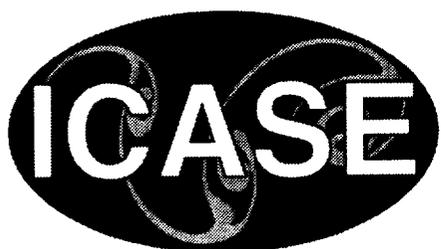

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Perceptions of Engineers Regarding Successful Engineering Team Design

Ronald H. Nowaczyk



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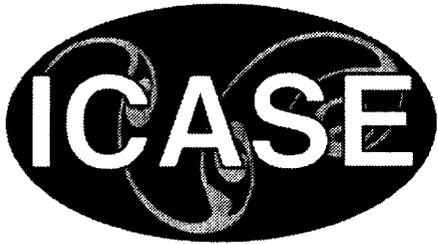
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PERCEPTIONS OF ENGINEERS REGARDING SUCCESSFUL ENGINEERING TEAM DESIGN

RONALD H. NOWACZYK¹

Abstract. The perceptions of engineers and scientists at NASA Langley Research Center toward engineering design teams were evaluated. A sample of 49 engineers and scientists rated 60 team behaviors in terms of their relative importance for team success. They also completed a profile of their own perceptions of their strengths and weaknesses as team members. Behaviors related to team success are discussed in terms of those involving the organizational culture and commitment to the team and those dealing with internal team dynamics. The latter behaviors focused on team issues occurring during the early stages of a team's existence. They included the level and extent of debate and discussion regarding methods for completing the team task and the efficient use of team time to explore and discuss methodologies critical to the problem. The discussion includes a comparison of engineering teams with the prototypical business team portrayed in the literature.

Key words. teamwork, group dynamics, group decision-making

Subject classification. Psychology

1. Introduction. The success or failure of a team depends on a number of factors. Previous research has indicated that teams often evolve through a series of stages [1, 3, 5, 6]. In addition, overall team success depends on the success of different, but related, functions [2]. Most of the research on team behavior has focused on the prototypical management team in industry or artificial teams (often, consisting of college students) formed solely for research purposes. To date, there has been little research on the functioning of teams of individuals working on an engineering or science problem.

A current view on the stages of team dynamics [3] is a blend of contributions from earlier research [1, 5, 6]. Morgan et. al. have proposed that a team passes through two phases of "performing" the team task. The first "performing" phase is preceded by the first team meeting which is viewed as critical to the success of the team. Team norms and roles are often defined during the early team meetings [1]. The two phases are separated by a transition stage when the team examines its progress and reevaluates its approach to the task or problem. This transition stage often occurs around the midpoint of the team's existence [1]. The second performing phase is followed by task completion and the disbanding of the team.

Research has indicated that teams serve multiple functions. McGrath has identified three separate but interrelated team functions [2]. The first function, which is obvious to most, is task production. Teams exist to complete their mission or task. The other two functions, member support and group well-being, can often be overlooked by individuals evaluating teams solely on the basis of task performance. Member support refers to the individual team members' perceptions that service on the team has been professionally or personally rewarding. Group well-being describes the social atmosphere that occurs within the team. A team that functions well in terms of group well-being will include members that feel

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that team communication and interactions were successful and that team members were able to fulfill specific team roles.

Little systematic research has been conducted on the effectiveness of teams of engineers and scientists working on specific engineering or scientific problems. The most definitive work on the performance of engineers and scientists was based on research prior to the increased emphasis on teaming in the management and R & D environments [4]. Pelz and Andrews identified eight creative tensions that they said contributed to a productive climate for scientists and engineers. Several of these creative tensions, as shown in Table 1, are relevant to successful team functioning.

TABLE 1. Creative tensions identified by Pelz & Andrews that are relevant to team functioning [4].

| <u>Security</u> | <u>Challenge</u> |
|---|---|
| <i>Tension A</i> | |
| Effective scientists were intellectually independent or self-reliant; they pursued their own ideas and valued freedom . . . | . . . But they did not avoid other people; they and their colleagues interacted vigorously |
| <i>Tension B</i> | |
| Among mature scientists, high performers had greater self-confidence and an interest in probing deeply . . . | . . . At the same time, effective older scientists wanted to pioneer in broad new areas |
| <i>Tension C</i> | |
| High performers named colleagues with whom they shared similar sources of stimulation (personal support) . . . | . . . but they differed from colleagues in technical style and strategy (either or intellectual conflict) |
| <i>Tension D</i> | |
| R & D teams were of greatest use to their organization at that "group age" when interest in narrow specialization had increased to a medium level . . . | . . . but interest in broad pioneering had not yet disappeared |
| <i>Tension E</i> | |
| In older groups which retained vitality the members preferred each other as collaborators . . . | . . . yet their technical strategies differed and they remained intellectually combative |
| <i>Tension F</i> | |
| In departments having moderate coordination, it seems likely that individual autonomy permitted a search for the best solution . . . | . . . to important problems faced by the organization |

These tensions are indicative, perhaps, of the inquisitive, probing characteristics associated with the scientific method. The challenges listed in Table 1 describe individuals who seek and appreciate the intellectual and technical interchange and challenges with others. This approach to completing a task or solving a problem would have important implications to team success. Intellectual and technical conflict

may be a hallmark to team success. The function of member support might include the opportunity to expand one's knowledge. Group well-being may involve healthy debate and critical evaluation of technical strategies and approaches to the task. Successful task production, therefore, may depend critically on how well the team encourages conflict and debate. Whereas, the prototypical management team is characterized by reaching consensus, one might hypothesize that for engineering and scientific teams, consensus-building may be achieved only after considerable scientific and technical debate. And, in some instance, consensus may not be fully achieved, if the "correct" solution to a problem is the selection of a particular methodology over another and not the "blending" of methodologies.

Tension F in Table 1 includes the appreciation of the organization setting goals and identifying problems. While scientists and engineers in private industry favored freedom in defining the approach and strategies to solving a problem, they felt organizational guidance in selection of the problem or task was important. This emphasizes the potential importance of external factors on successful engineering team performance.

The current study was based on these observations and was designed to identify factors that are related to successful engineering team performance. For the purposes of this study, a team was defined as "a group of individuals working together toward a common goal, or solution that requires the sharing of expertise, knowledge, and ideas in a cooperative and interdependent fashion . . . working on an engineering problem design, process or product." Based on the previous literature and informal discussions with NASA engineers in management positions, 60 behavioral statements were constructed to describe team actions. These statements focused on either external or organizational influences on team performance or internal team dynamics. Additionally, an individual performance profile was developed in order to assess the respondents' views of how they perceived their behaviors on teams.

2. Method.

2.1. Participants. Volunteers were solicited from several branches from the Research and Technology Group (RTG), the Airframe Systems Program Office (ASPO), and the Internal Operations Group (IOG) at NASA Langley Research Center (LaRC). (Additional information about NASA and NASA-LaRC can be found at www.nasa.gov and www.larc.nasa.gov, respectively.) The experimenter described the purpose of the study and answered questions at branch or team meetings. All attendees at those meetings were given a packet containing the survey material and were encouraged to return the completed surveys via interoffice mail. Forty-nine of the 91 surveys distributed were returned (a return rate of 54 percent). Respondents were asked not to include their names on any of the survey forms.

2.2. Survey & Procedure. There were three sections in the survey. The first described the purpose of the survey and provided the definition of a team as described in the introduction of this paper. The second section consisted of 60 statements.¹ The first 20 statements described behaviors that involved the interactions of the team and its members with the organization. Examples of these external statements included “externally imposed time deadline is ambitious or challenging and job time allotted by supervisor for team service is appropriate.” The remaining 40 statements described behaviors internal to the team and its interactions. Example statements included “the commitment of time to the team is uniform across team members, team members are concerned about the feelings of others, and the team adopts a shared vocabulary and set of methods for solving the problem.”

For each of these statements, the participant was asked to indicate the importance of the behavior to team success using a 5-point scale. A “1” was labeled “Not at all Important.” A “3” indicated “Somewhat Important” and a “5” represented “Very Important.” After rating these 60 statements, the participants read each behavior once again and place a check mark before any behaviors that they felt would hurt team performance. They were also given the opportunity to add two external and two internal behaviors that hindered the effectiveness of engineering teams.

The third section of the survey dealt with demographic information and a profile of the participant’s own team behavior. Participants were asked a series of questions regarding their discipline, gender, tenure at NASA and in the profession, experience on teams (including their size, duration of existence and success), and the effect of team service on both their professional effectiveness and skill development and also their career advancement. The team member profile consisted of 20 statements. Participants were asked to rate on a 6-point scale (from 1 = “very much unlike me” to 6 = “very much like me”) each statement as it applied to the sentence stem “Others would view me as . . .” Example statements included “willing to challenge the ideas proposed by others, a person who is fact- and information-oriented, and one who strives to ensure that the team stays together.” The statements were designed to capture the 3 team functions of task production, member support and group well-being.

Completion of the survey took approximately 30 minutes and participants were encouraged to complete the survey at their own leisure and return it within 10 working days. A reminder email was sent to all participants approximately one week after they received the surveys.

¹ Copies of the survey may be obtained by contacting the author at rhnow@clemsn.edu. Specific statements used can also be found in a web-based report of this study under www.icase.edu (Research and then Psychology links).

3. Results.

3.1. Description of the Participants. Seventy-four percent of the respondents were male and 26 percent were female. Eighty-seven percent indicated that they had been in their profession 7 or more years and had also been at NASA for at least 7 years. Seventy-eight percent indicated that they were engineers, the majority in either aerospace or mechanical engineering. The remaining individuals were trained in a science discipline, many in either computer or mathematical science. The profile of these individuals was similar to the demographic data available at NASA-LaRC regarding their population of engineers and scientists in the RTG, ASPO, and IOG.¹

Regarding team experience, the participants indicated that they had served on a median of 3 teams over the past three years. They reported serving on teams that averaged eight or fewer members and had a mean lifespan of approximately 16 months. They indicated that the mean success rate of these teams was 62.97 ($s = 33.28$). There was a difference in the responses to the beneficial effects of team service to professional skills and career advancement. Respondents indicated that the beneficial effects of team service on professional skills, Mean = 4.96 on the 6-point scale, was significantly greater than on career advancement, Mean = 4.22 ($t(44) = 4.47, p < .05$).

3.2. Factors Important to Team Success. The mean ratings for the 60 behaviors ranged from a low of 1.87 to a high of 4.69 (on the 5-point scale). Twenty-one behaviors had mean ratings of 4.00 or higher (with 4 indicating “important” and 5 representing “very important”). The mean importance ratings for these items are shown in Table 2 in descending order of importance separately for external

TABLE 2. Mean ratings and standard error s of the mean for the 21 behaviors viewed as important to team success.

| Behavior | Mean | S.E.M. |
|--|------|--------|
| <i>External Factors</i> | | |
| 1. Job time allotted by supervisor for team service is appropriate. | 4.69 | .07 |
| 2. Assigned job priority to team service (as assigned by the supervisor) is commensurate with team responsibility and efforts. | 4.58 | .09 |
| 3. Relevant information that is external to the team is available to the team. | 4.43 | .10 |
| 4. Team sponsor is technically competent to evaluate team product. | 4.41 | .12 |
| 5. Service on the team is professionally rewarding. | 4.33 | .12 |
| 6. External resources (e.g., staff & budget) are assigned to the team. | 4.32 | .13 |
| 7. The product or task is well-defined before the team meets. | 4.23 | .13 |
| 8. Team has the ability to alter or refine its goal or product. | 4.14 | .12 |
| <i>Internal Factors</i> | | |
| 9. There is a sense of “team responsibility” among the team members. | 4.64 | .09 |
| 10. The team openly and critically debates various solutions to the problem based on their scientific and technical merits. | 4.51 | .10 |
| 11. The team engages in “healthy” debate over various approaches to the problem or task early on. | 4.43 | .09 |

¹The data were analyzed separately for individuals from these divisions and no significant differences were found. Therefore, the data discussed in subsequent sections have been combined across divisions.

| | | |
|--|------|-----|
| 12. The team experiences a point during its lifetime where it steps back and critically examines where it is going. | 4.35 | .10 |
| 13. Not all team members may agree with the approach or method taken to completing the task, but are support of the “team decision.” | 4.30 | .12 |
| 14. Debate and critical evaluation of member ideas are encouraged. | 4.29 | .12 |
| 15. Team members take the time to explain their ideas and methods so that team members learn from each other. | 4.26 | .11 |
| 16. The team is able to redefine its approach to goal or task. | 4.20 | .11 |
| 17. Team “team road map” is developed by the team. | 4.18 | .12 |
| 18. A variety of engineering or science “tools” or “methodologies” are considered by the team. | 4.14 | .11 |
| 19. The team leader is able to wear a variety of “hats” depending on the team’s needs (e.g., from directive to facilitative). | 4.12 | .12 |
| 20. The team uses time to understand the technical approaches and methods of its members. | 4.02 | .12 |
| 21. The team spends time “exploring” new or potentially high-risk, high-payoff methods to completing its task. | 4.00 | .11 |

and internal factors. Eight of the behaviors were related to external or organizational influences on a team. The other 13 behaviors dealt with internal team dynamics.

Three of the statements related to organizational influences (Behaviors 1, 2, and 6) highlight the need for the organization to provide the successful team with the required resources in terms of service time, staffing and budget. Pelz and Andrews’ Tension F, which relates to organizational influence regarding the definition of the task or goal, is captured in several of the other behaviors on external influence. Statements 3, 7, and 8 deal with team goals, information, and the ability to alter or redefine those goals. Behavior 16, that deals with the teams ability to internally alter its approach, also contributes to this creative tension. It is the respondents’ perception that successful teams have organizational guidance in defining the team task, but that the team should also have freedom in dictating the approach to solution. Statement 5 addresses the member support function of teams. Team members feel professionally rewarded serving on successful teams. It is interesting that team members rated that behavior higher than the behavior addressing career rewards (Mean = 3.94). These data are consistent with the participants’ ratings of the benefits of team service. It is also consistent with the underlying desire to be intellectually stimulated found among the creative tensions in Table 1. The statement dealing with the technical competence of the team sponsor is consistent with other research reported by Pelz and Andrews which indicated that scientists felt most comfortable when their professional evaluations were conducted by someone within their area of expertise or discipline.

A review of the internal factors reveals a pattern of behaviors among successful teams that is characterized by critical debate of scientific and engineering ideas and methodologies. There is evidence supporting Creative Tensions A, C, and E from Table 1. It appears the participants expect dialogue and debate to occur during team meetings. Yet, the intellectual debate and potential conflict that appears to

describe a successful engineering team (Statements 10, 11, 14, 16, 18, and 21) is balanced by the recognition of added responsibilities on the part of team members (Statements 9, 13, 15, 17, 19 and 20). The “pioneering” interests of scientists and engineers described in Creative Tensions B and D of Table 1 appear to be captured in several team behaviors (Statements 15, 18, and 21). Lastly, there is support for the existence of a midpoint or transition stage during a successful team’s lifespan (Statement 12).

There were six behaviors that had mean ratings of less than 2.50 which indicates that participants viewed them as unimportant to team success (1 = “not at all important” and 3 = “somewhat important”). The statements dealt with team composition. Respondents indicated that the following behaviors were less important to team success:

- the team is culturally diverse (Mean = 2.08)
- the team is gender diverse (Mean = 2.15)
- team members have fairly uniform seniority and status (Mean = 2.15)
- the team consists of individuals with a wide range of job experiences (Mean = 2.27)
- the team leader is assigned (Mean = 2.31)
- the team has 4 or fewer members (Mean = 2.32)

The respondents’ perceptions are that team composition is less critical to team success than the interactions that occur among team members.

3.3. Identification of Problem Behaviors. Each participant was asked to review the list of 60 behaviors and indicate with a checkmark any that would hinder or hurt team performance. Table 3 lists the 10 problem behaviors that were identified by at least 35 percent of the participants. This list includes three behaviors dealing with organizational influences (Statements 3, 4, and 10). The remaining seven behaviors address internal team dynamics.

TABLE 3. Ten problem behaviors identified by participants

| <i>Statement</i> | <i>% of Participants</i> |
|---|--------------------------|
| 1. Some members believe that their technical status insulates their opinions from evaluation by other team members. | 87 |
| 2. When multiple disciplines are involved, the methods from one discipline tend to dominate the team’s thinking. | 85 |
| 3. Changes in team membership are externally imposed and occur during the life of the team. | 81 |
| 4. Team deals with external organizational issues that are not task specific. | 71 |
| 5. The team finds itself often revisiting and reconsidering the methods it has chosen to solving the problem or task. | 46 |
| 6. The team selects a “safe and proven” method to solving a problem rather than a “new and risky” method. | 45 |
| 7. A subset of the team defines the problem and possible solutions to it. | 43 |
| 8. The team encounters and tolerates unequal participation from some of its members. | 38 |
| 9. The “team road map” is developed by the team leader. | 36 |
| 10. Externally imposed time deadline is ambitious or challenging. | 35 |

These problem behaviors reinforce the findings from the previous section. Statements 1 and 8 describe a lack of “team responsibility” which was viewed by participants as the most important factor to team success. A lack of critical debate and discussion characterizes Statements 2, 7, and 9. These problem behaviors describe situations where the team selects its methods on the basis of something other than what may be the best from a scientific or engineering viewpoint. Statement 5 may be related to this problem if it describes cases where a team is unsure of its choices or finds itself reconsidering previously rejected approaches. Statement 6 describes behaviors that go against the “pioneering approach” characterized in Creative Tensions B and D of Table 1.

Two of the three statements dealing with organizational issues, Statements 3 and 4, can disrupt the dialogue and debate that seems so crucial to engineering team success. Changes in team membership may force the team to revisit previously argued positions in order to satisfy new team members. The imposition of tight deadlines as described in Statement 10 may result in team members feeling inadequate time is given to debate. Yet, it should be noted that this problem behavior was identified by only 35 percent of the participants. Previous research [2] has shown that in some instances, teams operate best when under time constraints.

3.4. Profile of the Participants’ Team Behaviors. Each participant described himself or herself in terms of behaviors that focused on the task production, member support, and group-well being functions. The behaviors were rated on a 6-point scale with lower values representing uncharacteristic behaviors (e.g., 1 = “very much unlike me”) while larger values were descriptive of an individual’s behavior (e.g., 6 = “very much like me”). Table 4 lists the seven most descriptive team behaviors, with mean ratings from 4.79 to 5.13 (5 = [behavior is] “like me”), and the three least descriptive behaviors, with mean ratings between 3.15 and 3.46 (3 = [behavior is] “somewhat unlike me”).

TABLE 4. Behaviors that most and least describe respondents.

| | |
|------------------------------------|---|
| | |
| <i>Most Descriptive Behaviors</i> | |
| 1. | A person who is fact- and information-oriented. |
| 2. | One who is a “team-player.” |
| 3. | A person who tends to be task-oriented. |
| 4. | A person who enjoys learning about the different approaches taken toward a problem by other team members. |
| 5. | A person tolerant of concerns of other team members. |
| 6. | A person who knows one’s role and responsibilities on the team. |
| 7. | A person who will focus the team on the task. |
| <i>Least Descriptive Behaviors</i> | |
| 8. | A person who feels conflict is not healthy on a team. |
| 9. | One who is careful not to influence the team’s direction more than other team members. |
| 10. | One who is able to influence decision-makers beyond the team. |
| | |

These behaviors describe individuals who are aware of the task production function of teams (Statements 1, 3, 4, and 7), as well as the group well-being function (Statements 2, 5, and 6). The non-

descriptive behaviors indicate that the respondents see conflict occurring on teams and are willing to shape the team's direction.

Ratings on these behaviors were correlated with the ratings of the 60 statements regarding behaviors important to team success. Four statements involving internal team dynamics were positively related (r s $> .40$) to at least two of the profile behaviors. Individuals who fit the profile in Table 4 were likely to view these team behaviors as important to team success: "there is a sense of team responsibility among the team members; the team is able to redefine its approach to the goal or task; the 'team road map' is developed by the team; and, debate and critical evaluation of member ideas is encouraged." The only two organizational behaviors that were related to the profile in Table 4 were "the team is provided with sufficient organizational information to be able to adjust its goals and tasks, and the team sponsor is technically competent to evaluate the team product." Clearly, individuals fitting the profile in Table 4 value the team's ability to modify and adjust its work plan and that this is accomplished best by responsible and open debate among team members.

4. Discussion. This study speaks to two issues. The first deals with the behavior and performance of successful engineering teams within the context of team dynamics. The second, which is related to the first, focuses on the application of Pelz and Andrews' "creative tensions" to describe the behaviors and perceptions of engineers and scientists in a team environment.

4.1. Team Dynamics. The findings from this study can be interpreted in terms of the three functions of team performance and the stages of team development. The three functions of a team include task production, member support, and group well-being [2]. The engineering teams at NASA-LaRC place heavy emphasis on the task production function. This is not unexpected. The goal or task of an engineering team is an engineering design or solution to an engineering or science problem. Participants focused on the importance of task production in terms of critical and open debate and dialogue concerning engineering and science methodologies and solutions. (See TABLE 2.)

It was also apparent that engineers viewed group well-being as an essential component for successful teams. The participants valued the sense of "team responsibility" and indicated that it was important for team members to allow others to express their views and to be supportive of a team decision. There was less evidence that the participants felt the function of member support was as crucial to team success. What evidence that does exist points to team service providing professional rewards rather than career rewards. They suggested that successful teams allow the engineer or scientist to expand or increase his or her knowledge and skills within one's discipline. Career rewards coming from team success were not as evident. This may be a reflection of the organizational culture at NASA-LaRC. It may be the case that the changing work environment has not allowed for the relationship between team performance and resulting career rewards to have been realized yet.

The successful engineering team at NASA-LaRC does not fit the team conception proposed by Tuckman, which consisted of the sequential stages of "forming, storming, norming, performing, and adjourning" [5, 6]. The successful engineering team exhibits a more complex pattern. First, there is support for Gersick's contention that teams experience a period in their existence where they examine their progress and reevaluate their work plan [1]. Second, using the Morgan et al. model, the successful engineering team places more emphasis on the early phases of team development than the latter phases. Morgan, et al. proposed that teams have three distinct phases. The first and third are performance phases separated by a transition phase similar to Gersick's concept of a period of reevaluation. The first phase is characterized by considerable debate regarding the task and identification of member roles and team norms. This first phase also includes task work and performance. There is evidence that the successful engineering teams are those who have a productive first phase. Participants identified several behaviors that will lead to a productive first phase. These include critical and open debate, careful and reasoned explanations of ideas, and to some extent, a willingness to explore new approaches to the problem. The debate is described as being grounded in scientific and engineering principles.

A number of behaviors can work against a team being productive during this first phase. These include organizational influences such as externally imposed changes in team membership and insufficient time and organizational resources being devoted to the team to engage in the debate and discussion that seems to be so critical. The team may also contribute to its lack of success if it does not allow and expect participation from all of its members. Teams less likely to succeed may short circuit the debate and dialogue by allowing a single discipline, method, or subset of the team to dominate the team's direction.

While participants noted the importance of team responsibility and acceptance of a team decision, they listed as their most frequent problem behavior, the actions of some members who believe that their status insulates them from evaluation and criticism by other team members. Clearly, the unwillingness of one or two individuals on a team to allow for open and constructive debate can be detrimental to the **team's** success. It appears this unwillingness may be evident during the scientific or engineering debate that the team experiences. Lastly, teams that feel restricted in their choices or approaches to the problem or task may be less likely to succeed than those who feel that they have some freedom in defining the problem and solution.

Engineering teams appear to differ from the prototypical business team on a few critical dimensions. The members on an engineering team will share some level of expertise (i.e., technical knowledge) among themselves that may not always be found on a business team where individuals come from unrelated disciplines. This shared expertise provides for a “shared mental model” among engineers and scientists, allowing for engineering teams to move more quickly into substantive debate and dialogue. The risk, in this instance, however, is that team members assume that their mental model (i.e., knowledge base) is either superior to or more complete than that of other team members. In those instances, an individual may feel that he or she possesses the solution to the problem at the exclusion of other team members.

On successful engineering teams, members may find themselves debating among a number of potential solutions, many of which have common principles or assumptions. The debate in these instances may be more focused and may involve subtle and technical distinctions not found in a business team. Hence, this phase of debate may be more critical to an engineering team's success than the “storming” stage associated with business teams.

The nature of the problem facing an engineering team may also reveal an important difference with business teams. The respondents focused on the importance of task definition. Problems assigned to engineering teams may be viewed as well-defined problems. That is, the goal or solution to the engineering problem can be evaluated and tested. The set of methods for solving the problem may be known. While one “best” solution may not be definable, solutions can be rated relative to their success in meeting requirements. Engineering solutions can often be evaluated against a known set of criteria. Problems assigned to business teams may not be as objectively evaluated or tested. In some cases, the impact of the solution for the business team may not be known for a fairly long period of time.

These differences in problem definition and methods to solution result in the later phases of team dynamics involving task performance as being *less* of an issue for engineering teams. Engineering teams at NASA-LaRC appear to consist of individuals with the necessary expertise to solve the problem. The problem tends to be better defined than those for business teams. The main hurdle for engineering teams is the selection of the best or most appropriate methods for solving the problem. Once those methods are agreed upon, the team possesses the expertise and knowledge to work toward problem solution.

On the other hand, business teams may encounter greater difficulty in reaching a solution during the task performance phase. The problem may not be as well-defined. The solution method may not be one with which all team members have some level of expertise and a shared mental model. And, lastly, the evaluation of the product may not be as clearly and objectively defined as that for the engineering team.

4.2. Existence of “Creative Tensions.” Pelz and Andrews had identified eight creative tensions in the work environment for scientists and engineers [4]. Six of these eight tensions were examined in this study. (See TABLE 1.) Each tension was described in terms of “security” and “challenge” components.

The behaviors reported in successful engineering teams generally supported these tensions, especially in terms of “challenges.” Pelz and Andrews had found that successful engineers and scientists interact vigorously, differ in technical style and strategy from each other, and remain intellectually combative. The importance of open and critical debate on successful teams certainly supports these challenges. The fact that successful teams were also likely to explore new methods fits with the challenges scientists and engineers prefer in terms of pioneering in broad new areas.

It should be noted that the team environment does threaten some of the “security” components of these tensions cherished by engineers and scientists. For instance, the team environment makes it more difficult for “effective scientists to be intellectually independent or self-reliant.” Organizational control and influence is also a consideration. Pelz and Andrews, noted that scientists and engineers preferred moderate coordination that made it likely that an individual had the autonomy to search for the best solution. In a team environment, that autonomy may be extended to the team rather than the individual. This may explain why participants viewed successful teams as those that had the ability to alter or refine their goals and to develop their own “road map.” The fact that the team sponsor should also be technically competent to evaluate the team product fits within this notion of effective oversight from the organization.

Therefore, it appears that the team environment offers the scientist or engineer the opportunity for dialogue and debate among colleagues that seems to be characteristic in many of the “challenge” components of Pelz and Andrews’ creative tensions. The risk that is faced within the team environment, however, is that the “security” components may be restricted. While the intellectual debate and dialogue in a team environment are welcome, the effective engineer or scientist may feel uneasy about the loss of individual autonomy. The successful organization must work to make this transition from individual autonomy to team autonomy acceptable and palatable to the engineer or scientist. This may be accomplished through effective communication between the team and the team sponsor and effective leadership within the team so that the team is given as much autonomy and flexibility as possible in working toward its goal.

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