AFIT/GLM/LAS/93S-20

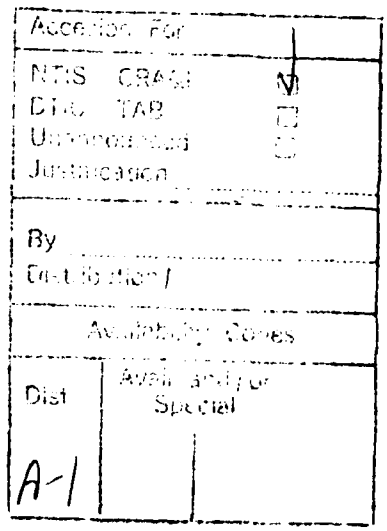
AN ANALYSIS OF RESEARCH AND DEVELOPMENT PRODUCT TEAM CHARACTERISTICS FOR THE SYSTEM ACQUISITION ENVIRONMENT

THESIS

Robert C. Gibson, Captain, USAF
Mary E. Waker, GS-12

AFIT/GLM/LAS/93S-20

The views expressed in this thesis are those of the authors and do not reflect the official policy or position of the Department of Defense or the U.S. Government.



AFIT/GLM/LAS/93S-20

AN ANALYSIS OF RESEARCH AND DEVELOPMENT PRODUCT TEAM CHARACTERISTICS FOR THE SYSTEM ACQUISITION ENVIRONMENT

THESIS

Presented to the Faculty of the School of Logistics and
Acquisition Management of the
Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

Robert C. Gibson, B.S.
Captain, USAF

Mary E. Waker, B.S.
GS-12

September 1993

Preface

The purpose of this thesis was to examine product team characteristics in a system acquisition environment. Both private industry and the government are adopting the product team organizational structure in order to minimize cost and maximize the quality of their products. The Saturn Corporation has successfully developed and marketed a new automobile using this approach and now the government has also instituted this concept under the Integrated Weapon System Management (IWSM) program.

We studied the Saturn Corporation in order to obtain team characteristics essential to their success and incorporated them into a survey. The survey was administered to evaluate the F-22 SPO's progress in product team implementation. We feel that the recommendations derived from the analysis could help the F-22 SPO or other organizations to determine areas of improvement.

We are greatly indebted to Lt Col Murphy and Maj Graham for their guidance and support in this endeavor. We are also grateful to the members of the F-22 SPO for their participation and comments. We would also like to acknowledge "our group." AFIT would not have been nearly as much fun without Dave and Jessie. Last but certainly not least, thanks to Rhonda and Danny for their constant love and encouragement and to all the kids - Jenny, Beth, Conner, and Ryan - for their mostly good behavior and cooperation.

Bob Gibson and Mary Waker

Table of Contents

List of Figures

List of Tables

Abstract

The focus of this thesis was on product team characteristics in the systems acquisition environment. This research investigated the characteristics of the Saturn Corporation product team organizational structure and also reviewed literature relevant to this area. The characteristics identified by Saturn that contribute to the success of their product teams were incorporated into a product team effectiveness survey and administered to personnel in the F-22 System Program Office (SPO) located at Wright-Patterson AFB OH. This SPO was selected as an excellent candidate for analysis due to its high visibility, large funding profile, and the fact that it has eight more years of research and development. The results of the F-22 SPO survey were then compared to the Saturn product team characteristics in order to identify achievements and possible weaknesses.

Overall, it appears that the F-22 is a thriving organization with all the attributes required to produce an end product designed to meet the needs identified by the users. The organization contains many of the essential characteristics that were identified by the Saturn Corporation to contribute directly to the success of its product and organization. Thus, it can be inferred that the

F-22 will be a successful organization in its own right. Although the majority of survey respondents agreed that they are able to influence the design, development, and supportability of their team's product, there are several areas that could be enhanced. Areas identified for improvement are communication, training, team autonomy in the decision-making process, and contractor involvement in the product team concept.

AN ANALYSIS OF RESEARCH AND DEVELOPMENT PRODUCT TEAM CHARACTERISTICS FOR THE SYSTEM ACQUISITION ENVIRONMENT

Chapter I. Introduction

General Issue

In the fiscal year 1993, the Department of Defense (DOD) Research and Development (R&D) budget contained a request for $38,921,203,000. Although the Appropriations Committee reduced this amount by $606,775,000, the huge remainder still made it beneficial to the United States to be able to acquire systems in the most efficient manner possible (3:152). Research has shown that the structure of the organization acquiring systems has a great influence on the cost, schedule, performance, and quality of the system throughout its life cycle (9:120). Traditionally, the organizational structure for major acquisitions has been in a functional or matrix format. Recognizing the lack of product focus, the lack of a total systems perspective and the functional parochialism within these organizational structures, many leaders within both the government and private industry have turned to a product team approach in an attempt to minimize cost and maximize the quality of their product.

To ensure that a product team is progressing at a favorable rate, it is desirable for a manager to

periodically assess its progress throughout the system life cycle. Lieutenant General Thomas R. Ferguson Jr., then Commander of the Aeronautical Systems Center (ASC) at Wright-Patterson Air Force Base, Ohio, emphasized that "you can not manage what you do not measure" (20:15). However, metrics, the method to measure the progress of product teams, have proven to be difficult to develop for the R&D phase of major system acquisitions.

Background

Leaders of industry have recognized customer satisfaction as the fundamental basis for measuring success. Manufacturing organizations can track the number of defects per unit given to the customer. Service-oriented businesses can measure percentage of repeat business and amount of time customers spend waiting. Unfortunately, an R&D product team does not have these types of customer contact performance measures.

The Saturn Corporation has developed and produced a successful product using the product team approach. The J.D. Power's Survey of New Car Buyers shows the Saturn to be the highest rated American car in terms of customer satisfaction (18:95). The Saturn car line trails only the higher priced foreign automobiles, Lexus and Infiniti, in the Customer Satisfaction Index. Demand for this highly popular car far exceeds the annual production capacity of

325,000 automobiles and caused them to add a third shift to reduce backorders (24:88). Since the Saturn Corporation has been praised for producing a high quality product at an affordable price in a reasonable time, research of the Saturn team during the R&D phase proved beneficial to the Department of Defense.

Major weapon system acquisitions are the responsibility of System Program Offices (SPOs). Several new acquisition programs have forged new ground by using an integrated product team approach. The Integrated Product Team (IPT) is composed of a group of individuals who are each expert in their functional discipline. In order to integrate their functional specialty into the end product, these experts are encouraged by top management to maintain a systems life cycle perspective during development. The various IPTs that comprise a SPO are each responsible for the development of a particular element of the aircraft. Generally, these IPTs are working in parallel and must coordinate their activities with each other. The ultimate customer of a SPO sometimes does not receive the weapon system until ten to fifteen years after the inception of the program, which can lead to tremendous cost overruns and delays if the customer needs were not met or the system fails to meet operational requirements. This is why it is essential that the customer be involved in the R&D product team process. In discussing the measurement of success, Captain Randy Kosinski, Special

Assistant to Lt. Gen. Ferguson and Chairman of ASC's Metric Tiger Team, said "the ultimate metric is customer satisfaction" (20:15).

In 1991, the F-22 SPO was one of twenty-one programs selected to be a prototype for the product team style of management. Considering this high visibility and high dollar program has eight more years of research and development scheduled, it was an ideal candidate for analysis. In this thesis, the innovative management techniques of the Saturn Corporation have been used as a guide to assess to the F-22 SPO, and the outcome serves as a product team benchmark for future major acquisitions within the government.

Specific Research Issue

The continued decline in real defense spending sparks an increased competition for acquisition funds. The cuts force many SPOs to reduce their individual budgets and operate in an atmosphere that more closely resembles private industry than the stereotypical spendthrift government bureaucracy of the past. Although the SPOs do not have to be concerned with realizing a profit, the current fiscal reductions will encourage SPOs to minimize their costs. Since it appears the number of new acquisitions will be limited in the future, the SPOs must also maximize the quality of their product in order to increase reliability and lengthen the

system life cycle. SPOs are not driven by time to market, market share, or gross profit as in private industry, but instead are driven by the need to produce a product that counteracts a threat to our national defense and is the best value.

Research Objective

The methodology of this thesis began with the identification of the characteristics of product teams that the Saturn Corporation has asserted are necessary to produce a quality product, and then incorporated them into a Likert survey. The survey provided the respondants an opportunity to record their level of agreement to a series of carefully selected statements based on Saturn Corporation management literature. The survey was administered to all members of the F-22 SPO that were available at the time of survey administration, and the results were analyzed to determine if team characteristics were similar to those identified for the Saturn Corporation. The status of the F-22's product teams helped to determine if the F-22 team is on the way to producing a successful product. The goal of this research was to utilize lessons learned from Saturn literature, product team literature and the F-22 analysis, and record lessons learned to benefit current and future government acquisitions utilizing product team approaches.

Scope

Investigation of the Saturn Corporation product team characteristics focused on the overall and individual team organizational structure, the philosophy used to determine goals and objectives, the criteria for determining success or completion of the goals, and how Saturn management leads and evaluates each team. The methodology was to identify those characteristics that contributed to the success of the Saturn team, incorporate them into a survey, administer the survey to F-22 SPO personnel, and compare the results to the Saturn product team characteristics.

Limitations

The main limitations to this study were the inaccessibility of Saturn plant personnel and specific measurements of their product team's performance. The measurement instrument was based solely on characteristics of product teams Saturn identified in its management articles and which Saturn considers essential to success. A letter was sent from the Dean, School of Logistics and Acquisition Management, Air Force Institute of Technology, to the Vice-President of Engineering, Saturn, requesting additional information on the Saturn product team, but the response denied access to any Saturn-specific measurement tools or development methodology. Saturn cited proprietary rights, intense competition, and time constraints as reasons for not providing specific measurement instruments. This

limitation made it impossible to compare the F-22 directly to the Saturn Corporation team using the product team effectiveness survey device (see Appendix).

A second limitation was that this study deals with only one private firm and one government acquisition. The results of this research may or may not be generalized across other DOD acquisition offices. This concern was reduced significantly by canvassing product team literature and finding many key themes (e.g., team autonomy, clear vision of end product) present in the R&D phase of nearly all successful product team acquisitions. The survey device may serve as a benchmark for periodic evaluations as well as comparisons between product teams across organizations.

Thesis Overview

The remainder of this thesis provides a summary of related product team measurement and Saturn-specific literature (Chapter II), details of the research design methodology and survey instrument (Chapter III), analysis of Saturn product team characteristics applied to the F-22 SPO (Chapter IV), and conclusions and recommendations for future research and acquisition applications (Chapter V).

Chapter II. Literature Review

Introduction

Increasing competition in the world marketplace is causing reexamination of project management methods in hopes of increasing market share. This chapter shows that in the past, product management was organized along functional lines of expertise. This works fairly well when the right number and composition of functional experts and program managers are involved. Unfortunately, many decisions are made by inexperienced managers who lack the detailed information or are based on functional parochialism. The result is an inferior product or service that could damage a corporation in a highly time competitive and technologically advanced market.

To correct these deficiencies, many organizations in both the private sector and government are moving toward a "product team" management approach in hopes of making smart decisions in the acquisition phase that will improve the entire life cycle of the product. As this literature review reveals, the product team approach incorporates the ideas of total quality management, quality function deployment, quality circles, and participative management to empower even the lowest level workers in the key decisions relating to processes that they know best. It was crucial to the success of this thesis to observe the unique traits of the

Saturn Corporation and develop a survey that incorporated these characteristics. The survey was then administered to personnel in the F-22 SPO to determine if team characteristics are similar to those identified for the Saturn Corporation. The results of the analysis help to determine if the F-22 SPO is proceeding in the right direction and also provide a benchmark for future acquisitions.

Meaningful measures of merit for different phases of the product life cycle are available in forms such as statistical process control (SPC) methods for production, and sales conversion rates on dealers. These methods are of no help in attempting to assess the progress of research and development oriented organizations. This research team set out to find literature dealing with product team effectiveness, management of groups and teams, and current group measurement techniques. The belief was that the review of team effectiveness measures in academic literature would provide a baseline for comparison when the USAF R&D product team characteristics were evaluated. The resultant team characteristics were developed into a useful measurement device for future Air Force and industry R&D product management programs.

Since the focus of this thesis is identification of successful product team characteristics, this literature review:

(1) identifies the relative merits of product teams as compared to other organizational structures;

(2) assesses some of the characteristics of successful product teams;

(3) discusses the relative usefulness of several analytical frameworks for measuring product team effectiveness in various life cycle phases; and

(4) provides a summary of the Saturn approach to making top quality automobiles using the product team approach.

Literature Summary

Product Team Structures. The well tested and verified merits of the product team provide incentive for management attention. A clear definition of product teams is essential when comparing various combinations of organizational structures. Larson identifies the product team as one where "a project manager is formally designated to manage a select group of specialists who work outside the normal boundaries of the organization to complete the project" (9:119). This quotation indicates that Larson perceives that a product team does not operate under the same rules that other groups within the organization must follow.

Conversely, a product team should be defined as a group of multi-talented individuals who work together within the organization to optimize all aspects of their product within the constraints of cost and schedule. The internal cooperation among an organization's product teams and product focus are the key ingredients. Larson cites examples, such as the famous Lockheed Aerospace

Corporation's "Skunk works," as teams dedicated to project completion. (9:119)

Although the composition of product teams is as varied as the products and services they produce, product teams enjoy overwhelming support from workers, chief executive officers (CEOs), and the academic community. Steven Jobs, co-founder of Apple Computers, told Inc. magazine "The way you accomplish anything is with a team....Superman went out a long time ago" (5:9). In "Building High-Performing R&D Teams", Michael Wolff interviewed Bell Laboratory personnel who believe, "the future of technology management belongs to teamwork" (22:11).

Why are managers around the world praising product teams? The top reason, oddly enough, is the bottom line. Companies in high technology fields are able to produce quality products in a shorter cycle time than through traditional management methods. Such time savings translate into tremendous amounts of money. Anacona and Caldwell suggested "[that] much of the delay in product development comes from the difficulty in coordinating the efforts of various groups that must contribute to...the product" (1:25). These coordination delays are not the only problems with this serial method of functionally oriented development. Anacona suggests "Examples abound of the difficulties of ensuring that product designs can be easily manufactured, or of failing to include important information

from marketing or sales and service early in the design process" (1:25). The resultant rework time costs millions of dollars in lost labor hours and delayed time to market. How critical is "time to market"? Digital Equipment Corporation management estimated they would lose $9 million for each week a delay is experienced in reaching the extremely competitive computer market with their high performance VAX 9000 (12). For smaller corporations with a small product base, the product approach could be the difference between cornering the market and going broke.

Product Team Characteristics. The consensus of the successful leaders and organizational theorists is that no one method will work in all situations. In researching literature for this thesis, it was determined that there are common themes that run throughout the literature that suggest key elements to product team success:

(1) The Leader
(2) Team Norms and Process Control
(3) Use of Productivity Enhancing Tools
    (A) Quality Circles
    (B) Quality Function Deployment
    (C) Total Quality/Participative Management
    (D) Concurrent/Simultaneous Engineering
(4) Project Measurements
    (A) Clarity of Objectives
    (B) Customer Satisfaction
    (C) Team Cohesiveness
    (D) Team Attitudes
    (E) Market Share
    (F) Product Quality/Defects per Unit
    (G) Product Cycle Time
    (H) Cost Performance
(5) Analytical Frameworks

The Leader. Wolff views the selection of the leader as key. He says the leader should "be more of an enabler or facilitator who can 'catalyze communication'....He or she must build trust among the team members while...enjoying the trust of upper management" (23:9). The leader's goal must be to "Increase the quality of the interdependence so that the individual team members not only strive to improve their own work output but that of their colleagues as well" (22:10). To accomplish this, Wolff says the leader must give every team member 'a clear, visceral knowledge of what truly matters to the organization,' and structure the position of every team member so that the position itself is not a barrier to performance. (22:10) Smith & Reinertsen offer ten areas in which R&D leaders can shorten the product development cycle and improve team productivity. They emphasize flexibility, proper staffing, and common sense to continually improve processes and control key complexity factors. (19:44-48)

Team Norms and Process Control. For a product team to be successful, Walsh suggests the team must accept the new methods of product development to include:

(1) a holistic approach to development where all functional departments are appropriately involved in the program from the up-front planning stage to final completion,

(2) date making and date keeping (team commitment),

(3) individualized commitment based on education and training, and

(4) program control by means of a New Product Integration Manager (21:33).

This quality commitment to the product team and process improvement is the foundation of any successful new team.

Use of Productivity Enhancing Tools. A good portion of the success that product teams have experienced is due to their ability to enhance their worker productivity. Several productivity-enhancing tools are discussed in the following paragraphs along with their contribution to product team success.

Quality Circles (QC). These are broadly defined as "group[s] of workers from the same area who usually meet for an hour each week to discuss their problems, investigate solutions, and take corrective actions when authority is in their purview" (4:2). The product-team approach is ideally suited to QCs since each team member is working toward the same goal, often on the same processes, and the team leader has the autonomy to implement their corrective actions on the spot. Saleh's study of 65 companies in the automobile parts industry validated the use of QCs for both quality improvement and organizational effectiveness (14:198).

Quality Function Deployment (QFD). This technique is currently in use with tremendous success in over 100 U.S. and Japanese firms (7:360). QFD is a product-development process which "enhances communication levels within the core team (marketing, engineering, manufacturing)... [and] changes communication patterns from 'up-over-down' flows

through management to more horizontal routes where core team members communicate directly with one another" (7:360). After examining the customer's requirements, the product team members communicate directly with one another during product development (7:363). This often produces better integration within the product team and a higher quality product. Griffin does warn that his empirical research has shown that this process often reduces communication with external communication sources (7:360).

Total Quality/Participative Management. Total Quality Management concepts, such as the focus on customer satisfaction, continuous improvement, and teamwork, are utilized in the properly designed and managed product team. These concepts of management transcend the bounds of organizational structure and apply universally to all product-oriented, customer-focused organizations. Their contributions maximize quality, customer satisfaction and team member satisfaction (2; 7:364; 20:15).

Concurrent/Simultaneous Engineering. Previous concurrent engineering attempts have met with only mixed success. This tool provides the possibility of greatly decreasing the product cycle time. Anacona points out that

> the use of a cross-functional team has the potential to improve inter-unit coordination, to allow for project work to be done in parallel, not just sequentially, to reduce delays due to the failure to include the necessary information from throughout the organization (1:25).

Anacona's article reports on the cross-functional interface management activities of 45 new product teams in five high technology companies and includes detailed recommendations for managers attempting to incorporate concurrent engineering techniques into their product team environment (1:25-29).

Project Measurements. The cumulative literature on team, group, and organizational effectiveness measures yielded nearly 40 operationalized measures of group effectiveness which were included in compilation of the survey administered to the F-22 SPO. The majority of specific measures focused on abstract measures, such as clarity of team objectives, customer satisfaction, team cohesiveness, and team attitudes. These were typically measured through survey devices or interviews. Other measures were "hard" variables such as market share, product defects per unit, cycle time, and cost performance.

Analytical Frameworks. Researchers often develop complex frameworks to explain how their research fits into the body of academic literature. Product team effectiveness measurements are certainly no exception. Although for this research, product team effectiveness measurements were based on the successful Saturn team, other noted frameworks do exist:

(1) Erik W. Larson charted the success of over 500 projects relative to their management structure. He

developed complex evaluations of organizational differences as well as contextual factors to account for the type of project (9:119-120). He addressed the need for additional research when he said the following:

> Since measures of those factors (customer satisfaction, market share, technological breakthrough) as well as other objective indicators of performance that are comparable across different projects have yet to be developed, previous research relied on perceptual indicators of success. (9:120).

Larson's multivariate analysis did suggest this summary:

> New development projects that used the traditional functional organization had the lowest level of success in controlling cost, meeting schedule, achieving technical performance, and overall results. This was followed by projects using the functional matrix that fared slightly better than the functional projects. On the other hand, projects that used balanced matrix, project matrix, or the project team appear to do equally well on all four measures of success. (9:120)

(2) Blanchard, Carew, and Carew (2:22-23) developed a team performance rating form to evaluate 28 characteristics of effective organizations. They suggested this be used as a manager's tool to troubleshoot his or her team and follow the more detailed evaluation procedures later in the book to diagnose and correct the team deficiencies. Their study focused on measures of team purpose, empowerment, relationships and communication, flexibility, optimal productivity, recognition and appreciation, and morale.

(3) Goodman (6:5-20) designed a complex but intuitive model. He combined the inputs of group composition and structure, resource availability, and organizational structure into a model that yields group processes, such as communication and conflict resolution techniques, which influence the group's task completion efforts and the resultant group effectiveness. This model lacks operationalized effectiveness measures but compensates for this deficiency with its ability to consider group performance of teams ranging from sales to manufacturing to education. Goodman also provides a summarized literature review of organizational frameworks for studying team effectiveness.

The Saturn Philosophy

In response to the increasing loss of market share to foreign competition, General Motors (GM) surmised that they would have to find alternatives to their traditional way of doing business. The days when the big three auto makers, General Motors, Ford, and Chrysler, ruled the industry had disappeared. Out of economic necessity, GM and the United Auto Workers (UAW) formed an unprecedented alliance whose purpose was to create a small car to compete with the foreign auto makers. This new partnership, code named the Saturn Project, would utilize an organizational structure and philosophy that was very similar to what their foreign

competitors were using (11:2). This new team developed this mission statement that became the Saturn Corporation's guiding philosophy:

> Market vehicles developed and manufactured in the United States that are world leaders in quality, cost and customer satisfaction through the integration of people, technology and business systems and to transfer knowledge, technology and experience throughout General Motors. (10:10)

To fulfill the fundamental mission of Saturn, the core group of partners further developed the mission statement into a philosophy that states their intent to meet the needs of their customers, members, suppliers and dealers, as well as their neighbors in the communities. "After long and serious reflection, it [this philosophy] became the guiding framework for the company's decision-making process" (10:13).

Customers. To meet the needs of the customers, Saturn committed itself to producing products and services that would be world leaders in value and satisfaction. In 1991, Saturn's efforts paid off with four awards - 1991 Driver's Choice Award for Best Small Car, 1991 Easy Maintenance Car of the Year, Best Car in the $10,000 to $15,000 Range, and the 1991 Design and Engineering Award. Their commitment to customer satisfaction was most evident in May 1991 when Saturn chose to replace 1,836 cars due to improperly formulated coolant supplied by Texaco Refining and Marketing, Inc. Saturn, already popular in the United

States and Canada, announced on February 6, 1992, that it would begin exporting cars to Taiwan (16:3-4).

Members. The Saturn Corporation believes that all people want to be involved in the decisions that affect them and will be more committed to decisions that they make. Saturn self-directed work units, consisting of six to fifteen people, are responsible for hiring and firing within their group, training, and near-term decision making involving daily, weekly, and monthly activities. All members of the work unit who reach consensus must be at least 70% comfortable with the decision and 100% committed to its implementation. If a member blocks a decision, they are allocated a reasonable time frame to provide an alternate solution.

Each work unit is accountable for the decisions it makes, and responsible for its member's behavior, internal and external communications, job design and assignments, and workplans. They control their own material and inventory, perform equipment maintenance (within their expertise), develop their own budget, keep their own records, and monitor their own quality. All of this happens without a formal leader! (15:1-2)

Suppliers and Dealers. Saturn strives to create real partnership with their suppliers and wants them to feel ownership in the Saturn philosophy. "The goal is to establish a long-term partnership with only one supplier per

input. The relationship is based on mutual trust, high quality standards, just-in-time deliveries, and continuous improvement" (10:15). Saturn's retail dealers are also part of the team. Since they have direct contact with the end users, it is important for them to understand the values that guide Saturn. They provide instantaneous feedback on inventory control and repair information to the Saturn plant via a computer system and a twenty-four hour satellite communication system, and, in turn, the Saturn plant can provide information about vehicle production status. (10:15-16)

Neighbors and Community. Saturn has pledged to protect the environment and conserve natural resources through cooperation with the government at all levels. In order to demonstrate this commitment, Saturn has provided $1.25 million to the city of Spring Hill, Tennessee for a new city hall building and has donated 50 acres of property for a new high school. They located their plant away from the highway, behind rolling hills, in order to preserve the rural aesthetics of the landscape and switched from the traditional polluting power house to a permanent power source provided by the Tennessee Valley Authority. (17:3)

The Saturn Organization. Following the development of the Saturn philosophy, the original team began to assemble a new organizational structure. Linear organizational charts were replaced by "circles that nest into the overall

structure of the organization" (10:13). As Figure 1 shows, the core of the organization is the self-directed work unit whose tasks are coordinated with other work units and formed into a work unit module.

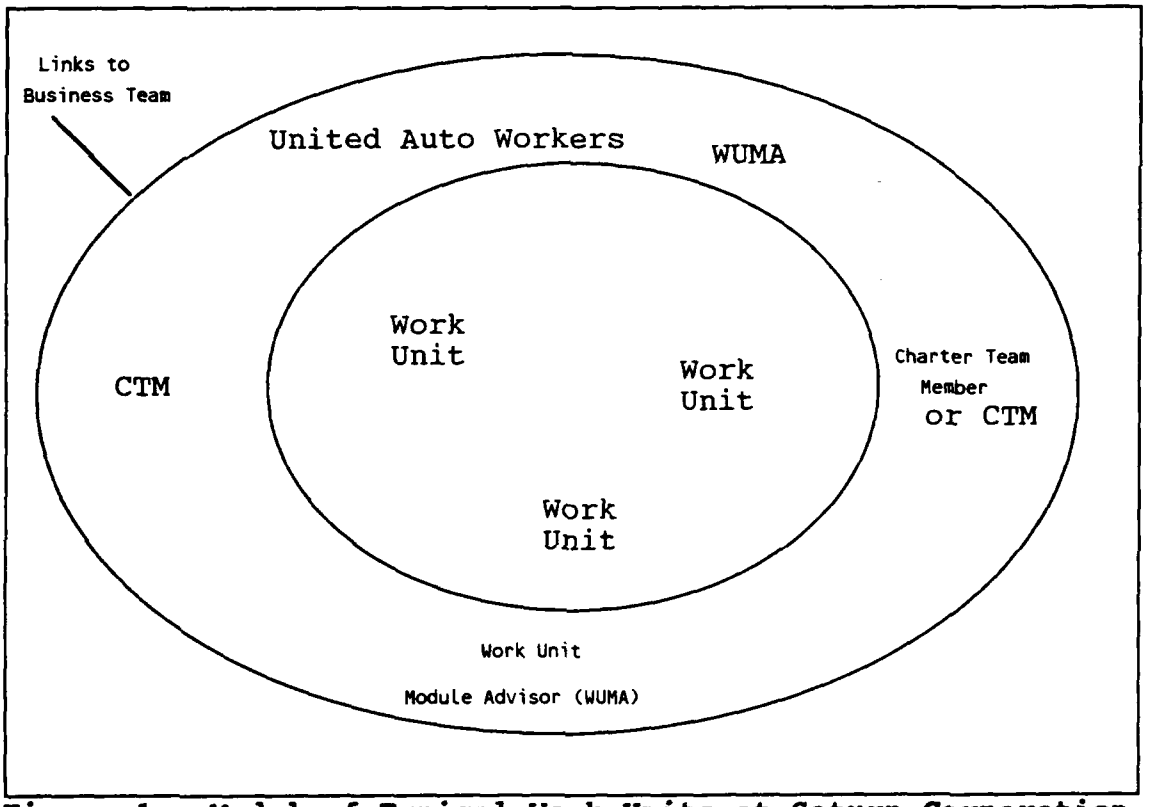


Figure 1. Model of Typical Work Units at Saturn Corporation

Each module has an advisor (normally assigned to oversee four to six modules) who is a charter team member of the decision circle. A work unit makes decisions that affect that individual unit alone. However, when a problem arises that may affect other units, decisions are coordinated at the decision circle with representatives from all affected work units.

Work unit modules, their advisors and other members of

the decision circle form one of the three business units - powertrains, body systems, and vehicle systems. The three business units fall under the purview of the Manufacturing Action Council (MAC). The Technical Development Action Council (TDAC) and the Customer Action Councils (CAC) are organized in a similar fashion and report to the Strategic Action Council (SAC) who oversees the strategic direction of the Saturn Corporation. All of the councils can be assisted by Resource Teams who operate as centralized entities at corporate level when the need arises.

A reward system further strengthens the organization. Goals are negotiated, and if met, all team members receive 100% of their salary. The members can lose 20% of their salaries if the pre-determined goals are not met, or they can receive bonuses if the goals are exceeded. The emphasis in the reward/risk system is placed on goals at the highest levels. Since no individual or individual group performance goals are established, there is no need for internal competition. Each individual and group motivate one another for the benefit of the entire company.

Conclusion

Many product development efforts are successfully using the product team approach and are risking billions of dollars, and often organizational survival, on the life cycle effectiveness of decisions made by product team

organizations. This literature review dealt with product-team success versus other organizational forms, the characteristics of successful teams, several analytical frameworks, and the Saturn Corporation's philosophy for utilizing product teams to regain GM's competitive edge.

Chapter III. Methodology

Overview

The following methodology combines subjective evaluation of product team effectiveness with objective survey measures obtained through product team measurement literature guidelines specifically tailored for this research. The strength of this analysis is due to the success of the Saturn program. The incredible demand for Saturn's cars when other car makers are downsizing and Saturn's ranking as the highest American car ranked on the J.D. Power's Customer Satisfaction Index for the second year in a row makes it a proven winner (13:95). Saturn's product team management philosophy and techniques provided guidance to design the data collection instrument and to eventually compare the F-22 survey results with the Saturn characteristics. The Saturn team characteristics were utilized as a basis for comparison of the F-22 product team by a product team characteristics survey in hopes of enhancing future DOD acquisitions.

Research Design

The methodology in this study is to compare the characteristics of the F-22 product team during the R&D phase of product development to the Saturn product team characteristics. The F-22 effectiveness was measured by how

well the R&D product teams conform to the key areas that Saturn has asserted are crucial to creating a successful product. These items were addressed specifically by the investigative statements listed in this chapter and are discussed further in Chapter IV analysis.

The selection of the highly successful Saturn Corporation as the product team model greatly enhances the credibility of this research by utilizing their innovative guidelines as the basis for the product team effectiveness survey. The Saturn Corporation product team management guidelines and their applications in systems acquisitions provide the measurement stick for this research.

Review of Saturn's product team effectiveness guidelines provided the investigative questions for evaluating F-22 product teams through the product team effectiveness survey device (see Appendix). The survey measurement device was tested on a pilot group of product team personnel from ASC/SM, Subsystems SPO, before being administered to the F-22 subjects to ensure its clarity and usefulness. The survey was then administered to the F-22 SPO by the researchers to obtain actual data. The data was then analyzed, and in areas where the F-22 appears to be deviating from the desireable Saturn management characteristics, the researchers provide recommendations for improvement based on the Saturn management techniques.

Selection of Subjects

In light of the high visibility and the large sum of funds to be expended by the F-22 program during the next eight years, all personnel on the F-22 Program Office roster have been selected for survey administration. To get a statistically representative cross-section sampling of the approximately 300 F-22 SPO personnel and the associated perceptions of product team development, it was necessary to have at least 159 surveys returned to provide 95% confidence in our responses (8:607-610).

Investigative Statements

The survey consists of the following statements posed to SPO personnel as a Likert survey with responses ranging from Strongly Disagree to Strongly Agree. The complete measurement instrument is in the Appendix. The key variables of interest developed from the Saturn management literature are bolded.

1. The product team organizational **structure enhances my productivity.**
2. I am **able to make a difference** in the development of my product.
3. I'm not sure **how** my team's **efforts contribute** to the end product.
4. My team's objectives **contribute directly** to the quality of the end product.
5. My team leader seems **unaware** at times **of the critical issues** facing our product development.
6. My team leader **promotes growth and training** among our team.
7. My team leader makes decisions based on **team discussion and consensus.**
8. My team leader doesn't **emphasize the "systems" perspective** enough.

9. My team is not given enough **freedom and flexibility** to make decisions about our product.
10. My team has the **right mix of functional disciplines** to do the job.
11. My team has too many people to facilitate **group decision-making.**
12. I **enjoy working on product teams more** than the previous organizational approaches to acquisition.
13. I don't believe product teams will result in a **better end product.**
14. The product team approach is **more responsive to customer requirements** than previous organizational approaches.

The statements listed above were areas specifically identified by the Saturn Corporation as key ingredients to obtaining successful product teams and end product. The implications of the statements and survey results are discussed in Chapter IV.

Data Collection

Due to the close proximity of the F-22 SPO, the survey device was personally administered directly to SPO personnel and their responses were collected upon completion. This technique provided a high confidence that the required sample size would be obtained.

Data Processing and Analysis

The statements posed in the survey instrument were based upon findings from Saturn Corporation and other product team effectiveness journal articles and are relevant to the attitudes under study. One half of the statements were phrased positively and one half were phrased negatively

about each relevant attitude to avoid having repetitive answers from survey respondents. The statements assessed the characteristics of F-22 product teams as compared to areas that the body of literature found to be crucial. For the surveys collected, descriptive statistics were performed for each statement to measure the relative success of the SPO in each of these areas. Each statement was marked from Strongly Agree to Strongly Disagree corresponding to the appropriate attitude toward the statement. Where results suggest improvement can be made, the researchers surveyed Saturn management literature for methods of improving product team performance. The statement response analysis and subjective conclusions are summarized in Chapter IV.

Chapter IV. Findings and Analysis

Introduction

In accordance with the research methodology discussed in chapter three of this thesis, the survey was administered to the F-22 System program office from 13 May 1993 until response close-out 3 June 1993. The researchers hand-carried the surveys to the subjects, discussed intent and methodology when possible, and gave detailed instructions for completion and return. This time-consuming process gave the participants some insight into the surveys purpose and more incentive to complete it.

Survey Data

Since the F-22 SPO consisted of approximately 300 personnel, it was imperative that we receive at least 169 surveys back to achieve a 95% confidence level. A large number were returned rapidly but then declined to a trickle after two weeks. For this reason, when the total of our responses reached 178, collection was discontinued. With 252 surveys handed out, a 71% response rate was achieved. We believe this unusually high response rate was due to our presence in the SPO and discussions with participants, E-mail messages, and assistance by product team secretaries to get the surveys completed and returned.

Data Breakdown

The raw data are categorized in Table 1 by (1) statement number and (2) by the number of surveys returned with each numerical response to that statement number.

Statement #	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
5	4	7	6	21	41	62	37
6	1	8	4	10	45	60	50
7	76	58	9	7	7	13	8
8	4	4	2	7	19	83	59
9	35	56	20	23	29	13	2
10	8	5	19	29	39	64	14
11	2	19	14	16	37	70	20
12	30	65	32	28	14	5	4
13	19	69	27	15	27	15	6
14	11	11	32	13	34	61	16
15	27	77	29	14	14	11	6
16	5	9	15	30	22	45	52
17	59	64	14	15	9	10	7
18	2	11	8	16	35	74	32

Table 1 - Number of Responses For Each Statement

Investigative Statements and Results

This section discusses each individual statement's responses, possible inferences to be made from the responses, comments returned with the surveys from F-22 SPO personnel, and provides a comprehensive summary of the results as a measure of F-22 product team characteristics. The "mean response" is the weighted mean based on the number of surveys returned for the 1 through 7 response scale. "Rank Net Deviation from Neutral" provides a relative

ranking of the statements deviation from a neutral response. This method accounts for both positive and negatively phrased statements and gives a relative strength of response for each statement.

Statement 5

THE PRODUCT TEAM ORGANIZATIONAL STRUCTURE ENHANCES MY PRODUCTIVITY.

Mean Response: 5.37 (Closest to Somewhat Agree)

Rank Net Deviation from Neutral: 5th out of 14

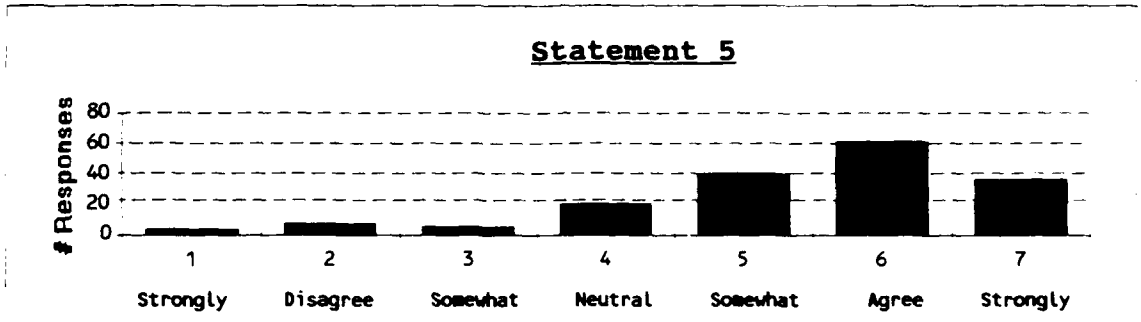


Figure 2 - Graphical Representation of Response Distribution

With 87% of responses agreeing with this statement, it appears that the F-22 SPO personnel have the perception that the product team organizational structure makes them better able to do their job. One respondent said "It [IPT structure] provides a more disciplined approach and being the first ones to implement the IPT approach gave us room to be innovative." They appear fairly convinced that this structure will work. "The way the F-22 has organized into IPTs is conducive to maximizing productivity." Another IPT person says the IPT structure is more productive "...by

definition since they are more focused on their work - having the responsibility and commensurate authority to steer the development of a specific capability or set of capabilities."

There was some concern about implementation of IPT by the contractor teams. Four SPO personnel made comments that "the 'IPTism' does not go far within the contractor's organizational structure." Comments that contractor members of IPTs exclude SPO personnel and are more aligned along traditional management lines appears to be a point of concern for some. This could be a source of problems that proved similar to ones experienced between the management of the Saturn Corporation and the United Auto Workers. Disagreement between parties on decision-making practices and relative influence in the product design and support can cause conflict and must be carefully managed and monitored to ensure the product does not suffer.

Statement 6

I AM ABLE TO MAKE A DIFFERENCE IN THE DEVELOPMENT OF MY PRODUCT.

Mean Response: 5.64 (Closest to Agree)

Rank Net Deviation from Neutral: 4th out of 14

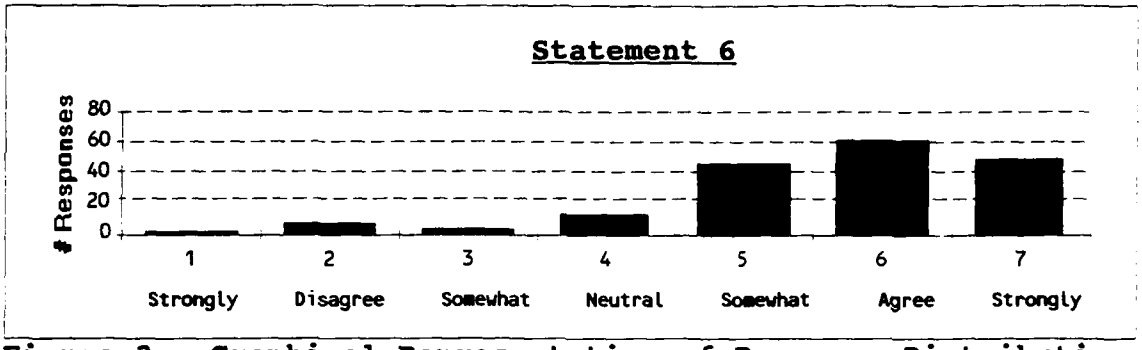


Figure 3 - Graphical Representation of Response Distribution

The response to this investigative statement was overwhelmingly positive. 87% of respondents agreed that they were able to influence the design, development, and supportability of their team's product. Saturn pointed out that this feeling by workers is crucial for them to stay involved and actively pursuing a better product. One F-22 SPO person commenting on this statement said, "This is true because product team structures are more able to give individuals the responsibility and commensurate authority to decide the course of the development effort within a general set of guidelines." Similarly, "[We] have responsibility and accountability." One dissenting comment noted that some "Managers are reluctant to pass on authority and resources." The responses overall indicate a sense of empowerment and involvement that are crucial to the development of a successful F-22 Advanced Tactical Fighter.

Statement 7

I'M NOT SURE HOW MY TEAM'S EFFORT CONTRIBUTES TO THE END PRODUCT.

Mean Response: 2.34 (Closest to Disagree)

Rank Net Deviation from Neutral: 3rd out of 14

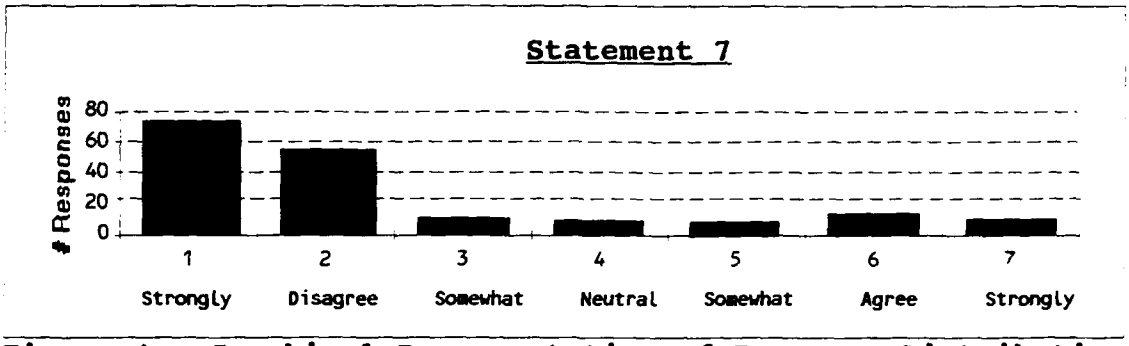


Figure 4 - Graphical Representation of Response Distribution

This was the first of the negatively phrased statements designed to measure the participants understanding of their team's role in the development of the end product. This statement produced very strong responses (disagreement 80%) and also a fair amount of agreement (16%) which may indicate that some teams are doing a better job of making their role clearer to their people that others. One worker exhorts "I know it contributes very positively. I know who is responsible for each product and it's elements." It appears that the closer the team is to the end product, the clearer their role in the development of the end product. Staff functions, such as the Analysis and Integration (A&I) groups, appear less clear about their role in product development.

Statement 8

MY TEAM'S OBJECTIVES CONTRIBUTE DIRECTLY TO THE QUALITY OF THE END PRODUCT.

Mean Response: 5.91 (Closest to Agree)

Rank Net Deviation from Neutral: 1st out of 14

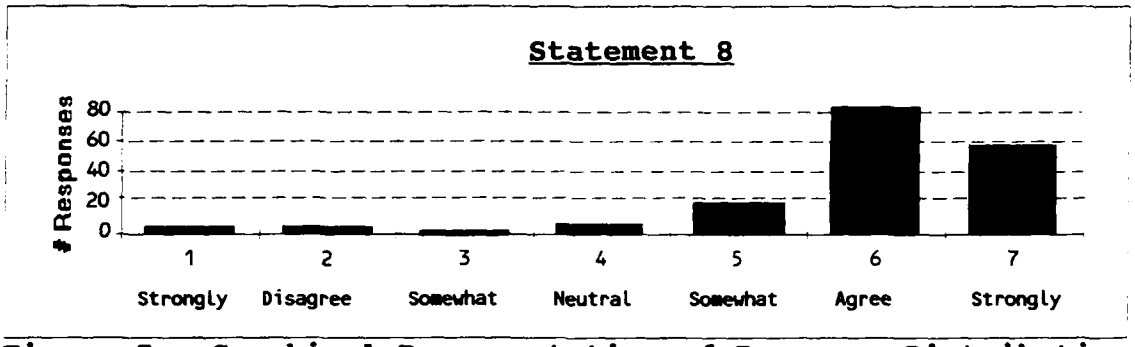


Figure 5 - Graphical Representation of Response Distribution

Statement 8 produced the largest deviation from neutral and was similar to the positively phrased statement 7. It also evaluates participants perceptions of their team's objectives and how they relate to the end product. A staggering 90% of respondents agreed that their team's objectives contribute directly to the quality of the end product. "Quality **is** our objective!" responded one person. It may be possible to infer from this strong response that there is genuine agreement about the objectives within each team and across teams. This clarity of objectives gives every person a clear picture of their obligations and contributions and is the cornerstone to the development of any successful product.

Statement 9

MY TEAM SEEMS UNAWARE AT TIMES OF THE CRITICAL ISSUES FACING OUR PRODUCT DEVELOPMENT.

Mean Response: 3.01 (Closest to Somewhat Disagree)

Rank Net Deviation from Neutral: 11th out of 14

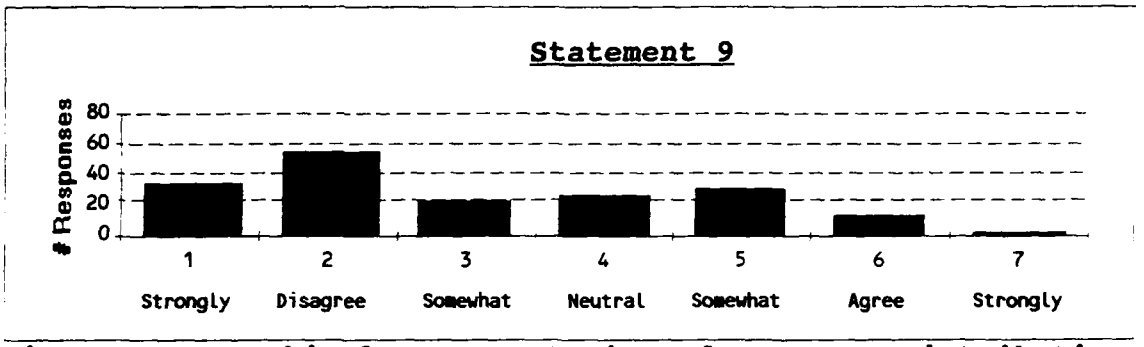


Figure 6 - Graphical Representation of Response Distribution

This negatively phrased statement investigated participants' perceptions of information flows within and also between teams. A lack of communication about the critical issues may indicate either an organizational or personal communication problem. While 62% disagreed, 30% agreed that communication may perhaps be a problem at times and team personnel are not always properly informed of critical issues. A myriad of comments surfaced about this statement. One said, "Issues are not always identified because of the complexity of all the IPT interfaces. However, we can directly cause decisions to be changed because we have great visibility into the product development." The problem of contractor participation also surfaced in this investigative statement. "Contractor is not willing to totally change his business methodology. Contractor believes in contractor/customer relationships." Another F-22 SPO personnel said, "Because some members are short-sighted, this [unaware members] is many times true." The challenge for all organizations including integrated product teams is to ensure communication occurs between

members of the teams (both government and contractor) and between teams.

Statement 10

MY TEAM LEADER PROMOTES GROWTH AND TRAINING AMONG OUR TEAM.

Mean Response: 4.88 (Closest to Somewhat Agree)

Rank Net Deviation from Neutral: 12th out of 14

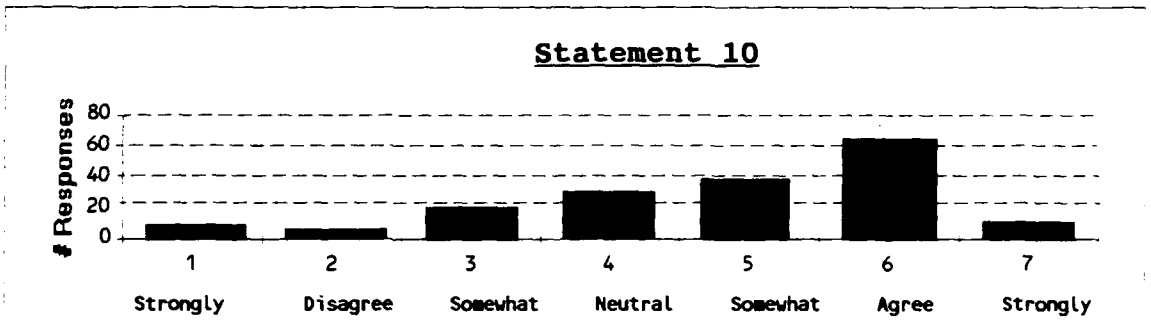


Figure 7 - Graphical Representation of Response Distribution

There was general agreement on this statement that team leaders do indeed promote growth and training with only 18% in disagreement. Not all leaders do as much as others so it is also incumbent upon the personnel themselves to ensure they get the training they need. Often a team leader is "too busy doing his own tasks to track other's progress." Sparse comments, both positive and negative, about individual team leaders were not included. It appears from the responses that team leaders need to focus not only on the product but on their people too!

Statement 11

MY TEAM LEADER MAKES DECISIONS BASED ON TEAM DISCUSSION AND CONSENSUS.

Mean Response: 5.01 (Closest to Somewhat Agree)

Rank Net Deviation from Neutral: 10th out of 14

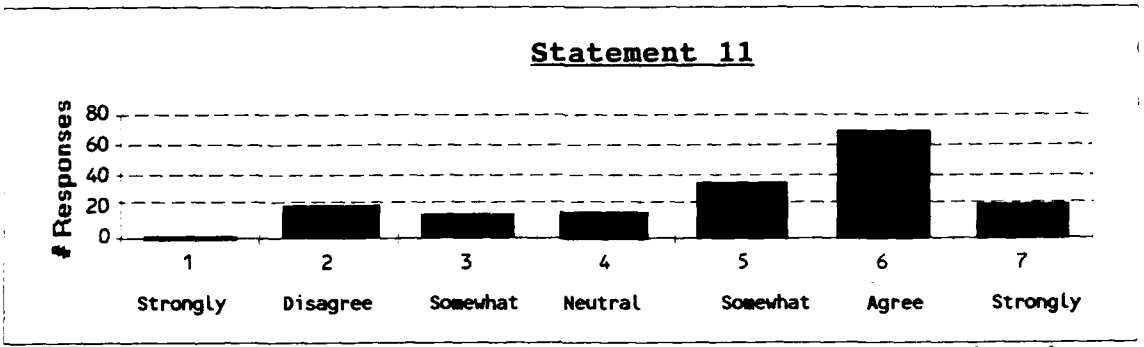


Figure 8 - Graphical Description of Response Distribution

This statement was designed to acquire perceptions of team leader's decision-making style. Saturn emphasizes team discussion and involvement in decisions as a key component to worker involvement and team unity. There was general agreement that team leaders are doing well in the F-22 (71%) and that only a few leaders need to work more closely with their people. One unique feature of the F-22 SPO did cause some concern among respondents. The idea of a co-leader for each integrated product team

> results in a lack of decision-making ability because now two people must decide rather than me. The 'co-leads' here at the F-22 are not interchangeable entities. Hence there are problems in getting decisions made regardless of team decisions.

Further concern was raised about team leads making decisions without consulting team members or getting all the facts. Also, some concern about team leaders flowing information

back down to team members and across the government-contractor lines is not working as effectively as it should. The role of the team leader is crucial in any product development. The F-22's goal of achieving a balance of managerial and technical expertise creates some conflict in decision-making processes. Compound these troubles with contractor personnel, hectic travel schedules, and part-time team members, and the task of getting the appropriate people involved in every issue in order to make a 'systems' decision in a timely manner greatly intensifies the challenge. Saturn team members are dedicated to the team with one team leader. This may facilitate their decision-making process but may not be a cost-effective solution for a program office with limited personnel and funding.

Statement 12

MY TEAM LEADER DOESN'T EMPHASIZE THE "SYSTEMS" PERSPECTIVE ENOUGH.

Mean Response: 2.79 (Closest to Somewhat Disagree)

Rank Net Deviation from Neutral: 8th out of 14

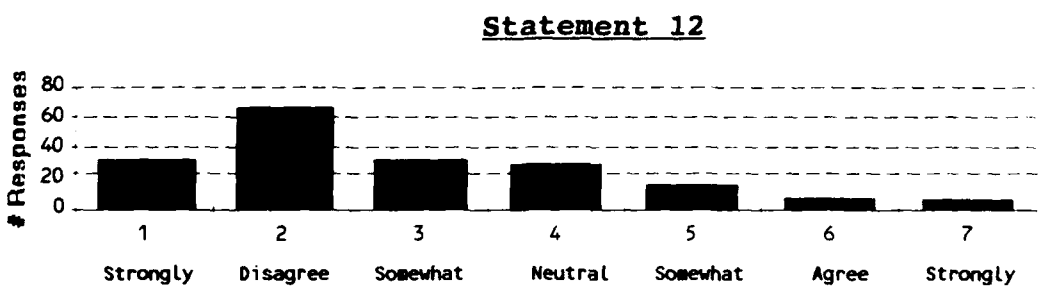


Figure 9 - Graphical Description of Response Distribution

This negatively phrased statement was designed to investigate respondents' perceptions of how well team leaders incorporate all aspects of product development into the decisions they make. Our results indicate that F-22 team leaders are doing a good job emphasizing the "systems" perspective. It is very important for successful product teams to avoid functional parochialism which optimizes one aspect of the design while producing shortcomings in others. One area of concern relates to the interface between users (pilots) and their understanding of the acquisition process and the implications of their decisions. Having people experienced not only with the system being developed, but also with the processes used to develop that product, are important. Further, the "systems" perspective must be utilized in <u>all</u> product decisions if the end product hopes to reflect the optimum mix of functional disciplines, quality, and life cycle cost savings.

<u>Statement 13</u>

MY TEAM IS NOT GIVEN ENOUGH FREEDOM AND FLEXIBILITY TO MAKE DECISIONS ABOUT OUR PRODUCT.

Mean Response: 3.12 (Closest to Somewhat Disagree)

Rank Net Deviation from Neutral: 12th out of 14

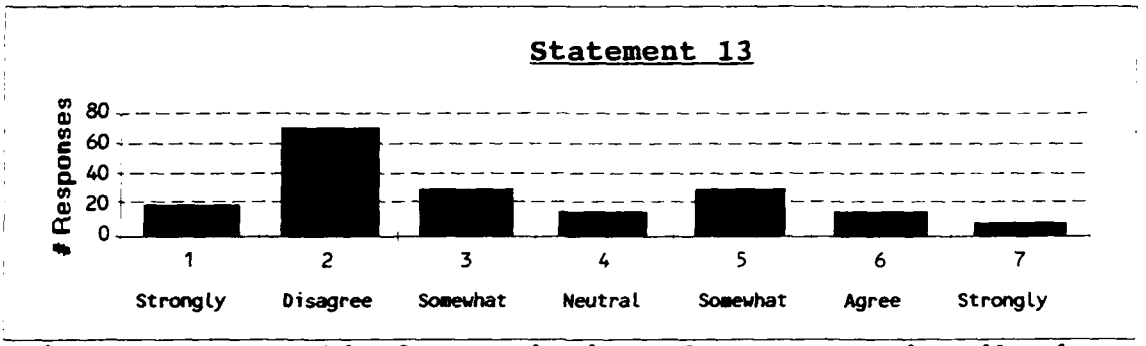


Figure 10 - Graphical Description of Response Distribution

Team autonomy and flexibility in the development of their product can be a powerful tool for improvement of the overall product. The nature of this fairly neutral response indicates that there may be perceptions that teams are not given enough autonomy. There is significant concern that political and rank-based decisions are made regardless of the decisions made by the team. Respondents believe team autonomy and flexibility is *sometimes* curtailed as decisions move up the chain. This comment, "My team is given freedom until management disagrees," indicates that some frustration occurs when trying to integrate team decisions while still controlling cost, schedule, and performance factors. Management that alienates team members by overruling team decisions when "We are the ones who are the experts in the area!" can't help but decrease motivation and productivity. These comments are very isolated instances as the majority of the surveys returned indicated the F-22 is doing a superior job at delegating authority to the appropriate levels.

Statement 14

MY TEAM HAS THE RIGHT COMPOSITION OF INDIVIDUALS TO DO THE JOB.

Mean Response: 4.66 (Closest to Somewhat Agree)

Rank Net Deviation from Neutral: 14th out of 14

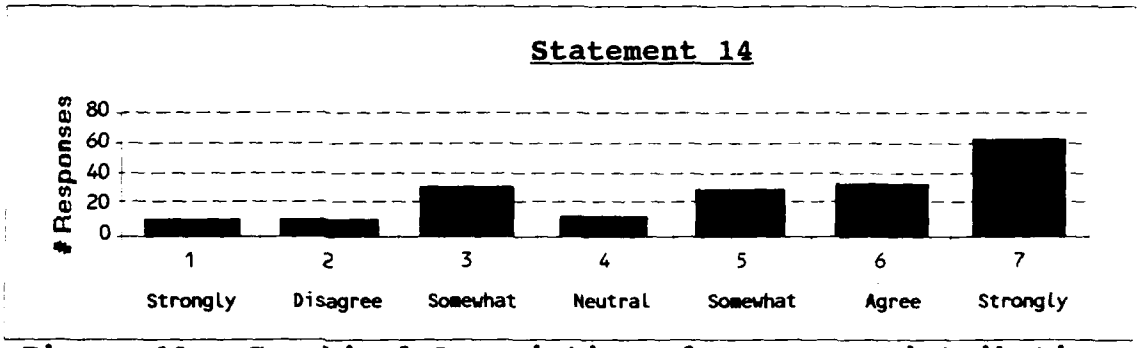


Figure 11 - Graphical Description of Response Distribution

This statement hoped to gain insight into perceptions of team composition. It attempted to answer the question, "Do the teams have the right people to get the job done?" The responses indicate that this may not be the case. 57% of respondents only somewhat agreed or disagreed in some manner with this statement. From the comments provided, the problem appears to be a combination of a lack of skilled personnel and too few numbers. Some related comments suggested that there is indeed a problem with filling skilled positions with dedicated product team personnel. This issue may become even more critical to weapons system development in the future as technically skilled personnel move away from the aerospace industry for various reasons.

The "right composition" is also a point of concern for a respondent that suggests the SPO may be too top heavy in

rank/grade structure. Too many leaders and not enough workers..."puts a serious drain on the ability of these workers to work the problems and manage their piece of the pie."

Statement 15

MY TEAM HAS TOO MANY PEOPLE TO FACILITATE GROUP DECISION-MAKING.

Mean Response: 2.82 (Closest to Somewhat Disagree)

Rank Net Deviation from Neutral: 9th out of 14

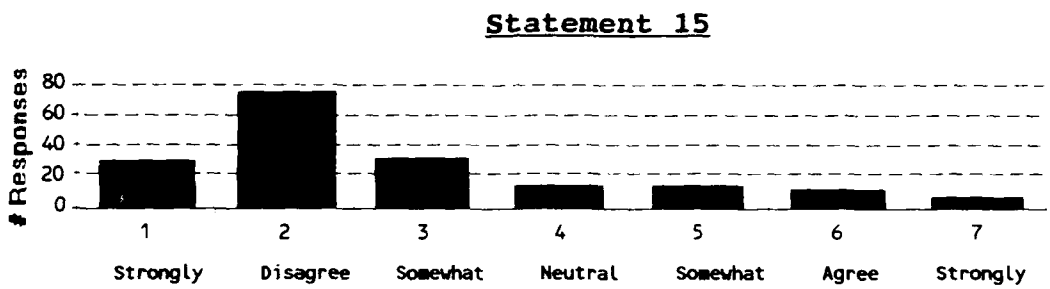


Figure 12 - Graphical Description of Response Distribution

This negatively phrased investigative statement was designed to evaluate the size of the product teams and its associated impact on group decision-making. Whether teams are too large or too small, decision-making may suffer. Comments on this statement were nearly all favorable. Team members think smaller teams can work more effectively than larger groups. They also caution that as the groups become larger, filled with strong personalities, it becomes increasingly difficult to arrive at an acceptable solution to all parties. This seems to indicate that product team

size is indeed a critical component to successful and effective decision-making. Consensus decisions are not always practical as the size of the groups increase.

Statement 16

I ENJOY WORKING ON PRODUCT TEAMS MORE THAN THE PREVIOUS ORGANIZATIONAL APPROACHES TO ACQUISITION.

Mean Response: 5.24 (Closest to Somewhat Agree)

Rank Net Deviation: 7th out of 14

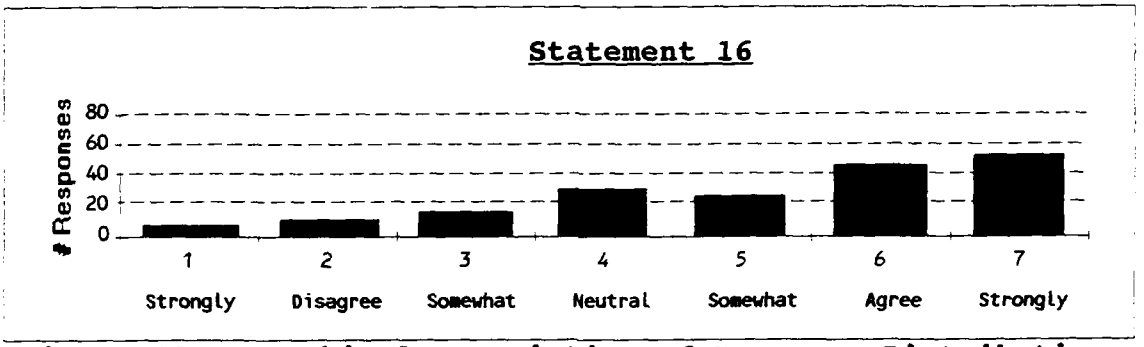


Figure 13 - Graphical Description of Response Distribution

This statement was designed to investigate satisfaction with the product team environment relative to other organizational approaches to acquisition they may have worked in before. 67% agreed that they preferred the new product team environment. This may infer an increased job satisfaction and worker fulfillment from the new approach. Both of these characteristics have been linked to increased worker productivity. Comments focused on the problems of past organizations, such as fragmentation and management reluctance to act, and how the IPT structure "provides better focus and discipline and tools to do the job."

People referred to the tremendous workload of developing the F-22 weapons system but commented "The job satisfaction of contributing to an important product makes it bearable."

The largely favorable response to the IPT structure was one of the surprises of this research. Considering how little change is desired in most organizations, this response indicates that F-22 SPO personnel have recognized the benefits of the IPT structure and are embracing the opportunity to improve the product as much as possible.

Statement 17

I DON'T THINK PRODUCT TEAMS WILL RESULT IN A BETTER END PRODUCT.

Mean Response: 2.24 (Closest to Disagree)

Rank Net Deviation from Neutral: 2nd out of 14

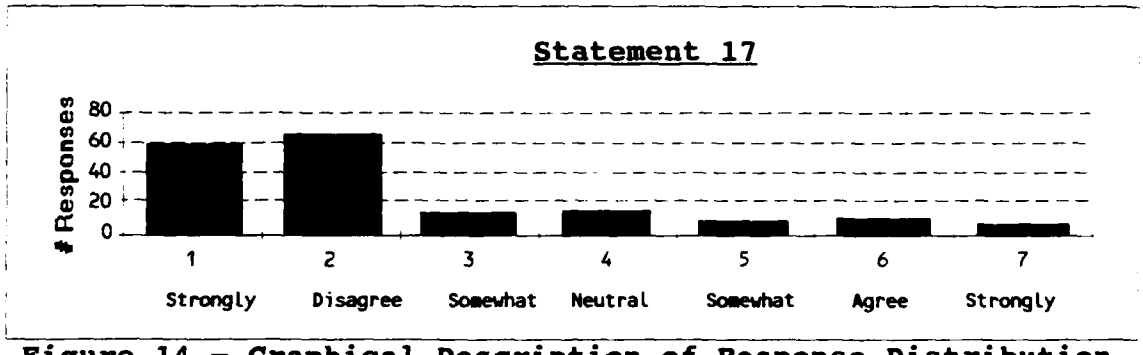


Figure 14 - Graphical Description of Response Distribution

This negatively phrased statement produced overwhelming support for the perception that the product team approach will result in a better end product. Nearly 80% of F-22 SPO personnel believed that the weapons system will benefit from the product team approach. Reasons for this response

included "There is inherently more buy-in by those responsible for the product due, in part, to the higher degree of accountability."

Not all responses were favorable. Communication between teams and the willingness of managers to delegate authority yielded these comments. "If we truly work as teams and integrate efforts between teams, we can be successful. Currently we are the independent team." "Product teams will result in a better end product but management must be willing to relinquish that powerbase that they have spent so many years building." These comments emphasize that communication efforts must be increased at all levels, whether informally or by an organizational modification, and team leaders must use their people wisely.

Statement 18

THE PRODUCT TEAM APPROACH IS MORE RESPONSIVE TO CUSTOMER REQUIREMENTS THAN PREVIOUS ORGANIZATIONAL APPROACHES.

Mean Response: 5.37 (Closest to Somewhat Agree)

Rank Net Deviation from Neutral: 5th out of 14

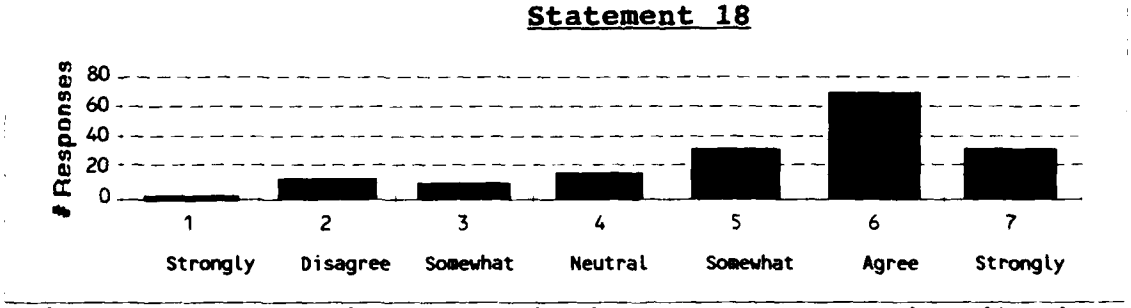


Figure 15 - Graphical Description of Response Distribution

A resounding 79% of SPO personnel agree that the product team approach is more responsive to customer requirements than previous organizational approaches. Being responsive to the customer's needs is the basis for any successful product. Respondents emphasized that customer requirements will only be met if good communications are maintained between the IPT members to include the contractor, the government, and the user. This involvement by the users in product development is obvious in hindsight but easily forgotten when the workload piles up and deadlines are near. Saturn management literature views the customer as the reason for the product in the first place. This focus appears to be present in the F-22 SPO as well.

Summary

The F-22 system program office has the basis for a very strong product team approach. Their goal congruence, leadership, and willingness to implement the precepts of integrated product development may explain some of the success they have already achieved. One F-22 SPO representative wrote "Given the complexity of today's weapons systems, you can't develop a quality product using older techniques and tools." The IPT organizational structure and management techniques are the tools needed to deal with the increased complexity.

From the results of our analysis, the main areas for emphasis in the F-22 should be in ensuring IPTs have the right composition of individuals to do the job and **communication** across and within teams must be emphasized. The willingness of team leaders and top management to stick with team decisions and utilize the expertise the team members have, is essential.

Figure 16 provides a summary of the relative intensity of responses for the 14 statements included in the survey device. The larger the net deviation from neutral, the closer the statement was to either strongly disagreeing or strongly agreeing, depending on whether the statement was negatively or positively phrased. For instance, statement 8 produced a mean response of 5.91. Its net deviation from neutral (a 4 on the Likert Scale) is 1.91. Those statements with the largest net deviation from neutral suggest the areas where the F-22 management may differ the greatest with the Saturn Corporation's precepts of management.

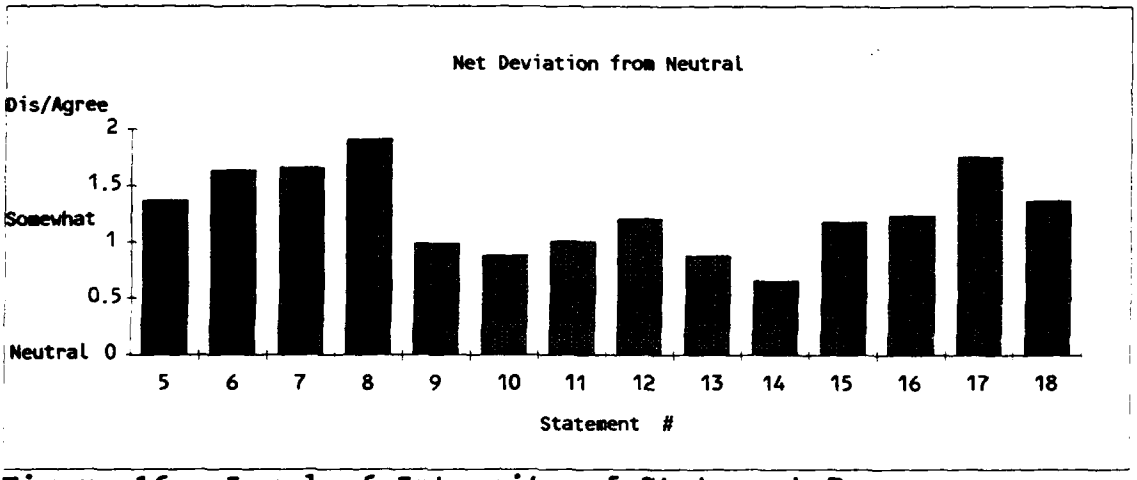


Figure 16 - Level of Intensity of Statement Responses

Chapter IV will provide conclusions from the research and recommendations for future research in related areas.

Chapter V. Conclusions and Recommendations

Summary

Introduction. Since the fiscal year 1993 Department of Defense Research and Development budget contained a request for over $38.3 billion, it is prudent for the United States to acquire systems in the most efficient manner possible. The structure of the organization acquiring a system has a great influence on the cost, schedule, performance, and quality of the system throughout its life cycle. Major acquisition organizations within the DOD are moving from the traditional functional or matrix format to a product team approach in an attempt to minimize cost and maximize the quality of their products.

The Saturn Corporation has developed and produced a successful product using the product team approach. It has been praised for producing a high quality product at an affordable price in a reasonable time which made it an excellent candidate for research. Within the DOD, the F-22 is one of twenty-one programs selected to be a prototype for the product team style of management. Considering this high visibility and high dollar program has eight more years of research and development scheduled, it was also an ideal candidate for analysis. The scope of this thesis included an investigation and identification of the Saturn Corporation product team characteristics which were then

incorporated into a Likert survey. The survey was administered to F-22 SPO personnel, and the results were compared to the Saturn product team characteristics.

Literature Review. An in-depth literature review was also conducted in order to gain knowledge regarding product team effectiveness, management of groups and teams, and current group measurement techniques. This provided a baseline for comparison when the F-22 product team characteristics were compared to the Saturn Corporation team characteristics. It became clear that product teams enjoy overwhelming support from workers, chief executive officers and the academic community. The literature review also revealed that a good portion of the success of product teams is due to the ability of managers to enhance worker productivity through the use of tools such as Quality Circles, Total Quality/Participative Management, and Concurrent/Simultaneous Engineering. The measurement of product team effectiveness was generally achieved through survey devices or interviews and focused on abstract measures such as clarity of team objectives, customer satisfaction, and team cohesiveness. Measurement can also involve "hard" variables such as market share, product defects per unit, cycle time, and cost performance when applicable.

Investigation of the Saturn Corporation literature disclosed a philosophy quite different from that of the

other American automobile manufacturers. Their mission statement reflected their intent to meet the needs of the customers, members, suppliers, dealers, as well as neighbors in the community. This has become the guiding framework for the company's decision-making process. (18:13) Saturn committed itself to producing products and services that would be world leaders in value and satisfaction. This is achieved through a decision making process that involves all members affected by the decision. The Saturn Corporations has also created long-term partnerships with their suppliers and dealers based on mutual trust, high quality standards, and continuous improvement. Performance goals are established at the highest level so that each group and individual within the corporation are motivated to cooperate with each other for the benefit of the entire corporation.

Methodology. The methodology for this thesis combined subjective evaluation of product team effectiveness with objective survey measures obtained through product team measurement literature guidelines specifically tailored for this research. Saturn's product team management philosophy and techniques provided guidance to design the data collection instrument. This survey was then administered to F-22 SPO personnel and the results were compared to the Saturn characteristics. The ultimate goal is to identify factors which could be used to enhance current and future DOD acquisitions by studying F-22 product team

characteristics as compared to key areas that Saturn has identified. The investigative statements focus on those characteristics of teams identified that make them effective and the management techniques for maximizing their effectiveness.

Review of Saturn's product team effectiveness guidelines provided the investigative statements for evaluating F-22 product teams through the product team effectiveness survey device (see Appendix). This device was tested on a pilot group to ensure its clarity and usefulness before being administered to the F-22 personnel. The survey was then administered to the F-22 SPO by the researchers to obtain actual data which was then analyzed for significant deviations from the Saturn characteristics. It was determined that at least 169 surveys had to be returned to provide a 95% confidence rate in the analysis. (21: 607-610) The statements posed in the survey instrument were based upon findings from the Saturn Corporation literature and other product team effectiveness journal articles and were relevant to the attitudes under study. Each statement was marked by the F-22 respondents from Strongly Agree to Strongly Disagree corresponding to the appropriate attitude toward the statement. Descriptive statistics were then performed for each statement to measure the relative success of the F-22 SPO in each of these areas.

Findings and Analysis. The findings obtained as a result of the survey clearly indicate that the personnel in the F-22 SPO are convinced that the product team organizational structure will allow them to produce a higher quality product that is more responsive to the customers needs. Although most respondents agreed that they are able to influence the design, development and supportability of their team's product, there are a number of personnel who need to obtain a clearer idea of their individual role within the organization. Administrative and staff functions have a more difficult time defining their role in the product-oriented world of IPTs. The overwhelming positive response to statement eight, "My team's objectives contribute directly to the quality of the end product," indicated that team objectives are congruent with the organization's goals which is a crucial aspect to the success of any program.

Nearly one third of the respondents indicated that there may be communication problems either within or between the individual product teams which constrict the flow of information, and thus, affect the decision-making process. There is a perception by the government SPO personnel that part of the communication problems originate with the contractors implementation of the IPT structure and their willingness to exclude government personnel from daily communications.

Other problems identified by a minority of respondents on the survey include the lack of personal growth and training promoted by team leaders due to excessive work requirements, the lack of team autonomy in the decision-making process as issues are elevated through channels, and the lack of contractor participation in the product team concept.

Conclusions

Overall, it appears that the F-22 SPO is a thriving organization with all the attributes required to produce an end product designed to meet the needs identified by the users. The organization contains many of the essential characteristics that were identified by the Saturn Corporation to contribute directly to the success of its product and organization. Thus, it can be inferred that the F-22 will be a successful organization in its own right if it continues to emphasize a "team attitude", enhances communication within and between teams, and strives for continuous improvement.

The product team organizational structure appears to greatly enhance the ability of the SPO personnel to contribute to the success of the F-22. The majority of respondents (80%) perceive that their membership on a team within the SPO contributes to the quality of the end product and that they (and their team) can influence the final

outcome of decisions. The ultimate test for any product is customer satisfaction. Respondents largely believe (79%) that the integrated product team structure allows them to be more responsive to customer requirements.

Since an R&D atmosphere within the military environment discourages the use of a reward/risk system similar to the one employed by Saturn, the increased satisfaction of being a team member over previous organizational approaches (67% agree) and having the responsibility and accountability to positively contribute to the success of a major weapon system are critical components to overall program success.

The F-22 SPO should reinforce their organizational structure through the use of more effective communication techniques. Saturn product teams schedule their own communications within and outside the group to ensure this necessity is not overlooked. Although most personnel were satisfied with the flow of information, nearly one third of SPO personnel indicated that their team was not always aware of critical issues. This could have a negative impact as the program continues through the EMD phase and more detailed decisions are required. It appears that this is a fairly isolated problem occurring sporadically, but team leaders need to be reminded of the importance of communicating all issues that affect their team and receive adequate feedback from team members to ensure that the message was received properly. Team members need to take

the responsibility for scheduling these external and internal networks of communication instead of merely relying on the team leader.

Some team members (27%) were also dissatisfied with the lack of autonomy. Team autonomy, the ability to make decisions as a result of team discussion and consensus, was not always present. This could be explained by the uniqueness of a military organization attempting to introduce the product team approach. Micro-management, or the lack of autonomy, may discourage the responsibility and commitment that comes with "ownership" of a product and ultimately undermine the team concept.

Nearly 20% of the respondents indicated that their team leader did not promote growth and training to their satisfaction. Given that the survey was distributed to a fairly well educated population, this aspect of personal development should not be overlooked. The SPO environment is, by nature, a rapidly changing environment that often consumes more than eight hours in a workday, which may account for the lack of attention given to this area. However, team leaders should be cautious of neglecting this important facet of this high technology, ever-changing climate. Individuals must also be encouraged to adopt some responsibility for their own career and training.

Although most SPO personnel are satisfied with the product team structure employed by the F-22 program office,

a significant number of comments indicated that they perceive that the contractors are not wholly committed to operating in a team structure. Although the contractors were not mandated by contract to participate in this organizational style, they were highly encouraged to align themselves with the government program office. In many cases this has been done, but government employees believe that the program could be further enhanced if the contractors were using a similar team structure.

Recommendations

The results of this research indicate that the F-22 is well on its way toward becoming a successful program. Recommendations for improvement focus on the team leadership, the team members themselves, and information flows within and between teams.

Team leaders appear to be doing a very good job in the F-22 SPO of using their teams to reach decisions. The weakness in communication appears to be causing many of the major problems. Concerns by team members who think decisions are being made by the leaders without their input, or that upper levels of management ignore team decisions, can undermine the team integrity. It is necessary for team leaders to make more of an effort to communicate to the team on the progress of crucial issues, provide the team with the management rationale behind reversed decisions, and fight

vigorously to preserve the integrity and autonomy of their team. AFMC Pamphlet 800-60R2, The IWSM Guide, provides team building techniques and advice for team leaders trying to enhance group effectiveness.

The second area of concern is with IPT members themselves. It will not be unusual in the future for product teams to be undermanned and often lacking in the technical skills or training necessary to do the best job. Team leaders cannot be solely responsible for the training and education of the team. Team members need to establish their training requirements and the technical skills required to perform their job. They need to take personal responsibility for their own careers.

The product team approach appears to be fostering "synergistic group growth," as defined by Saturn Corporation, where the team, "demonstrates a clear understanding of its goals and displays the ability of enhancing group knowledge and effectiveness" (16:14). The cross-talk between functional disciplines and the product focus are making all acquisition personnel better able to manage critical tasks and perform crucial integration functions on major weapons systems development.

The information flows within and between product teams present a challenge not only for team leaders but for every member of every product team. Saturn Corporation holds its teams responsible for "establishment and maintenance of an

effective, timely, internal and external communications system...in order to accomplish its purpose in an effective, timely manner" (16:18). These communications paths need to be formalized, regularly scheduled and utilized. Each product team member and their contractor counterpart will work together most effectively when communication is frequent and effective. Many product team members within the F-22 SPO have succeeded in formalizing communication channels through weekly teleconferencing, both video and telephone, across computer communication systems, and through face-to-face interactions. Future acquisition training and education programs should emphasize such simple communications techniques as the key to staying informed about issues within their teams and with other teams that have issues affecting their product.

Other government programs, whether using integrated product development or not, may be encountering difficulties and could benefit from recognizing the root causes of their organizations' problems and also insight into areas for possible improvement. Therefore, the researchers recommend that this survey (with minor adjustments) be provided to other product teams that are concerned with uncovering problems in the product team environment.

Statement 15 should be revised to state, "My team does not have the right amount of people to facilitate group decision-making." This would allow for the possibility that

the group has too few people as well as too many people. Also, an additional statement should be included to reveal the extent of the problem surrounding the contractors' involvement with the team. It could state, "My contractor counterparts participate in the product team structure both within their own organization and with the government."

Future Research

Opportunities for follow-on research include performing case studies of other acquisition programs that participated in the IWSM experiment. Programmatic issues presumably would differ among programs to large aircraft SPOs with different leadership styles and in different life cycle phases, but many of the organizational issues would remain the same. It would also be useful to compare non-aircraft (or smaller systems) programs for differences in management techniques. If it were practical, these follow-on case studies should also include participation by the contractors to fairly represent their role in the acquisition process and identify possible problems caused by the SPO in interacting with the contractor.

In closing, the researchers believe any product team organization can benefit from reexamination of the F-22 program following this investigation and comparison of Saturn techniques and applying the lessons learned to current and future DOD acquisitions.

Appendix: Product Team Questionnaire

In an effort to identify beneficial characteristics of product team development, we are studying product team acquisitions. Please take a minute to give us some feedback of your perceptions of product teams. Please record your responses using a #2 pencil and filling the bubbles in completely on the accompanying scanner form.

1. Your Product Team
   1. Air Vehicle
   2. Engines
   3. Support
   4. Training

2. Your status
   1. Civilian
   2. Military

3. Your grade
   1. O-2/GS-12 or below
   2. O-3/GS-13
   3. O-4,5/GS-14
   4. O-6/GM-15 or higher

4. Your sex
   1. Female
   2. Male

The remainder of the questionnaire will be scored on the following scale to the extent that you agree with each statement.

1 - Strongly disagree
2 - Disagree
3 - Somewhat disagree
4 - Neutral **Please score on scan sheet!**
5 - Somewhat agree
6 - Agree
7 - Strongly agree

5. The product team organizational structure enhances my productivity.

Comments:_____

_____

_____

_____

_____

_____

1 - Strongly disagree
2 - Disagree
3 - Somewhat disagree
4 - Neutral
5 - Somewhat agree
6 - Agree
7 - Strongly agree

Please score on scan sheet!

6. I am able to make a difference in the development of my product.

Comments: _____

7. I'm not sure how my team's effort contributes to the end product.

Comments: _____

8. My team's objectives contribute directly to the quality of the end product.

Comments: _____

9. My team seems unaware at times of the critical issues facing our product development.

Comments: _____

10. My team leader promotes growth and training among our team.

Comments: _____

1 - Strongly disagree
2 - Disagree
3 - Somewhat disagree
4 - Neutral
5 - Somewhat agree
6 - Agree
7 - Strongly agree

Please score on scan sheet!

11. My team leader makes decisions based on team discussion and consensus.

Comments:_____

12. My team leader doesn't emphasize the "systems" perspective enough.

Comments:_____

13. My team is not given enough freedom and flexibility to make decisions about our product.

Comments:_____

14. My team has the right composition of individuals to do the job.

Comments:_____

15. My team too many people to facilitate group decision-making.

Comments:_____

1 - Strongly disagree
2 - Disagree
3 - Somewhat disagree
4 - Neutral
5 - Somewhat agree
6 - Agree
7 - Strongly agree

Please score on scan sheet!

16. I enjoy working on product teams more than the previous organizational approaches to acquisition.

Comments: _____

17. I don't think product teams will result in a better end product.

Comments: _____

18. The product team approach is more responsive to customer requirements than previous organizational approaches.

Comments: _____

The questions above were areas specifically identified by the Saturn Corporation as key ingredients to having successful product teams and end product. Thank you for your cooperation.

Capt Bob "Hoot" Gibson and Ms Mary Waker

Bibliography

1. Anacona, Deborah Gladstein and David Caldwell. "Improving the Performance of New Product Teams" Research-Technology Management, 33:25-29 (March-April 1990).

2. Blanchard, Kenneth, Donald Carew and Eunice Parisi-Carew. The One Minute Manager Builds High Performing Teams. Escondido CA: Blanchard Training and Development, Inc., 1990.

3. Department of Defense Appropriations Bill, 1993. Report 102-627. 102D Congress, 2d Session.

4. Dewar, Donald L. The Quality Circle Guide to Participative Management, Englewood Cliffs NJ: Prentice-Hall Inc., 1980.

5. Gendron, George. "The Entrepreneur of the Decade," Inc., 11: 114-128 (April 1989).

6. Goodman, Paul S. Designing Effective Work Groups. San Francisco: Joey-Bass Publishers, 1986.

7. Griffin, Abbie and John R. Hauser. "Patterns of Communication Among Marketing, Engineering and Manufacturing-A Comparison Between Two New Product Teams," Management Science, 38: 360-368 (March 1992).

8. Krejele, R.V.and D.W. Morgan, "Determining Sample Size for Research Activities," Educational and Psychological Measurement, 30: 607-610.

9. Larson, Erik W. and David H. Gobeli. "Significance of Project Management Structure On Development Success," IEEE Transactions on Engineering Management. 36: 119-125 (May 1989).

10. Lefauve, Richard D. and Arnaldo C. Hax. "Managerial and Technological Innovation at Saturn Corporation," MIT Management: 13-15 (Spring 1992).

11. O'Toole, Jack and Jim Lewandowski. "Forming the Future: The Marriage of People and Technology at Saturn." Address to Stanford University, Industrial Engineering and Engineering Management students and faculty. Stanford University, 29 March 1990.

12. Personal Conversation with Digital Equipment Corporation public affairs personnel at their Portland ME manufacturing plant, March 1992.

13. Rumple, Jo Anne. "ASC Completes Snapshot of Road to TQ," The Skywriter, 2 July 1992.

14. Saleh, Shoukry D., Zengying Guo and Treat Hull. "The Use of Quality Circles in the Automobile Parts Industry," IEEE Transactions on Engineering Management, 7: 198-207 (August 1990).

15. Saturn Corporation. Company Bulletin, undated.

16. Saturn Corporation. Company Bulletin, 17 March 1992.

17. Saturn Corporation. Company Fact Sheet, 31 January 1992.

18. Schirmer, Mark H. "Others' All-Stars," Automobile Magazine, 7: 95 (January 1993).

19. Smith, Preston G., and Donald G. Reinertsen. "Shortening the Product Development Cycle," Research-Technology Management, 35: 44-49 (May-June 1992).

20. Vadnais, Scott. "QIP," Leading Edge, 34: 14-15 (July 1992).

21. Walsh, William J. "Get the Whole Organization Behind New Product Development," Research-Technology Management, 33: 32-36 (November-December 1990).

22. Wolff, Michael F. "Building High-Performing R&D Teams," Research-Technology Management, 34: 11-14 (September-October 1991).

23. -----. "Building Teams - What Works (Sometimes), "Research-Technology Management, 32: 9-10 (November-December 1989).

24. Woodruff, David; James B. Treece, and Karen Lowry. "Saturn," Business Week: 86-91 (August 17, 1992).

Vita

Captain Robert C. Gibson graduated from the United States Air Force Academy in June 1988 with a Bachelor of Science in International Relations/International Law and was commissioned a Second Lieutenant. His first assignment was with the 14th Flying Training Squadron at Columbus AFB MS. The next assignment brought him to work for the Deputy for Avionics Control in the former Acquisition Logistics Division at Wright-Patterson AFB OH. His last assignment was as an F-22 Avionics Logistics Manager specializing in systems avionics before entering the Air Force Institute of Technology. Captain Gibson also has a Masters of Science Degree in Economics from Wright State University. Following graduation, Captain Gibson will be transferring to Space Systems Center, Los Angeles AFB CA.

Permanent Address: 272 Harrison Street
Galena OH 43021

Vita

Ms Mary E. Waker graduated from Park College (Wright-Patterson AFB Residence Center) in May 1989 with a Bachelor of Science in Management with a concentration in Logistics. She has been employed at WPAFB for fourteen years in various capacities. She has spent the last nine years in the Logistics Management career field, specializing in Acquisition Logistics. She entered a rotational training program in 1984 and worked in various System Program Offices (SPO) within Aeronautical Systems Center (then Division) and several staff positions. Her first permanent assignment was in the Aeronautical Equipment SPO where she was responsible for all logistics support for Common Ground Support Equipment. In June 1991, she moved to the F-22 SPO where she was the government Integrated Product Team leader for the Digital Product Definition Data system and also responsible for all product drawings. She entered the Air Force Institute of Technology in May 1992. Following graduation, Ms Waker will return to the F-22 SPO.

Permanent Address: 1876 S. Highgate Court
Beavercreek OH 45432-1880

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1993	Master's Thesis

4. TITLE AND SUBTITLE
AN ANALYSIS OF RESEARCH AND DEVELOPMENT PRODUCT TEAM CHARACTERISTICS FOR THE SYSTEM ACQUISITION ENVIRONMENT

5. FUNDING NUMBERS

6. AUTHOR(S)
Robert C. Gibson, Captain, USAF
Marv E. Waker, GS-12

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Air Force Institute of Technology, WPAFB OH 45433-6583

8. PERFORMING ORGANIZATION REPORT NUMBER
AFIT/GLM/LAS/93S-20

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
The focus of this thesis was on product team characteristics in the systems acquisition environment. This research investigated the characteristics of the Saturn Corp product team organizational structure and also reviewed literature relevant to this area. The characteristics identified by Saturn that contribute to the success of their product team were incorporated into a product team effectiveness survey and administered to personnel in the F-22 System Program Office (SPO) located at WPAFB. The results of the F-22 SPO survey were then compared to the Saturn product team characteristics in order to identify achievements and possible weaknesses. Overall, it appears that the F-22 SPO is a thriving organization with all the attributes required to produce an end product designed to meet the needs identified by the users. Although the majority of survey respondents agreed that they are able to influence the design, development, and supportability of their team's product, there are several areas that could be enhanced. Areas identified for improvement are communication, training, team autonomy in the decision-making process, and contractor involvement in the product team concept.

14. SUBJECT TERMS
Management Theory, Organization, Performance (Engineering), Teams

15. NUMBER OF PAGES
83

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

AFIT Control Number AFIT/GLM/LAS/93S-20

AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. Please return completed questionnaires to: DEPARTMENT OF THE AIR FORCE, AIR FORCE INSTITUTE OF TECHNOLOGY/LAC, 2950 P STREET, WRIGHT PATTERSON AFB OH 45433-7765

1. Did this research contribute to a current research project?

a. Yes b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?

a. Yes b. No

3. The benefits of AFIT research can often be expressed by the equivalent value that your agency received by virtue of AFIT performing the research. Please estimate what this research would have cost in terms of manpower and/or dollars if it had been accomplished under contract or if it had been done in-house.

Man Years _____ $ _____

4. Often it is not possible to attach equivalent dollar values to research, although the results of the research may, in fact, be important. Whether or not you were able to establish an equivalent value for this research (3, above) what is your estimate of its significance?

a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

5. Comments

_____ _____

Name and Grade Organization

_____ _____

Position or Title Address

DEPARTMENT OF THE AIR FORCE
AFIT/LAC Bldg 641
2950 P St
45433-7765

OFFICIAL BUSINESS

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 1006 DAYTON OH

POSTAGE WILL BE PAID BY U.S. ADDRESSEE

Wright-Patterson Air Force Base

AFIT/LAC Bldg 641
2950 P St
Wright-Patterson AFB OH 45433-9905