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AIR COMMAND AND STAFF COLLEGE

STUDENT REPORT

ORGANIZATION STRUCTURE AND
TECHNOLOGICAL INNOVATION
IN THE AIR FORCE

MAJOR THOMAS J. BARTOL 85-0165

"insights into tomorrow"

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TITLE ORGANIZATION STRUCTURE AND TECHNOLOGICAL INNOVATION IN THE AIR FORCE

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Technology is an important determinant to success on the modern battlefield and is of particular importance to aerospace forces. This study analyzes the relationship between organization structure and technological innovation and addresses whether organization structure can enhance the integration of new technology into Air Force weapons systems. Focusing on the organizations which acquire Air Force weapons systems, the study concludes organization structure can positively affect adoption of new technology in the Air Force.

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PREFACE

This study was prepared to fulfill the Air Command and Staff College's requirement for a staff problem solving project. As a research associate to the Leadership and Management Development Center (LMDC), I prepared this document in the format best suited to LMDC and specified in an LMDC/AN letter, 30 October 1984, subject "SPS Projects." Hence, there are numerous deviations from the standard Air Command and Staff College study format, the more obvious being a double-spaced final product and the method of documenting source material. However, LMDC generally follows the American Psychological Association (APA) format which is familiar to most researchers.

I faced a significant challange in satisfying the potential audiences for this project. First, LMDC sponsored this endeavor and may use it to further their organizational objective of enhancing effectiveness and productivity within the Air Force. Second, staff problem solving projects are an important part of the Air Command and Staff College's curriculum and are evaluated as such. Finally, the study may be provided to Air Force staff and line agencies interested in organization structure and technological innovation. Clearly the above audiences require different approaches to the presentation of research. I have

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compromised and provided some detail and technical information for the potential researcher, while providing background information and interim conclusions for those less familiar with organization management theory and weapons systems acquisition in the Air Force. For those desiring more information on specialized areas, the source material is available at most university-equivalent libraries.

I selected the topic of organization structure and technological innovation because of prior academic work at Purdue University's Krannert Graduate School of Management. While enrolled in the Strategic Management portion of the M. S. in Management program, I concentrated on the management of technology. This study is a natural continuation of previous education and focuses where technology can further our ability to meet national security objectives--in military weapons systems.

ABOUT THE AUTHOR

Major Thomas J. Bartol is an Air Force civil engineering officer with a background in base civil engineering and intercontinental ballistic missile (ICBM) engineering. He comes from an Air Force family and graduated from the U. S. Air Force Academy in 1972 with a Bachelor of Science in Civil Engineering. At the Academy, he was Chairman of the Cadet Professional Ethics Committee during his final year. Upon graduation, he served two assignments in base civil engineering squadrons. Following Squadron Officer School in residence in 1976, Major Bartol was assigned as an engineer for the Space and Missile Systems Organization detachment at Whiteman Air Force Base, Missouri as a developmental engineer in the modernization of the Minuteman missile weapons system. In 1979, he attended Purdue University and graduated from the Krannert Graduate School of Management with a Master of Science in Management. Enrolled in Krannert's Strategic Management option, Major Bartol specialized in the management of technology. His work at Purdue resulted in his membership to Beta Gamma Sigma, the national scholastic honor society in business and administration. Immediately prior to Air Command and Staff College, Major Bartol was assigned to the Pentagon as an Air Staff action officer in the Directorate of

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Engineering and Services. He was responsible for providing environmental support to the Special Assistant for ICBM Modernization and worked on the Peacekeeper (M-X) and small missile programs.

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REPORT NUMBER 85-0165

AUTHOR(S) MAJOR THOMAS J. BARTOL, USAF

TITLE ORGANIZATION STRUCTURE AND TECHNOLOGICAL INNOVATION IN THE AIR FORCE

I. Purpose: To determine if organization structure can enhance the integration of new technology into Air Force weapons systems.

II. Project Framework: The Air Force is dependent upon technology to ensure we can meet our national security objectives. Acquisition of new weapons systems is expensive and a significant portion of the Air Force budget. However, organizational changes which could possibly increase our capability to meet acquisition goals are relatively inexpensive. Through an analysis of organization structure and technological innovation, the study presents characteristics of organization's likely to innovate. Next, the project addresses technology and organization structure in the Air Force and looks at some selected Air Force Systems Command organizations. The report ends with project conclusions.

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III. Discussion of Analysis: The study approach was developed in response to the problem statement, "Can organization structure enhance the integration of new technology into Air Force weapons systems?" In order to resolve this problem, the first step is to determine the relationship between organization structure and technological innovation. From a review of innovation research, the most appropriate case for this analysis was a study in the health care industry by John Kimberly and Michael Evanisko in 1981. The study, "Organizational Innovation: The Influence of Individual, Organizational, and Contextual Factors on Hospital Adoption of Technological and Administrative Innovations", provided empirical evidence of a correlation between organizational variables and adoption of technology into an organization. The second step in the study approach was to determine if recognition of the above relationship can affect integration of technology into Air Force weapons systems. The analysis examined the structure of Air Force organizations responsible for acquisition of weapons systems and reviewed the procedures for weapons systems acquisition to determine how the Air Force acquires new technology. It was determined that most program offices are organized in the matrix organization

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structure. Finally, a review of acquisition procedures revealed the Air Force can influence the organization structures of appropriate aerospace contractors involved in Air Force projects.

IV. Conclusions: The overall conclusion of the study is that the problem statement, "Can organization structure enhance the integration of new technology into Air Force weapons systems?" is affirmative. The conclusions leading to determination of the problem statement are that organization structure enhances technological innovation and recognition of the above relationship can affect technology integration into Air Force weapons systems.

V. Recommendations for Future Research: This study would be complemented by future research into two areas. First, it would be beneficial to determine the innovation climate in the Air Force. This research would investigate whether the military institution discourages innovation. The second recommended future research issue is a study of how military contracts affect defense contractors. It would be productive to determine the organizational character of companies involved in defense-work versus those in the purely private sector and draw conclusions on the resulting tendency for technological innovation.

CHAPTER I

INTRODUCTION

Purpose

This project analyzes the relationship between organization structure and technological innovation and focuses on whether knowledge of this relationship can enhance the integration of new technology into Air Force weapons systems. In a speech to the Air Force Association in September 1983, Secretary of Defense Casper Weinberger stated, "I have noted the first two crucial elements of America's military airpower: our people and our technology. The third is more difficult to describe. But we never could have taken to the air without the element of imagination." (Weinberger, 1983, p. 99) This paper addresses two of the above three elements of aerospace power outlined by Secretary Weinberger--technology and imagination. The project is tied to an on-going series of studies conducted by the Air Force Leadership and Management Development Center (LMDC) at Maxwell Air Force Base, Alabama. As related in a 1984 LMDC study, A Field Study of Air Force Organization Structures, (Conlon, Daft, Austin, and Short) Headquarters United States Air Force had requested research assistance in the area of organization structures. A 4 December 1981 letter from Headquarters USAF/MPMO stated, "The Air Force does not have a capability to make an objective, a priori comparison of the advantages and disadvantages of alternate techniques of organizing and utilizing people to accomplish mission requirements." (Cited in Conlon et al., 1984, p. 3) Previous LMDC research focused on several portions of the organizational structure issue. These include studies on the matrix form of organization structure and "non-traditional" organization structures. Having a background in organizational management, and, in particular, the management of new technology, I discussed with LMDC their interest in sponsoring a project relating organization structure and technological innovation. Approval was granted in October 1984 to proceed with this study as an adjunct to the above LMDC research effort.

Overview

This study is organized into two major areas. First, the report addresses a literature search and analysis of the relationship between organization structure and technological innovation. This portion is provided in Chapter II. Second, the report looks at technology and organization structure in the Air Force. Chapter III addresses the second major area. The paper ends with conclusions in Chapter IV.

The above organization flows from the logic in resolving the the problem statement, "Can organization structure enhance the integration of new technology into Air Force weapons systems?" In order to resolve this problem, the first step is to determine the nature of the relationship between organization structure and technological innovation. Assuming empirical evidence exists correlating organization structure and technological innovation, the second step is to determine if knowledge of the above relationship can enhance integration of technology into Air Force weapons systems. This will be accomplished by reviewing the procedures for weapons systems acquisition to determine how the Air Force acquires new technology and examining the structure of Air Force organizations responsible for integrating technology into weapons systems. Finally, the problem statement is affirmative given empirical evidence that organization structure enhances technological innovation and that recognition of the relationship between organization structure and technological innovation can effect the integration of new technology into Air Force weapons systems.

Project Framework and Significance

The significance of this project is that the Air Force is increasingly dependent on technology to meet national security objectives. As depicted in the September 1984 issue of

Defense 84, $102 billion of the 1983 Department of Defense budget was appropriated for procurement and research, development, test, and evaluation purposes. This expenditure represented 43 percent of the total defense budget. New technology is of particular importance to aerospace forces. Air Force Manual 1-1, Basic Aerospace Doctrine, 16 March 1984, addresses the technology issue as follows:

> The challenge is to equip today's forces sufficiently while developing the aerospace forces to fight and win tomorrow's war. The capability to win tomorrow's war demands that Air Force research and development efforts must not only exploit new technologies, they must also push the limits of technology to discovery and breakthrough. (AFM 1-1, 1984, p. 4-9)

The above significance provides the framework for this project. Without digressing into a detailed study of the future direction of aerospace warfare, clearly we will continue to push the limits of the lower atmosphere outward into space. This biophysically hostile environment will demand further reliance on technology as we posture our aerospace forces to meet our future national security objectives.

Figure 1 graphically depicts the framework from which this project was developed. Winning tomorrow's war depends on technology. Technology is only one of several determinants of battlefield success and technology itself is a function of several factors including financial resources, personnel, and organization. Moreover, any contribution from an organizational management perspective to our objective of ensuring the latest technology for Air Force weapons systems is relatively easy and inexpensive with respect to today's research and development expenditures. In summary, it is recognition of the relationship between organization structure and technological innovation from which this project can possibly assist future Air Force warfighting capabilities.

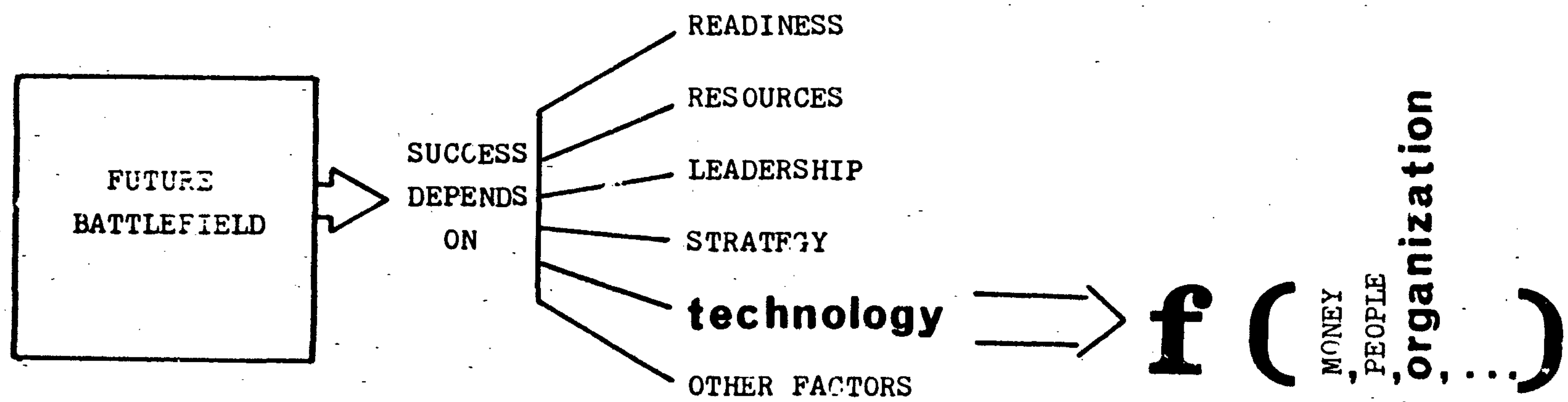

Figure 1. The Framework

CHAPTER II

ORGANIZATION STRUCTURE AND TECHNOLOGICAL INNOVATION

Introduction

This chapter provides the foundation for the study and addresses the relationship between organization structure and technological innovation. The early part of the chapter presents background on organization theory, organization structure and design, and technological innovation. Next, the body of the chapter discusses the relationship between organization structure and technological innovation and analyzes research in the health care industry on the influence of individual, contextual, and organizational factors on technological innovations. The chapter ends with an analysis of the above relationships.

To set the context for this chapter, the structure of an organization is an important tool for managers, particularly when facing new technologies or changing strategies. As Peter Drucker wrote in _Management: Tasks, Responsibilities, Practices_:

> A business should always analyze its organization structure when its strategy changes. Whatever the reason--a change in market or in technology, diversification or new objectives--a change in

strategy requires a new analysis of the key activities and an adaptation of the structure to them. (Drucker, 1974, p. 532)

Another contextual factor possibly affecting technological innovation within organizations involves the size of the organization itself. Large organizations are required to accomplish much of the research involving sophisticated weapons systems. This is necessary in order to effectively utilize the large amount of resources required to develop, test, and produce technologically complex systems. However, it is generally accepted that these same large organizations foster resistance to change. In other words, large organizations are needed to integrate new technology into complex systems, however their institutionalized nature provides barriers to change. Analysis of empirical research relating structure and innovation follows.

Background

Organization Theory

A thorough presentation of organization structure must include a brief discussion of organizational management. As previously explained, structure can be a tool for the manager to meet organization goals. However, there are many other tools included in a manager's organizational toolkit. These include job design, reward systems, group and individual behavior, control and feedback mechanisms, and organizational strategies.

This report focuses solely on organization structure, but all organizational management factors are interdependent. It is clear that an organization's structure as a single factor cannot accomplish organization tasks, however the poorly designed structure can put serious barriers into an organization and prevent accomplishment of organization goals and objectives.

Organization structure is defined as the way organizations are segmented into units and the pattern of relationships among the units. (Author's notes, AS 681, 1979) There are four commonly accepted structures in organizing for innovation. First, a product organization is structured around an organization's product lines. For example, Proctor and Gamble may have several divisions each involved in research, development, production, and marketing a single product. Within a product organization structure there might be a toothpaste division, soap division, and numerous other groups representing product lines. A second structure is project management, in which the organization structure normally follows a project from design to completion. In the military, organizations responsible for major new construction initiatives use project management structures. In a typical construction company, a project management organization would be formed to supervise all activities for a large project. The organization would disband upon completion of the project. The third structure is organization by scientific discipline. These structures are often used in basic research, for example in research laboratories or colleges and universities. A typical college of science would contain, among others, biology, chemistry, and physics departments. The newest structure is matrix organization. Matrix organizations contain two lines of responsibility. In a typical matrix organization, groups or individuals would be responsible to a project chief while also representing a scientific discipline. I worked in a matrix organization in 1977 while assigned to the Air Force's Space and Missile Systems Organization. As a project engineer, my team of five engineers was responsible for all engineering activities at a Minuteman missile flight consisting of one launch control center and ten launch facilities. Our team had representatives from various engineering disciplines. However, all the team engineers also reported to chief engineers of their particular discipline. More recently, hybrid organization structures have been developed which go beyond matrix structure and are normally tailored to a particular organizational requirement.

A final definition is organization design. Organization design is determining and developing the most effective structure for a set of units or an organization as a whole. (Author's notes, AS 681, 1979) The design function normally involves manipulating three factors: aggregation, intraunit relationships, and interunit relationships. Of course, the objective of any organization design effort is to match the structure for the most efficacious means to meet the organization's goals and objectives.

Organization Structure and Design

One milestone in organization structure theory occurred in 1967 with Lawrence and Lorsch's publication of Organization and Environment: Managing Differentiation and Integration. This classic work advanced a contingency theory of organization structure in which there was a need to fit the organization to its several external environments. Differentiation, which is the analysis of external environmental conditions and their resultant responses, and integration, which involves the coordinated internal interactions, must be balanced for successful organizational performance. An application of this approach was presented in a Gerstenfeld and Sumiyoshi article (1980) titled, "The Management of Innovation in Japan--Seven Forces That Make the Difference", which stated:

> Integration and differentiation are recognized as necessary for effective organizations and these appear well balanced in Japan while in the United States the differentiation rather than the integration is often emphasized. It is more common in the United States that the differentiation portion of the formula is much more dominant, and indeed adversary relationships continually exist particularly between marketing and R & D. (Gerstenfeld and Sumiyoshi, 1980, p. 31)

A later approach to organization structure is the Galbraith framework presented in the LMDC study (Conlon et al.) in 1984. The major determinant in this framework is the organization's strategy and resulting elements of goals and objectives, environment, human resources, and technology. Without a review of the original Galbraith work, it appears the framework is one of constraints imposed by the above four elements and resulting strategy. This appears as another contingency approach to organization structure.

This author's approach to organization structure and design is information-based. In other words, the single most important determinant to organization structure is the information processing needs of the individuals and groups assigned to the tasks. Following this logic, organizations should be structured to facilitate the required information flow both into and out from the individuals/groups which make up the work units. For example, work which demands extensive coordination requires an organization structure that provides easy access to information from other work units. However, the information needs of an assembly line worker are minimal and a highly structured organization is most appropriate. This approach is also a contingency approach as differing information needs require different responses. Maruta, in a 1980 Research Management article titled, "The Management of Innovation in Japan--The Tetsuri Way", wrote that successful innovation in one Japanese laboratory resulted from a organization which put all disciplines of professionals into an open space to encourage and facilitate information flow. The professionals were free to speak out and communicate when necessary.

Technological Innovation

This section begins with a definition of technological innovation. James Bright states technological innovation as:

> A unique chronological process involving science, technology, economics, entrepreneurship, and management is the medium that translates scientific knowledge into physical realities that are changing society. This process of technological innovation is the heart of the basic understanding which the competent manager, the effective technologist, the sound government official, and the educated member of society should have in the world of tomorrow. (Bright cited in Twiss, 1980, p.1)

The importance of technology in today's society is well documented. Additionally, technology is developing at an increasing rate. In a 1979 article, "Stimulating Technological Innovation--Nurturing the Innovator", Merrifield wrote, "Moreover, 90% of our knowledge in the sciences has been generated in the last 40 years, and much of that in the United States". (Merrifield, 1979, p. 12) In the U. S. military, reliance on qualitative superiority of our forces and equipment is a basic tenet of our strategy. Secretary of Defense Weinberger stated, "Overall the Soviets outnumber us two to one in tactical aircraft; yet the United States, faced by a potential adversary with far larger ground forces, relies heavily on high-quality air support to redress the military balance." (Weinberger, 1983, p. 99) This concept is also captured in Air Force doctrine. As written in Air Force Manual 1-1, Basic Aerospace Doctrine (1984):

> Providing this force involves selecting reliable systems, in adequate numbers, and with the capability to survive and be maintained in all combat environments. National military objectives describe this as developing a strong force prepared to "fight at whatever level of intensity necessary and for as long as necessary to ensure that the US postwar position is superior to that of any adversary." (AFM 1-1, 1984, p. 4-8)

Who are the technological innovators? Most research relates innovators in the private sector with entrepreneurial qualities. Roberts of the Massachusetts Institute of Technology (cited in Twiss, 1980, p. 15) showed the characteristics of technical entrepreneurs as:

1. 50 percent came from homes where the father is self-employed
2. well-educated
3. early thirties
4. developmental oriented rather than research oriented.

James Brian Quinn, in his article, "Technological Innovation, Entrepreneurship, and Strategy", wrote "To solve the world's problems, we need innovation on a large scale. Our only hope is to make room for the inventive approaches of entrepreneurs in our large organizations." (Quinn, 1979, p. 73) Quinn relates that entrepreneurial innovation has historically been responsible for meeting new human needs. According to Quinn, some of the more important factors that allow entrepreneurs to succeed while others fail are summarized below:

1. Fanaticism/Commitment. Large organizations typically second-guess non-traditional ideas and personnel pressures discourage any form of aberrant behavior. In some cases, individuals need to pursue their ideas in a fanatical way with total commitment.

2. Chaos acceptance. Many innovators are terribly disorganized and enjoy the chaos of development. Moreover, progress is not hampered by fear of failure or control systems which require lengthy justification and explanation of failures.

3. No detailed controls. Early estimates and projections for markets and products are frequently wrong and seldom justify further pursuit. For example, initial market estimates repeatedly indicated a requirement for only 5,000 xerographic machines and a total computer market of 300 units. (Quinn, 1979, p.73)

Quinn further advocates that large firms can be innovative, but current approaches stifle creativity. Some of the well-documented examples of innovative large organizations are IBM, Xerox, 3M, and AT&T's Bell Laboratories. Common factors in the successes of these corporations were strong incentives for successful development, longer-term time horizons, multiple competing approaches, and committed product champions.

In Managing Technological Innovation, Twiss (1980) presented factors from highly creative scientists which enhanced creativity in their organizations. The top four factors which were positively correlated with creativity were:

1. Freedom to work on areas of greatest interest
2. Recognition and appreciation
3. Broad contacts with stimulating colleagues
4. Encouragement to take risks.

The factors which least enhanced creativity were:

1. Creativity training programs
2. Criticism by supervisors
3. Regular performance appraisals. (Twiss, 1980, p. 74)

In summary, the body of literature on technological innovation appears to agree on several factors. While large organizations can afford the resources necessary to perform complex technological research, often the climate and environment for producing innovative work exists in smaller entrepreneurial enterprises.

Relationship Between Organization Structure and Technological Innovation

Multiple Approaches

While previously addressing multiple organizational factors influencing technological innovation, this section focuses on organization structure. In Productivity, Technology, and Capital, Gold (1979) relates numerous elements of Japanese success in advancing technology. A dominant organization structure factor was fewer interdepartmental barriers. Interunit integration was emphasized and loyalty to overall corporate identities was much higher than to departmental units. Another view is from a RAND Corporation study, "Introducing Technological Change in a Bureaucratic Structure", by Hoffman and Archibald (1968). This paper advocated the task force approach to organization structure. "The extent that recommendations are likely to be implemented and innovative ideas generated and acted upon is undoubtedly a function of meaningful, individual participation in the change process." (Hoffman and Archibald, 1968, p. 30) Another study of technological success in Japan also emphasized the task force approach. In a chemical research group, (Maruta, 1980, p. 41) the study concluded, "Thus we believe in an informal and flexible organization which is able to mobilize the collective knowledge of the staff."

Robert Prochaska, in an article "The Management of Innovation in Japan--Why It Is Successful", (1980) provides a slightly different view from the task force approach. However, a similar idea is more participation in decision-making. Prochaska states the fundamental difference in organization and decision-making in Japan is that Japanese companies are organized from the bottom up. American companies are organized from the top down, with decision-making power concentrated at the top. Decisions tend to come down from the power at the top with "Yes" and "No" answers. "In contrast, the Japanese system is based on consensus where the consensus decision must work from the bottom up." (Prochaska, 1980, p. 38)

The Kimberly and Evanisko Study

In 1981, John Kimberly and Michael Evanisko published an article, "Organizational Innovation: The Influence of Individual, Organizational, and Contextual Factors on Hospital Adoption of Technological and Administrative Innovations", which examined the combined effects of certain variables on adoptions of innovation in the medical care industry. Of particular note, the study focused on adoption of technological innovation, which is a good fit to the case of integration of technology into Air Force weapons systems. This is because the vast majority of Air Force technological integration is accomplished through management of contractors who provide goods and services. The details of how technology is actually integrated into Air Force weapons systems is presented in Chapter III. Most existing research of organization management and technological innovation focuses on new product development, which is of immense interest and importance to the private sector. However, it is difficult to correlate new product development and the subsequent market share/product life cycle approach for new technology to Air Force weapons systems development. The Kimberly and Evanisko study can reasonably be compared to an Air Force case due to the adoptive approach to technological innovation.

Secondly, the above study has an organizational focus. In the conceptual overview, the article states, "Of interest here is innovation in the context of organizations." (Kimbarly and Evanisko, 1981, p. 690) The authors agree there has been an immense amount of attention given to the subject of technological innovation. However, there is little agreement at an empirical level. "Despite--or perhaps because of--the involvement of a diverse group of researchers, results at the empirical level often are noncomparable and occasionally contradictory." (Kimberly and Evanisko, 1981, p.689)

The purpose of the Kimberly and Evanisko study was to examine the combined effects of individual, organizational, and contextual variables on organizational adoption of innovation. Two types of innovation were addressed--administrative innovation and, of importance to this paper, innovation directly related to an organization's core technology. The study examined the variables ". . . across a large number of organizations with the objective of moving toward a more comprehensive treatment of organizational innovation. . ." (Kimberly and Evanisko, 1981, p. 691) The measure of technological innovation was based on responses by hospitals regarding the presence or absence of 12 new developments in the health care industry. The innovations were chosen from an inventory of 300 items suggested by a group of 15 individuals randomly selected from a panel of 75 leading experts.

The authors research strategy was to use a number of bivariate hypotheses for variables that had previously been found to be significant to innovation adoption. Subsequent to the hypotheses development, they examined the relationships in a multivariate environment using the technological and administrative innovations as dependent variables. The result was an informed, comparative study.

> This strategy was thus informed by previous research, was deliberately designed to include individual, organizational, and contextual factors, and was intended to capitalize on the advantages of comparative research. It thus was neither purely deductive nor purely inductive, the primary interest being to develop a more comprehensive set of analyses of innovation adoption than had previously been available in the literature. (Kimberly and Evanisko, 1981, p. 691)

The Kimberly and Evanisko study used three clusters of predictors for adoptive innovation behavior--characteristics of organizational individuals, characteristics of contexts, and characteristics of the organizations. This analysis focuses on the organizational variables.

The five organizational variables were centralization, specialization, size, functional differentiation, and external integration. Centralization refers to the degree in which decision-making is delegated to lower levels of an organization. For example, a highly centralized organization retains authority and power at the upper levels of the organization structure. Specialization addresses the number of different specialties or occupations within an organization. For example, in the Air Force, a highly specialized organization would be one that contained only engineers. A low degree of specialization increases the number of specialists and, possibly, increases the need for coordination and control mechanisms at the work-unit level. Size represents a comparison of how large an organization is relative to other units which are in the same field or accomplish similar tasks. Functional differentiation refers to the extent an organization is divided into subunits with similar functions. A highly differentiated organization contains numerous work units which normally create multiple interest groups. Finally, external integration addresses the mechanisms in an organization which successfully allow information to be communicated to the work units. A highly integrated organization normally can quickly assimilate and transmit information to the applicable work unit.

Interestingly, all of these organizational variables are related to organization structure and can be exploited in the design of an organization. The five hypotheses were:

1. Centralization is negatively related to the adoption of technological innovations.

2. There is a positive relationship between specialization and adoptive innovation.

3. Size is positively related to adoption.

4. Functional differentiation is positively related to adoption of technological innovations.

5. There is a positive relationship between external

integration and adoptive innovation.

The hypothesis with regard to size deserves additional explanation. In this study, size refers to the overall organizational unit, for example, the total number of employees. Kimberly and Evanisko present rationale for two commonly accepted views that size is positively correlated with innovation adoption. First, increasing size facilitates adoptive behavior because ". . . size creates a critical mass which justifies the acquisition of particular innovations." (Kimberly and Evanisko, 1981, p. 699) A second view is that size necessitates adoptive behavior because it is a way to rationalize and coordinate organizational activities. Kimberly and Evanisko only briefly suggest that size may be negatively related to innovation. However, there is a considerable body of literature which contradicts the Kimberly and Evanisko size hypothesis, not the least of which is the entrepreneurial approach to technological innovation.

The actual analysis of the above organizational hypotheses was divided into two parts. This was performed in the context of the bivariate hypotheses in which the relationships were examined in a multivariate environment using the technological and administrative innovations as dependent variables.

> Eight multiple regression equations were estimated to assess the effects of predictor variables both within and across classes. The first six regressions examine the effects of individual, organizational, and contextual variables separately on technological innovation and then on administrative innovation. The

final two examine the combined effects of all variables on the two types of innovation. (Kimberly and Evanisko, 1981, p. 702)

The final two equations referenced above, in effect, determine the relative significance of each of the variables. The results are shown in Table 1. The other part of the analysis addressed the effects of the individual, organizational, and contextual variables on the two types of innovation separately. This report focuses on the organizational variables. The results of this portion of tho analysis are shown in Table 2.

From Table 2, the results of the regression show organizational level variables account for 62 percent of the variance in technological innovation. By contrast, and in conflict with many non-empirical studies of technological innovation, individual variables (such as tenure, cosmopolitanism, and educational level) account for only 21 percent of the variance. In many studies, individuals, particularly innovation product champions, are presented as major contributors to technological innovation. For example, James Brian Quinn concludes that one successful factor found in innovative firms is committed champions such as IBM's Chairman Vincent Learson. Learson encouraged groups to compete against each other to bring forward successful designs. "At one time it was difficult to find a successful major IBM innovation that originated in formal product planning rather than this championship process." (Quinn, 1979, p. 80) Contextual variables

TABLE 1

Correlations Among All Variables
(Relative to This Study)

(N = 210)

Variable	1	2	3	4	5	6	7
1. Technological Innovation	-						
2. Administrative Innovation	.42	-					
3. Centralization	-.38	-.13	-				
4. Specialization	.70	.46	-.32	-			
5. Size	.69	.52	-.30	.75	-		
6. Functional Differentiation	.70	.47	-.29	.72	.77	-	
7. External Integration	.55	.37	-.33	.62	.58	.58	-

(Note: The total analysis involved 19 variables. The organizational variables had significantly higher correlations on both types of innovation than the contextual or individual variables.)

(Partial table from Kimberly and Evanisko, 1981, p. 703)

TABLE 2

Regression of Technological Innovation

on

Organizational Variables

Variable	Beta	SE
Centralization	-.14 **	.046
Specialization	.17 *	.082
Size	.34 ***	.091
Functional Differentiation	.19 *	.076
External Integration	.10	.058

$R^2 = .62$

* $p < .05$

** $p < .01$

*** $p < .001$

(Partial table from Kimberly and Evanisko, 1981, p. 704) (competition, size of city, age of hospital) account for 30 percent of the variance. From Table 2, Kimberly and Evanisko interpret the results of the organizational variables on technological innovation as, "The pattern and strength of the relationships reveal that high adopting hospitals tend to be large, are specialized, are highly differentiated, and have a tendency for decisions to be made near or at the level of department heads." (Kimberly and Evanisko, p. 705) Four of the five organizational variables were significant predictors of technological innovation. The strongest predictor was hospital size and there was a positive relationship between hospital size and adoption of technological innovations. Specialization, centralization, and functional differentiation were determined also to be positively correlated with adoptive innovation.

The Kimberly and Evanisko study concludes with three primary points. The first two conclusions, not the primary purpose of this paper but indirectly related, are:

1. Variables used in the study are much better predictors of technological innovation than administrative innovation.

2. Adoption of the two types of innovation were not influenced by the same sets of variables.

However, the last conclusion was that the organizational variables utilized were much better predictors of innovation than the individual or contextual variables used in the study. In conclusion, the study reported:

> In the case of technological innovations, the only nonorganizational level variable that emerged as a significant predictor was the age of the hospital, which had been conceptualized as a contextual variable. And in the case of administrative innovation, the only significant nonorganizational level predictor was the cosmopolitanism of the hospital administrator, although the educational level of the hospital administrator approached significance. Although it was anticipated that organizational level variables would play a role in predicting innovation, their empirical dominance was not expected. (Kimberly and Evanisko, 1981, p. 709)

Conclusion

There are two significant conclusions from the above analyses of technological innovation. The first, and most important, is that organization structure is important. Organization structure can affect technological innovation. The Kimberly and Evanisko research provides empirical evidence of a correlation between organizational variables and adoption of technology into an organization. The second significant conclusion is that organizations likely to adopt new technology tend to be large, specialized, highly differentiated, and decisions are made at or near the department level. The four variables shown to be significant in the multiple regression analysis all can be manipulated in the design of an organization. While the Kimberly and Evanisko study is a single research point, the study appears to be a good fit when compared to the Air Force as a parallel. Both organizations have institutional frameworks and are less product and marketing oriented than most organizations depicted in research on technological innovation. Both organizations are primarily non-profit based. In the case of adoption of technology into hospitals, the focus is on health care. The Air Force focus, of course, is national defense. Finally, the Kimberly and Evanisko study centered on adoption of technology. This is comparable to the integration of technology into Air Force weapons systems.

In summary, the conclusion is that empirical evidence exists that organization structure and technological innovation are related.

CHAPTER III

TECHNOLOGY, ORGANIZATION, AND AIR FORCE WEAPONS SYSTEMS

Introduction

This chapter analyzes technology and organization structure in the Air Force. The purpose is to determine if application of the knowledge of the relationship between organization structure and technological innovation can enhance integration of technology into weapons systems. This is accomplished by first addressing the need for technology in Air Force weapons systems followed by a look at how technology is acquired and developed by the Air Force. The second portion of the chapter presents technology in the organizational context. After covering Air Force organization policy, the chapter examines the structure of organizations responsible for acquisition, development, and procurement of weapons systems.

Technology is an important part of the United States' defense strategy. Secretary of Defense Weinberger, in Defense 84 (October 1984), presented the four components of our total combat capability. Following a discussion on readiness, Secretary Weinberger wrote:

> The other three components are: force structure--the number of air wings, divisions, and ships in the armed forces; modernization--the equipping of this force structure with **more technically sophisticated and capable weaponry and facilities**; and sustainability--the staying power of our forces. . . (Weinberger, 1984, p.4) (emphasis added)

This chapter expands on our defense strategy of qualitatively superior forces by linking technology and organization to Air Force weapons systems.

Technology and Air Force Weapons Systems

The Need for Technology

Technology is an important factor in the Air Force's ability to accomplish our mission. As related by the former commander of Air Force Systems Command, General Robert Marsh, in an Air Force magazine (August 1984) article:

> For more than three decades now, the United States has relied upon its qualitatively superior weapons systems to deter aggression. In effect, we have relied upon our technological and industrial superiority to offset the numerical advantages enjoyed by our adversaries. (Marsh, 1984, p. 42)

General Marsh continues in this article to state our strategy of using our technology to deter our enemies continues, but the threat we face has changed. In other words, our technological superiority has been eroding since the 1970's. For example, in 1975 we had an approximate ten- to twelve-year lead over the

Soviet Union in microelectronics and computers, while today that lead has slipped to three- to five-years. Another requirement for technology comes from a critical U. S. national defense objective of maintaining a credible and capable nuclear deterrence force. This deterrent force is accomplished through the nuclear triad of manned bombers, sea-launched ballistic missiles, and land-based intercontinental ballistic missiles. The United States strategic triad has deterred the Soviets for more than thirty years and is based on the diversity of the three elements. A primary purpose of this triad is to prevent a single technological breakthrough from crippling more than one leg of the triad and damaging our deterrent strategy.

Surprisingly, some of the emphasis on technology and qualitative forces is not backed by Air Force resource allocation. General Marsh in Air Force magazine (August 1984) presents the story of Air Force research and development expenditures since 1965. In 1965, the Air Force spent approximately 2.5 percent of the total Air Force obligation authority on basic research and exploratory development. In fiscal year 1984, the technology base funding had decreased to 0.8 percent of the total obligation. In fact, addressing the technology base expenditures in 1965 dollars shows a decrease from $400 million in 1965 to approximately to $200 million today.

Despite the reduced funding levels for technology base, the Air Force must continue to invest in future technologies. In an Air Force magazine article by senior editor John Correll (August

1983), General Marsh stated, "Closer to home, one finds that the Air Force is losing its traditional role of technological leadership among the services." (Correll, 1983, p. 39) The Air Force has fallen behind other services and even the Department of Defense's Defense Advance Research Projects Agency (DARPA) in funding for basic and applied research. The former Commander of Air Force Systems Command further stated, ". . . the most technically advanced service cannot afford to mortgage its future through inadequate attention to the maintenance of a viable weapons technology base." (Correll, 1983, p. 39)

The Air Force Systems Command Technology Planning Guide (1980) states two planning objectives that clarify our technology planning goals. The first objective is to assure technological superiority through exploiting technology opportunities and advancing knowledge in scientific disciplines. The second objective is to avoid technological surprise. In concluding the need for technology in Air Force weapons systems, the Aeronautical Systems Division's Blueprint for Tomorrow related the importance of the United States's aerospace industry. This 1984 joint Air Force and industry assessment of the aerospace industrial base explained:

> There is probably no other industry in the world which both develops and applies the diversity of high technology as well as the U.S. aerospace base. . . . This high technology base provided by the aerospace industry is a highly valued national resource. (U.S. Air Force, 1984, p.6-4)

While it could be argued that any self-assessment would praise itself, in 1982 the U.S. aerospace industry contributed a surplus $11.2 billion in trade during a year which the U.S. balance of trade deficit was $35.2 billion (U.S. Air Force, 1984). This is a significant contribution toward reducing the negative economic impacts associated with a balance of trade deficit.

The Integration of Technology

Within the Air Force, Air Force Systems Command (AFSC) is responsible for the research, development, and acquisition of Air Force weapons systems. As related in the annual almanac issue of Air Force magazine (May 1984), "The primary mission of Air Force Systems Command (AFSC) is to advance aerospace technology, apply it to operational aerospace systems development and improvement, and acquire qualitatively superior, cost-effective, and logistically supported aerospace systems." (Air Force Systems Command, 1984, p. 94) Air Force Systems Command is the Air Force's major employer of scientists and engineers.

The process of integrating technology into Air Force weapons systems is accomplished by two primary means. The vast majority of research and development activities are accomplished through Air Force management of contracts to procure equipment, information, and technology. However, the Air Force does accomplish some in-house research and development, primarily in laboratories and centers. The Air Force Wright Aeronautical Laboratories, Air Force Rocket Propulsion Laboratory, Air Force

Weapons Laboratory, Rome Air Development Center, Air Force Armament Laboratory, and the Air Force Human Resources Laboratory are examples of organizations with research objectives. An example of the type of work accomplished in Air Force Systems Command can be found in AFSC Regulation 23-3, Aeronautical Systems Division, 19 January 1982. This regulation establishes the organization and missions for the Aeronautical Systems Division which plans and manages the acquisition of aeronautical systems, subsystems, and associated equipment for the Air Force. While primary importance is on planning, managing, and coordinating, many other roles are accomplished. Some of the responsibilities of the Aeronautical System Division from AFSC Regulation 23-3 are:

1. Accomplishes systems engineering and technical direction to designated programs. . .

2. Plans, conducts, and manages development planning activities.

3. Accomplishes assigned advanced and engineering development.

4. Establishes technology needs with AFSC laboratories for exploratory and advanced development required to satisfy new capabilities or eliminate deficiencies.

5. Provides engineering support. . .

6. Conducts aircraft flight testing of developmental avionic equipments. . . (AFSCR 23-3, 1982, p. 1)

The above list is a sample of the Aeronautical Systems Division's responsibilities and depicts a broad spectrum of activity. Accomplishment of this mission requires a diverse organization. From these responsibilities comes the process to acquire and manage technology within Air Force Systems Command.

As previously presented, Air Force Systems Command contracts the majority of its research and development work. The process begins with a requirement, usually identified through a new threat or capability that requires a response. Once the threat is understood, the Air Force documents the new requirement with a Statement of Need. For major weapons systems, this is the beginning of a long and sometimes arduous process known as the Defense System Acquisition Review Council (DSARC) process. While not important to this study, the process involves multiple milestones and reviews before various Department of Defense and Air Force councils and boards. However, it is important to understand the mechanics of the process by which the Air Force acquires technology and weapons systems. First, the Air Force internally develops a Request for Proposal (RFP) which states the requirements of the acquisition. The Request for Proposal usually contains desired performance characteristics, specifications, time limits, and criteria which the Air Force uses to evaluate the bids form the contractors. Next, upon receipt of bids from prospective contractors, the process enters source selection, whereby an Air Force board evaluates the bids. The source selection process concludes with a decision on the contractor or contractors which will perform the work. Following source selection, the process enters a negotiating period where the contract is negotiated between the Air Force and the contractor. Negotiations include detailed evaluations of the contractors team, including the number and composition of the engineering teams assigned by the contractor. The negotiating process concludes with a contract signing between the Air Force and the contractor and work begins on the effort. Of note is the ability of the Air Force to evaluate and influence the organization structure of aerospace contractors. This will be discussed later in the organizational context. Additionally, during the process of selecting and managing these contracts, the Air Force can specify and request certain technologies and performance factors be integrated into the weapons systems. In summary, the integration of technology into major weapons systems is accomplished by Air Force Systems Command. While a major portion of the research and development effort is performed by contract management, the Air Force has considerable control over the amount of sophistication and technological advancement in our weapons systems.

Structure of Selected AFSC Organizations

Air Force Organization Policy and Guidance

Air Force organizations are structured to most efficiently accomplish the assigned mission. The overall guidance is contained in Air Force Regulation 26-2, 6 January 1982, Organization Policy and Guidance. The regulation expresses five principles of Air Force organization. The first principle is functional grouping and requires each part of an organization meet the following requirements:

1. Be directed toward achieving a major goal.

2. Constitute a logical, separable field of responsibility.

3. Have a clear-cut charter that is definite in scope, purpose, objectives, and goals to achieve, with a single commander, supervisor, or staff member in full charge.

4. Cover all the elements of a function that are closely related and constitute a complete entity.

5. Have easy, workable relationships with other parts of the organization, but with natural, definable divisions among them. (AFR 26-2, 1982, p. 4)

There is a heavy emphasis on functional grouping in the policy's first principle. The second principle is unity of command. This principle requires that each person's responsibilities should be clearly defined and each person responsible to only one superior. Span of control is the third principle and sets factors for determining the number of subordinates that can be effectively supervised by one person. Some of the factors in determining span of control include the complexity of the mission, organizational differentiation, amount of coordination required, and the type of management and communication systems. The fourth organization principle in the Air Force's regulation on organization policy and guidance is delegation of authority. This principle encourages delegation as much as possible and states each situation must be studied individually to determine the correct amount of delegation. The last organization principle involves decision-making requirements. The regulation writes, "An organization should be structured to permit rapid decision-making. Every time a new level is added between the commander or supervisor and the doer, the flow of communication slows down and the probability of misinterpretation increases." (AFR 26-2, 1982, p. 5)

The objectives of Air Force organization are also presented in Air Force Regulation 26-2, Organization Policy and Guidance (1982). The three primary objectives are to maintain a structure in peacetime that avoids organizational turbulence during transition to war, to maintain a structure that operates effectively with the least cost, and to standardize organizations as much as possible. One of the secondary objectives deals with technology. The objective is, "Keep pace with technological advances, changing missions, and concepts of operation." (AFR 26-2, 1982, p. 5) The remaining portion of Chapter 1 of the regulation presents Air Force policies on organization. Two areas are of interest to this study. First, while the policy emphasizes a functional approach to organization structure, it does allow other approaches. "Organization based on functions predominates in the overall Air Force structure. However, in an organization as large and complex as the Air Force, the functional approach does not always apply." (AFR 26-2, 1982, p. 6) Finally, the policy does not restrict Air Force organizations to established structures. "MAJCOMs are encouraged to develop and test new organizations that promise to increase effectiveness and efficiency." (AFR 26-2, 1982, p. 7) The remainder of the regulation explains the various organization units, gives examples of standard structures, and explains procedures for establishing organizations and making changes.

Another guide for organization structure is Air Force Regulation 26-6, 16 November 1983, Manpower and Organization Management Objectives and Responsibilities. This brief regulation establishes basic manpower and organization management objectives and responsibilities. One of the management objectives is, "Establish organizational configurations suitable for the best possible use of all available resources at the minimum essential cost." (AFR 26-6, 1983, p. 1) Overall responsibility for manpower and organization management in the Air Force is given to the Director of Manpower and Organization at Headquarters U.S. Air Force. However, responsibility for the execution of the policy is given to individual commanders and supervisors.

> Personnel responsible for the command or supervision of each organization, function, or office must: (1) Ensure that their internal organization structure and stated manpower requirements are the most economical to improve

combat readiness, enhance wartime effectiveness, and complete prescribed workloads under peacetime conditions. (AFR 26-6, 1983, p. 2)

In summary, Air Force regulations provide policy and guidance for structuring organizations. While emphasis is on functional organization, mechanisms exist for other organization structures. Responsibility for efficient organizational management rests at all levels of command.

Air Force Systems Command Organizations

As previously presented, most technology is integrated into Air Force weapons systems by Air Force Systems Command. This section addresses some of these organizations and the manner in which they accomplish their assigned missions. The subsequent section analyzes the structure of some selected AFSC organizations.

Different from most Air Force organizations, Air Force Systems Command is organized by product. The product organization structure is organized very similar to private sector companies engaged in the very competitive environment of consumer goods and services. For example, many companies have separate divisions (soap, toothpaste, etc.) that engage in all aspects of one product from research and development to marketing.

The four product divisions and one product office in Air Force Systems Command are the Aeronautical Systems Division, Armament Division, Electronic Systems Division, Space Division, and the Ballistic Missile Office. As described in <u>Air Force</u> magazine (Lacombe, August 1983), the organizations and their general responsibilities are as follows:

1. Aeronautical Systems Division is responsible for aircraft systems and subsystems.

2. Armament Division develops and acquires the Air Force's conventional armaments.

3. Electronic Systems Division is responsible for electronic systems, including command and control communications systems.

4. Space Division is the Air Force's space-related organization, performing all preoperational space activities.

5. Ballistic Missile Office is responsible for Intercontinental Ballistic Missile functions. (Lacombe, 1983, p. 53)

The above product organizations function similar to product organizations in the private sector. They have responsibility for the full range of activities associated with each product. This includes research and development in the basic sciences to testing and acquiring aircraft and missile systems.

Within the product divisions are the organizations directly responsible for individual weapons systems--the systems program offices. It is at this level where the actual development and management of programs such as the F-16 aircraft occur. The director of an Air Force systems program office is the single point of contact for all activities associated with the particular weapons system. The systems program office level is where organization structure changes could have the greatest impact on technological innovation. The program office can be compared to a basic production unit in the private sector. A single program manager heads the program office and is responsible for the successful completion of program goals within budget and on-schedule. A program office is a form of a task force which is organized to complete certain tasks and will normally disband upon deployment of the weapons system.

Air Force Systems Command analyzes completed programs and produces "lessons learned" volumes for many weapons systems. The 1980 AFSC Lessons Learned Volume 1 from the Aeronautical Systems Division contained characteristics which typify some of the more successful programs. One factor was to have a single individual responsible for all aspects of the program with the appropriate amount of authority. Another successful characteristic was support for the program manager, either through a ". . . projectized or matrix organization structure." (U. S. Air Force, 1980, p. III-1) This implies centralized control can be a determinant of success at the systems program office level. In summary, at a macro-level, the Air Force's organizations responsible for most research, development, test, and evaluation of weapons systems are organized by product. Within the product divisions are the individual program offices, each normally responsible for a single weapons system or support component.

Structure of Selected AFSC Organizations

This section addresses the organization structure of selected Air Force Systems Command organizations. The 1984 Leadership and Management Development Center publication A Field Study of Air Force Organization Structures analyzed some organizations within Air Force Systems Command responsible for systems and development acquisition. The field study describes that prior to 1976, these organizations were typically organized on a program basis. Each program office contained all the necessary resources to accomplish its assigned mission. However, responding to a manpower shortage and other factors such as lack of cross-feed between programs, the matrix organization structure was implemented in 1976. Many of the professional staff personnel, including engineers and scientists, were assigned to a program office from a functional area such as contracting or engineering. This matrix organization had several benefits. First, program uncertainties and changing priorities allow more flexibility in product resource management. For example, the engineers and professionals in a program which suddenly experienced a demise in funding could be rapidly moved to another program office or even back to their functional organization for productive work. Another benefit was a stretching of critical technical personnel among programs. Finally, the people involved were able to keep their professional proficiency and contact with functional areas while being dedicated to a program manager. The LMDC field study presented two key issues with the effects of the matrix organization structure in Air Force Systems Command. First, the study concluded that the impact of the program manager often seemed diffused. Confirming other sources, the study addressed the importance of the program manager. "Respondents repeatedly told us that an effective program was determined by the ability of the project team to meet schedules and milestones. They also said that the single most important cause of a successful program was the program manager." (Conlon, Daft, Austin, and Short, 1984, p. 65) The second major issue associated with the matrix structure was the control dilemma. The program manager has day-to-day control over all of the assigned personnel, but formal administrative control of those from a functional organization is retained by the functional manager. While there are some administrative changes which could alleviate some of this problem, the very nature of a matrix organization structure requires dual reporting channels. In conclusion, the field study summarizes, "The matrix structure is the correct structure because it is compatible with environmental changes, non-routine technology, and goals that emphasize both program effectiveness and the efficient utilization of scarce personnel resources." (Conlon, Daft, Austin, and Short, 1984, p. 66)

Another analysis of the structure of an Air Force System Command organization is Organizational Change Patterns in the Air Force Systems Program Offices (Connors and Maloney, 1979).

This study looked at the program office from a life-cycle approach similar to the product life-cycle in marketing research. The authors concluded program offices are organized in project structures in the early phases of the acquisition cycle. During the middle phase of the acquisition cycle, where most of the work is accomplished and the organization is largest, the organization is structured by function. Finally, during the close-out of the program, the organization reverts back to a project structure. Somewhat contradicting the previous analysis, the authors address some of the problems associated with the matrix organization. While the study presents the program manager as the focal point of the office with broad responsibilities, the program manager has ". . . no real authority over the participating organizations that supply vital support." (Connors and Maloney, 1979, p. 22) Additionally, the study concludes larger organizations have a perceived more favorable organizational climate.

A case study approach is presented in A Case Study of Aeronautical Systems Divisions Systems Program Office by Hulslander and Matthews (1982). The study addressed a single portion of a systems program office which was involved in the research and development of standard aircraft sensor units. One issue presented was the engineering support provided to this organization. The study reported engineering support for the systems program offices came from the Aeronautical Systems Division Deputy for Engineering. In other words, the functional, centralized engineering unit provided resources to the program managers for their individual programs. The study relates that the engineers were not as responsive to the program manager as they could be, presumably because of dual reporting requirements. One person in the case concluded,". . . [it is the] way that the system is organized that is at fault." (Hulslander and Matthews, 1982, p. 19)

From the above analyses this study will address the actual structure of three Air Force Systems Command organizations as depicted in organization and functions chart books. This will provide a determination of some of the current organization structures of these organizations. First, as detailed in the Organization and Functions Chart Book, Electronic Systems Division (Air Force Systems Command, August 1984) appears to be organized functionally. For example, below the Commander are numerous support functions such as public affairs, personnel, safety, and civil engineering. Also reporting to the Commander are eight deputates which appear to be the production units of Electronic Systems Division. Some of these include Tactical Systems, International Programs, Strategic Systems, and Acquisition Logistics and Technical Operations. The system program offices are one or two levels below the above deputates. For example, in the Tactical Systems deputate the next organizational level is tactical communications systems, tactical air battle management systems, combat theater communications systems, and joint stars. While these program offices appear to be functionally aligned, a reading of the functions associated with each organization reveals the nature of the structures. In fact, many functions within these units are provided from other Electronic Systems Division offices. For example, in the Directorate of Engineering and Test, the organization functions include, "Manages the allocation and reallocation of ESD computer systems engineering, test, configuration/data management personnel. . . Provides direct support to ESD program offices in assigned areas." (Air Force Systems Command, 1984, p. 18-5) At a lower level, the Systems Engineering Division within the Engineering and Test Directorate has some of the following responsibilities, "Provides policy and procedural guidance and specialized technical and management support to ESD Deputies and Program Managers. . . Provides direct support to ESD program offices in selected functional areas." (Air Force Systems Command, 1984, p. 18-6) In conclusion, while systems program offices in Electronic Systems Division appear to be structured based on functionality, support is provided from other organizations to the program manager. From the information provided in the Organizations and Functions Chart Book, the matrix organization structure is a reality in the program offices.

Another organization from Air Force Systems Command is the Armament Division at Eglin Air Force Base, Florida. As detailed in the Organization and Functions Chart Book, (Air Force Systems Command, July 1983) the Armament Division is divided primarily between a test and evaluation organization and a research, development, and acquisition organization. At one or two levels below each of the above deputy commanders are the program offices. The narrative portion of the chart book provides insight into the organization structure of the program offices. For example, within the research, development, and acquisition side (called AD/CZ in the chart book) of the Armament Division, there is an engineering organization called the Deputy for Engineering. Under this deputy, the electronics office "Provides support to AD/CZ program offices for embedded computer, resources hardware and software design, documentation reviews, and test programs. . ." (Air Force Systems Command, 1983, p. 65) Another unit, the aeromechanics office, "Provides guided weapons systems engineering support to AD/CZ program offices by developing and maintaining digital computer simulations to evaluate system performance, performance sensitivity and stability analysis, trajectory and accuracy prediction, and flight analysis." (Air Force Systems Command, 1983, p. 65) The Armament Division program offices depend on other organizations for support services and are organized in a matrix structure.

The third organization is the largest product division in Air Force Systems Command--the Aeronautical Systems Division at Wright-Patterson Air Force Base, Ohio. As shown in the Organization and Functions Chart Book, (Air Force Systems Command, June 1981) the structure appears to be functionally aligned. However, technical support is provided by some centralized groups of specialists. For example, the Deputy for Engineering "Provides the system engineering, technical direction, and systems engineering management to ASD program offices. . ." (Air Force Systems Command, 1981, p. 27) At a lower level, the Performance Analysis Branch of the Propulsion Division, ". . . provides systems engineering and technical direction to system program/project offices in the areas of propulsion system performance analysis and analytical solutions to propulsion problems." (Air Force Systems Command, 1981, p. 33) As an example, the program manager of an aircraft program office would look to the Propulsion Division for engineering support and technical assistance for propulsion issues on that particular aircraft.

In conclusion, it is evident that some program offices within selected Air Force Systems Command product organizations often require support not immediately available within their organizations. The matrix organization structure is one design solution to spread scarce resources to other organizations while maintaining certain identities with the functional areas. For example, engineers within the F-16 program office could still maintain administrative and professional ties to the Deputy for Engineering. This is a good coordination mechanism within professional disciplines. Moreover, the matrix organization structure is a good mechanism for maximizing information flow between work units. A critical piece of electrical engineering design information is easily disseminated from the electrical engineering group to its members throughout the various program offices.

CONCLUSION

This chapter has transitioned from the relationship between organization structure and technological innovation to how we integrate technology into Air Force weapons systems and the organization structure of these organizations. The purpose is to become familiar with technology integration and organization structure to determine if the conclusions from Chapter II can be effectively applied to the Air Force situation. Specific conclusions from Chapter III include the following:

1. Most technology is integrated into Air Force weapons systems via contracts managed through the research, development, and acquisition process.

2. Air Force contract management personnel evaluate contractor's organizations at two key points. First, the organization is analyzed during the evaluation of contractor's proposals from which the Air Force selects a potential contractor. Second, the organization is evaluated during the contract negotiation period prior to final contract award.

3. From evaluations of a contractor's organization, the Air Force has influence over the structure of the contractor's

organization.

4. Some technology is exploited directly by Air Force personnel and contractors in Air Force laboratories and, in these cases, there is direct control over organization structure.

5. Air Force Systems Command is organized by product divisions at the macro-level. The basic production unit for technology integration is the program office.

6. The program manager is the single point of contact for all activities affecting the specific program office and is held accountable for timely, efficient acquisition.

7. The program office is organized in a matrix structure and may depend upon other organizations for specialized support, particularly scarce engineering assets.

In summary, the organization most responsible for integration of new technology into Air Force weapons systems is the program office. The program office is organized in a manner which increases information flow into and from the work units. While the Air Force contracts for most research and development efforts to integrate technology into weapons systems, our contracting process provides significant influence on the contractor's organization structure. In the final chapter I will present overall project conclusions given the results of the analysis in Chapters II and III.

CHAPTER IV

PROJECT CONCLUSIONS

Introduction

This final chapter presents the conclusions of the project and a determination of the problem statement. Also included are overall findings and some recommendations for future research. The purpose of this project was to determine if we could enhance the integration of technology into Air Force weapons systems through organization structure. Technology is an important part of the United States' armed forces. The Organization of the Joint Chiefs of Staff writes in the United States Military Posture for FY 1985:

> Technological progress increases the deterrent value of US forces and provides a hedge against a Soviet technological breakout. . . . The importance of technology has never been more obvious than it is today. . . . US and allied technological leadership is even more critical now because the Soviets have fielded new equipment comparable in quality to that produced in the West. (Organization of the Joint Chiefs of Staff, 1984, p. 16)

While previous information from a former Commander of Air Force Systems Command indicated that our technological superiority has decreased in recent years, technology is still a very important force multiplier for United States and allied forces on the battlefield.

Project Conclusions

This section summarizes conclusions from Chapters II and III and presents overall conclusions for the project with the objective of determining the validity of the problem statement. First, the primary conclusion from Chapter II is that organization structure can affect technological innovation. A second conclusion is that organizations which are most likely to adopt technological innovations tend to be large, centralized, specialized, and functionally differentiated.

From the above two conclusions, Chapter III addressed the second part of the problem statement to determine if knowledge of the relationship between organization structure and technological innovation can enhance integration of technology into Air Force weapons systems. The approach in Chapter III was twofold. First, how is technology actually integrated into weapons systems, and second, what is the structure of the organizations responsible for weapons systems acquisition and modernization? The first conclusion is that the Air Force adopts technology into weapons systems primarily through contractors. However, the Air Force has influence over the organization structure of the contractors through the contract selection and contract negotiation processes. A second conclusion from Chapter III is that program offices, the organizations responsible for acquisition of weapons systems, are organized in the matrix structure. A project finding is that it appears the matrix organization structure is the most appropriate for the program office given the information-based theory of organization structure.

Based on the above conclusions, I conclude the problem statement, "Can organization structure enhance the integration of new technology into Air Force weapons systems?" in the affirmative. All three parts of the logic in resolving the problem statement are affirmative. The subelements in the problem statement are as follows:

1. There is a relationship between organization structure and technological innovation.

2. Knowledge of the above relationship can be effectively applied to organizations responsible for technology integration into Air Force weapons systems.

3. There is empirical evidence that organization structure enhances technological innovation and recognition of the relationship can affect technology integration into Air Force weapons systems.

One additional project conclusion not directly related to the problem statement is that the program offices are organized in a manner which would promote adoption of new technology. The major program offices are large, specialized, centralized at the program office level, and somewhat functionally differentiated within the organization.

Project Issues

There are two issues that are not project conclusions but are contributing factors to the issue of technological innovation in the Air Force. The first issue is institutionalism in the Air Force. I hypothesize that the military nature of our profession does not encourage innovation. Organization structures, except in the few cases within Air Force System Command that have matrix structures, are very rigid and by necessity simple and direct. The military command system ensures each person is accountable to a higher authority. While difficult to validate, it is possible that the military institution discourages innovation. Lieutenant Colonel Henry Staley in an Air University article (May-June 1982), "Feedback. . . A unique key to leadership", addresses some of this institutionalism. Lieutenant Colonel Staley writes, "Am I suggesting that we overcome our basic natures? Should we resist those aspects of USAF training and education that reinforce the 'yessir, yessir, three bags full' mentality? Yes! There is something wrong here, and you can sense it." (Staley, 1982, p. 62) The author provides an alternative to this institutionalism which suggests leaders must make determined efforts to solicit feedback from subordinates. It is these same attitudes that I hypothesize provide barriers to technological innovation in the Air Force.

A second issue is that the Air Force must ensure contractors do not become mirrors of our own institution. From my own experience in the Minuteman missile program office and, more recently, working with the Ballistic Missile Office, contractors occasionally give the Air Force only what they expect we want to hear. I once was a member of a source selection committee and several contractors' proposals were clearly geared to a military briefing format that stressed order and organization but were weak in substance. While several of the non-engineer members of the committee were impressed by the military-type briefings, others were more concerned about selecting a firm that could provide an innovative design at the lowest cost. In Blueprint for Tomorrow, a joint Air Force and industry assessment of the aerospace industrial base (U.S. Air Force, 1984), there are similar concerns about institutionalism. The report writes, "As a corollary to improved data availability, the contractors organize in a manner to fit government organizations." (U.S. Air Force, 1984, p. 2-100) A more gloomy assessment in the same report follows:

> According to one study participant, "underlying this adversarial relationship seems to be mutual distrust which results in DOD increasing regulations and controls which, in turn drive up costs. In response, industry is inclined to take a 'by the book' approach to programs and problems which **discourages innovation** and experimentation, and further results in industry seeking to place as much risk as possible on the government." (U.S. Air Force, 1984, p. 2-101) (emphasis added)

The above quote is evidence that in at least one aerospace executive's viewpoint, contractors occasionally mirror our own Air Force institutionalism.

Future Research

Having concluded the problem statement, "Can we enhance the integration of new technology into Air Force weapons systems?" in the affirmative, I recommend future research in two areas. First, is it possible to determine the innovation climate in the Air Force? In other words, does the military institution discourage innovation and/or are military members not inclined to innovate? The results of this research would determine if there are fundamental structural problems to overcome when attempting to innovate in the military.

A second recommended future research issue is a study of the effect military contracts have on defense contractors. One suggested approach is to determine if there are organizational differences in companies that perform predominately defense-work versus companies that are primarily in the non-defense sector. This study has already presented the vast amount of defense dollars that are dedicated to research, development, test, evaluation, and procurement. It would be productive to determine the character of some of the major defense contractors compared to some of the more competitive sectors of private industry. There is potential for significant cost savings in this area.

Ending

This project has determined that organization structure can enhance the integration of new technology into Air Force weapons systems. Technology is an important factor in the success of future battles. In 1983, President Reagan initiated an intensive research and development effort to determine if there is a way to exploit new technologies for strategic defense. The President stated,

> Let us turn to the very strengths in technology that spawned our great industrial base and that have given us the quality of life we enjoy today. . . . I know this is a formidable technical task, one that may not be accomplished before the end of this century. Yet, current technology has attained a level of sophistication where it is reasonable to begin this effort.
> (President's speech on military spending, 1983, p. 20)

While many people, including military officers, have criticized the Strategic Defense Initiative, it is an effort that can introduce significant changes in future warfare. We must take the necessary action to begin the research in earnest and proceed on high technology areas such as the Strategic Defense Initiative. With the proper organization structures, we can develop an organizational climate that enhances technological innovation in the military so that we can meet our future national security objectives.

REFERENCES

Administrative Science 681, Behavior in organizations. Krannert Graduate School of Management, Purdue University, W. Lafayette, IN. Authors notes, Fall 1979.

Conlon, E. J., Daft, R. L., Austin, J. S., & Short, J. S. A field study of Air Force oganization structures. (LMDC-TR-84-4) Maxwell Air Force Base, AL: Leadership and Management Development Center, Air University, May 1984.

Connors, D. & Maloney, D. Organization change patterns in the Air Force systems program offices. Wright-Patterson Air Force Base, OH: Air Force Institute of Technology, June 1979.

Correll, J. T. R & D works up the options. Air Force, August 1983, pp. 38-44.

Drucker, P. Management: Tasks, responsibilities, practices. New York: Harper & Row, 1974.

Gerstenfeld, A., & Sumiyoshi, K. The management of innovation in Japan--Seven forces that make a difference. Research management, January 1980, pp. 30-34.

Gold, B. Productivity, technology, and capital. Lexington, MA: D. C. Heath, 1979.

Hoffman, R. B. & Archibald, R. W. Introducing technological change in a bureaucratic structure, Paper to the Academy of Management, the Rand Corp, New York, 1968.

Hulslander, D. & Matthews, K. A case study of Aeronautical Systems Divisions system program office. Wright-Patterson Air Force Base, OH: Air Force Institute of Technology, September 1982.

Kimberly, J. R. & Evanisko, M. J., Organizational innovation: The influence of individual, organizational, and contextual factors on hospital adoption of technological and administrative innovations. Academy of management journal, 1981, 24, pp. 689-713.

CONTINUED

Lacombe, P. Acquiring systems, step by step. Air Force, August 1983, pp. 52-55.

Lawrence, P. & Lorsch, J. Organization and environment: Managing differentiation and integration. Boston: Harvard University, 1967.

Marsh, R. T. A preview of the technology revolution. Air Force, August 1984, pp. 42-49.

Maruta, Y. The management of innovation in Japan--the Tetsuri way. Research management, January 1980, pp. 39-41.

Merrifield, B. Stimulating technological innovation--nuturing the innovator. Research management, November 1979, pp. 12-14.

Prochaska, R. J. The management of innovation in Japan--why it is successful. Research management, January 1980, pp. 35-38.

Quinn, J. B. Technological innovation, entrepreneurship, and strategy. Sloan management review, Spring 1979, pp. 73-82.

Reagan, R. President's speech on military spending and a new defense. The New York Times, 24 March 1983, p. 20.

Staley, H. A. Feedback. . . A unique key to leadership. Air University review, May-June 1982, pp. 61-63.

Twiss, B. Managing technological innovation (2nd edition). London: Longman Group Ltd, 1980.

U. S. Air Force Systems Command, AFSC lessons learned vol I, Aeronautical Systems Division, Wright-Patterson Air Force base, OH: May 1980.

U. S. Air Force Systems Command, Air Force, May 1984, pp. 94-95.

U. S. Air Force Systems Command, Air Force Systems Command technology planning guide, Director of Science and Technology, Headquarters Air Force Systems Command, Andrews Air Force Base, Wash D. C.: 15 February 1980.

CONTINUED

U. S. Air Force Systems Command, Organizations and functions chart book, Aeronautical Systems Division, Wright-Patterson Air Force Base, OH: June 1981.

U. S. Air Force Systems Command, Organizations and functions chart book, Armament Division, Eglin Air Force Base, FL: July 1983.

U. S. Air Force Systems Command, Organizations and functions chart book, Electronic Systems Divsion, Hanscom Air Force Base, MA: August 1984.

U. S. Department of Defense. Defense 84, September 1984, p. 19.

U. S. Department of the Air Force, Basic doctrine of the United States Air Force, Air Force Manual 1-1, Wash D. C.: 16 March 1984.

U. S. Department of the Air Force, Blueprint for tomorrow, vol I, executive summary, Aeronautical Systems Division, Wright-Patterson Air Force Base, OH: January, 1984.

U. S. Department of the Air Force, Manpower and organization management objectives and responsibilities, Air Force Regulation 26-6, Wash D. C.: 16 November 1983.

U. S. Department of the Air Force, Organization and mission--Aeronautical Systems Division, AFSC Regulation 23-3, Headquarters Air Force Systems Command, Andrews Air Force Base, Wash D. C.: 19 January 1982.

U. S. Department of the Air Force, Organization policy and guidance, Air Force Regulation 26-2, Wash D. C.: 6 January 1982.

U. S. Organization of the Joint Chiefs of Staff. United States Military posture for FY 1985. Wash D. C.: 1984.

CONTINUED

Weinberger, C. W. Imagination shapes the future. Air Force, November 1983, pp. 98-100.

Weinberger, C. W. The state of our defenses. Defense 84, October 1984, pp. 2-15.

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