	4	4
	5	4	3	5	5	5	5	5	4	5	4	5
	4	2	1	4	1	2	4	3	4	3	2	3
	4	2	1	4	2	2	1	4	2	4	2	2
	4	2	2	5	2	2	3	3	4	4	3	3
C	4	4	5	5	4	4	4	4	5	4	4	4
	2	2	3	4	4	3	3	3	4	4	3	3
	5	4	5	5	5	5	1	2	2	2	2	2
	4	4	5	5	5	5	4	4	5	4	2	4
	4	4	5	5	5	5	5	4	5	5	4	5
	4	4	4	5	4	4	5	2	4	4	4	4
	5	5	5	5	5	5	5	4	5	5	2	5
	3	3	1	4	2	3	4	3	4	1	2	3
	2	4	4	5	4	4	4	3	5	5	2	4
D	4	4	5	4	4	4	5	5	5	5	2	5
							5	4	5	4	3	4
	4	4	4	5	4	4	4	4	5	5	4	4
	2	2	4	4	4	4	3	3	4	3	4	3

Structure and cohesion survey data (continued)

Project ID	Q3	Q11	Q19	Q27	Q35	Structure Median	Q4	Q12	Q20	Q28	Q36	Cohesion Median
D	4	2	5	5	4	4	2	4	5	4	4	4
	1	1	1	1	1	1						
	4	4	5	5	5	5	5	4	5	5	2	5
	5	5	3	5	4	5	4	5	5	5	4	5
	2	2	4	4	3	3	3	4	4	3	2	3
	2	2	4	5	2	2	4	2	4	5	4	4
	4	4	4	2	4	4	5	4	5	5	2	5
	2	2	4	5	2	2	5	4	5	4	4	4
	4	3	5	5	4	4	2	4	5	5	4	4
	5	5	5	5	5	5	5	5	5	5	4	5
	1	1	2	4	1	1	4	2	2	1	1	2
	3	1	3	2	2	2	5	3	5	3	4	4
	2	5	4	4	2	4	4	4	4	3	2	4
	4	4	5	5	5	5	5	5	5	5	4	5
	4	4	5	4	5	4	5	4	5	5	1	5
	2	4	5	2	3	3	5	3	5	3	2	3
	5	5	4	5	5	5	5	3	5	5	2	5
E	5	4	5	4	4	4	5	4	4	4	3	4
	5	4	5	5	5	5	5	5	5	5	5	5
	4	4	4	5	4	4	2	3	4	4	4	4
	2	4	3	4	3	3	3	3	4	4	3	3
	3	3	2	4	4	3	3	3	3	4	4	3
	5	4	3	4	4	4	5	3	5	3	2	3
	3	3	3	5	4	3	3	3	3	3	4	3
	2	4	2	4	4	4	4	5	5	5	2	5
	5	4	4	5	5	5	4	5	5	5	5	5
	4	4	3	5	4	4	4	3	4	3	4	4
	3	3	3	4	3	3	2	3	3	2	3	3
	4	4	4	5	4	4	5	4	5	4	4	4
	4	4	2	5	4	4	5	4	4	3	4	4
	5	3	4	5	4	4	3	3	4	3	4	3
	4	4	4	5	4	4	4	3	4	3	5	4
	4	3	4	4	3	4	3	3	3	3	3	3
	5	4	4	4	4	4	4	3	4	4	3	4
	2	4	4	4	3	4	3	4	4	4	4	4
	5	4	3	3	4	4	3	3	3	3	3	3
	4	3	2	5	4	4	4	3	4	2	3	3
	5	2	4	3	4	4	5	4	4	5	5	5
	5	3	5	5	5	5	4	3	5	3	3	3
	5	5	5	5	5	5	5	5	5	5	5	5
	2	4	2	5	3	3	5	3	4	3	4	4
	2	3	2	4	2	2	2	2	4	4	4	4
	5	4	4	4	4	4	5	4	5	4	4	4
	5	3	2	5	4	4	2	2	4	5	4	4
	2	2	1	5	3	2	2	3	1	3	2	2
	3	3	4	3	3	3	3	3	5	3	3	3
	3	2	3	4	3	3						
	4	3	5	5	4	4	5	3	5	5	2	5

Structure and cohesion survey data (continued)

Project ID	Q3	Q11	Q19	Q27	Q35	Structure Median	Q4	Q12	Q20	Q28	Q36	Cohesion Median
E	5	5	5	4	5	5	5	5	5	5	5	5
	1	2	3	5	2	2	3	3	2	2	4	3
	4	4	5	4	4	4	5	4	5	3	4	4
	5	4	4	5	4	4	4	4	4	3	4	4
	4	3	4	4	4	4	5	4	4	4	4	4
	2	3	3	5	3	3	2	4	3	2	1	2
	2	2	3	4	3	3	2	3	4	4	4	4
	4	4	5	5	4	4	4	2	5	3	3	3
	4	4	4	4	4	4	5	3	4	4	4	4
	2	2	3	4	2	2	4	2	4	2	4	4
	2	3	3	4	3	3	3	3	4	3	3	3
	3	2	2	4	3	3	4	3	4	3	3	3
	4	4	2	5	4	4	2	4	5	5	4	4
	2	3	3	4	2	3	2	5	2	3	4	3
	4	3	2	3	3	3	5	3	4	4	3	4
	5	2	2	5	4	4	5	3	5	4	3	4
	3	2	1	3	3	3	3	2	4	3	3	3
	5	5	4	4	5	5	5	4	5	5	4	5
	4	4	3	5	4	4	4	4	4	4	4	4
F	2	1	3	4	2	2	3	3	3	3	3	3
	2	1	2	5	2	2	5	2	5	4	1	4
	3	2	4	4	3	3	2	3	4	4	3	3
	4	4	4	5	2	4	5	5	5	5	3	5
	2	3	4	4	2	3	4	4	4	3	3	4
	2	2	4	5	2	2	4	4	4	2	2	4
	2	1	1	4	2	2	1	3	2	3	1	2
	3	3	4	4	3	3	4	5	4	4	4	4
	5	2	4	5	5	5	5	4	2	4	4	4
	5	4	2	5	2	4	5	5	5	3	1	5
	1	2	4	5	3	3	4	3	5	3	1	3
	4	4	5	4	2	4	5	2	5	3	2	3
	4	2	4	5	4	4	4	4	4	4	2	4
G	5	2	2	4	4	4	5	4	5	5	2	5
	4	4	4	5	4	4	4	4	5	2	2	4
	5	4	4	5	4	4	4	4	5	5	1	4
	3	2	4	3	2	3	4	2	5	4	4	4
	4	5	4	5	2	4	4	2	4	3	4	4
H	4	4	3	5	4	4	4	3	4	4	5	4
	3	4	4	4	4	4	4	3	4	3	2	3
	2	2	4	4	3	3	4	3	4	3	1	3
	5	4	5	5	4	5	5	5	5	5	3	5
	4	4	4	4	4	4	4	4	4	4	4	4
	4	3	3	4	4	4	3	4	4	4	3	4
	4	2	3	4	4	4	4	3	4	3	2	3
I	4	4	4	5	4	4	5	4	5	3	1	4
	3	2	4	5	4	4	4	3	5	3	2	3
	4	4	3	5	4	4	2	4	5	4	2	4
	5	3	5	5	4	5	5	2	5	5	4	5

Structure and cohesion survey data (continued)

Project ID	Q3	Q11	Q19	Q27	Q35	Structure Median	Q4	Q12	Q20	Q28	Q36	Cohesion Median
I	5	2	5	4	4	4	5	3	4	4	4	4
J	5	4	4	4	3	4	5	4	5	3	4	4
	4	5	2	5	4	4	3	1	4	4	3	3
	5	4	5	5	5	5	4	4	5	4	4	4
	3	4	3	4	4	4	2	2	4	4	3	3
	5	5	3	4	4	4	4	4	4	4	3	4
	4	4	4	4	4	4	4	4	4	3	2	4
	4	4	4	5	3	4	4	2	5	3	3	3
	3	2	4	4	3	3	4	2	4	2	1	2
K	4	2	5	5	4	4	2	3	4	4	2	3
	4	5	4	5	5	5	5	5	5	5	3	5
	5	3	4	5	4	4	3	2	4	3	4	3
	4	4	5	4	4	4	4	3	4	4	4	4
N	5	4	5	5	5	5	5	4	5	5	4	5
	1	1	5	3	3	3	2	4	2	3	1	2
	2	2	5	4	2	2	2	2	4	4	3	3
	4	4	3	5	4	4	4	4	5	5	4	4
	4	4	4	4	3	4	2	2	4	4	3	3
Q	3	4	4	5	5	4	4	4	5	4	3	4
	3	2	2	4	3	3	3	2	2	3	3	3
	4	2	5	5	4	4						
	3	4	4	5	4	4	4	4	4	4	4	4
	4	4	4	4	4	4	4	5	5	4	4	4
R	4	4	4	5	4	4	2	5	4	3	2	3
	3	4	4	5	3	4	4	3	4	4	4	4
	4	2	5	5	4	4	4	2	4	4	2	4
	4	2	4	4	2	4	4	3	4	2	3	3
	2	2	2	2	2	2	5	2	5	4	4	4
	2	5	5	5	4	5	4	5	5	5	2	5
	2	3	3	3	1	3	2	3	1	2	3	2
	3	3	3	3	3	3	3	3	3	3	2	3
	4	5	5	5	4	5	3	3	4	5	2	3
	2	4	4	4	2	4	2	3	2	4	5	3
	1	1	2	1	2	1	2	1	2	2	1	2
	4	5	5	5	4	5	4	5	5	4	4	4
	4	2	2	2	3	2	2	4	4	5	4	4
	2	1	4	5	2	2	1	2	2	2	1	2
	5	5	5	5	4	5	5	5	4	4	2	4

Recognition and independence survey data

Project ID	Q5	Q13	Q21	Q29	Q37	Recog Median	Q6	Q14	Q22	Q30	Q38	Indepen Median
A	5	5	4	4	5	5	4	5	4	5	5	5
	4	3	3	3	3	3	4	5	3	4	5	4
	4	3	3	4	2	3	3	3	3	3	3	3
	4	5	4	5	4	4	4	5	5	3	4	4
	4	4	3	4	3	4	4	4	4	4	4	4
	4	5	5	4	3	4	2	4	4	3	4	4
	5	5	5	5	5	5	5	5	5	5	5	5
	5	5	4	5	5	5	5	5	5	5	5	5
	4	5	4	4	4	4	4	5	4	4	4	4
	5	5	5	5	5	5	4	5	5	5	5	5
	5	5	5	5	5	5	5	5	1	5	5	5
							5	5	5	5	5	5
	4	3	3	2	3	3	3	4	3	2	2	3
	5	5	3	4	2	4	5	5	3	4	3	4
	4	4	4	4	3	4	4	4	4	3	3	4
	5	5	4	5	5	5	5	5	5	4	4	5
	5	4	5	4	3	4	4	5	4	4	4	4
	5	4	4	5	5	5	4	5	4	4	5	4
	4	5	5	5	4	5	4	5	5	5	5	5
	5	5	4	5	4	5	5	5	5	4	4	5
	5	4	5	5	5	5	4	5	5	5	5	5
	4	4	3	4	3	4	4	4	3	4	4	4
	5	5	5	5	5	5	5	5	5	5	5	5
	5	4	4	5	4	4	3	5	4	5	5	5
	5	5	4	5	4	5	4	4	4	4	5	4
B	5	5	4	5	4	5	4	5	4	5	4	4
	4	5	3	4	3	4	4	4	3	4	3	4
	4	4	5	5	4	4	4	5	5	4	4	4
	5	5	4	5	4	5	4	5	4	5	5	5
	4	4	4	5	4	4	5	4	4	4	5	4
	4	3	3	3	3	3	5	4	3	4	4	4
	2	4	2	2	2	2	4	5	4	2	4	4
	5	5	4	4	4	4	4	4	3	4	2	4
C	4	5	4	4	4	4	4	5	5	4	5	5
	4	3	4	4	3	4	4	3	3	4	3	3
	2	2	1	1	4	2	5	2	4	2	4	4
	4	4	3	4	2	4	5	5	5	4	4	5
	5	4	4	5	4	4	4	5	4	4	5	4
	5	4	5	5	4	5	4	4	4	4	5	4
	5	4	3	5	4	4	4	5	4	5	5	5
	4	3	3	3	2	3	2	4	3	4	1	3
	5	5	3	5	5	5	5	5	4	5	4	5
D	5	4	5	4	4	4	5	5	5	5	5	5
	5	5	3	5	4	5	4	5	3	5	5	5
	5	5	4	5	4	5	4	5	5	5	4	5
	3	4	3	4	4	4	4	5	4	4	4	4
	5	5	5	5	4	5	4	5	4	5	5	5

Recognition and independence survey data (continued)

Project ID	Q5	Q13	Q21	Q29	Q37	Recog Median	Q6	Q14	Q22	Q30	Q38	Indepen Median
D							1	1	1	1	1	1
	5	2	4	5	5	5	4	4	4	5	5	4
	5	5	4	5	5	5	4	5	5	2	4	4
	4	4	4	4	3	4	3	4	3	4	4	4
	5	4	4	4	4	4	2	5	4	5	4	4
	5	2	4	5	3	4	4	5	5	4	5	5
	4	4	2	4	4	4	4	4	4	4	5	4
	4	5	3	4	4	4	4	4	4	4	4	4
	5	5	5	5	5	5	4	5	5	5	5	5
	1	1	1	2	1	1	2	3	1	1	1	1
	5	3	3	5	4	4	2	5	3	5	5	5
	4	5	4	4	4	4	2	5	5	5	4	5
	5	5	5	5	5	5	4	5	5	5	5	5
	5	2	4	5	5	5	4	5	5	5	5	5
	4	2	4	4	4	4	4	5	4	4	4	4
	4	4	4	4	3	4	4	5	5	5	5	5
E	4	5	5	5	4	5	4	4	4	5	5	4
	5	5	5	5	4	5	5	5	5	5	5	5
	4	4	4	5	5	4	5	5	4	4	4	4
	3	4	4	4	3	4	4	4	3	3	4	4
	4	5	3	4	3	4	3	3	3	3	3	3
	5	3	3	4	3	3	5	3	4	3	4	4
	4	4	4	3	3	4	4	4	3	3	4	4
	5	3	4	4	3	4	3	4	4	4	4	4
	5	5	5	5	5	5	5	5	5	5	5	5
	3	4	3	3	3	3	4	4	4	4	4	4
	3	3	3	3	2	3	3	3	3	3	3	3
	5	5	4	4	4	4	5	5	4	4	4	4
	5	5	5	5	4	5	4	4	3	5	4	4
	4	5	3	4	3	4	3	5	3	3	4	3
	3	4	5	4	4	4	4	5	4	3	4	4
	3	3	3	3	3	3	3	5	4	3	5	4
	5	4	4	4	2	4	4	4	4	4	4	4
	4	4	4	4	3	4	4	4	4	4	4	4
	3	3	3	3	3	3	4	2	3	3	3	3
	3	3	4	4	3	3	4	5	4	4	3	4
	5	3	4	5	5	5	4	5	5	5	5	5
	5	3	4	5	4	4	5	5	4	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	5
	5	5	5	5	3	5	5	3	3	4	3	3
	2	4	2	2	4	2	2	4	3	2	3	3
	5	5	5	4	3	5	5	5	4	3	5	5
	4	4	4	4	2	4	4	5	4	2	4	4
	3	2	3	4	3	3	4	4	3	4	2	4
	4	3	4	4	3	4	3	4	5	4	4	4
	5	4	4	4	3	4	3	3	3	3	3	3
	5	5	5	5	4	5	4	5	4	5	5	5
	5	5	5	5	5	5	5	5	5	5	5	5

Recognition and independence survey data (continued)

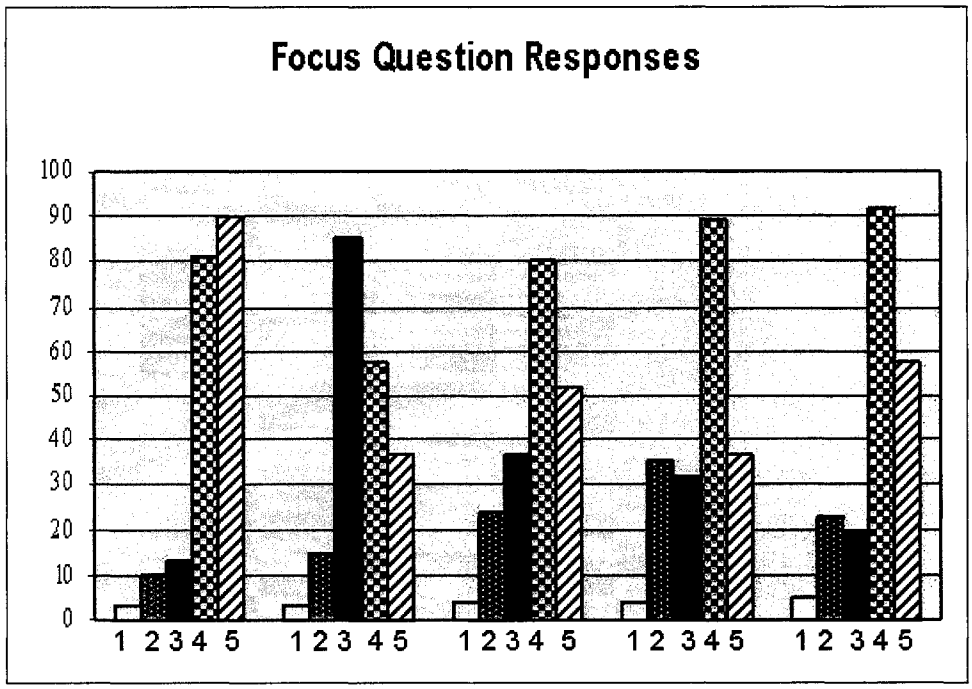
Project ID	Q5	Q13	Q21	Q29	Q37	Recog Median	Q6	Q14	Q22	Q30	Q38	Indepen Median
E	4	2	3	4	3	3	2	4	4	4	4	4
	4	4	4	5	4	4	5	5	4	4	4	4
	4	4	3	4	4	4	4	5	3	4	4	4
	5	5	4	5	4	5						
	3	3	2	3	2	3	3	4	3	2	2	3
	3	5	4	3	3	3	4	4	3	4	4	4
	5	5	2	4	4	4	4	4	4	5	5	4
	5	3	4	4	4	4	4	4	4	4	4	4
	2	4	4	2	4	4	4	4	2	2	4	4
	3	4	3	4	3	3	3	4	3	3	4	3
	2	4	4	4	3	4	4	4	3	3	4	4
	4	5	5	4	5	5	4	5	2	4	2	4
	4	2	3	3	3	3	4	3	3	3	3	3
	4	4	3	3	3	3	2	4	3	4	3	3
	4	4	3	5	5	4	4	4	3	5	4	4
	3	4	3	3	3	3	4	5	3	3	4	4
	5	4	5	4	5	5	5	5	5	5	4	5
	4	4	4	4	5	4	4	4	3	4	5	4
F	4	4	3	4	1	4	3	3	1	3	1	3
	3	3	2	3	3	3	2	2	2	4	3	2
	3	4	3	4	4	4	3	5	4	4	4	4
	5	5	5	5	3	5	4	3	4	4	4	4
	4	4	3	3	4	4	4	4	4	4	4	4
	2	2	1	1	2	2	2	2	2	2	4	2
	2	3	1	3	2	2	3	3	3	3	2	3
	4	5	4	4	4	4	4	5	4	4	4	4
	4	4	4	5	4	4	4	5	4	4	4	4
	5	5	4	5	2	5	4	5	4	5	2	4
	4	1	3	4	1	3	3	3	4	5	3	3
	5	4	4	5	3	4	4	4	4	5	4	4
	4	2	4	4	4	4	4	4	4	4	2	4
G	5	2	5	5	5	5	4	5	5	5	5	5
	4	4	4	4	4	4	4	5	4	4	5	4
	5	4	5	5	5	5	4	5	4	5	4	4
	2	2	4	4	3	3	3	4	2	4	4	4
	5	5	5	5	4	5	1	5	5	4	4	4
H	5	5	4	5	4	5	5	4	4	3	3	4
	3	4	4	4	3	4	3	4	4	4	3	4
							2	3	2	3	3	3
	5	5	4	5	4	5	4	5	4	5	4	4
	4	4	4	4	4	4	4	5	5	4	4	4
	4	4	3	4	3	4	4	4	4	4	3	4
	2	2	3	4	3	3	2	4	4	3	3	3
I	4	2	3	5	3	3	2	5	4	5	5	5
	5	2	4	3	3	3	4	5	4	5	5	5
	5	2	5	5	5	5	5	5	3	5	4	5
							4	5	5	5	5	5
	5	4	3	4	5	4	4	5	4	4	4	4

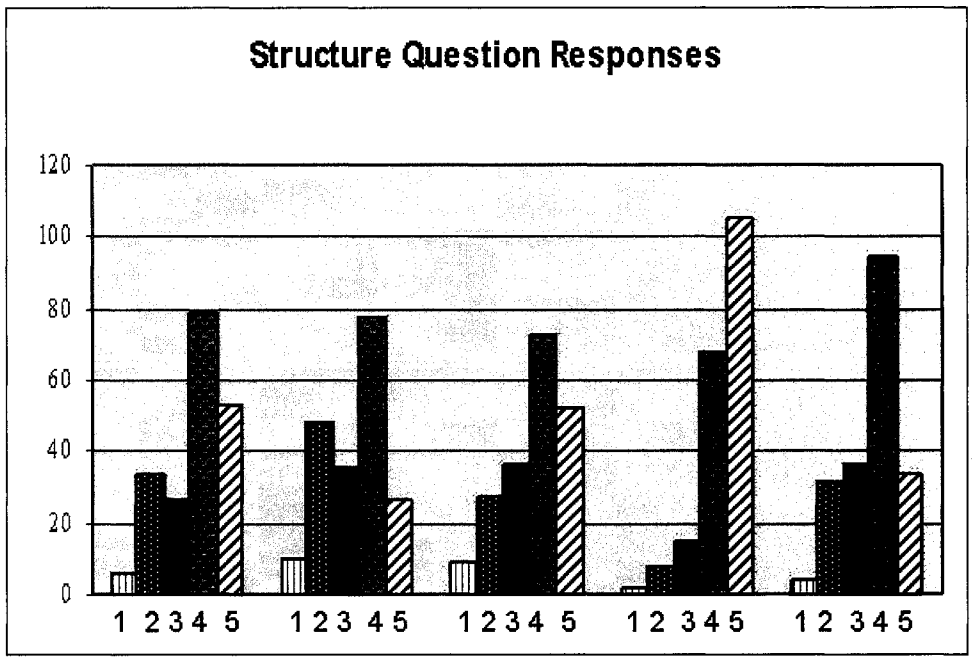
Recognition and independence survey data (continued)

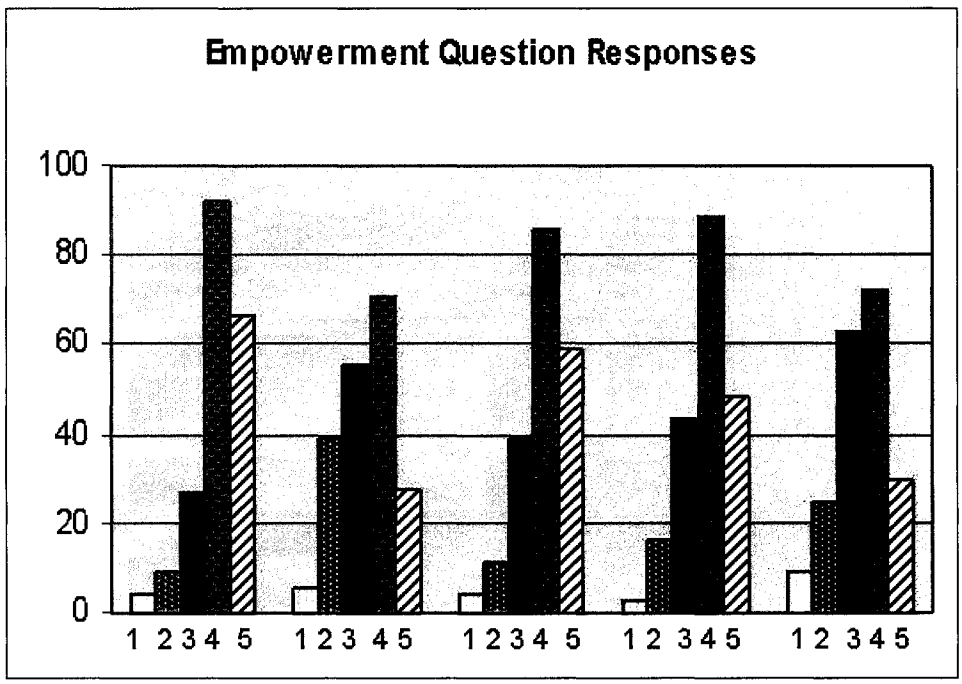
Project ID	Q5	Q13	Q21	Q29	Q37	Recog Median	Q6	Q14	Q22	Q30	Q38	Indepen Median
J	5	4	4	4	4	4	4	5	3	3	4	4
	4	3	4	4	4	4	2	4	3	3	3	3
	4	5	5	5	4	5	5	5	5	5	4	5
	4	4	3	4	2	4	2	4	3	3	3	3
	5	5	4	5	4	5	4	5	4	4	4	4
	4	4	4	4	4	4	4	5	4	4	4	4
	5	2	4	5	3	4	4	5	3	5	5	5
	3	4	4	4	2	4	5	4	4	2	5	4
K	2	2	4	4	2	2	4	5	4	2	3	4
	5	4	5	5	4	5	5	5	5	5	5	5
	5	4	4	4	4	4	5	5	3	3	4	4
	5	4	4	4	4	4	4	4	4	4	4	4
N	5	5	5	5	4	5	4	5	4	5	5	5
	4	3	4	4	3	4	3	3	2	3	3	3
	4	4	5	4	3	4	2	3	4	2	2	2
	5	4	4	5	4	4	5	5	4	5	5	5
	5	4	4	5	3	4	3	5	3	3	5	3
Q	4	3	4	5	4	4	4	5	4	5	4	4
	2	2	3	3	3	3	2	4	3	2	4	3
	4	3	5	4	4	4	4	5	4	5	5	5
	5	5	3	5	5	5	4	5	4	5	3	4
R	4	5	4	5	4	4	4	5	4	5	4	4
	4	3	4	4	3	4	4	4	4	4	4	4
	4	5	3	4	3	4	4	4	4	4	3	4
	5	4	3	4	4	4	4	3	3	3	2	3
	3	5	3	3	3	3	4	4	3	3	2	3
	5	2	5	5	4	5	4	2	2	5	5	4
	2	2	3	2	3	2	1	1	2	2	3	2
	2	3	3	3	3	3	2	3	2	3	2	2
	4	4	4	4	3	4	4	4	4	5	5	4
	5	2	2	4	4	4	2	4	2	2	4	2
	2	4	4	2	4	4	2	2	1	2	4	2
	4	5	5	4	5	5	4	4	4	5	4	4
	5	2	5	4	4	4	4	2	3	5	5	4
	1	5	4	4	1	4	2	2	1	2	2	2
	2	4	4	4	2	4	4	4	4	5	5	4

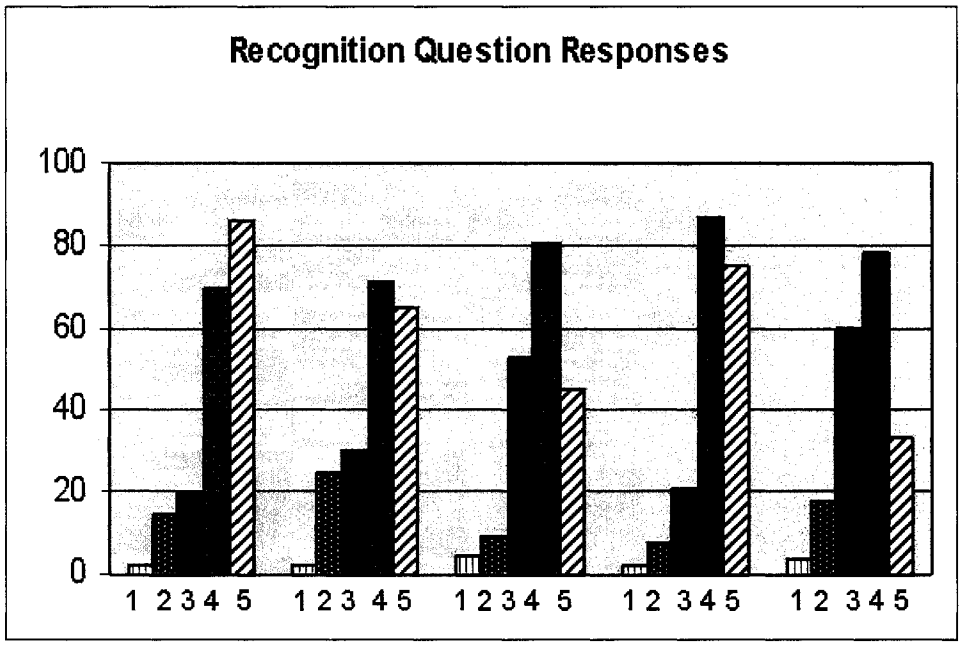
In the following graphs, each set of bars represents the responses to one question within that team attribute. Each individual bar represents the number of persons answering the question with the value noted on the horizontal axis.

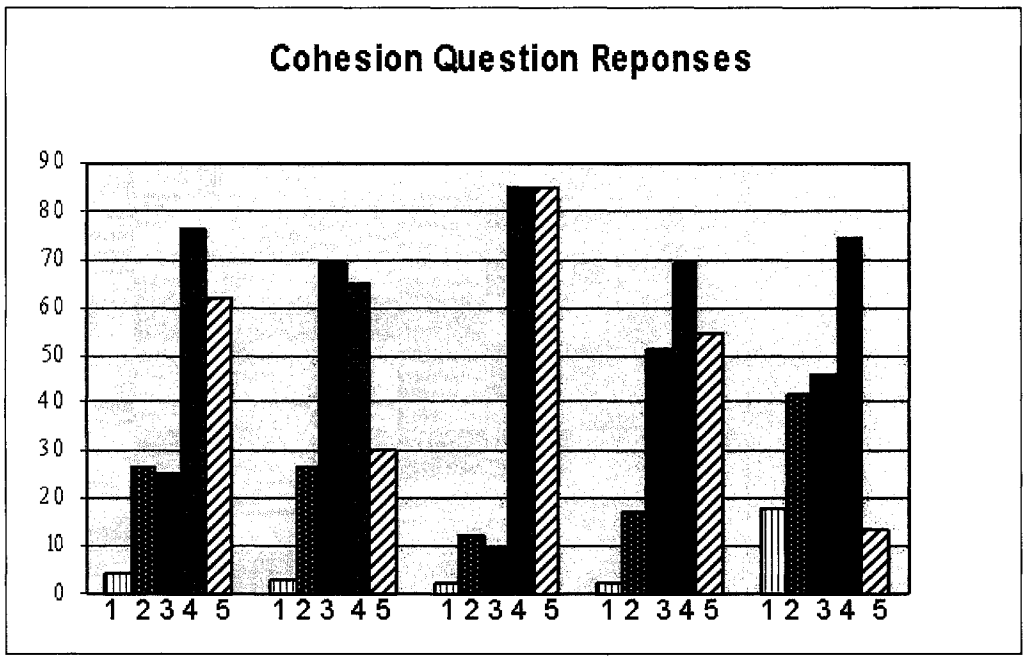
Frequencies of survey question responses

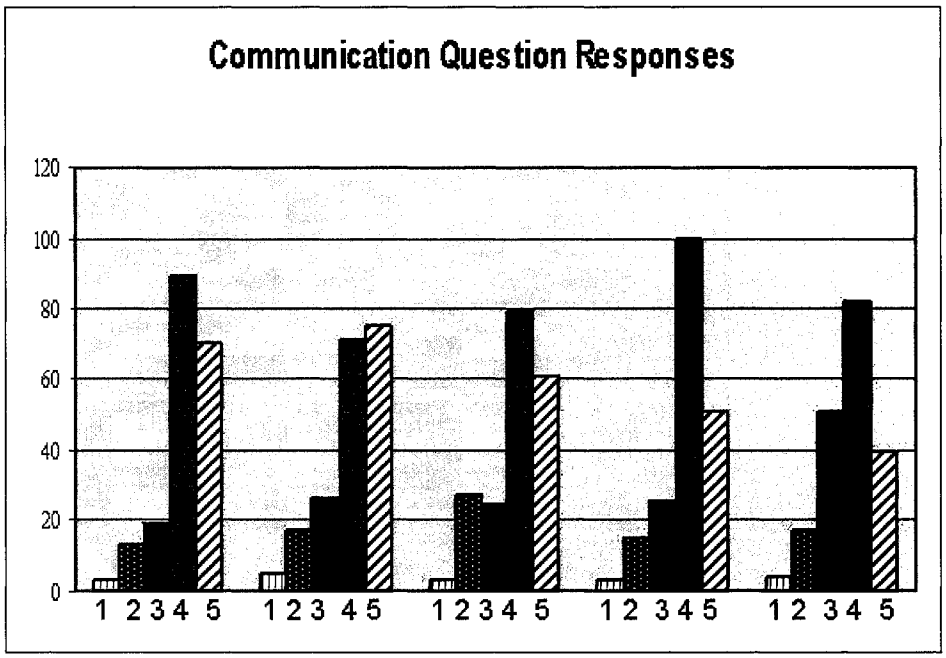


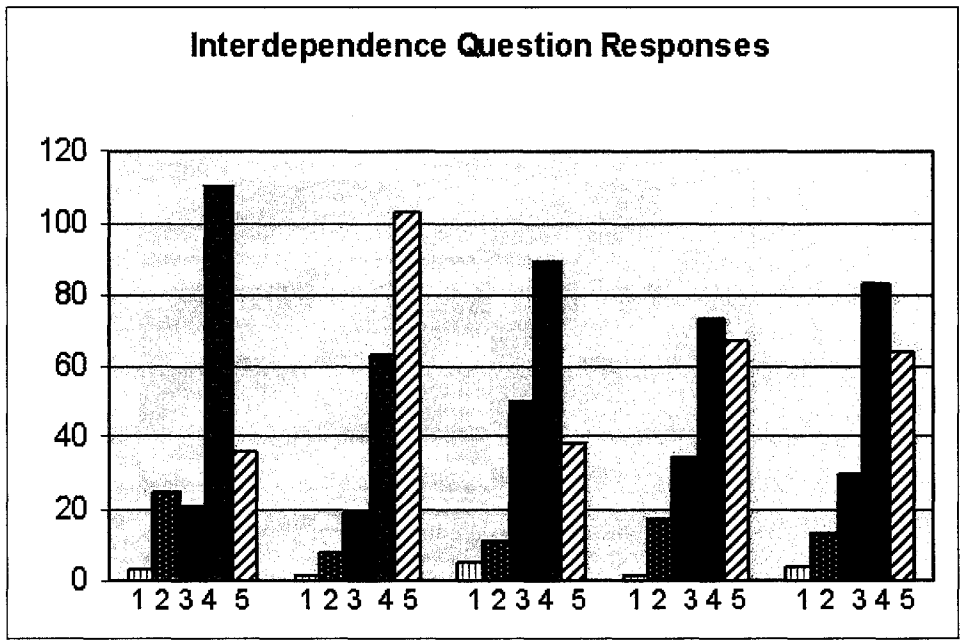












For all the tables in this Appendix, the Q followed by a number represents the number of the question from the team attribute survey. In these question relationship tables, the questions are grouped by team attribute.

Question relationships – gamma values

Focus	Q1	Q9	Q17	Q25	Q33	Empow	Q2	Q10	Q18	Q26	Q34
Q1		.434	.588	.557	.771		.101	.089	.095	.088	.176
Q9	.434		.529	.518	.481		.073	.118	.091	.156	.126
Q17	.588	.529		.671	.653		.091	.066	.089	.086	.103
Q25	.557	.518	.671		.604		.052	.057	.051	.082	.104
Q33	.771	.481	.653	.604			.130	.089	.099	.093	.171
Q2	.101	.073	.091	.052	.130			.505	.628	.589	.464
Q10	.089	.118	.066	.057	.089		.505		.498	.599	.479
Q18	.095	.091	.089	.051	.099		.628	.498		.635	.507
Q26	.088	.156	.086	.082	.093		.589	.599	.635		.591
Q34	.176	.126	.103	.104	.171		.464	.479	.507	.591	
Q3	.124	.045	.083	.101	.102		.001	.000	.026	.022	-.004
Q11	.115	.110	.114	.162	.143		.007	.076	.047	.076	.097
Q19	.073	.065	.077	.080	.096		.029	.050	.055	.049	.068
Q27	.106	.078	.079	.092	.110		.057	.051	.083	.064	.067
Q35	.130	.090	.126	.144	.146		.072	.040	.086	.065	.081
Q4	.107	.066	.100	.079	.117		.356	.321	.366	.381	.330
Q12	.073	.090	.079	.046	.083		.350	.338	.337	.381	.311
Q20	.093	.101	.054	.093	.097		.371	.335	.422	.433	.329
Q28	.015	.082	.021	.010	.060		.356	.356	.373	.394	.321
Q36	.037	.083	.053	.066	.075		.234	.251	.220	.262	.247
Q5	.089	.128	.105	.123	.106		.025	.045	.025	.063	.044
Q13	.029	.123	.051	.079	.098		.042	.032	.045	.078	.046
Q21	.085	.115	.102	.110	.118		.051	.080	.097	.125	.086
Q29	.074	.118	.087	.109	.140		.074	.070	.092	.119	.104
Q37	.080	.152	.107	.134	.131		.066	.079	.079	.124	.094
Q6	.051	.065	.085	.038	.059		.074	.056	.041	.062	.103
Q14	.133	.081	.101	.072	.099		.104	.122	.157	.124	.132
Q22	.075	.090	.146	.075	.088		.103	.146	.134	.177	.130
Q30	.057	.032	.071	.005	.034		.092	.100	.115	.121	.108
Q38	.064	.102	.085	.063	.070		.105	.126	.129	.151	.134
Q7	.123	.113	.116	.139	.149		.068	.082	.114	.120	.099
Q15	.071	.108	.080	.101	.123		.041	.050	.081	.098	.061
Q23	.058	.123	.101	.109	.094		.089	.060	.106	.144	.081
Q31	.074	.067	.084	.081	.096		.035	.063	.109	.086	.044
Q39	.103	.108	.121	.142	.127		.046	.045	.088	.091	.092

Question relationships – gamma values (continued)

Struct	Q3	Q11	Q19	Q27	Q35	Cohes	Q4	Q12	Q20	Q28	Q36
Q1	.124	.115	.073	.106	.130		.107	.073	.093	.015	.037
Q9	.045	.110	.065	.078	.090		.066	.090	.101	.082	.083
Q17	.083	.114	.077	.079	.126		.100	.079	.054	.021	.053
Q25	.101	.162	.080	.092	.144		.079	.046	.093	.010	.066
Q33	.102	.143	.096	.110	.146		.117	.083	.097	.060	.075
Q2	.001	.007	.029	.057	.072		.356	.350	.371	.356	.234
Q10	.000	.076	.050	.051	.040		.321	.338	.335	.356	.251
Q18	.026	.047	.055	.083	.086		.366	.337	.422	.373	.220
Q26	.022	.076	.049	.064	.065		.381	.381	.433	.394	.262
Q34	-.004	.097	.068	.067	.081		.330	.311	.329	.321	.247
Q3		.629	.435	.495	.752		-.001	.055	.022	.067	.089
Q11	.629		.499	.478	.679		.035	.076	.039	.087	.070
Q19	.435	.499		.433	.537		.066	.055	.078	.065	.071
Q27	.495	.478	.433		.611		.089	.043	.093	.061	.094
Q35	.752	.679	.537	.611			.049	.098	.094	.083	.083
Q4	-.001	.035	.066	.089	.049			.526	.672	.509	.315
Q12	.055	.076	.055	.043	.098		.526		.577	.557	.341
Q20	.022	.039	.078	.093	.094		.672	.577		.599	.319
Q28	.067	.087	.065	.061	.083		.509	.557	.599		.540
Q36	.089	.070	.071	.094	.083		.315	.341	.319	.540	
Q5	.367	.403	.343	.366	.429		.030	.037	.014	.015	.053
Q13	.270	.314	.233	.316	.322		.009	.081	.034	.086	.103
Q21	.355	.391	.339	.390	.416		.051	.060	.063	.074	.083
Q29	.365	.406	.383	.454	.455		.042	.065	.074	.047	.046
Q37	.303	.375	.323	.326	.405		.039	.046	.056	.086	.085
Q6	.060	.022	.018	-.007	.056		.086	.081	.124	.107	.063
Q14	.061	.060	.024	.083	.050		.117	.097	.175	.130	.067
Q22	.018	.060	.020	.052	.012		.114	.127	.113	.122	.069
Q30	.072	.067	.031	.094	.059		.098	.099	.115	.100	.038
Q38	.056	.071	.020	.071	.051		.117	.102	.161	.145	.063
Q7	.250	.259	.246	.270	.293		.094	.127	.096	.105	.050
Q15	.227	.238	.240	.267	.307		.124	.117	.088	.065	.056
Q23	.199	.236	.166	.239	.241		.063	.113	.070	.090	.089
Q31	.278	.270	.220	.277	.318		.116	.105	.090	.090	.070
Q39	.248	.250	.226	.257	.337		.066	.094	.064	.062	.063

Question relationships – gamma values (continued)

Recog	Q5	Q13	Q21	Q29	Q37	Interdep	Q6	Q14	Q22	Q30	Q38
Q1	.089	.029	.085	.074	.080		.051	.133	.075	.057	.064
Q9	.128	.123	.115	.118	.152		.065	.081	.090	.032	.102
Q17	.105	.051	.102	.087	.107		.085	.101	.146	.071	.085
Q25	.123	.079	.110	.109	.134		.038	.072	.075	.005	.063
Q33	.106	.098	.118	.140	.131		.059	.099	.088	.034	.070
Q2	.025	.042	.051	.074	.066		.074	.104	.103	.092	.105
Q10	.045	.032	.080	.070	.079		.056	.122	.146	.100	.126
Q18	.025	.045	.097	.092	.079		.041	.157	.134	.115	.129
Q26	.063	.078	.125	.119	.124		.062	.124	.177	.121	.151
Q34	.044	.046	.086	.104	.094		.103	.132	.130	.108	.134
Q3	.367	.270	.355	.365	.303		.060	.061	.018	.072	.056
Q11	.403	.314	.391	.406	.375		.022	.060	.060	.067	.071
Q19	.343	.233	.339	.383	.323		.018	.024	.020	.031	.020
Q27	.366	.316	.390	.454	.326		-.007	.083	.052	.094	.071
Q35	.429	.322	.416	.455	.405		.056	.050	.012	.059	.051
Q4	.030	.009	.051	.042	.039		.086	.117	.114	.098	.117
Q12	.037	.081	.060	.065	.046		.081	.097	.127	.099	.102
Q20	.014	.034	.063	.074	.056		.124	.175	.113	.115	.161
Q28	.015	.086	.074	.047	.086		.107	.130	.122	.100	.145
Q36	.053	.103	.083	.046	.085		.063	.067	.069	.038	.063
Q5		.515	.678	.746	.617		.068	.014	.031	.071	.089
Q13	.515		.510	.490	.532		.025	.018	.040	.063	.069
Q21	.678	.510		.717	.618		.068	.070	.047	.097	.099
Q29	.746	.490	.717		.680		.122	.106	.066	.148	.113
Q37	.617	.532	.618	.680			.078	.081	.068	.120	.111
Q6	.068	.025	.068	.122	.078			.612	.591	.577	.601
Q14	.014	.018	.070	.106	.081		.612		.716	.674	.671
Q22	.031	.040	.047	.066	.068		.591	.716		.704	.663
Q30	.071	.063	.097	.148	.120		.577	.674	.704		.747
Q38	.089	.069	.099	.113	.111		.601	.671	.663	.747	
Q7	.101	.068	.120	.137	.090		.077	.073	.047	.068	.079
Q15	.113	.051	.073	.094	.072		.040	.071	.080	.085	.071
Q23	.135	.079	.097	.122	.090		.042	.058	.088	.071	.087
Q31	.142	.091	.092	.130	.076		.028	.055	.046	.059	.063
Q39	.127	.058	.095	.136	.110		.049	.062	.046	.070	.061

Question relationships – gamma values (continued)

Communication	Q7	Q15	Q23	Q31	Q39
Q1	.123	.071	.058	.074	.103
Q9	.113	.108	.123	.067	.108
Q17	.116	.080	.101	.084	.121
Q25	.139	.101	.109	.081	.142
Q33	.149	.123	.094	.096	.127
Q2	.068	.041	.089	.035	.046
Q10	.082	.050	.060	.063	.045
Q18	.114	.081	.106	.109	.088
Q26	.120	.098	.144	.086	.091
Q34	.099	.061	.081	.044	.092
Q3	.250	.227	.199	.278	.248
Q11	.259	.238	.236	.270	.250
Q19	.246	.240	.166	.220	.226
Q27	.270	.267	.239	.277	.257
Q35	.293	.307	.241	.318	.337
Q4	.094	.124	.063	.116	.066
Q12	.127	.117	.113	.105	.094
Q20	.096	.088	.070	.090	.064
Q28	.105	.065	.090	.090	.062
Q36	.050	.056	.089	.070	.063
Q5	.101	.113	.135	.142	.127
Q13	.068	.051	.079	.091	.058
Q21	.120	.073	.097	.092	.095
Q29	.137	.094	.122	.130	.136
Q37	.090	.072	.090	.076	.110
Q6	.077	.040	.042	.028	.049
Q14	.073	.071	.058	.055	.062
Q22	.047	.080	.088	.046	.046
Q30	.068	.085	.071	.059	.070
Q38	.079	.071	.087	.063	.061
Q7		.666	.510	.677	.625
Q15	.666		.544	.671	.625
Q23	.510	.544		.646	.560
Q31	.677	.671	.646		.728
Q39	.625	.625	.560	.728	

Calculated team attribute data

Focus

Project ID	Medians					Variable Median
	Q1	Q9	Q17	Q25	Q33	
A	5	4	4	4	4	4
B	4	3	4	4	3	4
C	5	3	4	4	5	4
D	4	4	4	4	4	4
E	4	3	4	4	4	4
F	4	3	3	4	3	3
G	4	5	4	5	4	4
H	4	3	4	4	4	4
I	5	3	4	4	4	4
J	5	3	3.5	4	4.5	4
K	5	3	3.5	3	4	3.5
N	4	3	4	4	4	4
Q	4	4	4	3	4	4
R	5	3	4	3	4	4

Empowerment

Project ID	Medians					Variable Median
	Q2	Q10	Q18	Q26	Q34	
A	4	4	4	4	3	4
B	3.5	3.5	4	4	4	4
C	4	4	4	4	4	4
D	4	4	4	4	4	4
E	4	3	4	4	3	4
F	4	3	4	4	2	4
G	5	3	5	4	5	5
H	4	3	4	3	4	4
I	4	3	5	4	4	4
J	4	3.5	4	4	4	4
K	5	3.5	4	3.5	3.5	3.5
N	4	3	4	5	4	4
Q	4	4	5	4	4	4
R	4	3	4	4	3	4

Calculated team attribute data (continued)

Structure

Project ID	Medians					Variable Median
	Q3	Q11	Q19	Q27	Q35	
A	4	4	4	5	4	4
B	4.5	2	2.5	5	4	4
C	4	4	5	5	4	4
D	4	4	4	4.5	4	4
E	4	3.5	3	4	4	4
F	3	2	4	5	2	3
G	4	4	4	5	4	4
H	4	4	4	4	4	4
I	4	3	4	5	4	4
J	4	4	4	4	4	4
K	4	3.5	4.5	5	4	4
N	4	4	5	4	3	4
Q	3	4	4	5	4	4
R	3	3	4	5	3	3

Cohesion

Project ID	Medians					Variable Median
	Q4	Q12	Q20	Q28	Q36	
A	4	4	5	4	4	4
B	4	3.5	4	4	3	4
C	4	3	5	4	2	4
D	5	4	5	5	3.5	5
E	4	3	4	4	4	4
F	4	4	4	3	2	4
G	4	4	5	4	2	4
H	4	3	4	4	3	4
I	5	3	5	4	2	4
J	4	3	4	3.5	3	3.5
K	3.5	3	4	4	3.5	3.5
N	2	4	4	4	3	4
Q	4	4	4.5	4	3.5	4
R	3	3	4	4	2	3

Calculated team attribute data (continued)

Recognition

Project ID	Medians					Variable Median
	Q5	Q13	Q21	Q29	Q37	
A	5	5	4	5	4	5
B	4	4.5	4	4.5	4	4
C	4	4	3	4	4	4
D	5	4	4	4.5	4	4
E	4	4	4	4	3	4
F	4	4	3	4	3	4
G	5	4	5	5	4	5
H	4	4	4	4	3.5	4
I	5	2	3.5	4.5	4	4
J	4	4	4	4	4	4
K	5	4	4	4	4	4
N	5	4	4	5	3	4
Q	4	3	3.5	4.5	4	4
R	4	4	4	4	3	4

Interdependence

Project ID	Medians					Variable Median
	Q6	Q14	Q22	Q30	Q38	
A	4	5	4	4	5	4
B	4	4.5	4	4	4	4
C	4	5	4	4	4	4
D	4	5	4	5	5	5
E	4	4	4	4	4	4
F	4	4	4	4	4	4
G	4	5	4	4	4	4
H	4	4	4	4	3	4
I	4	5	4	5	5	5
J	4	5	3.5	3.5	4	4
K	4.5	5	4	3.5	4	4
N	3	5	4	3	5	4
Q	4	5	4	5	4	4
R	4	4	3	4	4	4

Calculated team attribute data (continued)
Communication

Project ID	Medians					Variable Median
	Q7	Q15	Q23	Q31	Q39	
A	4	5	4	4	4	4
B	4	4	4	4.5	3.5	4
C	4	5	4	5	4	4
D	4	5	4	4	4	4
E	4	4	4	4	3	4
F	4	4	5	4	3	4
G	5	5	4	4	4	4
H	4	4	4	4	3	4
I	5	5	4	4	4.5	4.5
J	4	4	3.5	4	3.5	4
K	4.5	4	3	4	4.5	4
N	4	5	2	4	3	4
Q	4	4.5	4.5	4	4	4
R	4	2	4	4	4	4

Expert rankings of RFAs

E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3
3	2	1	4	1	2	3	1	3	4	2	5	4	2	5
4	2	2	2	2	1	3	1	3	3	2	5	3	1	3
3	1	4	2	1	1	4	1	3	4	1	5	3	2	3
4	2	5	3	2	5	4	1	1	2	1	1	3	2	4
4	2	3	2	2	1	3	1	1	3	2	2	3	2	4
3	1	3	3	2	3	4	1	1	4	2	5	4	2	4
3	1	2	3	2	3	3	2	1	4	2	3	4	2	5
4	3	4	3	2	3	4	2	3	3	2	3	3	2	4
4	3	4	2	1	1	3	1	4	4	3	4	3	2	4
4	1	4	4	3	4	3	2	3	3	1	2	3	2	3
4	2	2	3	3	3	3	2	3	3	2	3	3	2	3
4	2	4	3	2	3	3	1	2	3	2	4	3	2	3
4	2	2	3	1	2	4	1	4	4	3	5	3	1	2
3	2	1	4	3	5	4	1	2	2	1	1	3	1	1
4	3	5	4	3	4	4	1	4	3	3	3	3	2	2
3	1	1	4	3	3	3	2	4	4	1	2	3	2	3
3	2	3	4	2	3	3	2	4	3	2	4	3	1	3
4	2	2	3	2	3	4	1	4	3	1	2	3	1	3
4	2	4	3	2	4	4	2	4	3	2	5	3	2	4
4	2	3	4	2	5	3	3	2	3	2	2	3	2	3
3	1	2	4	3	4	4	2	2	3	3	2	3	2	2
4	2	3	2	2	1	4	2	2	3	1	1	3	2	1
4	1	2	2	1	3	3	1	3	4	2	4	3	1	1
4	4	5	3	2	3	4	2	3	3	3	3	3	1	1
2	1	1	3	1	1	3	2	2	3	1	3	3	1	2
3	1	4	5	2	3	4	2	2	4	2	4	4	1	2
4	3	4	3	2	1	3	2	3	2	1	1	3	1	1
3	3	4	3	3	5	3	2	3	3	1	1	3	1	2
3	3	3	3	2	5	4	3	3	3	1	1	3	2	2
4	3	4	3	2	3	4	2	2	3	1	1	3	1	2
4	2	4	4	3	3	3	1	2	3	2	1	3	1	2
3	2	2	3	1	3	4	1	2	3	2	1	3	1	1
3	1	2	3	2	3	4	2	2	3	2	5	4	2	3
3	2	4	2	2	2	3	2	3	4	2	5	3	1	3
4	3	5	3	3	3	3	2	2	3	1	3	3	1	1
3	2	2	3	2	1	3	1	3	4	3	5	4	3	5
3	2	3	3	2	2	3	2	3	2	1	1	3	1	3
4	2	3	4	2	2	4	2	3	4	2	4	3	1	3
5	2	5	4	2	4	4	3	3	3	1	1	3	1	3
3	4	2	4	3	5	3	2	2	4	2	1	3	1	2
4	2	4	4	1	1	3	2	1	5	2	4	3	1	3
3	2	4	4	3	4	4	2	3	2	1	1	3	1	3
4	3	4	3	1	4	3	2	2	2	1	1	3	1	2
3	1	2	3	1	2	3	2	4	2	1	1	3	2	3
4	2	3	3	1	2	3	2	3	2	1	1	3	2	2
3	2	3	3	2	1	3	2	3	2	1	1	3	2	2
4	2	3	3	2	2	3	2	2	4	2	5	3	1	4
5	2	3	2	1	4	4	3	4	2	2	2	3	1	2
3	3	4	3	3	3	3	3	4	3	1	5	3	1	3
4	3	5	3	1	3	3	2	2	4	2	5	3	2	2

Expert rankings of RFAs (Continued)

E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3
3	2	2	3	1	1	3	1	3	3	1	1
3	2	2	3	1	1	3	2	4	3	2	1
3	2	2	3	2	2	3	3	4	3	2	2
3	1	1	3	2	3	3	2	2	3	1	2
3	2	4	3	2	3	3	2	4	4	1	4
3	1	2	3	2	3	3	1	2	3	1	2
3	1	1	3	2	4	3	1	2	3	1	3
3	2	2	3	2	2	3	1	1	4	4	5
3	2	2	3	2	2	3	1	2	3	3	5
4	2	1	3	2	3	3	2	3	4	2	5
3	2	1	3	2	2	3	2	3	4	3	4
3	2	1	3	1	2	3	2	4	3	2	4
3	2	3	3	2	2	3	1	3	3	2	3
3	1	4	3	1	2	3	1	2	3	3	4
3	1	3	3	1	1	3	1	1	3	2	4
3	1	3	4	3	3	3	1	1	3	1	3
4	1	1	3	2	3	3	1	1	3	1	2
3	1	2	5	3	4	3	2	3	3	2	4
4	1	4	3	2	4	4	2	4	3	2	1
4	3	3	3	2	4	4	2	4	3	1	1
3	2	4	3	1	2	3	2	2	3	1	3
3	3	3	3	2	2	3	2	3	3	1	1
3	2	2	3	2	2	3	2	4	3	2	1
3	2	3	3	2	2	5	2	5	4	1	1
3	2	3	3	2	3	4	2	4	3	1	1
3	1	3	3	2	3	3	2	1	3	1	1
3	2	3	3	2	2	3	1	2	3	1	1
4	2	2	4	2	3	4	2	3	3	1	1
3	2	3	3	2	3	3	2	2	3	1	3
3	2	2	3	2	4	3	2	2	3	1	1
3	1	2	3	2	4	3	2	3	3	1	3
3	2	4	3	3	4	3	1	4	3	2	3
3	2	3	3	2	4	3	1	4	3	1	1
4	2	3	3	1	2	3	2	4	3	2	3
3	2	3	4	2	3	3	1	3	3	2	3
3	2	4	4	2	3	3	1	2	3	2	3
3	1	2	3	2	3	3	2	4	3	2	3
3	3	4	3	2	4	3	2	3	3	2	5
3	1	2	3	1	2	3	2	3	3	2	5
3	1	2	3	1	3	3	1	4	3	3	5
3	2	3	3	2	3	4	2	5	4	2	1
3	1	2	3	1	2	3	2	3	3	1	3
3	2	2	3	1	3	3	2	3	3	2	1
4	1	2	3	1	3	3	1	3	3	1	1
3	1	2	3	1	2	3	1	4	4	2	3
3	1	1	3	1	3	3	2	4	3	2	4
3	1	1	3	1	4	3	2	3	3	2	2
3	1	2	3	2	3	4	3	4	3	2	4
3	2	3	3	1	3	3	2	3	3	2	3
3	2	4	3	1	1	3	1	3	3	2	4

Expert rankings of RFAs (Continued)

E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3
4	2	2	3	2	4	2	2	2	3	2	1	3	1	2
3	2	2	3	1	5	3	2	2	3	2	1	3	1	2
4	1	5	3	2	2	3	2	4	4	2	1	4	3	3
4	1	3	3	3	3	3	2	4	4	3	4	3	1	2
4	2	4	3	1	4	3	2	4	4	2	4	3	1	2
4	1	3	3	2	3	3	1	5	4	2	2	3	1	2
3	2	2	2	1	1	4	2	4	3	2	1	3	2	2
3	2	5	3	1	1	4	2	3	3	2	3	3	1	3
3	2	5	3	1	1	4	2	3	3	2	1	3	2	3
4	2	1	3	2	2	5	3	4	4	2	1	3	2	3
3	1	3	3	2	2	4	3	4	4	3	2	3	1	4
4	2	3	3	1	3	4	2	5	4	1	1	3	2	4
3	2	4	4	3	3	3	2	3	4	2	1	3	2	3
3	1	2	3	2	4	3	2	4	4	3	1	3	2	2
3	1	2	3	2	3	3	1	2	3	2	1	3	2	3
3	1	2	3	2	2	3	2	3	3	3	3	3	1	2
3	1	3	4	1	4	3	1	3	3	2	1	3	2	3
3	2	4	3	2	3	4	2	3	3	1	1	3	2	3
3	1	2	3	2	3	4	2	4	3	1	1	4	3	4
3	2	2	4	1	3	3	2	2	4	3	3	3	2	4
3	2	2	4	1	3	4	3	2	4	3	5	3	1	4
3	1	2	3	2	5	3	2	2	3	3	1	3	2	3
3	1	3	4	2	4	3	2	3	3	2	2	3	1	3
4	1	4	3	1	1	3	2	3	4	3	4	3	1	3
4	1	4	3	2	1	3	1	3	4	3	4	3	2	4
3	1	4	3	2	2	3	1	2	3	4	4	3	2	2
3	1	5	3	2	4	3	2	2	4	3	4	3	1	2
3	1	2	3	2	3	3	2	3	4	2	2	3	1	3
3	1	5	3	2	2	4	1	3	2	2	2	3	2	4
3	2	1	4	2	4	3	1	3	3	2	1	3	2	4
3	1	2	4	2	4	3	2	3	3	1	1	3	1	2
3	1	2	4	2	3	3	2	3	3	1	1	3	2	4
3	1	3	3	2	4	3	1	2	4	2	3	3	2	4
3	2	5	3	1	3	3	2	3	3	2	2	3	1	2
3	2	4	3	2	3	3	2	2	3	2	1	4	2	4
3	2	5	3	2	4	3	1	4	3	2	1	3	2	4
3	2	5	4	3	4	3	1	2	3	2	3	3	2	4
3	1	1	4	1	4	3	1	3	3	2	1	3	2	4
3	2	4	4	1	4	3	1	2	3	3	1	3	2	2
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3	2	2	3	1	1	4	1	4	4	4	3	3	2	2
4	1	4	3	1	1	3	2	4	4	1	3	3	2	2
3	2	1	3	2	1	3	2	4	3	1	4	3	1	2
3	2	3	3	2	3	3	2	4	3	2	3			

Summary of expert RFA rankings

Expert 1

Project	#5s	#4s	#3s	#2s	#1s
A	2	29	22	1	0
B	1	14	34	9	0
C	1	39	79	11	0
D	0	7	9	0	0
E	0	14	20	1	0
F	1	9	26	0	0
G	0	4	11	0	0
H	1	2	30	0	0
I	0	5	10	0	0
J	0	16	121	0	0
K	0	7	27	0	0
N	0	7	55	0	0
Q	1	4	12	0	0
R	0	2	22	0	0

Expert 2

Project	#5s	#4s	#3s	#2s	#1s
A	0	2	11	28	13
B	0	0	13	28	17
C	0	2	19	62	47
D	0	0	0	5	11
E	0	0	5	25	5
F	0	0	3	23	10
G	0	0	1	12	2
H	0	0	3	24	6
I	0	0	1	9	5
J	0	1	6	68	62
K	0	0	0	16	18
N	0	0	4	33	25
Q	0	0	0	11	6
R	0	0	0	11	13

Expert 3

Project	#5s	#4s	#3s	#2s	#1s
A	7	16	13	14	4
B	7	10	20	9	12
C	16	16	27	13	58
D	0	4	6	2	4
E	0	6	13	15	1
F	2	9	15	10	0
G	0	6	6	1	2
H	0	8	10	12	3
I	1	3	7	3	1
J	6	32	48	41	10
K	7	7	7	11	2
N	0	12	18	23	9
Q	1	4	4	4	4
R	1	9	8	6	0

APPENDIX F

EXAMPLE REQUESTS FOR ACTION (RFA'S)

Lacking a strong physical reason for procuring back-side-illuminated CCD's, the project should procure front-side-illuminated devices for generally better yield and delivery.

Technique has been tested in rocket experiments, which last 10 - 30 minutes. This does not validate the stability required of 100's of hours.

Business office staff seems inadequate to handle earned value implementation.

Apparent lack of consistency between Level 1 requirements and goals, and partner Memorandum of Understanding.

Develop a top-level schedule showing major project elements and their dependencies.

Project is missing project plan.

Alter 1553 bus schedule so that both star trackers can be exercised early in mission when power availability is not a constraint. This feature will allow better alignment calibration.

Project senior team was one deep in most positions, and potentially overburdened. Need to increase staffing promptly to allow robust, active management to detect and deal with problems before they become serious.

Requirements for the End-to-End data accountability, including assignment of unique identifiers for every science observation in uplink, flight, and downlink data systems are not yet defined and it is not clear where in the document tree they will reside.

Launch flexibility should be maximized.

The budget for model development may be inadequate.

Schedule documents inconsistent.

Revisit allocations for mass, power, and data rate.

APPENDIX G

PROJECT REVIEW CONTENT

"Evaluation during formulation assesses whether projects support Agency and program goals and strategic planning, and that projects can be successfully conducted within allocated resources and applicable constraints." (NASA NPG 7120.5B, 2002, p. 58)

"Independent reviews ... provide Senior Agency Managers with objective assessments of program/project planning, resource requirements, status, and risks. ... Reviews conducted in formulation support the approval subprocess....These reviews foster an environment that provides for informed decision making relative to the project's continuing ability to meet its technical and programmatic commitments.... Review team members are experts from organizations outside of the advocacy chain of the program/project being reviewed." (NASA NPG 7120.5B, 2002, p. 122-123)

"An NAR is an example of an independent review that provides ... an independent verification and evaluation of a program or selected project's readiness to proceed to implementation. An NAR, or similar type of review (e.g., Confirmation Assessment Review), assesses the following:

a. Compatibility with NASA policy and baselined documentation.
b. Clarity of goals and objectives.
c. Thoroughness/realism of technical plans, schedules, and cost estimates (including reserves and de-scoping options).
d. Adequacy of management plans, including organizational structure and key personnel credentials.
e. Technical complexity, risk assessment, and risk-mitigation plans." (NASA NPG 7120.5B, 2002, p. 123)

Critical Milestone Reviews (CMRs) "are the life-cycle series of rigorous system-level technical and programmatic evaluations conducted at key formulation and implementation milestones. Key milestones in this context are the major transition points in the life cycle, such as the transition from requirements development to design activities, ... include ... System Requirements Review, Preliminary Design Review .... The purpose of a CMR is to assess the technical and programmatic health of a program, project, or major element of a project with respect to the success criteria and acceptable risk. The reviews provide topdown systematic evaluations of the derivation and functional allocation of requirements, the engineering implementation to address the requirements, the validation and verification of the requirements, the preparation

for operations and data analysis, and the system management processes that tie it all together. The CMRs must also address the resources (e.g., workforce, budget, schedule) required to complete the formulation and/or implementation of the program or project, as well as any associated resource constraints, issues/risks, and reserves." (NASA NPG 7120.5B, 2002, p. 125)

The typical risk matrix used, as a guide, by independent review teams throughout the project life cycle is:

Rank	Probability	Technical	Cost	Schedule
5	Very High	Can not meet minimum mission success	> 10% increase and/or exceeds reserves	Major impact to critical path, can not meet major milestone
4	High	Major impact to full mission success, but still meets minimum mission success, threatens margins	7 – 10% increase and/or threatens reserves below prudent levels	Significant impact to critical path, can not meet lower level milestone
3	Moderate	Moderate impact to full mission success, but can handle within margins	5 – 7% increase, can handle within available reserves	Impact to critical path, can handle within schedule
2	Low	Minor impact to full mission success, can handle within margins	2 – 5% increase, can handle within available reserves	Minor impact, can handle within reserve, no impact to critical path
1	Very Low	Minimal impact to full mission success, or margins	< 2% increase, can handle within available reserves	Minimal impact, can handle within reserve, not impact to critical path

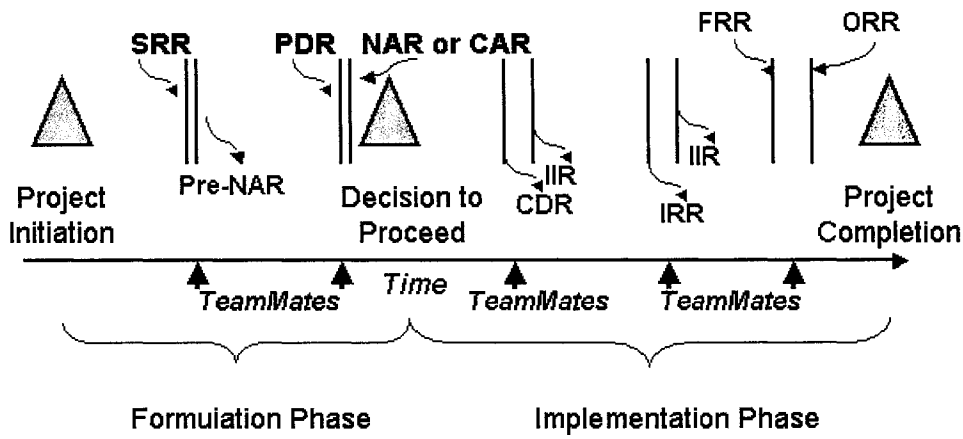
APPENDIX H

IMPLICATIONS FOR PROJECT MANAGEMENT PRACTICE

NASA's primary specification of guidance to projects and procedures for managing and accomplishing project activities is NPG 7120.5B (2002). Several areas within the document mention the importance of co-operative teams. For instance, in section 3.1, the project manager is tasked with developing "a cooperative and performance-oriented team" (NPG 7120.5B, 2002, p. 40). Effective teaming is also defined to include some of the team attributes investigated by this research – open communications, recognition, empowerment as well as overall team development. The project manager is tasked with the need to know superior team characteristics and the reference points to all of the *TeamMates's* survey attributes. However, the guidelines fall short in prescribing techniques for fostering these team attributes. Given the importance associated with the socio aspects of a project, NASA guidelines should formalize the planning to achieve an excellent project team. Appendix E of NPG 7120.5B (2002) outlines the content required in an official project plan. This area should be expanded to include the stipulation for a team development planning document.

One possible process for improving the critical team attributes is a structured use of the *TeamMates* survey in conjunction with prescribed independent project reviews. An administration of *TeamMates* during the project independent review would capture the team attributes. Repeating this process at

each review, along with a statistical analysis which compares team attributes to the objective interim performance metric developed in this research, would indicate where improvements are warranted. The NASA APPL (Academy for Program and Project Leadership) organization could tailor training and mentoring arrangements to facilitate specific improvements. The level of success for this scenario could be judged by the delta improvement to the team attributes and performance measured at the next independent review. This proposed cycle for application of the *TeamMates* survey and analysis at major project reviews is depicted below:



As shown in the graphic above, *TeamMates* would be administered and the team attributes evaluated five times during the project lifecycle: SRR and pre-NAR (preliminary Non Advocate Review), PDR and NAR (or CAR), Critical Design Review (CDR) and Independent Implementation Review (IIR), Independent

Readiness Review (IRR) and IIR, and at either the Flight Readiness Review (FRR) or Operational Readiness Review (ORR).

All projects, regardless of their origin or the responsible organization, would benefit from formal objective measures of their performance early in the lifecycle when corrective action can be effectively achieved. While earned value management systems are proclaimed as a rigorous measure of project technical, schedule, and cost performance, the subjective self-evaluation of accomplishments used by many projects can result in biased analyses and useless data. The interim project performance metric, developed for this research, provides an option to calibrate all aspects of a project at key decision points within its lifecycle. This metric was designed to function within the NASA specified project review cycle; however, similar evaluations could be designed for projects within other environments.

While this research focused on NASA aerospace projects, theory indicates a general applicability of the seven team attributes to improved performance of project teams. Due to the statistical criteria set, this research empirically supported only the relationship between interim project performance and team member interdependence. The surprising result was the total absence of a relationship between recognition and performance. The other five team attributes displayed varying non-significant levels of relationships with interim project performance. The level of relationships discovered in this research may have been affected by team composition (scientists and engineers), specific tasks undertaken (high risk technical achievements), the environment (federally

funded, political, non-profit), and applicable processes (regulations) that apply to NASA projects. However, to varying degrees these descriptions are transportable to projects outside the NASA culture. For example, other government agencies work projects within similar environments and subject to similar processes. Also, other research organizations use the project method to manage tasks with team composition and technical challenges similar to NASA. Therefore, based on the limitation of this research to one sample of NASA aerospace projects and the unanswered questions as to why these results were found, in general, all project management professionals should emphasize techniques to improve these team attributes. Overall, the project management theory and research tend to support the criticality of team dynamics in achieving project goals. Further investigation into which specific attributes are most important under different circumstances is warranted.

In general, whatever technique is chosen, to the practicing project manager, these research results provide areas that need to be addressed in order for project teams to function effectively, since "the personal elements of your project have to be resolved before budget and schedule" (Thomsett, 2002, p. 52). For the organization managers who select future project leaders, a practical application includes an increased emphasis on team development training of potential project managers before making project assignments. In conclusion, project managers should not ignore the socio aspects of their project team in their focus on the project objectives; the project planning phase must include attention to the development of team attributes as well.

VITA

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EDUCATION

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MPA Information Systems, Old Dominion University, Norfolk, VA, 1980
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PROFESSIONAL PROFILE

Mrs. Parsons is employed by NASA's Independent Program Assessment Office and is responsible for the leadership of assigned program reviews and the assessment of the project's implementation of program/project control techniques, cost estimates, and schedule projections. Prior to her current position, she spent ten years in line management and project management at NASA Langley Research Center. As a line manager, she managed the Project Controls and Systems Engineering Branch; as a project manager, she managed an aircraft instrument project, several project proposals, and an Earth science space flight project. She has 30 years of government experience in projects, management, and financial analyses.

PROFESSIONAL ACTIVITIES AND HONORS

Deputy Chair, Independent Review Teams for NASA Programs & Projects
Proposal Manager, several NASA Earth Science Mission proposals
Deputy Project Manager for Earth Science Technology Mission
Project Manager for Earth Science aircraft instrument
Deputy Program Manager for Earth Science studies
Supervisor, Systems Engineering & Controls
Lead, several Management Information System Requirements Studies
Chair, Information Systems Configuration Control Board
Chair, Innovation Award Team
Lead, various NASA workforce studies
Individual Performance Awards, 1978, 1981, 1984, 1985, 1986, 1987, 1988, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001; Group Awards, 2000, 2001; Army Aerostructures Directorate "Director's Award", 1989
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