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Understanding the Emergence of Disruptive Innovation in the Air Force Science and Technology Organizations

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UNDERSTANDING THE EMERGENCE OF DISRUPTIVE INNOVATION IN AIR FORCE SCIENCE AND TECHNOLOGY ORGANIZATIONS

THESIS

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Abstract

Although innovation is widely discussed in both military and industry venues, many organizations continue to struggle with what it means to be creative as well as maintain a competitive advantage. The United States Air Force has specifically struggled with the balance between improving existing technologies and employing revolutionary technologies. The purpose of this thesis research was to study the motivation, focus, barriers, and culture needed to foster disruptive innovation in Air Force Science and Technology (S&T) and to investigate how industry innovation strategies could improve breakthrough Air Force technology emergence. The Air Force Research Laboratory (AFRL), the primary organization responsible for planning and executing all aspects of the Air Force science and technology program, is the ideal study subject to represent the Air Force S&T community at large. Two previous industry research studies, now replicated in an AFRL organizational environment, provided quantitative and qualitative comparisons between the industry and Air Force S&T communities. The study results showed that Air Force S&T is capable of regaining its prominence as a leader in disruptive technological innovation by applying a basic improvement model, capturing the relevant best practices of industry, and exploiting the positive attributes of the military domain.

I would like to dedicate this work…

…to my children, that one day I will actually be as great as they believe me to be.

…and to my father, who is actually as great as I always thought he was.

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UNDERSTANDING THE EMERGENCE OF DISRUPTIVE INNOVATION IN AIR FORCE SCIENCE AND TECHNOLOGY ORGANIZATIONS

I. Introduction

Although innovation is widely discussed in both military and industry venues, many organizations continue to struggle with what it means to be creative as well as maintain a competitive advantage. Many believe that the Department of Defense (DoD) science and technology (S&T) community, once a great leader in developing breakthrough innovation, is losing the competitive edge in technology development (Krepenievich, 2001). The United States Air Force has specifically struggled with the balance between improving existing technologies and employing revolutionary technologies (USAF SAB, 2006). Therefore, the purpose of this thesis research is to study the emergence of disruptive innovation in Air Force S&T and to investigate how industry innovation strategies can foster breakthrough technology. By better understanding the principles of innovation, motivation, focus of resources, barriers, and characteristics of an innovative culture, the Air Force will be uniquely positioned to transform its S&T investment strategies and reassert technological relevance for the future.

Background

McKay, Hill, and Buckler (1987) found that, from the earliest prehistoric times to the present day, the development and fostering of technological innovation has been an essential element for survival. They cited various examples as evidence of this long-term

history of innovation. During the Paleolithic Age (400,000-7000 B.C.) for instance, they found that mankind relied on innovation to hunt for food, communicate with each other, and even produce works of art. Additionally, the early Egyptian, Greek, and Roman empires were spawned by new ideas in architecture, transportation, agriculture, and warfighting. Furthermore, innovation in energy and industry were the primary drivers of the Industrial Revolution, changing the human experience and opening the door to modern business commerce.

In modern times, innovation is equally important to business and military organizations. "In the commercial world, technology innovation is a means to stay competitive; in the military world it is a means for achieving and maintaining dominance" (SAB, 2006:1). Whether a company or military force, a thorough understanding of how to pursue revolutionary technologies and concepts is essential to survival. Although the importance of innovation is clear, the meaning of innovation and what it means to be an innovative organization is complex and multi-dimensional.

Innovation Defined

Innovation can be defined as the act of introducing something new in order to change a dimension of performance (American Heritage, 2007; Hesselbein, 2002). The definition of innovation is also articulated as a simple formula: Innovation = Invention + Exploitation. Innovation requires that that new idea, concept, or knowledge is exploited in such a way that implementation occurs and value is created (Fagerberg, 2004).

The magnitude of the performance change is the critical driver in classifying the innovation as either radical or incremental. How the innovation is introduced, and for

what purpose, characterizes the type of innovation. Additionally, the nature of new ideas helps shape the dynamics of innovation. While the basic definition is simple, a comprehensive examination of magnitude, purpose, and pattern are critical to understanding the meaning of innovation.

Innovative technology is often classified as either disruptive or sustaining, depending on the magnitude of the proposed performance improvement. According to Christensen (1997), a pioneer in the theory of disruptive innovation and the impacts of disruptive technology in the business market environment, most new technologies foster improvements in the performance of established products; this represents sustained innovation. However, disruptive technologies "bring a very different value proposition than had been available previously" (Christensen, 1997: xv). As shown in Table 1, Christensen provides a clear distinction between disruptive and sustaining innovation. Furthermore, the appearance of disruptive innovation is characterized by a discontinuity between the old and new technology (Foster, 1986). As illustrated in Figure 1, a disruptive technology is initially characterized by lower performance than the old technology. Over time though, the performance of the disruptive technology surpasses the old technology and establishes a new dominant design as the standard for the marketplace. While innovation can be classified based on technology performance, the overarching purpose for the innovation is also important to understand.

Table 1. Characteristics of Disruptive and Sustainment Innovation (Christensen, 1997)

Disruptive Innovation	Sustaining Innovation
• Bring new value proposition • Generally underperforms established products in mainstream markets • Have features that fringe (and generally new) customers value • Cheaper, simpler, smaller, more convenient • Most often pursued by entrant firms	• Improve performance of established products • Meet demands of mainstream customers in major markets • Can be discontinuous, radical, or incremental in nature • Vary in difficulty, cost, time, complexity • Most often pursued by established firms

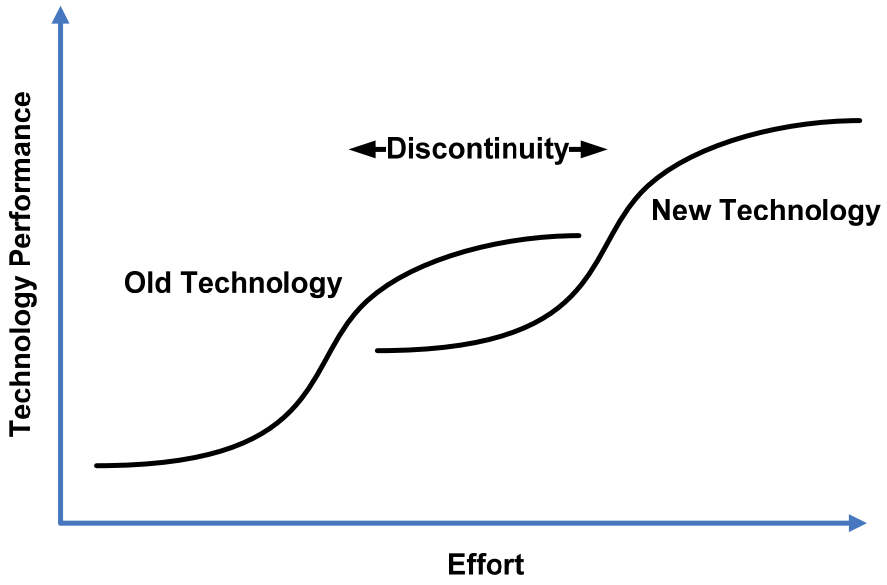


Figure 1. Foster's S-Curves (Foster, 1986)

According to many business scholars, innovation can be further differentiated based on the purpose, or type, of the innovation effort, as outlined in Table 2. Product or service innovation is intended to deliver new and improved products to the marketplace or enhance the customer experience and services provided (Wilhelm, 2006: 4-5). Process or operational innovation focuses on how products and services are developed and delivered (Wilhelm, 2006: 4). This type of innovation also revolutionizes how products are used in the operational environment (Krepinevich, 2001). Innovation focused on changing financial models, management techniques, and corporate structures of business is called organizational innovation (Hamel, 2002). While this classification of innovation based on purpose supports a more robust definition of innovation, patterns of innovation are also important.

Table 2. Types of Innovation

Type of Innovation	**Description**
Product/Service	Results in development of new or improved products or in the ways of delivering services (Wilhelm, 2006)
Process/Organizational	Involves the implementation of new or significantly improved production or delivery methods (Wilhelm, 2006); Innovation in terms of business models, management techniques and strategies, and organizational structures (Hamel, 2002)
Operational	The revolutionary application of new employment techniques for new and/or existing technologies (Krepinevich, 2001)

The patterns of innovation add a critical timespan component to innovation definition. Abernathy and Utterback (1978) have published several articles hypothesizing a patterned relationship between product and process innovation in conjunction with a strong connection to the business-oriented characteristics of organizational innovation. As illustrated in Figure 2, Abernathy and Utterback's model in the dynamics of innovation

> …focuses on three stages in the evolution of a successful enterprise: its period of flexibility, in which the enterprise seeks to capitalize on its advantage where they offer greatest advantages; its intermediate years, in which major products are used widely; and its full maturity, when prosperity is assured by leadership in several principle products and technologies. (Tushman and Moore, 1982:99)

Depicting the types of innovation in patterns over time, combined with understanding disruptive and sustainment characteristics, provides a working definition for innovation studies and the framework for further examinations at the organizational level.

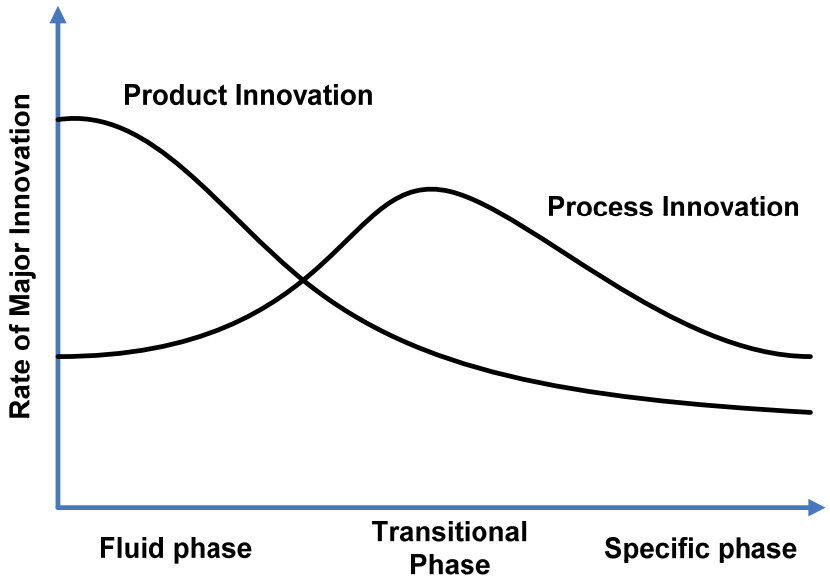


Figure 2. The Dynamics of Innovation (Utterback, 1994)

The Innovative Organization

In both business and military environments, innovative organizations embody, combine, and synthesize knowledge into original, relevant, and valued products, processes, or services (Luecke and Katz, 2003). According to Luecke and Katz (2003), innovative organizations display many distinct characteristics compared to their peers. In the business world, these idea-fostering organizations are revolutionary and competitive. These revolutionary companies capture new markets, win over the allegiance of customers, harvest top employees, and create wealth with non-linear ideas (Hamel, 2002). Innovative companies are able to succeed in business because they are always on the attack. Foster (1986:21) describes this concept by saying,

> In the end (innovation) is about companies the have more up years than their competitors because they recognize that they must be close to ruthless in cannibalizing their current products and processes just when they are most lucrative and begin the search again, over and over.

In the military technology environment, innovative organizations lead revolutions of a different nature. The military technology revolution is characterized by the

> …application of new technologies into military systems, combined with innovative operational concepts and organizational adoption to alter fundamentally the character and conduct of military operations (Krepinevich, 2001:3).

From General Billy Mitchell's use of aircraft against the perceived indestructible battleship in 1921 (Rose, 1996) to the once inconceivable employment of armed unmanned air vehicles during Operation Iraqi Freedom (USAF SAB, 2003), innovation on the battlefield, both technological and operational, has been a decisive factor in military success. Although the benefits of innovative organizations are readily evident,

the successful management and execution of idea-improvement models is a far more challenging principle.

Innovation Management

For several decades, business and military leaders have appreciated the importance of managing innovation within organizations (Tushman and Moore, 1982). Innovation management is a process of leading organizational culture, discovering opportunities, developing ideas, and delivering new value (AMA, 2006). Many recent studies of innovation, examined in detail in Chapter II, have succeeded in characterizing the industry's innovation culture and the critical drivers, barriers, and dynamics of innovation in global business. Leading industry innovators have further analyzed the situation by constructing innovation improvement models in an effort to capitalize on success. By studying these models and their relationship to various organizational culture attributes, both struggling and thriving organizations can improve their level of innovation and promote the competitive growth and technological dominance critical for survival.

Problem and Purpose Statement

In 2006, the United States Air Force Scientific Advisory Board conducted a quick-look study on the use of System Level Experimentation (SLE) to encourage disruptive innovation (USAF SAB, 2006). The largely qualitative study found that while the Air Force is very good at sustaining innovation, its S&T community has largely lost

its ability to foster disruptive innovation. Furthermore, the study stated that Air Force S&T organizations have failed to take advantage of a strong existing contingent of innovative personnel and have not created an organizational environment to promote the emergence of game-changing ideas. These assertions delineate a stagnant environment in which the Air Force has lost breakthrough technological momentum and is at risk of becoming irrelevant in the future battlespace. The purpose of the thesis research is to build on the investigations of the SAB quick-look study and provide additional quantitative and qualitative decision support for improvement measures designed to elevate the emergence of disruptive technology innovation.

Research Questions

This research effort strives to determine if the innovation improvement models successful in industry can be implemented in Air Force Science and Technology (S&T) organizations with similar results. Specifically, this effort examines the Air Force S&T community using the Air Force Research Laboratory (AFRL) as the model focus of study. AFRL is the primary organization responsible for planning and executing all aspects of the Air Force science and technology program; a more detailed organizational description is provided in Appendix A. It is chartered with leading the discovery, development, and integration of revolutionary technology and leading edge capabilities to the warfighter (AFRL, 2007). AFRL leads a worldwide partnership of government, industry, and academia with 5,400 personnel, in 10 technology directorates, across 14 major research sites, executing an annual budget of over $3 billion (AFRL, 2007). Based

on its size, influence, and structure, AFRL is the ideal study subject to represent the Air Force S&T community at large.

In order to better examine innovation improvement opportunities in the Air Force S&T community and fully answer the primary research question, several key investigative areas have been defined:

1. What is **motivation for innovation** in the Air Force S&T community (AFRL)? How does this compare to the motivation for innovation in industry?

2. What is the **focus of innovation resources** in the Air Force S&T community (AFRL)? How does this compare to the focus of innovation resources in industry?

3. What are the **barriers of innovation** in the Air Force S&T community (AFRL)? How does this compare to the barriers of innovation in industry?

4. What are the **key components of innovative culture** within Air Force S&T organizations (AFRL)? How does this compare to the innovative culture found in industry?

5. How do the **senior leaders** of the Air Force S&T community (AFRL) **characterize the innovation** environment of the Air Force S&T community (AFRL)? How does this compare to their CEO counterparts in industry?

6. What **model for fostering the emergence of disruptive innovation** can be applied to the Air Force S&T community?

Methodology

The proposed research methodology combines both quantitative and qualitative research elements. The proposed approach begins with a literature review to investigate key concepts and existing research. The second step is to identify relevant industry research studies and to mirror the survey and interview-based studies in an Air Force S&T environment. The next step is to examine the resulting Air Force research data using the same frequency and grounded theory analysis techniques as the identical

industry research. This investigation will then compare the results of the Air Force S&T research data with the published findings from the industry survey/interview research. The overall study will culminate with an outline of findings and implementation recommendations. Additional details on the specific data collection approach and data analysis techniques are presented in Chapter III.

Summary

This chapter introduced the overall topic by presenting background definitions of innovation, innovative organizations, and innovation management. In addition, the chapter outlined the problem, presented research questions, and provided a summary of the methodology employed in this study. Chapter II presents a detailed literature review of disruptive innovation, studies of innovation, and industry models for improving the emergence of disruptive innovation. Chapter III provides a full description of the study methodology including the instrument review, data collection scheme, and data analysis approach. Chapter IV illustrates the results of this study and delineates the analysis of data and findings. Finally, Chapter V provides the resulting conclusions for the study and outlines recommendations for further research.

II. Literature Review

This chapter provides a literature review of the concepts of innovation, recent studies of organizational innovation, and a model for fostering disruptive innovation. This review first establishes a multi-dimensional definition of innovation combined with an examination of the theory and relevance of disruptive innovation. Next, several recent studies of organizational innovation are reviewed under the context of: motivation for innovation, focus of innovation resources, barriers of innovation, and characteristics of organizational culture. The results of this previous research will establish an experimental control baseline for industry organizational innovation and the point of comparison for mirror studies conducted in the Air Force Science and Technology (S&T) environment. Different approaches to fostering disruptive innovation are also reviewed as a primer for possible organizational improvement recommendations. Finally, a model in the emergence of disruptive innovation is proposed based on the defined key investigative areas outlined previously.

Concepts of Innovation

Although the concepts of innovation have been applied since the beginning of civilization, the study of innovation as a means for organizations to facilitate successful growth has culminated over the last half century (AMA, 2006). The definition of innovation is a concept that has been the subject of considerable study and, as such, innovation is defined in various ways. The definition of innovation can be articulated as a simple formula: Innovation = Invention + Exploitation.

> An important distinction is normally made between (simply) invention and innovation. Invention is the first occurrence of an idea for a new product or process, while innovation is the first attempt to carry it out into practice. (Fagerberg, 2004:4)

Innovation requires that the new idea, concept, or knowledge is exploited in such a way that implementation occurs and value is created. The American Management Association (AMA) combines both the invention concept and exploitation concept in its definition for innovation.

> Innovation is the term used to describe how organizations create value by developing new knowledge and/or using existing knowledge in new ways. The term is often used to mean the development of new products or services, but organizations can also innovate in other ways, such as through new business models, management techniques, and organizational structures. (AMA, 2006:5)

Table 3 integrates the perspectives of many leading scholars and describes a multi-level approach to defining innovation in organizations. This comprehensive meaning for innovation expands on the "innovation = invention + exploitation" formula and further describes innovation concepts based on magnitude, type, and pattern. The concepts of this multi-level definition of innovation are used throughout this investigation.

Table 3. Multi-Level Definition of Innovation (AMA, 2006; Christensen, 2003; Wilhelm, 2006; Utterback, 1994)

Innovation = **Invention** (developing new knowledge and/or using existing knowledge in new ways) **+ Exploitation** (applying the knowledge in a way that creates value). The knowledge can take the form of products/services, processes/organizational considerations, and/or operational employment.

MAGNITUDE	**Disruptive** • New systems with completely new value proposition, destroying the value of the existing system	**Sustaining** • Improvements in the value of existing systems	
TYPE	**Product/Service** • Products and services	**Process/Organizational** • Production methods • Delivery methods • Business models • Management techniques • Organizational structures	**Operational** • Employment techniques for new and/or existing technologies
PATTERN	**Fluid Phase** • Greatest advantage	**Transitional Phase** • Widest use	**Specific Phase** • Full maturity

Disruptive Innovation Definition

The concept of disruption in the marketplace is a critical component to understanding the emergence and impact of innovation. Disruptive technology, introduced by Christensen (1997), is theorized as the primary reason large established organizations become irrelevant and fail. Christensen (1997) describes the theory by saying:

> Disruptive technologies bring to market a very different value proposition than had been available previously. Generally, disruptive technologies underperform established products (at least in the near term) in mainstream markets. But they have other features that a few fringe (and generally new) customers value. (p. xv)

Interestingly, disruptive technologies often overtake existing technologies, rendering them obsolete and forcing incumbent companies out of the market. Anderson and Tushman (1990) explain this principle by examining the discontinuities that exist between sustaining and disruptive technologies and their associated competencies. Some technologies are competency-destroying in that they render obsolete the expertise required to master the technology. For example, the incandescent lamp destroyed gas lamp technologies and electric refrigeration overcame the previously dominant ice box industry (Utterback, 1994). In contrast, other technologies are competency-enhancing as they "build on know-how of the technology that it replaces" (Anderson and Tushman, 1990:609). For instance, many technological advancements in film photography, computer disk storage, and even the artificial heart capitalized incrementally on the previous technology base (Christensen, 2003). The competency-destroying nature of disruptive technology illustrates why understanding disruptive innovation is vital to asserting advantage in the volatile and competitive centric marketplace.

Disruptive innovation is characterized by ideas that change the dynamics of the given marketplace. Christensen (2003) demonstrates this principle through the three critical elements of disruption.

> First, in every market there is a rate of improvement that customers can absorb, represented by the dotted line sloping gently across the chart. Second, in every market there is a distinctly different trajectory of improvement that innovating companies provide as they introduce new and improved products. The third critical element of the model is the distinction between sustaining and disruptive innovation. (p. 32)

These elements are illustrated in Christensen's (2003) Disruption Innovation Model shown Figure 3. The customer absorption line in the figure is actually a

family of curves representing users demanding high performance on the top end and users seeking low-end performance on the bottom end. Most customers will fall in between these two extremes. The Disruptive Innovation Model also illustrates that the pace of technological progress almost always outpaces the median market ability to utilize or absorb the technology advancements.

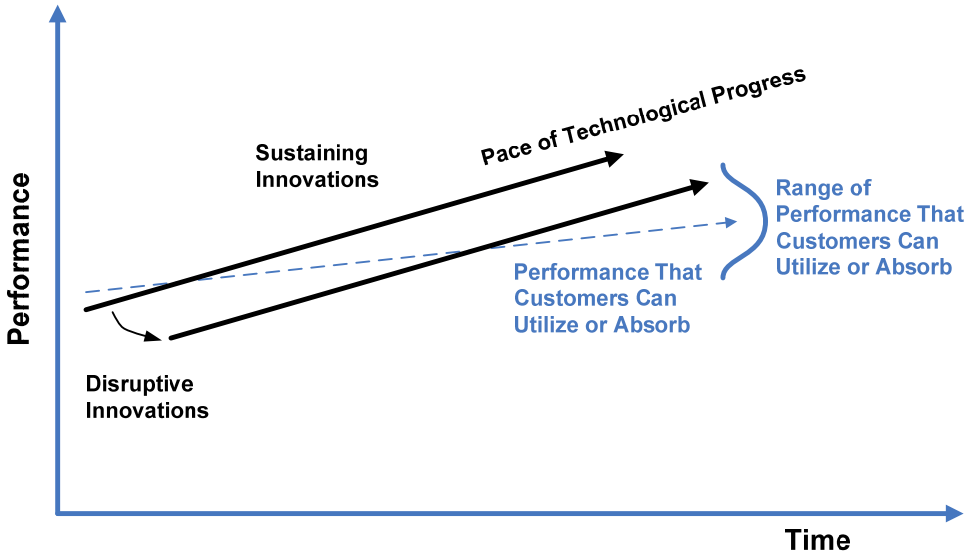


Figure 3. The Disruptive Innovation Model (Christensen, 2003)

Christensen (2003) clarifies that in battles of sustaining innovation, where improvements are made on the status quo, the incumbent almost always maintains market supremacy. However, when entrant firms attack the low-end market or propose a new value network to a new group of customers, the incumbent is often beaten by the competency-destroying advancement. Value networks are defined as "the context within

which a firm identifies and responds to customers' needs, solves problems, procures input, reacts to competitors and strives for profit" (Christensen, 1994:32). Christensen (2003) further expands the disruptive innovation model by adding a third-dimension, new value networks, to the existing context of time and performance. This dimension adds the concept of competition and consumption to the disruptive innovation framework.

> Different value networks can emerge at differing differences from the original one along the third dimension of the disruptive diagram … refer to disruptions that create a new value network on the third axis as new-market disruptions. In contrast, low-end disruptions are those that attack the least profitable and most overserved customers at the low end of the original value network (Christensen, 2003:45).

This third dimension of the Disruptive Innovation Model is shown in Figure 4. While the concepts of new-market disruptions and low-end disruptions are succinct, the true impacts are seen by combining these concepts with the types of innovation to formulate an overall innovation strategy.

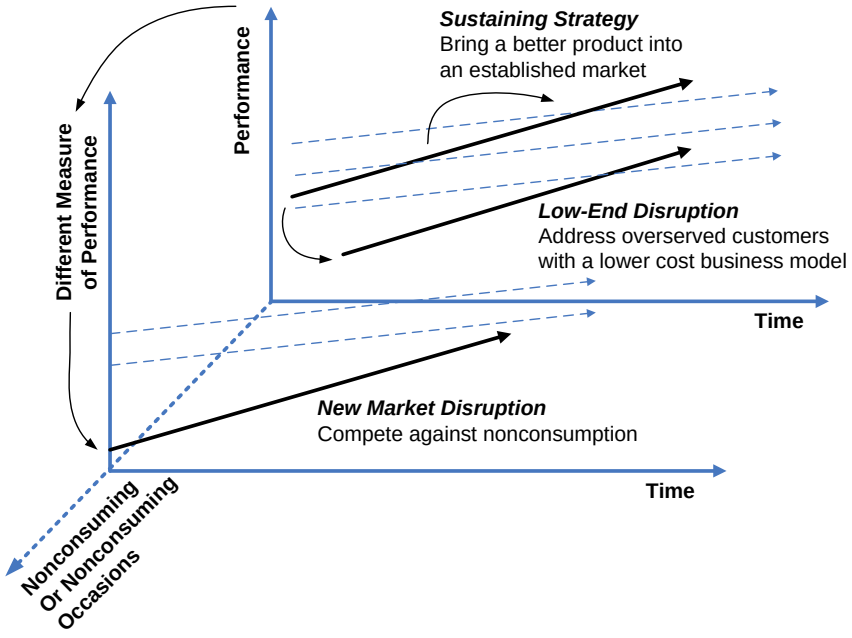


Figure 4. The Third Dimension of the Disruptive Innovation Model (Christensen, 2003)

Disruptive Innovation Strategies

For the last several decades, many business scholars have carefully examined the need for setting strategy and direction for innovation (Tushman and Moore, 1982). According to many business strategy experts, decisions regarding the allocation of innovation resources require a careful look at both technological and business unit strategy. Decisions to invest in new products or improvements in established products need to consider resource allocation demands, market share dominance, market growth rates, and financial objectives (Day, 1975). Maideique and Patch (1978) capitalized on the work of Ansoff and Stewart (1967) by outlining four alternative technological innovation investment strategies.

> These strategies … each have different implications for the level of technological competence, the relative emphasis on research and development, the use of external sources of technological information, the timing and level of technological investment and staffing for the firm, and the R&D management policies and organization (Tushman and Moore, 1982:285).

Theses strategies are shown in Table 2. Although technological policy plays an important role in planning for innovation, all types of innovation should be considered in a comprehensive strategy.

Table 4. Alternative Technological Strategies (Tushman and Moore, 1982)

Technological Strategy	**Description**
Early, *First-to-Market*, or Leader	Get the product to market before the competition; advantage of a *temporary monopoly* in the market
Second-to-Market or Fast Follower	Entry early in growth stage of the life-cycle and quick imitation of innovations pioneered by a competitor
Cost Minimization or late-to-market strategy	Entry at growth stage or later when market volume mature; significant economies of scale; avoids capital investments
Market-segmentation or specialist	Serve small pockets of demand with special applications on the basic technology

Another useful concept in innovation strategy is planning based on the innovation type or purpose. Product or service innovation is intended to deliver new and improved products to the marketplace or enhance the customer experience and services provided (Wilhelm, 2006). Process or operational innovation focuses on how products and services are developed and delivered (Wilhelm, 2006). This type of innovation also revolutionized how products are used in the operational environment (Krepinevich, 2001). Innovation focused on changing financial models, management techniques, and

corporate structures of business is called organizational innovation (Hamel, 2002). Christensen (2003) ties the types of innovation with the magnitude of innovation in his approaches to creating new-growth businesses. As shown in Table 5, the various innovation strategies have distinct characteristics with respect to targeted performance, targeted customers, and impact on required business models.

Table 5. Three Approaches to Creating New-Growth Businesses (Christensen, 2003:51)

Dimension	**Sustaining Innovations**	**Low-End Disruptions**	**New-Market Disruptions**
Targeted performance of the product or service	Performance improvement in attributes most valued by the industry's most demanding customers.	Performance that is good enough along traditional metrics of performance at the low end of the mainstream market.	Lower performance in "traditional" attributes, but improved performance in new attributes - typically simplicity and convenience.
Targeted customers or market application	The most attractive (i.e. profitable) customers in the mainstream markets who are willing to pay for improved performance.	Overserved customers in the low end of the mainstream market.	Targets non-consumption: customers who historically lacked the money or skill to buy and use the product.
Impact on the required business model (process and cost structure)	Improves or maintains profit margins by exploiting the existing process and cost structure and making better use of current competitive advantages	Utilizes a new operating or financial approach or both - a different combination of lower gross profit margins and higher asset utilization that can earn attractive returns at the discount prices required to win business at the low end of the market.	Business model must make money at the lower price per unit sold, and at unit production volumes that initially will be small. Gross margin dollars per unit sold will be significantly lower.

Christensen (2003) further explains the deliberate and assumption driven strategic planning works for sustaining innovations, but not for disruptive innovation. According to Christensen, "In the emergent world of disruption, this process causes bad decisions to be made because the assumptions upon which the projections and decisions are built often prove wrong" (p. 228). Discovery-driven planning, outlined in Table 6, is a rigorous method designed to help identify and strategize disruptive opportunities when assumptions are not mature. Under discovery-driven planning, strategies are developed from learning, experimentation, and testing of assumptions.

Table 6. A Discovery-Driven Method for Disruptive Innovation Strategy (Christensen, 2003:228)

Sustaining Innovations: Deliberate Planning	**Disruptive Innovations: Discovery-Driven Planning**
(Note: decisions to initiate these projects can be grounded on numbers and rules.)	(Note: decisions to initiate these projects should be based on pattern recognition.)
1. Make assumptions about the future.	1. Make the targeted performance projections
2. Define a strategy based in those assumptions, and build financial projections based on that strategy.	2. What assumptions must prove true in order for these projections to materialize?
3. Make decisions to invest based on those financial projections.	3. Invest in a plan to learn - to test whether the critical assumptions are reasonable.
4. Implement the strategy in order to achieve the projected financial results.	4. Invest to implement the strategy

Disruptive Innovation Patterns

Many scholars have attempted to model the patterns by which innovation occurs. Abernathy and Utterback's (1978) model in the dynamics of innovation describes the pattern as a fluid period of maximum invention followed by a transitional period of exploitation and eventually leading to a specific phase of optimization. Table 7, adapted from Utterback's (1978) model, shows the characteristics of each of these developmental phases with respect to various key attributes. Although the principles of low-end and new market disruption play the most significant role in the fluid and transitional phase of the model, the ultimate timelines of disruptive innovation vary. The disruptive invention combined with the exploitation of the idea may take place vary rapidly as in the case of the information storage media (Christensen, 1997) or over a long period of decades as with the artificial heart (Foster, 1986). While the timelines of disruptive innovation vary based on domain, the impact is significant within all technological domains and is an essential factor in organizational survival.

Table 7. Significant Characteristics in the Three Phases of Innovation
(adapted from Utterback, 1994)

	Fluid Phase	**Transitional Phase**	**Specific Phase**
Innovation	Frequent major product changes	Major process changes required by rising demand	Incremental for product and with cumulative improvements in productivity and quality
Source of Innovation	Industry pioneers; product users	Manufacturers; users	Often suppliers
Products	Diverse designs; often customized	At least one product design, stable enough to have significant production volume	Mostly undifferentiated, standard products
Production Processes	Flexibility and inefficient, major changes easily accommodated	Becoming more rigid, with changes occurring in major steps	Efficient, capital intensive, and rigid; cost of change high
R&D	Focus unspecified because of high degree of technical uncertainty	Focus on specific product features once dominant design emerges	Focus on incremental product technologies; emphasis on process technology
Cost of process change	Low	Moderate	High
Competitors	Few, but growing in numbers with widely fluctuating market shares	Many, but declining in numbers after emergence of dominant design	Few, classic oligopoly with stable market shares
Basis of Competition	Functional product performance	Product variation; fitness for use	Price
Organizational Control	Informal and entrepreneurial	Through project and task groups	Structure, rules, and goals
Vulnerabilities of industry leaders	To imitators, and patent challenges; to successful product breakthroughs	To more efficient and higher-quality producers	To technological innovations that present superior product substitutes

Studies of Military Organizational Innovation

Although examples of disruptive innovation are abundant in military history, research studies of organizational innovation in the military are less common. According to Krepinevich (2001),

> Because the current rate of technological change is accelerating, the time intervals between future military-technical revolutions could be progressively shorter for capable states that choose to compete energetically. If this occurs, it will stress competitor states' abilities for operational and organizational innovation. It will also have significant implications for the defense acquisition system: system obsolescence will occur more rapidly, and the importance of timely production on defense systems will increase. (p. 3)

Given the direct relationship between military-technical revolutions and warfare success, further understanding in fostering disruptive innovation is critical to the Air Force's continued aerospace dominance. Several recent research studies, outlined in Table 8, have attempted to examine innovation in Department of Defense (DoD) organizations.

Table 8. Recent Military Innovation Studies

Study Title	Author(s)	Study Description
Fostering Innovation and Intrapreneurship in an R&D Organization (1995)	J. Meng, Naval Undersea Warfare Center Division	• Survey of 300 employees of Naval Research Laboratory (NRL) • Examination of the origins of innovation barriers and ways to overcome them
Factors Affecting Innovation within Aeronautical System Center Organizations (2003)	Capt Eric Feil, Air Force Institute of Technology	• Inductive study of innovation in ASC using results from the 2002 CSAF Organizational Climate Survey
Understand Innovation Adoption in the Air Force (2006)	Capt Morgan Evans, Air Force Institute of Technology	• Survey of 50 employees in AMC • Examination of customer relationships on innovation success.
USAF Scientific Advisory Board Report on System Level Experimentation (2006)	USAF Scientific Advisory Board	• Quick look study regarding the use of experimentation to drive disruptive innovation in the Air Force

Meng (1995) published research on fostering innovation and entrepreneurship in an R&D organization. Having surveyed 300 employees of the Naval Research Laboratory (NRL), Meng studied the relationships between innovation barriers and their origins. The study identified seven major barriers of R&D innovation, outlined in Table 9. The research also concluded that tensions between innovators and the status-quo group were directly tied to the existence of innovation barriers.

Table 9. Major Barriers to Navy R&D Innovation (Meng, 1995)

- Predominant commitment to current products due to insufficient investment funding
- Reluctance to enter new fields due to need to invest in facility and infrastructure
- Inadequate cross-functional understanding due to over-differentiation and compartmentalization
- Cost of gaining market acceptance too high due to high start-up cost
- Information unavailable to decision-makers due to inadequate internal communications
- Risk of failure due to low incentives for risk-taking
- Threat to individual power structure by the proposed innovation due to the fact that the innovation is out of scope of the organization's charter

Feil (2003) conducted a study of innovation within the Air Force's Aeronautical Systems Center (ASC) to examine how organizational culture and intelligent risk taking affect innovation levels. His study utilized data collected from the 2002 Chief of Staff of the Air Force Organizational Climate Survey to examine trends in innovation. Feil's (2003) analysis identified seven propositions, outlined in Table 10, regarding the factors influencing Air Force R&D organizations.

Table 10. Organizational Factors Influencing Innovation (Feil, 2003)

1. Organizations with heavy work loads and good teamwork are more innovative
2. Units that listen to and implement their personnel's ideas are more innovative
3. Units that have personnel with a wide breadth of skills are more innovative
4. Units that adopt to change are more innovative
5. Organizations with trusted leaders are more innovative
6. Units with low morale are more innovative
7. Personnel must be equipped with the proper tools and equipment to help foster an innovative atmosphere with an organization

Another study examined the impact of Customer Relationship Management (CRM) on Innovation Diffusion Theory (Evans, 2005). Evans (2005) theorized that there was a relationship between how organizations interact with customers and how they decide to adopt or reject innovative ideas. In a survey of 50 employees at Air Mobility Command, Evans (2005) found that an organization's propensity to adopt innovation developed through a CRM process was directly related to the magnitude of top level management support, risk-promoting climate, and internal communication.

The USAF Scientific Advisory Board Quick Look Study (2006) was the only research study identified that specifically addressed disruptive innovation in the military. This effort examined the historical impact of disruptive technology on Air Force warfighting capabilities. The qualitative case study of Air Force S&T promoted the use of System Level Experimentation (SLE) as a means to drive disruptive innovation. The study identified four essential elements, outlined in Table 11, critical to the development of disruptive innovation using SLE.

Table 11. Disruptive Innovation Using System Level Experimentation (SAB, 2006)

- **Ideas**: Innovation occurs throughout an organization and must be sought out. It is critical to identify ideas that challenge standard ways of doing things.
- **People**: Not all people are innovative. Those that are must be identified, supported, protected, and valued.
- **Venue**: A venue is not a specific place or facility. It is an exploration space which might be a virtual environment or the battlefield of a war game.
- **Experiments**: The only way to explore the complexities of a system is through campaigns of experiments, based on the proper venue, people, and ideas. Combining these into a rigorous program of technology and CONOPS will create a deep understanding of what the future may be and now to best meet it.

These research studies provide a basic foundation for military understanding in innovation. Throughout the literature, there is evidence that disruptive innovation is a critical component in military success. Air bombardment, carrier warfare, intercontinental ballistic missiles, space-based surveillance, precision guided munitions, stealth, and armed unmanned air vehicles were all disruptive innovations that dramatically shifted the balance of warfighting (USAF SAB, 2006). In addition, barriers, culture, communication, and experimentation were all shown to have impacts on organizational innovation levels. While these research studies were conducted in military environments, several important investigations have also examined innovation as a monumental consideration for commercial business survival.

Studies of Industry Organizational Innovation

While many business scholars have articulated innovation as a key for survival, deriving a formula for organizational innovation has proven to be a difficult challenge. Innovative organizations are revolutionary in that they aggressively take markets from competitors (Hamel, 2002). Innovation helps good organizations become great organizations and equips strong companies to become long lasting entities (Collins, 1994; Collins, 2001). Resilient groups embrace disruptive change (Hamel and Valikangas, 2003) and competitive organizations use breakthrough ideas to destroy the opposition (Foster, 1986). The difficult challenge for most groups is creating an environment to foster breakthrough innovation while marginalizing practices that stifle creativity. Although many publications have captured the subject of innovation, the four studies outlined in Table 12 have best succeeded in capturing the industry perspective. These studies are briefly introduced in this section and are further detailed in later sections. The findings, combined with other literature sources, provide a base of insight into the motivation and views on innovation, the focus of innovative resources, the barriers of innovation, and characteristics of innovative culture.

Table 12. Recent Industry Innovation Studies

Study Title	Author(s)	Study Description
National Innovation Initiative Final Report 2005: Innovate America - Thriving in a World of Challenge and Change	Council on Competitiveness	• Results of National Innovation Summit • Provides analysis of innovation ecosystem and recommendations for improvement of innovative capacity
The Quest for Innovation: A Global Study of Information Management - 2006-2016	American Management Association (AMA)	• Survey of worldwide mgmt professionals • Characterizes innovative culture of worldwide companies now and in 10 yrs
Expanding the Innovation Horizon: The Global CEO Study 2006	IBM Global Business Services	• Interviews of worldwide CEOs • Captures industry's innovation thoughts, motivations, plans, and challenges
Business Week Special Report: The World's Most Innovative Companies 2007	Business Week Magazine	• Internet survey of global CEOs • Provides detailed ranking of companies who have used innovation to be profitable

The Council of Competiveness (consisting of corporate chief executives, university presidents, and labor leaders) spearheaded the National Innovation Initiative designed to investigate innovation in America. The 15-month study examined the performance of American government and business over the period 1990 to 2003 in order to characterize the need for greater innovation in America. The study stated that, "Innovation will be the single most important factor in determining America's success through the 21st Century" (Council on Competiveness, 2005). The study also outlined a series of recommendations organized into three broad categories: talent, investment, and infrastructure. This National Innovation Agenda, summarized in Table 13, is designed to "unleash (America's) innovation capacity to drive productivity, standard of living, and leadership in global markets" (Council on Competiveness, 2005).

Table 13. National Innovation Agenda (Council on Competitiveness, 2005)

Talent	Investment	Infrastructure
• Build a National Innovation Education Strategy for a diverse, innovative, and technically trained workforce • Catalyze the Next Generation of American Innovators • Empower Workers to Succeed in the Global Economy	• Revitalize Frontier and Multidisciplinary Research • Energize the Entrepreneurial Economy • Reinforce Risk-Taking and Long-Term Investment	• Create National Consensus for Innovation Growth Strategies • Create a 21st Century Intellectual Property Regime • Strengthen America's Manufacturing Capacity • Build 21st Century Innovation Infrastructures - the health care test bed

In 2006, the American Management Association (AMA) commissioned the Human Resource Institute (HRI) to study the emergence of innovation in global industries. The study surveyed 1,396 working level professionals representing companies from around the world; it examined the drivers of industry innovation and analyzed the components of an innovative culture. The AMA/HRI study concluded that "innovation is going to get considerably more important over the next decade;" therefore, it is essential for companies to eliminate the barriers of innovation and increase their innovative culture (AMA, 2006).

IBM Global Business Services conducted another innovation study in 2006 focused on public and private sector senior leadership. IBM conducted interviews with 765 CEOs, business executives, and public sector leaders spanning 20 different industries and 11 worldwide geographic regions. The study provided insight into the CEO views and management of innovation as a means to drive profitable growth. According to the study, CEOs expected fundamental changes for their organizations over the next two years and saw opportunities to be seized through innovation (IBM, 2006). The study

concluded that business model innovation and external collaboration are extremely important, as well as the role of senior leadership, in fostering an innovative climate.

For the last study, *BusinessWeek* publishes an annual special report on innovative companies. In the latest report, the *BusinessWeek*-Boston Consulting Group surveyed 1,500 of the largest global corporations from regions throughout the world (*BusinessWeek*, 2007). Respondents provided general information on innovation and innovation metrics. Survey participants were also asked to provide perspectives on which companies they considered the most innovative and why. The leading innovators were found to be organizations capable of consistent innovation fostered by risk taking and investment in the long-term (McGregor, 2007). The study also found that gimmick-driven, innovation-boosting campaigns were not the deciding factor. Companies became innovative through hard work.

These research studies combined with literature from various business and technology scholars can be combined to illustrate key elements in fostering innovation. Throughout the literature, there is evidence that motivation, focus, barriers, and culture play a crucial role in the emergence of breakthrough and game changing ideas. By examining these key elements with regard to industry innovation, a base model for the emergence of disruptive innovation can be formulated.

Motivation for Innovation

The overarching reason companies pursue innovation is to gain and/or maintain competitive advantage. Foster (1986) explained that competitive advantage would only be achieved by going on the attack and that companies can lose their markets almost overnight to faster-developing technologies. Based on recent research and literature (AMA, 2006; IBM, 2006), several consistent themes appear among both industry professionals and corporate CEOs. As illustrated in Table 14, the leading reasons for pursuing innovation are to grow profitability, respond to customer demand, improve efficiency, and capture markets.

Table 14. Reasons for Pursuing Innovation within Industry Organizations (AMA, 2006; IBM, 2006)

The Quest for Innovation: A Global Study of Information Management - 2006-2016		***Expanding the Innovation Horizon: The Global CEO Study 2006***	
Reasons	***Rank***	***Reasons***	***Rank***
To respond to customer demands	1	Profitable growth	1
To increase operational efficiency	2	Preempt business threats and create them	2
To increase revenues or profit margins	3	Drive needed efficiency	3
To develop new products and services	4	Develop multiple channels with different approaches for different customers	4
To increase market share	5		
To better use new technologies	6		

To Increase Profits. An increase in overall revenue and profit margins continues to be one of the primary motivations for companies to pursue innovation. The world's most innovative companies traditionally see greater revenue growth and margin growth compared to their less innovate counterparts (*BusinessWeek*, 2007). Although most agree that innovation eventually leads to increased profits, only a small percentage of

companies are satisfied with their return on innovation spending (McGregor, 2007). Companies are finding it takes time to see profit growth and are often abandoning innovation investments for more short-term gains.

To Respond to Customer Demand. In today's marketplace, customers are more demanding than ever before. Customers not only want improved performance and lower price, but they also want new technologies that provide new capabilities they have never seen before. Customers also have unprecedented buying power and the ability to rapidly change suppliers if their demands are not met. Therefore, innovation is often seen as paramount to acquiring and holding onto customers. Peters (1997) explained this concept best: "If the other guy's getting better, than you'd better get better faster than the other guy's getting better, or you're getting worse" (p. xii).

To Improve Efficiency. It is not surprising that companies are interested in more than just product and service innovation; they also desire new ideas that can improve the overall model in which they conduct business. As shown in Table 15, companies need to reduce cycle-times and improve operational efficiency in order to survive. Hammer and Champy (1993) explain that because of customer power and customer choice, simply relying on acceptable process performance is no longer enough; furthermore, they state that conventional business remedies do not address the source of the problem, which is non-value added work resulting from fragmented processes.

Table 15. Cycle-Time Reductions in Industry (DSB, 2007)

Industry	Past	Recent	Goal
Automobile	84 months	24 months	<18 months
Commercial Aircraft	8-10 years	5 years	2.5 years
Commercial Spacecraft	8 years	18 months	12 months
Consumer Electronic	2 years	6 months	<6 months

To Capture Markets. Both the AMA (2006) and IBM (2006) studies found that market share was a primary motivator for pursuing innovation. This is not insignificant considering that disruptive innovation is one of the primary means companies use to attack incumbent organizations in various markets. Most organizations that fail to foster innovation are eventually overtaken by market revolutionaries. "First the revolutionaries will take your markets and your customers … next they will take your best employees" (Hamel, 2002).

Focus of Innovation Resources

While the need to focus corporate resources on innovation is widely espoused, the optimal balance of investment is widely debated in the literature. Short-term investments necessitate close attention to detail, midterm investments demand capital and willingness to take risk, and long-term investments require imagination and technological daring (Hayes and Abernathy, 1980). Innovation strategies by companies today are best described by looking at investments by functional area, innovation magnitude, and

innovation type. The studies and literature indicate trends toward customer focus, reliance on business model innovation, and an emerging push toward new breakthrough products/services.

Customer Focused Innovation. According the AMA/HRI study (2006) results outlined in Table 16, more than 25% of the innovation resources in participating companies were focused on supporting customer experience and service. In addition, the study found that while innovation occurs across various functional areas, the areas directly related to customer relationships are absorbing the highest degree of focus. Marketing, sales, customer service, and supply chain functions equated for over 41% of the functional areas of innovation.

Table 16. Functional Innovation within Industry Organizations (AMA, 2006)

Functional Areas of Innovation		***Focus Areas of Innovation***	
Functional Areas	***Percent of Responses***	***Areas***	***Percent of Responses***
R&D	27%	Customer experience	15.2%
Marketing	17.2	Service	11.6
Information Technology	12.2	Core processes	12.4
Sales	9.7	Product performance	12.2
Customer Service	8.9	Enabling processes	11.8
Manufacturing	6.5	Business models	10.6
Supply Chain	5.4	Brand	8.4
Planning	5.1	Networks and alliances	8.1
Human Resources	3.9	Product systems	4.7
Finance	2.4	Channel	3.6

Emphasis on Business Model Innovation. Companies are finding with greater certainty that business process and organizational innovation is important. The IBM Global CEO study found that "four out of every ten companies were afraid that changes in a business competitor's business model would upset the competitive dynamics of the entire industry" (IBM, 2006:12). The data shown in Figure 5 further compounds that assertion, illustrating that stronger emphasis on business model innovation equates to higher operating margins. The CEOs of outperformers are placing nearly twice as much focus on business model innovation than the CEOs of underperformers.

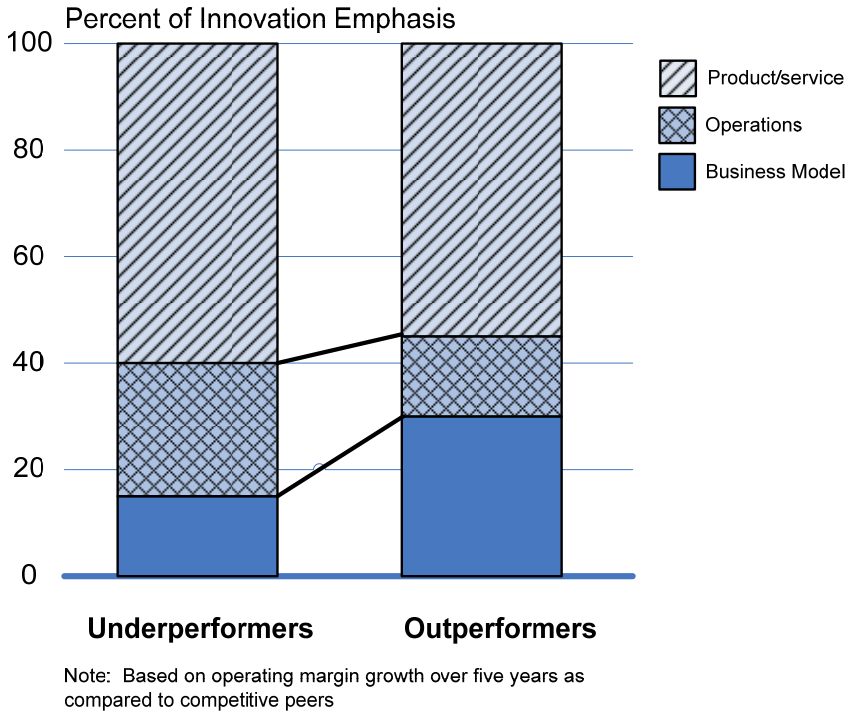


Figure 5. Innovation Emphasis (adapted from IBM, 2006)

Product/Service Migration toward Disruption. While competition has pushed companies to consider process innovation, the most popular type of innovation focus continues to be in the area of products/services. The recent industry shift is toward new products/services with "fewer companies focusing on incremental innovation or making minor changes to existing products" (*BusinessWeek*, 2007). The data depicted in Figure 6 shows a one-year increase in areas typically characterized as disruptive innovation. This significant global shift to new products/services further solidifies the importance of understanding the emergence of disruptive innovation.

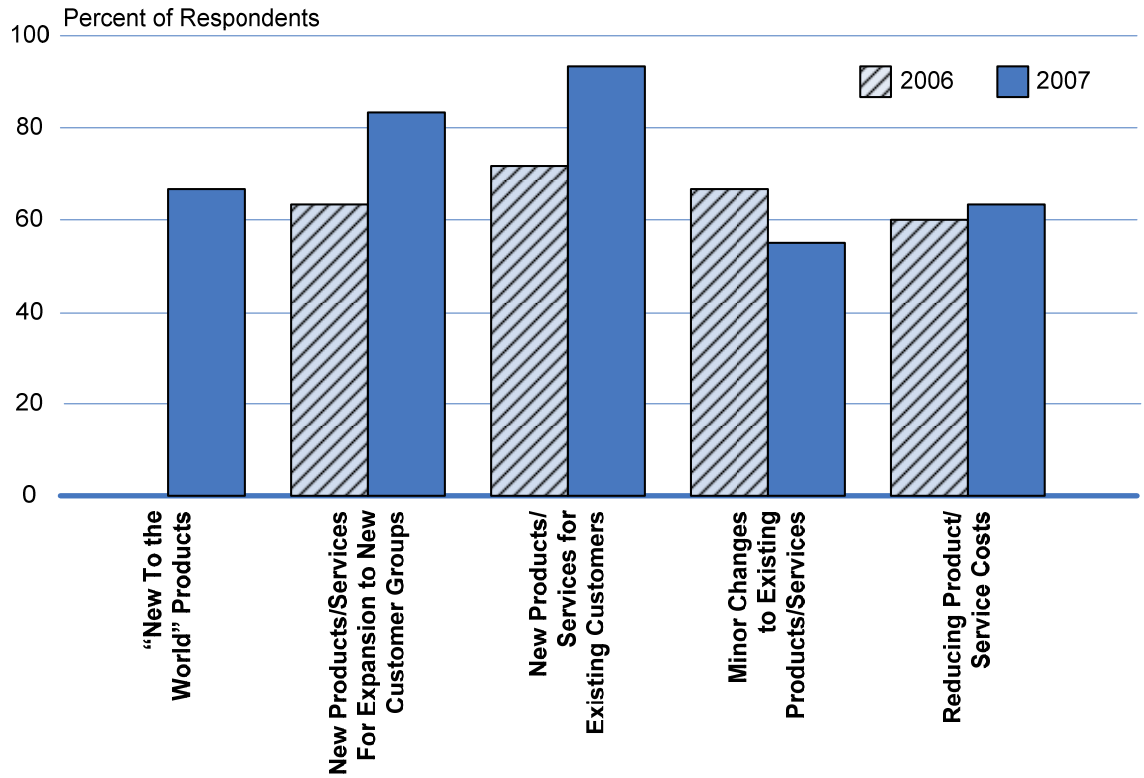


Figure 6 - Focus of Innovation Resources (adapted from *BusinessWeek*, 2007)

Barriers of Innovation

Most innovation experts agree that although growing innovation can be a difficult and daunting challenge, barriers that hamper innovation are abundant in companies today. Many companies invest considerable resources into fostering ideas only to have their innovation efforts squelched by internal and external barriers (Kelley, 2001). Table 17, based on recent innovation research, summarizes the most common barriers found in companies today. Although the semantics of obstacles varies from study to study, several common themes are consistent throughout the research: unsupportive culture, insufficient resources, lack of strategic vision, and poorly developed processes.

Table 17. Study Findings in Barriers of Innovation

The Quest for Innovation: A Global Study of Information Management - 2006-2016	***Expanding the Innovation Horizon: The Global CEO Study 2006***	***Business Week Special Report: The World's Most Innovative Companies 2007***
• Insufficient resources • Lack of formal strategy for innovation • Lack of clear goals and priorities • Unsupportive organizational structures • Short-Term mindset	<u>Internal</u> • Unsupportive culture and climate • Limited funding for investment • Workforce issues • Process immaturity • Inflexible physical and IT infrastructure • Insufficient access to information <u>External</u> • Government and other legal restrictions • Economic uncertainty • Inadequate enabling technologies • Workforce issues arising externally	• Lengthy development times • Lack of coordination • Risk-averse culture • Limited customer insight • Poor idea selection • Inadequate measurement tools • Lack of ideas • Marketing or communication failure

Unsupportive Culture. Company mindset has been articulated as one of the biggest barriers to innovation (Kelley, 2001). The AMA/HRI (2006) survey, IBM (2006) study, and *BusinessWeek* research all found unsupportive organizational cultures to be significant obstacles to innovation growth. Risk-adversity, inflexibility, communication failures, workforce issues, and lack of ideas are all common symptoms of poor innovative culture. Overcoming cultural barriers can best be addressed by positively cultivating an innovative culture. The characteristics of innovative culture are addressed in more detail in the next section.

Insufficient Resources. Innovation does not merely involve simple financial investments; it also involves investments in people, facilities, markets, training, and technology. Many organizations are falling into the "performance" trap where the company is doing well and fails to explore other opportunities because of the time, money, and personnel required (AMA, 2006). Still other organizations are opting to sacrifice long-term stability for short-term gains. With reductions in discretionary dollars and massive pressures from demanding stockholders, many CEOs are forced to divert R&D resources to lower-risk, guaranteed-return investments (IBM, 2006). According to the *BusinessWeek* (2007) assessment, "More than half of all CEOs, chairmen, and presidents of companies were happy with how they'd spent on growth initiatives. CFOs, not surprisingly, were among the least satisfied: A full 63% were unhappy with their results" (p. 1). This mindset clearly defines the difficulties faced by innovators attempting to gain access to needed resources.

Lack of Strategic Vision. Although it is debated in the literature whether companies can "direct" innovation, it is commonly acknowledged that innovation strategy plays a role in fostering new concepts. Based the AMA/HRI (2006) research highlighted in Table 18, most companies are falling dramatically short in developing a well understood strategy for innovation and a shared vision on how to execute a plan for innovation.

Table 18. Industry Lack of Innovation Strategy (AMA, 2006)

In my company…	***Percent of Respondents***
Have a shared definition of what innovation is.	41.3
Regularly review the progress of innovation.	22.4
Have a shared agenda to execute the innovation strategy.	12.3
Have a well-understood strategy for innovation.	12.1
Have well-defined roles and responsibilities.	11.3

Poorly Developed Processes. Long development times, insufficient access to information, poor idea selection, ineffective organizational structures, and communication failures are all indicative of poorly developed processes. Hammer (1996) explains that:

> Over the years, non-value added work in large organizations has expanded to the point where it often dominates and exceeds the value added work. It is not uncommon to find less than 10 percent of the activities in a process to be value-adding, with the rest of the rest mostly non value adding overhead. (p. 34)

Process improvement is based on a commitment to optimize value through a process view of accomplishing work. It is not surprising that companies with inefficient processes struggle with innovation given that it takes creative and radical thinking to develop effective processes.

Characteristics of Innovative Culture

Organizational culture is defined as "a system of shared meaning held by members that distinguishes the organization from other organizations" (Robbins and Judge, 2007). An innovative culture is therefore a shared organizational environment that is designed to best foster innovation. Many companies even specialize in teaching organizations to become more innovative. IDEO, ranked as the 28th most innovative company in the world (*BusinessWeek*, 2007), is considered a premiere leader in the development of the breakthrough spirit. With the recent innovation craze striking the business world, it is not surprising that hundreds of articles and publications have been written on the characteristics of innovative culture. Several common threads appear within the leading studies, summarized in Table 19, that help define the key characteristics of an innovative culture: strong customer focus, collaboration, effective processes, creative people, inspiring leadership, risk-taking, and motivation/reward systems.

Table 19. Studies Findings in Characteristics of Innovative Culture

The Quest for Innovation: A Global Study of Information Management - 2006-2016	***Expanding the Innovation Horizon: The Global CEO Study 2006***	***Business Week Special Report: The World's Most Innovative Companies 2007***
• Customer focus • Teamwork and collaboration with others • Appropriate resources • Organizational communication • Ability to select the right ideas for research • Ability to identify creative people	• Orchestration from the top • Collegial culture with individual rewards • Consistent business and technology integration	• Right (Organizational) Structures • Right Processes • Right People • Inspired Leadership

Strong Customer Focus. The research suggests that industry organizations that place their existing and future customers at the forefront are more innovative. Strong customer focus does not just mean delivering what customers ask for but rather "capturing their ideas or actually allowing them to innovate on their own behalf" (AMA, 2006). According to Kelly (2001), co-founder of IDEO, true understanding comes not by talking to customers, but watching them and becoming emerged in their environment. Christensen (2003) chronicled the extensive market analysis conducted by a quick-service restaurant chain with regard to milkshake sales. The group examined not just what the customers wanted, but why they wanted it, when they wanted it, who they were with, and what they would be doing if they were not there buying a milkshake. As a result of this strong customer focus, the firm was able to implement disruptive product and process innovations that transformed the marketplace and decimated the competition.

Collaboration. External and internal collaboration is a common characteristic found within the industry studies on innovation. According to Hargadon (2003), the most significant innovations come from collaborative groups of people than from brilliant lone individuals. Collaborative innovation can be defined using the organizational Garbage Can Model developed by Cohen, March, and Olsenhttp://en.wikipedia.org/wiki/Michael_D._Cohen (1972). The theory articulates that many solutions to problems can often be found by sifting through garbage in which ideas, or the ideas of others, have been tossed out as being irrelevant. Similarly, innovative cultures are best characterized by broad and often unrelated people that simply interact to make breakthroughs happen. As illustrated in Figure 7, industry organizations that collaborate to a large extent typically perform better than the competition and receive strong benefits from the innovate spirit generated.

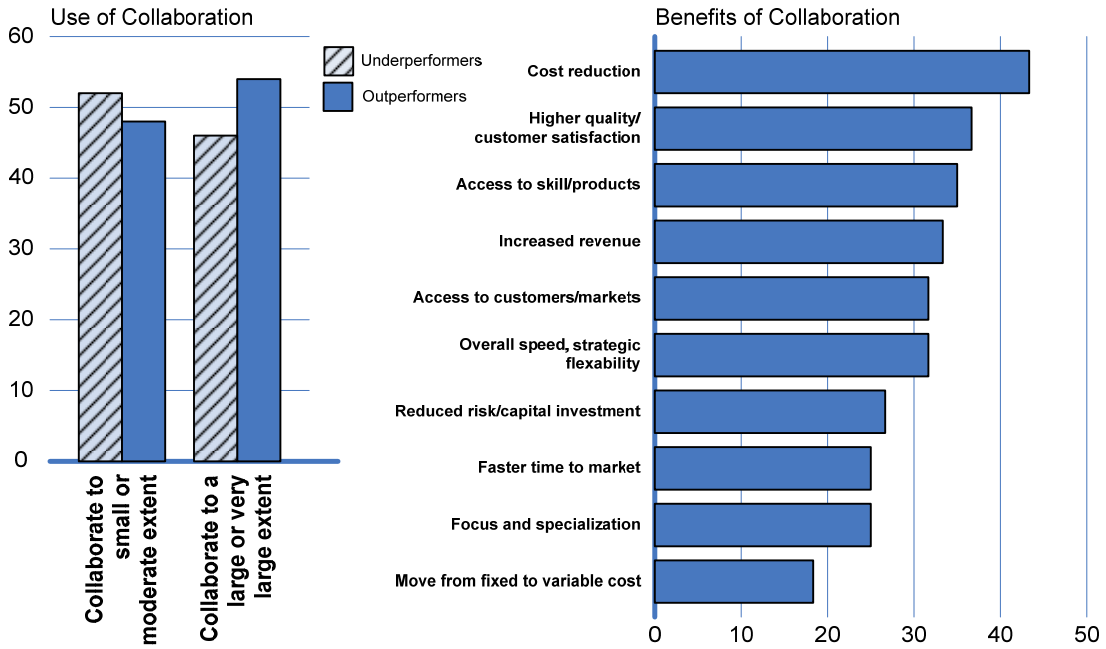


Figure 7. Collaboration (adapted from IBM, 2006)

Efficient Processes. Efficient processes are streamlined and provide the appropriate level of performance to the organization. In addition, efficient processes undergo an endless cycle of improvement where process performance is measured, benchmarks are established, gaps are identified, and modifications are implemented (Hammer, 1996). According to the AMA/HRI assessment, innovative cultures are strongly tied to how efficiently organizations can capitalize on ideas. Innovative organizations know how to balance resource investments, select the right ideas, mobilize the right resources, and measure results (AMA, 2006). The level of disruptive innovative passion is directly related to an organizations ability to get funding and manpower required to cultivate new idea proposals (Christensen, 1997).

Creative People. Both the AMA and *BusinessWeek* studies cited creative people as a key element in creating an innovate culture. Creative people have the ability to solve problems because of their willingness to examine the world from different perspectives (Glover and Smethurst, 2003). Innovators are able to look beyond the status quo and visualize the realm of the possible while not allowing risk and adversity to hamper their progress. Henry Ford said, "Failure is the only opportunity to begin again, more intelligently" (Ferguson, 1990). Not everyone is naturally creative and many companies like IDEO have developed a series of innovation roles, summarized in Table 20, that allow people to contribute to the innovative culture. Although business scholars believe that innovation comes from groups of creative people, breakthrough teams are composed of individual characters and diverse personalities deliberately recruited to generate energy and ideas (Kelley, 2000).

Table 20. The Ten Faces of Innovation (Kelly, 2005)

Role	***Description***
The Anthropologist	Brings new learning and insights into the organization by observing human behavior and developing a deep understanding of how people interact physically and emotionally with products, services, and spaces.
The Experimenter	Prototypes new ideas continuously, learning by a process of enlightened trial and error.
The Cross-Pollinator	Explores other industries and cultures, and then translates those findings and revelations to fit the unique needs of your enterprise.
The Hurdler	Knows the path to innovation is strewn with obstacles and develops a knack for overcoming or outsmarting those roadblocks.
The Collaborator	Helps bring eclectic groups together, and often leads from the middle of the pack to create new combinations and multidisciplinary solutions.
The Director	Not only gathers together a talented cast and crew but also helps to spark their creative talents.
The Experience Architect	Designs compelling experiences that go beyond mere functionality to connect at a deeper level with customers' latent or expressed needs.
The Set Designer	Creates a stage on which innovation team members can do their best work, transforming physical environments into powerful tools to influence behavior and attitude.
The Caregiver	Builds on the metaphor of a heath care professional to deliver customer care in a manner that goes beyond mere service.
The Storyteller	Builds both internal morale and external awareness through compelling narratives that communicate a fundamental human value or reinforce a specific spiritual trait

Inspiring Leadership. Collins (2001) found that Level 5 Executives, leaders that blended extreme personal humility with intense professional will, were the catalyst in building great companies. Supportive leadership has been shown to be an equally important characteristic in building an innovative culture. According to research presented at the 2002 Society for Industrial and Organizational Psychology Annual Conference, the extent to which the CEO reflects on organizational objectives, strategies, and processes and implements changes accordingly, is directly related to the organizational climate for innovation.

> [T]he more reflexive a CEO was rated, the higher the employee rated climate of innovation scores, the more non-traditional the organizational practices, and the greater extent of change in the organization. (Kazama and others, 2002:16)

Risk-Taking. "Innovation demands adherence to two fundamental principles: a willingness to accept risk and a willingness to wait for the return on investment" (Council on Competitiveness, 2005). While most scholars agree that innovation is a risky venture, only 20% of global companies actually recognize and reward intelligent risk-taking (AMA, 2006). Innovative cultures are made stronger by embracing failure as an option and taking the time to experiment. IDEO describes this innovation characteristic with the slogan, "Fail often to succeed sooner" (Kelly, 2001: 232). Encouraging risk-taking helps create an environment where employees are willing to take chances with radical ideas.

Motivation and Reward Systems. Rewards for innovative behavior were a common characteristic cited in several publications on innovative culture in industry. The AMA/HRI study found that most companies utilized non-financial rewards as a means to promote innovation (AMA, 2006). The IBM study found that "companies that

reward individual [innovation] contributions achieved 2 percent higher operating margins on average and grew nearly 3 percent faster than those who did not" (IBM, 2006:31). Motivation and reward systems are closely tied with organizational willingness to accept risk. Tohmatsu (2003) explains this relationship by saying,

> How you encourage and reward innovative activities will ultimately determine whether your employees undertake them. Innovation starts with employees willing to take risks. Employees will be apprehensive of these activities if they perceive the upside to be limited and the downside to be significant. A truly innovative culture needs to make employees feel secure enough to believe that failure itself will not affect their position within the firm. (p. 19)

Fostering Disruptive Innovation

Christensen (2003) proposes that building an organization capable of disruptive growth requires a careful balance of resources, processes, and values. Combining these thoughts with previous studies of organizational innovation provides a model for fostering disruptive innovation. The model proposes the following: an increase in the right motivation, plus an increase in the right focus of innovation resources, plus a decrease in the barriers of innovation, plus an increase in the characteristics of innovative culture, will foster an increase in the emergence of disruptive innovation. This model, illustrated in Figure 8, is not intended to be an equation for guaranteed success but rather a conceptual formula to ensure that all critical elements in the emergence of disruptive innovation are considered. While the interpretations, applications, and considerations will be domain dependent, the basic model is a universal framework for innovation improvement. The model, closely aligned with the thesis investigative areas, is also the framework of comparison for the data gathered in the remainder of this research effort.

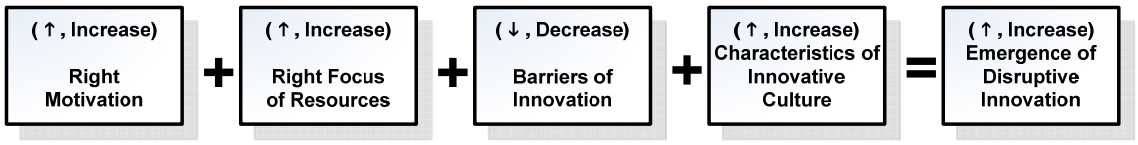


Figure 8. Model for Fostering Disruptive Innovation

Summary

This chapter provided a detailed literature review of the concepts of innovation, recent studies of organizational innovation, and approaches to fostering innovation. The review first defined innovation and outlined a comprehensive examination of the concepts of disruptive innovation. Next, several studies of organizational innovation were reviewed under the context of: motivation for innovation, focus of innovation resources, barriers of innovation, and characteristics of organizational culture. Various approaches to fostering disruptive innovation were also presented. Finally, a conceptual model intended to foster the emergence of disruptive innovation was proposed. The next chapter provides a full description of the research methodology, to include the survey instrument development, data collection scheme, and data analysis approach.

III. Methodology

This chapter provides a description of the study methodology including the data collection procedure, data analysis approach, and comparison. The chapter begins with a summary of the overall research approach. The data comparison section describes the research population, survey instrument, and interview instrument. The analysis section portrays descriptive statistics methods used to analyze the survey data as well as the grounded theory evaluation applied to the interview data. The data comparison section describes how the new research data will be compared to existing research studies

Overall Research Approach

The research approach used in this study, illustrated in Figure 9, combines both quantitative and qualitative research elements. The proposed approach began with a literature review to investigate key concepts and existing research. The second step identified relevant industry research studies and to mirror those studies in an Air Force Science and Technology (S&T) environment. The next step examined the resulting Air Force research data using the same analysis techniques as the identical industry research. This investigation then compared the results of the Air Force S&T research data with the published findings from the industry survey/interview research. The overall study culminated with an outline of findings and implementation recommendations.

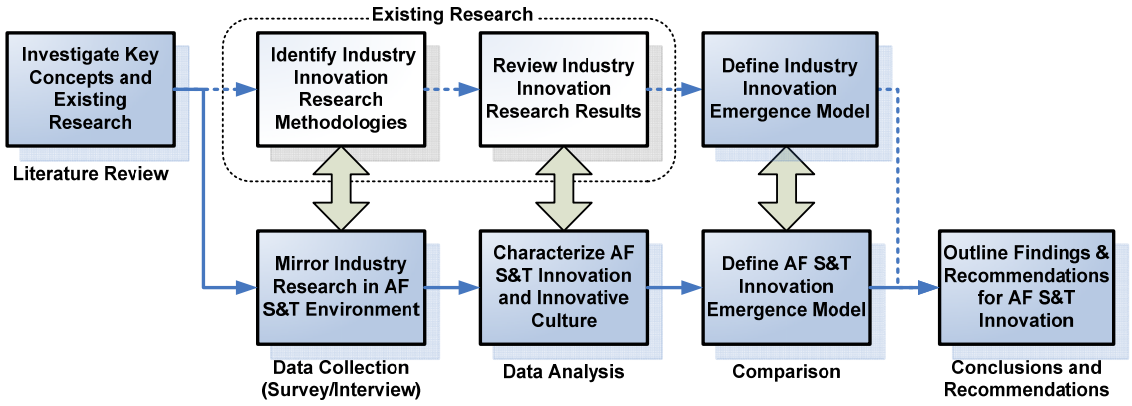


Figure 9. Overall Research Approach

Data Collection Approach

The data collection for this investigation consisted of replicating two separate research studies conducted previously in the industry environment. The new data was collected in an Air Force S&T environment. This research study was composed of two data collection efforts as outlined in Table 21. The first data collection consisted of a survey to government civilian and military personnel currently employed by the Air Force Research Laboratory (AFRL). This survey replicated the American Management Association/Human Resource Institute (AMA/HMI) survey, administered to a broad array of industry professionals as the basis of the report titled *The Quest for Innovation: A Global Study of Information Management - 2006-2015*. The second set of data came from semi-structured interviews designed and patterned after those described in an IBM report titled *Expanding the Innovation Horizon: The Global CEO Study 2006*. The interviews were conducted with CEO equivalents, i.e., senior members of the AFRL organization and technology directorates. This mixed method data collection approach

provided data at various organizational levels and delivered the solid replication of previous research needed for comparison purposes (Creswell and Clark, 2006).

Table 21. Research Data Collection

	Data Collection #1	***Data Collection #2***
Data Collection Instrument	Survey	Interview
Comparison Study	The Quest for Innovation: A Global Study of Information Management - 2006-2016	Expanding the Innovation Horizon: The Global CEO Study 2006
Collection Method	Online Survey	Personal Interview
Population	AFRL government scientist/engineering civilian and military personnel (approx 3500 persons)	AFRL senior headquarters and directorate leadership (15 persons)

Population

This investigation is intended to examine disruptive innovation within the Air Force S&T community. The Air Force Research Laboratory (AFRL) is the primary organization responsible for planning and executing all aspects of the Air Force science and technology program; a more detailed organizational description including fact sheet, organization chart, and research locations is provided in Appendix A. AFRL leads a worldwide partnership of government, industry, and academia with 5,400 civilian, military, and contractor personnel, in 10 technology directorates, across 14 major research sites, executing an annual budget of over $3 billion (AFRL, 2007). Based on its

size, influence, mission, and structure, AFRL is the ideal population to represent the Air Force S&T community at large.

The population for this research study consisted of government civilian and military personnel currently employed by AFRL. Based on personnel policies and bargaining unit restrictions, AFRL was only able to authorize the survey of science and engineering civilians and all military personnel at 8 of the 10 research locations. The result was a survey population of 3,280 persons. Although the survey was administered to persons at all levels of the AFRL organization, the interviews were conducted with AFRL's CEO-equivalent senior leaders. The purposive interview population consisted of 15 members of AFRL senior leadership staff or corporate board: five members of the AFRL senior command staff and the 10 Directors of the AFRL Technology Directorates.

Survey Instrument Review

The survey used in this research study was designed to replicate a survey conducted by the AMA (AMA, 2006). Although the overall content of the original AMA survey was maintained, several design adjustments were made to accommodate for the demographics and terminology of AFRL. The demographic items were modified to better capture AFRL specific qualifying information such as job function, employment type, level of responsibility, supervision, directorate, years of experience, work location, job satisfaction, and organizational life-cycle. The remaining survey items were kept in their original format to preserve the comparison integrity. Some of the response options were modified slightly to translate terminology differences between government and industry. For example, the expression *funding level and cost savings* was used in lieu of

revenue and profit margins. The phrase *to be state of the art* was further clarified to read *to be state of the art in warfighting*. The term *AFRL relevance* was substituted for *market share* and *directorate/organization* was used to replace references to *company*. While there were other minor response modifications, the changes were for clarification purposes and did not impact the intent of the overall construct.

Similar to the AMA instrument which characterized the industry view of innovation, the modified survey was designed to capture a government perspective of innovation. The survey, shown in its entity in Appendix B, consisted of 9 demographic items and 17 research items. The research items were a blend of multiple choice, ranking, and five-point Likert-type response scales (Likert, 1932). The various measures were identical to the measures used in the comparison AMA study. Several items had several possible answers which could each be measured using the five-point Likert-type response scale where 1 was "important" and 5 was "extremely important." As outlined in Table 22, the 26 survey items were closely aligned to the six investigative areas

The self-administered, online-survey was hosted on the AFIT Web Survey Information Management System and made accessible from any standard desktop web browser. The appropriate link was then electronically sent from the AFRL Executive Director (AFRL/CD) to the AFRL personnel population using the workflow email distribution list. The web-based survey was available for a two week period between 10 December 2007 and 2 January 2008. During that time period, 245 of the 3,280 potential participants at AFRL completed the survey, corresponding to a 7.5 % response rate. After reviewing the 245 submitted surveys, 14 surveys were deemed unusable due to incompleteness. In addition, survey item number 21 was removed because of technical

problems in the database collection algorithm for that single question. Therefore, the final data set for the survey portion of this research consisted of 231 surveys and 25 survey items.

An important element in the internal validity of this research was the sample demographics. Ideally, the AFRL sample demographics, shown completely in Appendix D, would closely match the actual proportions of various groups in the AFRL population. Table 23 shows the AFRL sample compared to some key demographic data provided by AFRL's human resources department. While the employment type comparisons are valid, the years of experience appears weighted in higher levels and the directorate and geographic distributions show some polarization. Volunteerism may have played a role in creating potential selection bias, as the persons who chose to participate in the survey were concentrated in certain geographic sites and directorates. Since the research scope did not involve correlation of responses to specific directorates and geographic sites and because key variables were more attributable to AFRL as a whole, these differences were deemed acceptable. Although the findings were not analyzed based on directorate or geographic demographics, the possible selection bias still needs to be considered when evaluating the generalizations made by the survey portion of this study.

Table 22. Survey Item and Investigative Area Alignment

Item Number	Item Summary	Alignment to Investigative Areas					
		1. Motivation for Innovation	2. Focus of Innovation Resources	3. Barriers of Innovation	4. Components of an Innovative Culture	5. Senior Leadership Perspective on Innovation	6. Model for Fostering Disruptive Innovation
1-9	Demographic information						
10	Importance of innovation in various organizational activities	X	X				X
11	Reasons for pursuing innovation	X					X
12	Factors for developing an innovative culture				X		X
13	External drivers of innovation	X					X
14	Ways of measuring creativity			X	X		X
15	Barriers of innovation			X			X
16	Leadership actions to foster innovation			X	X		X
17	Risk taking			X	X		X
18	Idea evaluation and selection			X	X		X
19	Reward and recognition for innovation			X	X		X
20	Opportunities for innovation		X				X
21	Organizational success at innovation		X				X
22	Feelings about innovation			X	X		X
23	Areas of innovation		X				X
24	Innovation in organizational functions		X				X
25	Innovation Strategy		X	X	X		X
26	Misc innovation comments (free-form)	X	X	X	X		X

Table 23. Comparison of AFRL Sample and Population Demographics

Selected Survey Demographic Items	***AFRL Survey Sample***	***AFRL Population****
	231 Respondents	3280 Persons
Survey Item 2 - Employment Type		
Military	21.2%	21.8%
Government Civilian	78.8%	78.2%
Survey Item 5 - Employment by Directorate/Organization		
Headquarters Air Force Research Laboratory	9.5%	3.4%
Air Vehicles Directorate	7.4%	7.1%
Materials and Manufacturing Processes Directorate	16.9%	11.9%
Propulsion Directorate	6.5%	11.3%
Sensors Directorate	44.2%	17.7%
Human Effectiveness Directorate	8.2%	11.7%
Information Directorate	0.4%	9.9%
Munitions Directorate	4.8%	7.2%
Space Vehicles Directorate	1.7%	9.5%
Directed Energy Directorate	0.4%	8.3%
Air Force Office of Scientific Research	0.0%	2.0%
Survey Item 6 - Years of Experience		
0-5 Years	18.6%	30.6%
6-10 Years	8.7%	12.5%
11-15 Years	8.2%	7.6%
16-20 Years	12.1%	15.0%
21-25 Years	22.9%	12.4%
25+ Years	29.4%	21.8%
Survey Item 7 - Employment by Geographic Research Site		
Wright Research Site	82.3%	49.4%
Brooks Research Site	4.8%	3.6%
Eglin Research Site	4.8%	7.1%
Mesa Research Site	1.7%	0.8%
Tyndall Research Site	1.7%	1.1%
Kirtland Research Site	1.3%	12.8%
Hanscom Research Site	1.3%	6.0%
Rome Research Site	0.4%	10.5%
Edwards Research Site	0.0%	3.8%
Air Force Office of Scientific Research Site	0.0%	2.0
Other	1.7%	2.8

* AFRL population statistics based on data provided by AFRL Human Resources (AFRL/DP)

Interview Instrument Review

The interview used in this research study was designed to closely match the content used by the IBM study (IBM, 2006). The semi-structured content of the interview was designed to mirror the content of the original IBM interview. The interview outline, shown in its entirety in Appendix C, consisted of 16 discussion questions in four research areas: views of innovation, innovation emphasis, role of collaboration in innovation, and innovative culture. As outlined in Table 24, the interview questions were designed to provide representative insights into the Air Force S&T senior leadership perspective of innovation as well as research support to the other investigative questions.

Table 24 - Interview Question Group and Investigative Areas Alignment

		Alignment to Investigative Areas					
Question Group	**Question Group Summary**	**1. Motivation for Innovation**	**2. Focus of Innovation Resources**	**3. Barriers of Innovation**	**4. Components of an Innovative Culture**	**5. Senior Leadership Perspective on Innovation**	**6. Model for Fostering Disruptive Innovation**
A	Views of Innovation	X				X	X
B	Emphasis of Innovation		X			X	X
C	Role of Collaboration in Innovation			X	X	X	X
D	Innovative Culture			X	X	X	X

The interviews were conducted with representative leadership of AFRL's senior staff. The AFRL Senior Staff, also called the AFRL Corporate Board, are shown in the organizational chart in Appendix A. The interview data was collected between 20 December 07 and 31 January 08 using a semi-structured, free flowing interview format. Although specific questions were asked, the participants were given the liberty to lead additional discussions wherever they saw fit. The interviews were recorded with the permission of the participants. Eleven of the 15 AFRL Corporate Board members contacted agreed to be interviewed, corresponding to a 73.3% response rate.

Data Analysis Approach

The data analysis for this research combined both quantitative and qualitative analysis methods in examining the survey and interview data sets. The survey data was analyzed using basic descriptive statistical techniques designed to summarize and describe the data collected (Patten, 2005). The interview data was evaluated using qualitative research methods designed at interpreting the content and patterns in the information collected (Michael, Quinn, and Patten, 2002).

Survey Analysis Approach

The survey data was collected using a combination of nominal, ordinal, interval, and ratio measurement scales. As shown in Table 25, the various scales were applied to specific types of items in the survey (Patten, 2005). A variety of descriptive statistical methods were used to analyze the collected survey data. Frequency and ranking analyses were conducted on all the survey items to establish a basis of comparison with previous

identical research studies. In addition, the mean, standard deviation, and sample variance were calculated for the survey items utilizing interval measurement scales. These descriptive statistics were used to support statistical significance tests described in the data comparison section.

Table 25. Measurement Scales Used in Survey

Scale	*Characteristic(s)*	*Survey Application*
Nominal	Naming; data expressed in words	• Basic demographics (questions 1, 2, 3, 4, 5, 7, and 9) • Simple multiple choice (questions 17, 18, 19, 21, 22, 23, 24, 25) • Open narrative comments (question 26)
Ordinal	Ordering; data expressed in terms of rank	• Rank from list of choices (questions 15, 16, and 20)
Interval	Data in equal intervals without an absolute zero	• Job satisfaction demographics (question 8) • Likert scale measures (questions 10, 11, 12, 13, and 14)
Ratio	Data in equal intervals with an absolute zero	• Experience demographics (question 6)

Interview Analysis Approach

The qualitative data collected from the interviews was analyzed using a grounded theory approach. Grounded theory refers to an inductive method of analysis were "researchers start with the data and develop theories based on the data" (Patten, 2005). As shown in Figure 10, "grounded theory begins with basic description, moves to conceptual ordering, and then theorizing" (Michael, Quinn, & Patten, 2002). The interview data collected in this research study was examined using this analysis approach and utilized conceptual ordering based on open coding, axial coding, and core

categorization (Patten, 2005). The qualitative analysis culminated in the development of theoretical observations designed to characterize the comparisons and patterns in the interview data. Additional detail regarding the qualitative coding decisions and specific examples of analysis categorizations are illustrated in Chapter IV and in the interview analysis data shown in Appendix F.

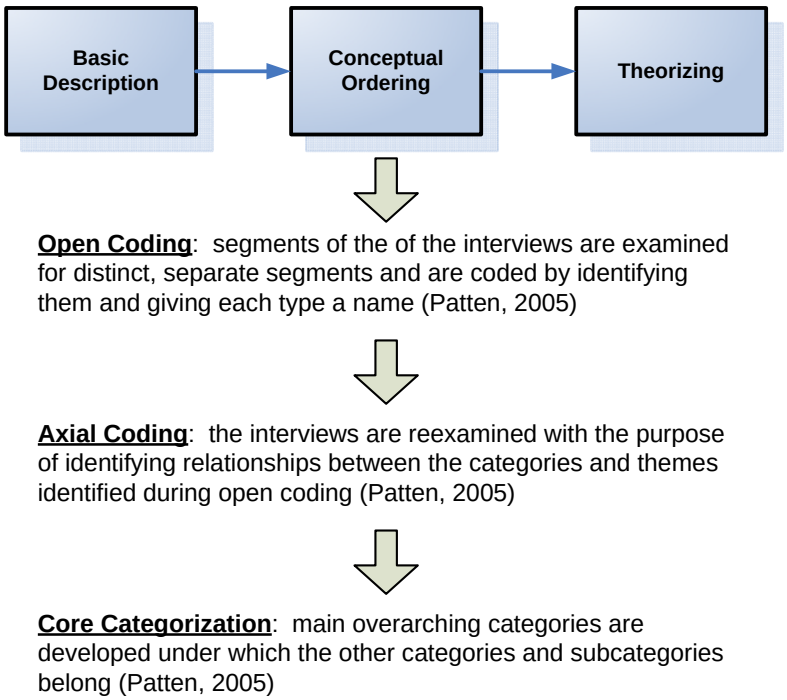


Figure 10 - Grounded Theory Methodology

Data Comparison Approach

The comparison of the data collected in the Air Force S&T environment to the data collected in the industry setting was a paramount component of this study. The survey data were compared to survey results in the AMA/HRI survey. Because the AFRL survey closely replicated the AMA/HRI survey, it was possible to compare the descriptive statistics between the two samples. Any similarities and differences in the data sets were critical in both the model analysis and overall research conclusions.

In the case of five critical survey items (10, 11, 12, 13, and 14) measured using interval based Likert-scale responses, the *t*-test was used to compare the independent sample means in the AFRL (sample 1) and industry (sample 2) surveys. The t-statistic was calculated for each response using the following equation (McClave, Benson, and Sincich, 2005):

$$t = \frac{x_1 - x_2}{\sigma_{\bar{X}1} - \sigma_{\bar{X}2}} = \frac{x_1 - x_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

where:
x = mean
s^2 = sample variance
n = sample size

The critical value of *t* for this paired difference experiment was determined using statistical tables and found to be 1.646 (McClave, Benson, and Sincich, 2005). This *t*-critical was determined for degrees of freedom (*df*) greater than 120 and a probability (*p*) less than 0.05. By convention, when *p* equals 0.05 or less, the result is said to be statistically significant (Patten, 2005). In each case, the resulting *t*-statistic was compared against the determined *t*-critical value. The difference in mean values between the AFRL

sample and industry sample was said to be statistically significant (for a $p < 0.05$) if the t-test statistic was greater than 1.645 or less than -1.645.

In addition, the AFRL Corporate Board interviews and the IBM CEO Study interviews were measured against each other. The overarching themes and theoretical explanations in the two studies were compared for variations and commonality. This comparative methodology step for both survey and interview data enabled clear comparison between Air Force S&T innovation and industry innovation captured in previously published findings.

Summary

This chapter provided an overall description of the study methodology including a detailed description of the data collection, data analysis, and data comparison approaches. The research methodology described two data collections, a survey and an interview, designed to mirror similar research studies conducted in the industry environment. The study population, survey design, interview outline, and respective response samples were described along with the details of instrument validity. Next, the analysis methods used in the survey and interview were introduced. The data comparison approach was also presented. The next chapter provides a full compilation of the study results and analysis.

IV. Results and Analysis

This chapter provides the results and analysis of the research and is presented in two sections. The first section provides a detailed quantitative analysis of the survey data including both the basic descriptive statistics and the comparative analysis between industry survey data and Air Force Science and Technology (S&T) data. The second section provides a comprehensive qualitative evaluation of the interview data that was collected as well as some comparisons between industry CEOs and Air Force Research Laboratory (AFRL) Senior Leaders. Finally, the survey and interview results are combined with the information gathered in the literature review to provide increased depth and support to the proposed innovation emergence model.

Survey Analysis

The quantitative analysis of the survey data consisted of a combination of descriptive statistics to determine means and frequency with inferential statistics to compare means and rankings across survey populations. The survey results are grouped based on the investigative questions defined for this research effort. These groupings also correspond with the components of the proposed model for innovation emergence.

Motivation for Innovation

Three survey items provided insight into how AFRL employees perceive the Air Force S&T motivation for innovation. Survey item 10 captured the overall importance of

innovation to AFRL, survey item 11 evaluated various reasons for pursuing innovation, and survey item 13 outlined specific external drivers of innovation. Respondents were able to score their answers using a Likert scale where 1=Not Important, 2=Somewhat Important, 3=Important, 4=Highly Important, and 5=Extremely Important. The mean values of all respondents were used to determine the overall response rankings. These results were used to characterize Air Force S&T motivation and were compared with the results from industry studies.

Survey Item 10 - Importance of Innovation: Table 26 provides survey responses regarding the overall perceived importance of innovation to the Air Force S&T community. The AFRL mean score (3.4) and standard deviation (1.3) indicate most AFRL respondents feel innovation is considered important to highly important by the organization. Comparing the means of the AFRL survey and the previously published industry survey indicate a strong statistically significant difference between the two values ($p < 0.05$). Based on the comparison, Air Force S&T personnel perceive less emphasis is placed on innovation in their respective organizations than their industry counterparts.

Table 26. Overall Importance of Innovation within AF S&T

	AFRL Mean	*AFRL StdDev*	*Industry Mean**	*Industry StdDev**	*t-test***	*Significant Difference*
Overall importance of innovation to organization	3.365	1.318	4.865	1.835	-17.763	Yes

* Industry rankings and means based on results of AMA/HRI survey (AMA, 2006)
** The difference in mean values between AFRL and industry is said to be statistically significant (for a $p < 0.05$) if the t-test statistic is > 1.645 or <-1.645

Survey Item 11 - Reasons for Pursuing Innovation: Table 27 provides an examination of AFRL reasons for pursuing innovation. This item contained several sub items that measured the importance of various motives. The various Air Force S&T motives were rank ordered based on the mean scores provided by AFRL respondents. Becoming state of the art in warfighting was deemed the most important reason for pursuing innovation (mean score of 3.9), followed by better use of technologies and responding to customer demands. Disruptive innovation is characterized by the desire for long-term dominance; therefore, the Air Force S&T desire for state-of-the art warfighting technology seems to be properly suited to promote disruptive technology emergence.

Table 27. Reasons for Pursuing Innovation within Air Force S&T

	AFRL Rank	*AFRL Mean*	*Industry Rank**	*Industry Mean**	*t-test***	*Significant Difference*
To be state of the art in warfighting (business***)	1	3.903	8	3.686	2.727	Yes
To better use new technologies	2	3.727	6	3.767	-0.530	No
To respond to customer demands	3	3.704	1	4.166	-6.244	Yes
To develop new products/services	4	3.632	4	3.911	-3.693	Yes
To increase AFRL (market***) relevance	5	3.632	5	3.824	-2.524	Yes
To define new areas for AFRL (market***) relevance	6	3.610	9	3.672	-0.801	No
To increase speed or time to delivery	7	3.386	7	3.701	-4.019	Yes
To increase funding levels (revenues***) and cost savings (profits***)	8	3.281	3	4.001	-9.538	Yes
To increase operational efficiency	9	3.197	2	4.076	-11.033	Yes
To diversify funding sources	10	2.987	10	3.413	-5.366	Yes
To defend against job loss	11	2.662	11	3.086	-4.859	Yes

* Industry rankings and means based on results of AMA/HRI survey (AMA, 2006)

** The difference in mean values between AFRL and industry is said to be statistically significant (for a $p < 0.05$) if the t-test statistic is > 1.645 or <-1.645

*** Industry survey used terms “business area”, “market”, “revenues” and “profits”

Comparing the Air Force S&T results and industry findings shows differences in many perspectives and several statistically significant ranking variations are illustrated by means differential *t*-tests. Becoming state-of-the-art in warfighting is seen as more important to the Air Force S&T community than being state-of-the-art in business is to industry companies. Conversely, industry sees greater importance in using innovation to respond to customer demands, increase operational efficiency, and grow revenues/profits. The comparison also shows that industry scores are all higher except for one reason and that the differences in scores are all significant except for two reasons. Air Force S&T appears to connect innovation more with inventing state-of-the-art technology and may be missing opportunities to exploit disruptive innovation in operations. The AFRL study results also indicate that Air Force S&T may not be effectively using business model innovation, common in industry, as a means to cost reduction and strategic flexibility.

Survey Item 13 - Drivers of Innovation: Table 28 describes the key external drivers of innovation for Air Force S&T organizations. Once again, several sub items were used to capture various drivers. The drivers were rank ordered based on the mean scores provided by AFRL respondents. Technology, government funding levels, and customer demands top the list of perceived innovation drivers. The AMA/HRI survey ranked customer demands as the highest driver of industry innovation (mean value of 4.1); although the Air Force S&T community also ranked customer demands high, the mean score of importance was lower (3.7).

Further data comparisons show that industry scored 7 of 11 drivers higher, all significant except one. Of the 4 that the government scored higher, 3 were found to be significant. Funding levels is not only ranked higher in the government data, but the

delta in mean values (3.7 and 2.7, respectively) illustrates a significant difference in the perceived importance of this innovation driver. Additionally, collaborations with academia/nonprofits/other government organizations also have stronger importance in AF S&T based on the statistical significance tests. The opposite result is evident in pace of change and globalization/increased competition where industry feels greater innovation pressures. These findings indicate that Air Force S&T considers funding and alliances more important to innovation than the industry does. As a result, innovation in Air Force S&T appears to be driven more by external influences.

Table 28. Drivers of Innovation within Air Force S&T

	AFRL Rank	*AFRL Mean*	*Industry Rank**	*Industry Mean**	*t-test***	*Significant Difference*
Technology	1	3.846	2	3.825	0.297	No
Government funding levels	2	3.699	11	2.682	12.890	Yes
Customer demands	3	3.693	1	4.088	-5.375	Yes
Collaborations/alliances with customers	4	3.596	4	3.669	-1.015	No
Collaborations/alliances with academia/nonprofits/government orgs	5	3.509	10	2.857	8.129	Yes
Availability and cost of talent	6	3.335	5	3.595	-3.359	Yes
Pace of change	7	3.307	3	3.673	-4.795	Yes
Collaborations/alliances with private sector firms/industry	8	3.307	9	3.095	2.754	Yes
Globalization/increased competition	9	2.811	6	3.472	-7.787	Yes
Legislation	10	2.767	7	3.331	-6.850	Yes
Environmental issues	11	2.537	8	3.154	-7.522	Yes

* Industry rankings and means based on results of AMA/HRI survey (AMA, 2006)

** The difference in mean values between AFRL and industry is said to be statistically significant (for a $p < 0.05$) if the t-test statistic is > 1.645 or <-1.645

Focus of Innovation Resources

Three survey items provided information regarding how AFRL professionals perceive the focus of innovation resources in the Air Force S&T community. Survey item 20 ranked investment opportunities and characterized the relative advantages, survey item 23 outlined various areas where organizations are innovating, and survey item 24 captured where specific innovation focus is being placed within core functional areas. These results combine to illustrate how AFRL professionals perceive the emphasis of innovation in Air Force S&T and establish a basis for comparison with industry.

Survey Item 20 - Competitive Edge from Innovation: Table 29 summarizes opportunities for innovation and the competitive edge they give to the organization. In this case, four opportunities were provided and respondents rank ordered the choices from 1 to 4 (1=most opportunity, 4=least opportunity). The AFRL survey results identified breakthrough development as providing the greatest competitive edge followed by collaboration, rapid response, and then protection of intellectual property. The AMA/HRI study found that collaboration offered the most opportunity with breakthrough development being viewed as second. Similar to the motivation results, Air Force S&T appears to have greater interest in technological domination, while industry may use innovation as a means to address the profit generating needs of customers.

Table 29. Competitive Edge within Air Force S&T

	AFRL Rank	*Industry Rank**
Develop new breakthrough products/services that lead warfighting (/markets)	1	2
Collaborate with customers, suppliers, and other firms to design products/services	2	1
Respond quickly and flexibly to the uncertainties of the warfighting (/market) environment	3	3
Protect our intellectual property from competition/adversaries	4	4

* Industry rankings based on results of AMA/HRI survey (AMA, 2006)

Survey Item 23 - Areas of Innovation: Table 30 outlines areas where respondents felt innovation was being applied within the Air Force S&T community. This question did not weigh answers on a scale of 1 to 5 but simply measured which areas are currently experiencing innovation success. AFRL scientists and engineers are seeing the largest successes of innovation in how AFRL works with other organizations for mutual benefit followed by providing value to customers and adding value to the central activities of the organization. Surprisingly, the results indicated a lower than expected emphasis on product performance and product system innovation. Conversely, industry results showed the greatest innovation focus was in the area of deepening customer relationships and building an engaging experience with those customers. The comparison identified two large differences in the results. Air Force S&T ranked networks and alliances as being the number one area of innovation, while the industry respondents ranked it eighth. In contrast, industry identified customer experience as being the highest area of innovation where AFRL ranked it as being fifth. Once again, these results indicate that

Air Force S&T relies more heavily on other organizations for innovation than industry does and industry places greater focus on the customer than Air Force S&T.

Table 30. Areas of Innovation within Air Force S&T

Area	*AFRL Response*	*AFRL Rank*	*Industry Response**	*Industry Rank**
Networks and alliances: how you work with other organizations for mutual benefit	15.7%	1	8.1%	8
Service: providing value to customers around your product offering	12.4%	2	11.6%	2
Core process: adding value to the central activities of your organization	12.3%	3	12.4%	3
Enabling processes: how you support the organization's core processes and workers	12.1%	4	11.8%	5
Customer experience: how to deepen the customer's relationship with you by generating an engaging experience around your offering	10.8%	5	15.2%	1
Product performance: design and delivery of the core offerings	10.4%	6**	11.8%	4
Product systems: widening the range of technology products you offer through linking technologies together	10.4%	6**	4.7%	9
Channel: how you get your technology products to the warfighter	7.2%	8	3.6%	10
Business model: how the company intends to increase budgets and funding levels	4.4%	9	10.6%	6
Brand: how you communicate to differentiate	4.4%	10	8.4%	7

* Industry rankings and percentages based on results of AMA/HRI survey (AMA, 2006)
** Tie

Survey Item 24 - AFRL Specific Functional Innovation: Table 31 outlines the importance of innovation to specific functional areas within AFRL and qualifies the perceived innovation success in those functional areas. Respondents were again able to score various answers using a scale of 1 to 5 where 1=Not Important, 2=Somewhat Important, 3=Important, 4=Highly Important, and 5=Extremely Important. Because the

responses were aligned with specific AFRL functional areas, there were no corresponding industry results for direct comparison. The top three functional areas (generating S&T knowledge, developing needed products from requirements, and delivering rapid solutions to urgent needs) are typically considered the core technology product functions in AFRL while the others are categorized as enabling or supporting processes. The results indicate that Air Force S&T may not be actively using the principles of radical thinking as a means to improve the supporting activities of organizations. The results might also show that Air Force S&T personnel are attempting to follow leadership core priorities by simply placing the greatest innovation emphasis in core processes.

Table 31. Functional Innovation in Air Force S&T

	Importance of Innovation in Functional Areas		*Innovation Success in Functional Areas*	
	Rank	*Mean*	*Rank*	*Percent**
Generating S&T knowledge and future technology ideas	1	3.909	1	67.1%
Developing needed products from requirements	2	3.630	3	45.0%
Delivering rapid solutions to urgent needs	3	3.624	2	47.6%
Managing customer relationships	4	3.335	4	30.7%
Operating and maintaining the organization	5	3.191	5	25.5%
Managing Business (including finance, contracting, etc.)	6	3.189	8	19.0%
Managing information technology within the organization	7	3.138	7	21.2%
Process and Policy development	8	3.117	6	22.1%
Recruitment, training, and management of personnel	9	3.078	9	18.2%

* Column does not equal 100% because respondents were permitted to check multiple functional areas where organization is currently finding innovation success

Barriers of Innovation

A collection of survey items provided information on the barriers of innovation in Air Force S&T organizations. Survey item 15 identified the most significant barriers to pursuing innovation. Survey items 17, 18, and 19 provided additional insight into obstacles observed by Air Force scientists and engineers. The responses not only characterized the Air Force S&T challenges but provided a basis of comparison with the industry survey as well.

Survey Item 15 - Barriers of Innovation: Table 32 portrays the perceived barriers to pursuing innovation in Air Force S&T organizations. Insufficient resources, organizational constraints, and lack of innovation strategy top the list of perceived barriers. AFRL persons also found a lack of clear goals and entrenched programs to also be obstacles for new ideas. In comparison, industry professionals found organizational policies and existing programs to be less threatening to innovation. Instead, the industry survey identified short-term mindset and lack of leadership support to be higher ranked barriers.

Table 32. Barriers of Innovation within Air Force S&T

Barriers	***AFRL Rank***	***Industry Rank****
Insufficient resources	1	1
Organizational constraints such as policy	2	7
No formal strategy for innovation	3	2
Lack of clear goals and priorities	4	3
New ideas threaten existing programs	5	11
Lack of rewards for creative behaviors	6	10
Structure not geared toward innovation	7	6
Short-term mindset	8	5
Too much management control	9	8
Lack of leadership/management support	10	4
Culture of fear about failure	11	9

* Industry rankings based on results of AMA/HRI survey (AMA, 2006)

In Air Force S&T, organizational constraints were considered a large barrier (ranked #2) while leadership/management support was not considered an overwhelming obstacle (ranked #10). However, this delta may imply that many AFRL personnel do not believe Air Force senior leadership are empowered to improve the organizational policy, strategy, and bureaucracy within the organization. Additionally, Table 33 summarizes several supporting multiple choice items providing insights into innovation barriers. These results indicate that in both Air Force S&T and industry organizations, employees are unclear on how to gain support for new ideas and feel the rewards and recognition for innovative behaviors to be somewhat limited.

Table 33. Additional Perceptions of Innovation Barriers

	AFRL Responses*	***Industry Responses****
Survey Question 17 - Risk-Taking		
Well analyzed risks are usually accepted	48.2%	47.2%
Risk is evaluated carefully to avoid error	28.6%	28.6%
Intelligent risk-taking is recognized or rewarded	23.2%	20.2%
Survey Question 18 - Evaluation of Ideas		
There is no standard policy for reviewing and evaluating ideas	42.9%	47.6%
There is an independent review and evaluation process for ideas	19.9%	16.5%
Ideas are evaluated by manager where idea was proposed	16.8%	15.4%
Ideas are evaluated by unit that would impacted by the idea	7.1%	12.6%
The employee is responsible for starting/managing review process	13.3%	7.6%
Survey Question 19 - Rewards and Recognition for Innovation		
Innovation is not rewarded in this organization	25.7%	26.0%
Innovation is recognized with nonfinancial rewards	22.6%	20.9%
Innovation often leads to more challenging work and/or autonomy	24.8%	19.3%
Innovation rewarded by individual bonuses/salary increases	15.9%	17.6%
Innovation is considered in promotion decisions	4.9%	9.2%
Innovation is rewarded through team bonuses	4.0%	4.4%
Innovation is rewarded with larger staff and/or budgets	2.2%	2.0%

* AFRL responses based on answers to basic multiple choice question, percentages show frequency of various responses
** Industry percentages based on results of AMA/HRI survey (AMA, 2006)

Characteristics of Innovative Culture

Several survey items also examined the characteristics of innovative culture in Air Force S&T organizations. Survey item 12 identified the most important factors for developing an innovative culture. Respondents scored various characteristics using a scale of 1 to 5 where 1=Not Important, 2=Somewhat Important, 3=Important, 4=Highly Important, and 5=Extremely Important. The results of survey item 22, and 25 provided further cultural observations by AF scientists and engineers.

Survey Item 12 - Developing an Innovative Culture: Table 34 outlines the importance of different factors for developing an innovative culture in Air Force S&T organizations. The factors were rank ordered based on the mean scores provided by AFRL respondents. Freedom to innovate (with a mean score of 3.79) was cited as the most important consideration followed by teamwork/collaboration (3.77) and the ability to select the right ideas for research (3.59).

The comparison survey in industry found customer focus to be the most important factor in developing an innovative culture. Comparing the means between the studies using statistical tests shows freedom to innovate to be strongly viewed in the Air Force S&T community while customer focus, organizational communication, and innovation measurement are more important to industry respondents. Although innovation goals, diversity, and organizational structures were the lowest ranked in both studies, the AFRL persons perceived these to be much less important to innovative culture than their industry counterparts.

Industry scored higher on 12 of the 14 factors, and 8 of the 12 were found to be statistically significant. The largest differences in rankings were freedom to innovate, customer focus, and organizational communication. These results support previous Air Force S&T findings indicating that AFRL personnel desire sense of freedom from bureaucratic constraints and non-value added work. The results also indicate that while Air Force S&T professionals desire a culture of technology push, industry places greater hope on addressing the direct and often short-term needs of the customer. Therefore, given the access to the appropriate resources (people, time, and money) and the freedom to experiment, a greater degree of long-term, dominant, and breakthrough technology may emerge from Air Force S&T investments.

Table 34. Important Factors in Developing an Innovative Culture within Air Force S&T

	AFRL Rank	*AFRL Mean*	*Industry Rank**	*Industry Mean**	*t-test***	*Significant Difference*
Freedom to innovate	1	3.792	7	3.585	2.449	Yes
Teamwork/collaboration with others	2	3.771	2	3.877	-1.486	No
Ability to select right ideas for research	3	3.589	5	3.704	-1.414	No
Appropriate resources (time and money)	4	3.545	3	3.718	-2.403	Yes
Ability to identify creative people	5	3.541	6	3.617	-0.905	No
Customer focus	6	3.535	1	4.112	-7.583	Yes
Encouraging both small ideas and big ideas	7	3.494	9	3.520	-0.318	No
Culture of risk-tolerance	8	3.459	11	3.437	0.245	No
Organizational communication	9	3.343	4	3.701	-4.648	Yes
Ability to measure results of innovation	10	3.247	8	3.584	-4.326	Yes
Balancing incremental and breakthrough	11	3.113	14	3.349	-2.988	Yes
Innovation accountability/goals	12	2.961	10	3.506	-6.867	Yes
Diversity	13	2.900	13	3.377	-5.593	Yes
Organizational structures	14	2.848	12	3.393	-7.156	Yes

* Industry rankings and means based on results of AMA/HRI survey (AMA, 2006)
** The difference in mean values between AFRL and industry is said to be statistically significant (for a $p < 0.05$) if the t-test statistic is > 1.645 or <-1.645

Table 35 summarizes several supporting items providing additional findings regarding innovative culture. These results indicated that while both Air Force S&T and industry employees understand the importance of innovation, industry is more confident in what innovation means and how to become more innovative. However, the study results indicate that the innovative culture found in industry might be better aligned to foster sustaining innovation than disruptive innovation. These findings indicate that the Air Force S&T community may be more cognizant that building a robust innovative culture, based on long-term disruptive technology dominance, is very challenging in today's fiscally constrained and operationally focused Air Force.

Table 35. Additional Perceptions of Innovative Culture

	AFRL Responses*	***Industry Responses*** **
Survey Question 22 - Feelings About Innovation		
I recognize the importance of innovation, have clear understanding of what innovation means, and how my directorate/organization can become more innovative.	38.4%	52.8%
I recognize the importance of innovation, have clear understanding of what innovation means, but do not have a clear understanding as to how my directorate/organization can become more innovative.	52.0%	40.9%
I recognize the importance of innovation, but I do not have clear understanding of what innovation means and how my directorate/organization can become more innovative.	9.6%	6.0%
Survey Question 25 - In my organization we…		
Have a shared definition of what innovation is	20.8%	41.3%
Regularly review progress in innovation	13.2%	22.4%
Have a shared agenda to execute the innovation strategy	6.9%	12.3%
Have a well-understood strategy for innovation	6.9%	12.1%
Have well-defined roles and responsibilities	52.2%	11.3%

* AFRL responses based on answers to basic multiple choice question, percentages show frequency of various responses
** Industry percentages based on results of AMA/HRI survey (AMA, 2006)

Interview Evaluation

The senior leadership interviews were analyzed using a grounded theory qualitative method of inductive study. The interview analysis, provided in complete detail under Appendix F, illustrates various themes and concepts evident in the responses. The major themes summarized in the following sections not only address the investigative question regarding senior leadership but also provide additional insight into the other investigative questions as well. In addition, the evaluation provides a point of comparison between the viewpoints of Air Force S&T leaders and their industry CEO counterparts. The interviews were designed to answer the investigative question on Air Force S&T senior leadership perspectives on innovation. Although the discussions were open-ended, the interviews were structured to provide a direct point of comparison between AFRL leadership and industry CEOs. The interview data and comparisons are presented in four areas: views, emphasis, collaboration, and culture.

Senior Leadership Views of Innovation

Some of the interview questions were designed to query AFRL senior leadership regarding innovation definitions, importance, and integration into business/technology strategy. Table 36 outlines the views of innovation expressed by the interview participants. Most AFRL leaders (64%) defined innovation in the same manner and perceived innovation as an extremely/highly important part of Air Force S&T (73%). The AFRL directors and senior staff felt innovation was most applicable in both responding to urgent needs and generating S&T knowledge. Fifty-five percent of the respondents saw innovation as less significant in developing technology based on specific

customer requirements. In addition, 82% of the AFRL senior leaders interviewed articulated that innovation was not properly considered in the current Air Force S&T business and technology strategy. Although AFRL senior leaders think innovation is important and relevant, they have been challenged in integrating innovation into Air Force S&T strategic planning. This finding indicates the AFRL business and technology strategy may be overly constrained and driven by external influences.

Table 36. AFRL Senior Leader Views of Innovation

Themes	***Number of Responses***	***Percent of Respondents***
Definition of Innovation		
Invention/Discovery/Science + Exploitation Application	7	64%
Appling existing knowledge in new ways	3	27%
Other	1	9%
Importance of Innovation		
Extremely/highly important	8	73%
Important, but cannot be applied to all areas	3	27%
Not important	0	0%
Importance of Innovation in AFRL Core Processes*		
Generating S&T knowledge and future technology ideas (CP1)	9	82%
Developing needed products from requirements (CP2)	6	55%
Delivering rapid solutions to urgent needs (CP3)	10	91%
Innovation as part of AF S&T Business and Technology Strategy		
Innovation well integrated and considered in S&T strategy	2	18%
Innovation not well integrated and considered in S&T strategy	9	82%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

As illustrated in Figure 11, integrating innovation into business and technology strategy is a challenge facing both industry CEOs and Air Force S&T leadership. Although company CEOs perceive much better integration than their Air Force counterparts, they are also frustrated (IBM, 2006). Most AFRL directors and staff cited administrative burdens, excessive planning, too much centralization, and over emphasis on requirements mapping as shortfalls in the current innovation strategy. Most AFRL senior leaders saw a definite need to change the way innovation is fostered. One respondent explained, "We have become so focused on planning for Focused Long-Term Challenges (FLTCs)…that we have forgotten to strategize on fostering the game-changing (disruptive) ideas that make the FLTCs work."

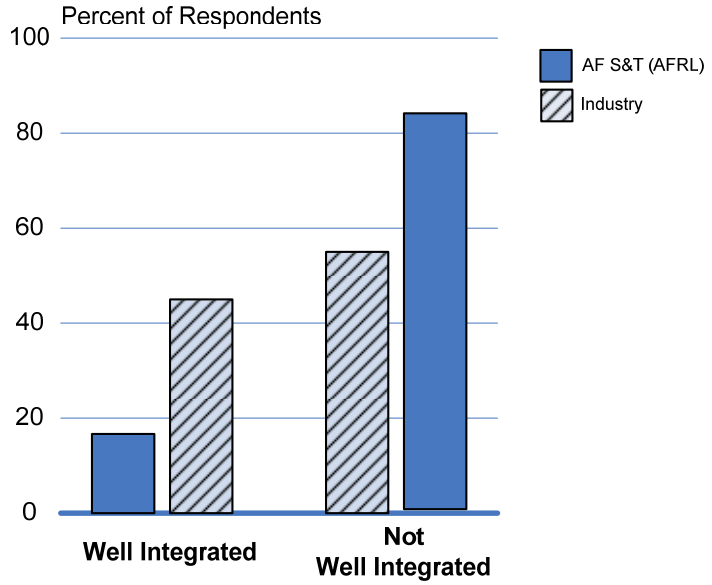


Figure 11. Integration of Innovation into Business and Technology Strategy

Senior Leadership Innovation Emphasis

Some of the interview questions examined what types of innovation are being stressed by Air Force S&T leadership and in what areas the greatest innovation success is perceived. Table 37 outlines the major themes in innovation emphasis. All the AFRL interviewees referenced product/service innovation (to include knowledge/technology) as the primary area of emphasis. Only 55% of the AFRL senior leaders referenced processes and organizational areas as places for creativity and idea encouragement. Even fewer participants (27%) emphasized innovation in operational activities including concepts of operations (CONOPS) and revolutionary techniques and tactics. One director explained that, "The service laboratories are designed to be innovative in technology products, especially in the exploitation and application side of innovation." Additionally, several respondents noted that while operational innovation is not currently a large area of emphasis and strength in AFRL, collaborating directly with the warfighter on the revolutionary use of technology to enhance the techniques and tactics of warfare is an opportunity the Air Force S&T community should foster.

Table 37. AFRL Senior Leader Disruptive Innovation Emphasis

Themes	*Number of Responses*	*Percent of Respondents*
Areas of Leadership Emphasis*		
Product/Service Innovation (including knowledge/technology)	11	100%
Process/Organizational Innovation (including business models)	6	55%
Operational Innovation (including CONOPS)	3	27%
Areas of Greatest Innovation Success		
Product/Service Innovation (including knowledge/technology)	9	82%
Process/Organizational Innovation (including business models)	1	9%
Operational Innovation (including CONOPS)	1	9%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

Comparing areas of focus, as depicted in Figure 12, shows nearly identical innovation emphasis by industry CEOs and AFRL senior leadership. According to the IBM industry study (2006), the CEOs of top performing companies are focusing about 55% of their idea attention on products with about 30% on process/organizational innovation. Air Force S&T leaders approximated similar levels of emphasis in their organizations. Companies are seeing business model innovation as the primary means to preempt threats and create them. However, several Air Force S&T senior leaders noted that operational innovation is an area where game-changing technology could have the most profound impact on Air Force wartime competiveness.

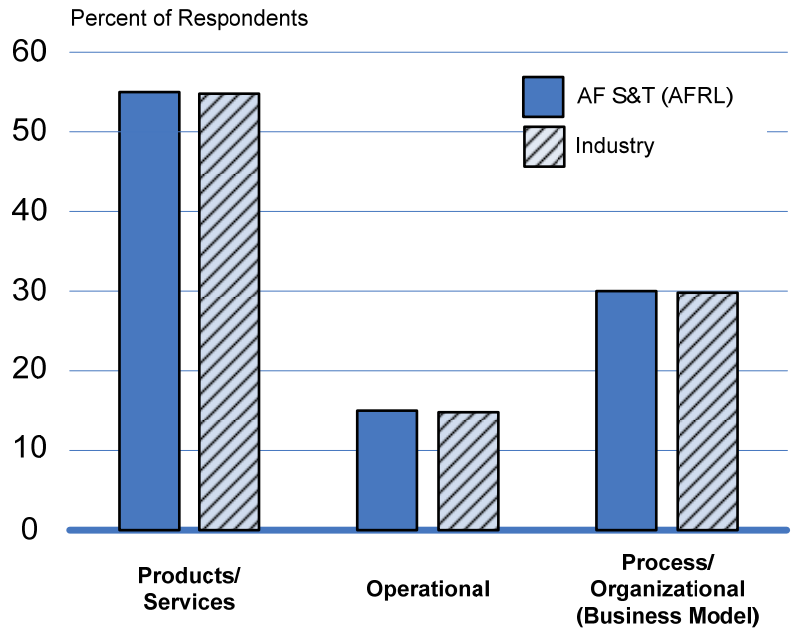


Figure 12. Innovation Emphasis

Senior Leadership Perspectives on Role of Collaboration

Numerous interview questions were structured to collect perspectives on how collaboration impacts organizational innovation. The importance of collaboration, benefits of collaboration, and productivity of collaborants were the primary questions answered. Table 38 illustrates that AFRL senior leader interviewees (100%) not only see collaboration as important but essential in harnessing the benefits of disruptive innovation. In addition, the majority of Air Force S&T senior leaders have the strongest confidence in the ideas of their in-house government, in-house support contractors, and academic resources.

Table 38. Role of Collaboration in Fostering Disruptive Innovation

	Number of Responses	*Percent of Respondents*
Importance of Collaboration to Innovation		
Essential to fostering disruptive innovation	11	100%
Not essential to fostering disruptive innovation	0	0%
Sources of Best Disruptive Ideas*		
Government (internal military/civilian personnel)	7	64%
Contractors (in-house contract personnel)	5	45%
Contractors (major industry firms)	4	36%
Contractors (smaller industry firms)	4	36%
Other government agencies/labs	3	27%
Customers/Users/Warfighters	3	27%
Academia (civilian and military)	6	55%
Others	3	27%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

Comparing industry CEO and AFRL senior leader responses identifies several similarities and differences in the sources of disruptive ideas. Figure 13 illustrates several comparisons in innovation catalysts for industry and Air Force S&T organizations. Leaders in industry and the Air Force S&T community rely heavily on internal resources for innovation. They also both see formal collaboration with external organizations as a solid source of new concepts. However, industry CEOs cited greater value in ideas from their customers and even considered the competition as a key resource for successful innovation. This confirms assertions made by Christensen (2003) that many innovative breakthroughs are initiated by company marketers who segment customers along a variety of psychological dimensions in order to define a profile of the customer most likely to buy a particular product. In contrast, Air Force S&T senior leaders placed greater confidence in the breakthrough ideas of academia. These results

align with previous survey findings where AFRL scientists and engineers cited collaboration with academia, nonprofits, and other government agencies as a leading driver of Air Force S&T innovation.

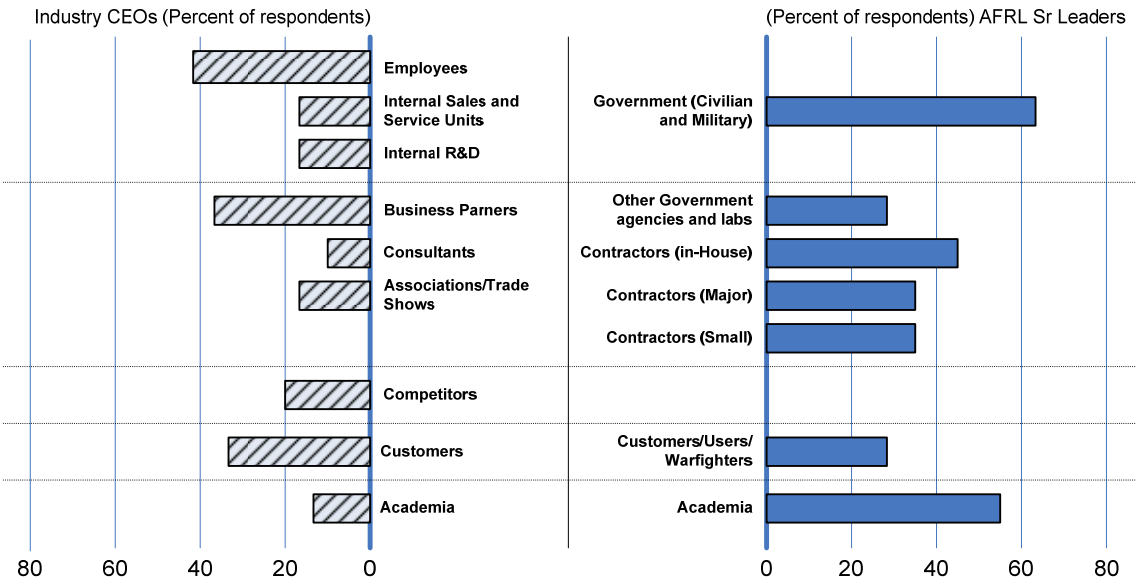


Figure 13. Sources of Disruptive Ideas

Senior Leadership Perspectives on Innovative Culture

Interview questions were also designed to query senior leadership observations on the innovative culture within Air Force S&T organizations. Table 39 summarizes the key perspectives on the strength of innovative culture, obstacles of innovation, actions to foster innovativeness, and rewards for disruptive innovation. Although all the AFRL leaders interviewed explained specific actions being taken to foster innovation in their

respective organizations, the majority (73%) did not consider AFRL as having a strong innovative culture. The lack of flexibility in strategic planning and budgeting was the most frequently cited obstacle to disruptive innovation. Limited resources and government policies, including the restrictiveness of the federal acquisition regulations, were also commonly mentioned barriers. Six of the AFRL senior leaders felt they personally had control over the barriers to innovative culture while the rest felt they had only some control to address the obstacles. In addition, 73% of the interview participants articulated that innovation is not properly rewarded in their respective AFRL organizations. While both non-financial rewards and compensatory motivations are being currently used, most AFRL senior leaders acknowledged that considerable efforts were needed to instill better incentives for creative risk-taking and breakthrough ideas.

Table 39. Senior Leadership Perspectives on AF S&T Innovative Culture

Themes	*Number of Responses*	*Percent of Respondents*
Strength of Innovation Culture		
AFRL has a strong innovative culture	3	27%
AFRL does not have a strong innovative culture	8	73%
Largest Obstacles to Innovation*		
Government policy and other legal restrictions	5	45%
Lack of tools and training	1	9%
Lack of rewards for innovation	1	9%
Unsupportive culture and climate	3	27%
Limited resources	5	45%
Process immaturity	3	27%
Leadership turnover and management instability	2	18%
Inflexibility in strategic planning and budgeting activities	6	55%
Communication and collaboration difficulties	2	18%
Bureaucracy, administrative burdens, and non-value added work	5	9%
Control Over Obstacles to Innovation		
Have control over innovation obstacles and barriers	6	55%
Have some control over innovation obstacles and barriers	5	45%
Current Actions in Fostering Innovative Culture*		
Developing an organizational strategy for innovation	3	27%
Redesigning organizational structure or work flow	5	45%
Advocating for workforce (less burdens, greater risk taking)	2	18%
Establishing flexible funding mechanisms to invest in ideas	6	55%
Changes in workplace environment/faculties	1	9%
Establishing new idea review processes	1	9%
Providing training and opportunities to learn about areas outside their expertise	2	18%
Creating new incentive programs	3	27%
Innovation Rewards		
Innovation is rewarded in this organization	3	27%
Innovation is not well rewarded in this organization	8	73%
Incentives Currently Being Used to Reward Innovation*		
Innovation is recognized with non-financial rewards (praise, awards)	6	55%
Innovation often leads to more challenging work and/or autonomy	2	18%
Innovation is rewarded by individual bonuses and/or salary increases	5	45%
Innovation is considered in promotion decisions	5	45%
Innovation is rewarded through team bonuses	0	0%
Innovation is rewarded with larger staff and/or budgets	3	27%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

Comparing the results of the AFRL interviews with those of the IBM CEO Study, several interesting similarities and differences were noted, especially in the area of innovative culture barriers. As outlined in Figure 14, a variety of internal and external obstacles make it difficult to build an innovative mindset. Government and other legal restrictions were cited as the largest external hindrance for both company CEOs and AFRL leadership. Limited resources, unsupportive culture, and process immaturity were also common internal challenges. Inflexibility in strategic plans and budgets, the most frequent Air Force S&T response, was not specifically identified in the IBM CEO study. Neither was leadership turnover and lack of effective collaboration. In contrast, industry CEOs cited economic uncertainty, technology shortfalls, infrastructure difficulties, and insufficient access to information as being greater hindrances than their Air Force S&T counterparts. Overall, both industry CEOs and AFRL senior leaders recognize the importance of innovative culture and acknowledge the need for organizational leaders to take responsibility in fostering a spirit of innovation.

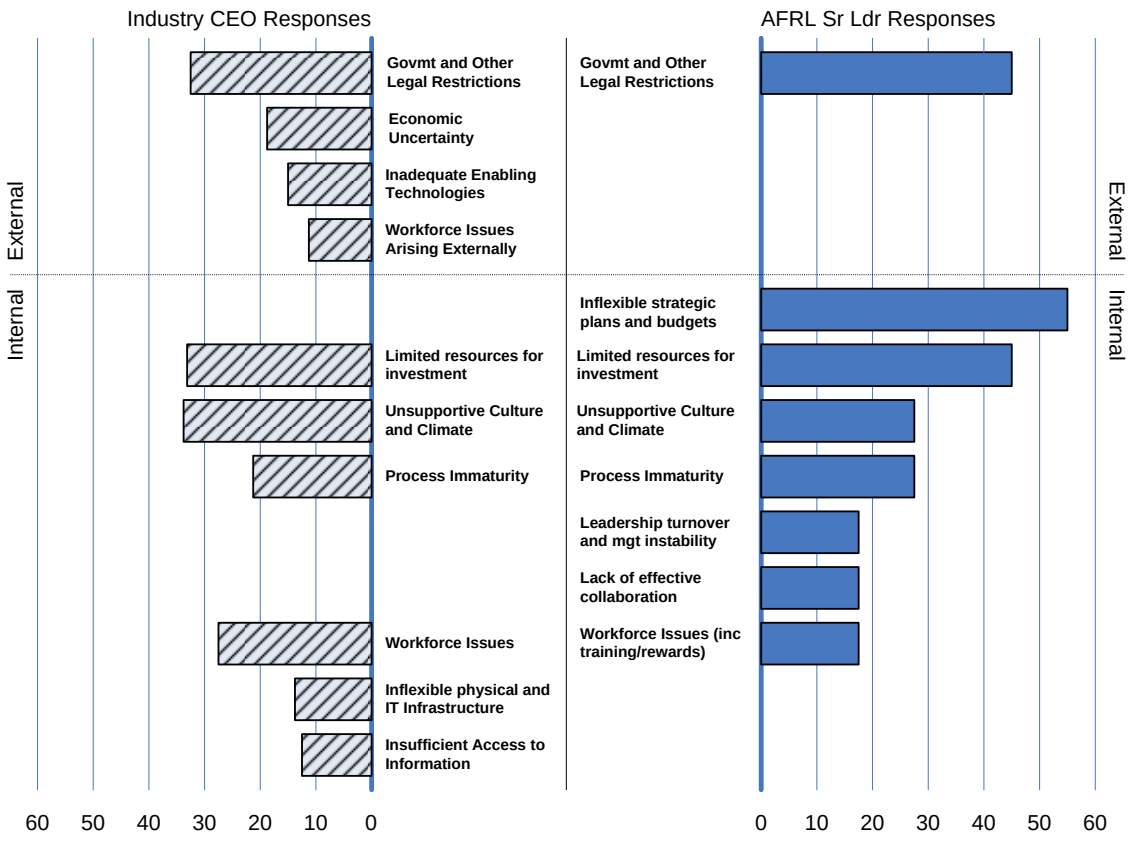


Figure 14. Innovation Obstacles Facing Senior Leaders

Model Analysis

Christensen (2003) proposed that building an organization capable of disruptive growth requires a careful balance of resources, processes, and values. Combining these thoughts with the research findings of this study provided a model for fostering disruptive innovation. The model presented in Chapter II for fostering disruptive innovation defined that an increase in the right motivation, plus an increase in the right focus of innovation resources, plus a decrease in the barriers of innovation, plus an increase in the characteristics of innovative culture, will foster an increase in the emergence of disruptive innovation. The comprehensive literature review of innovation concepts also

identified various ideal heuristics for motivation, focus, barriers, and culture that are credited with successful disruptive innovation. Figure 15 summarizes the study results and demonstrates the similarities and differences between industry and the Air Force S&T community with respect to the critical model variables. Specific findings that correspond to the concepts of disruptive innovation are highlighted to show organizational attributes that typically foster game-changing ideas. In addition, the summary shows that while the model serves as a basic framework for innovation improvement, the application and specific attributes will be domain dependent.

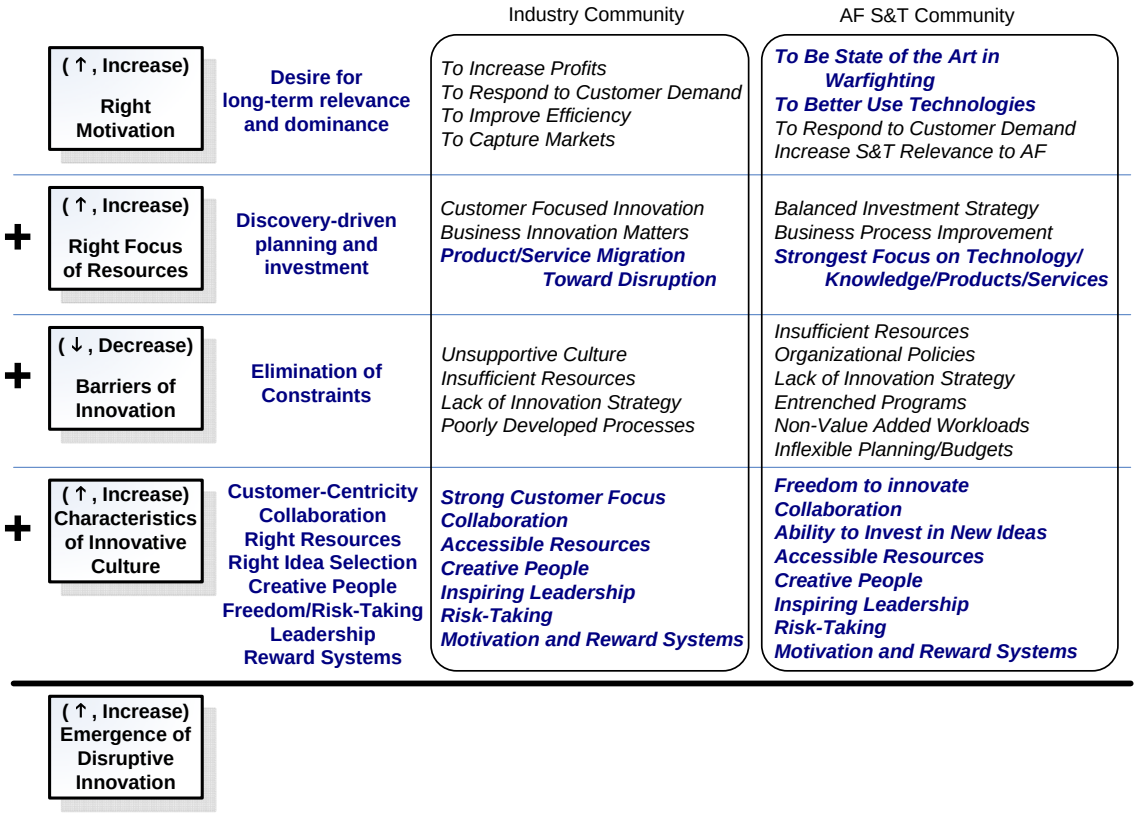


Figure 15. Analysis of Model for Fostering Disruptive Innovation

Summary

This chapter provided the results and analysis of the study research. First, a detailed quantitative analysis of the survey data including the comparative analysis was presented. Next, the qualitative evaluation of the interview data was outlined and presented. Finally, the survey and interview results were combined with the information gathered in the literature review to provide depth and support to the proposed innovation emergence model.

V. Conclusions and Recommendations

The purpose of this thesis research was to study the motivation, focus, barriers, and culture needed to foster disruptive innovation in Air Force Science and Technology (S&T) and to investigate how industry innovation strategies could improve breakthrough Air Force technology emergence. This chapter provides the conclusions, recommendations, limitations, and follow-on studies for this thesis effort. The first section provides a detailed description of the research conclusions. The next section outlines a series of recommendations for the Air Force S&T community based on the literature review, data results, and research findings. The third section summarizes the limitations of this study and provides guidance regarding interpretations and applicability of findings. The last section in the chapter provides some suggestions for future research designed to further enhance the knowledge base in this area of research.

Research Conclusions

Based on the defined investigative questions, comprehensive literature review, multifaceted data results, and detailed analysis findings, the following research conclusions have been developed:

1. *Air Force S&T pursues innovation in order to keep the warfighter state-of-the-art with leading edge technologies*. This motivation, exhibiting a desire for long-term relevance and dominance, coincides with the ideal attributes for increased disruptive innovation emergence. In contrast, industry appears to be more driven to innovation to respond to customer demands, improve operational efficiency, and increase profits.

Industry motivation, more short-term oriented, is less likely to foster new systems with completely new value propositions. Although the study results found Air Force scientists and engineers perceive less attention to innovation than their industry counterparts, Air Force S&T exudes the right motivation to foster disruptive innovation.

2. *Air Force S&T, heavily reliant on external resources, struggles with developing an executable strategy designed to foster disruptive innovation.* While most Air Force S&T professionals see a balance of investment focus, highly structured and rigid strategic planning make breakthroughs difficult for innovators. Air Force S&T appears to depend on other organizations for innovation, focusing primarily on the development of technological products. The Air Force S&T community has also failed to capitalize on opportunities for operational innovation, especially collaborating with the warfighter on technologically advanced techniques and tactics. In comparison, industry seeks to use innovation as a means to address the profit generating needs of customers, utilizing a balance of product and business model innovation to compete in market segments. The study results suggest that Air Force S&T may not be actively using the principles of radical thinking as a means to gamechanging improvement in business organizational activities.

3. *Air Force S&T professionals perceive significant internal organizational barriers hampering the emergence of disruptive innovation.* Insufficient resources, organizational constraints, lack of innovation strategy, and entrenched programs were perceived as the greatest obstacles to new ideas. Both the industry and Air Force S&T communities acknowledge the detrimental affect of innovation barriers, although industry appears more confident in its ability to overcome bureaucratic constraints. Industry

creativity was less threatened by organizational policies, possibly indicating that the increased focus of resources in business model innovation returned benefits in overall company efficiency.

4. *Air Force scientists and engineers believe strong innovation culture is best characterized by freedom and collaboration***.** The study indicated that Air Force S&T professionals desire a culture that allows them freedom to research without administrative burdens and non-value added diversions. In addition, Air Force S&T innovation is contingent on alliances and partnerships with internal and external entities. While Air Force S&T believes in a culture of freedom and industry sees customer focus as the key to innovation emergence, both Air Force S&T and industry employees understand the tremendous importance of organizational culture in fostering breakthroughs.

5. *Air Force S&T senior leaders understand the criticality of innovation but struggle with the optimal approach to fostering disruptive innovation in their organizations* Most Air Force S&T leaders agreed that innovation was not well integrated into their business and technology strategy which was hampered by overly constrained planning and restrictive external influences. Although other findings indicate strong reliance on external sources, Air Force S&T leadership places great confidence in the ideas of their in-house personnel. Unfortunately, most senior leaders do not perceive that Air Force S&T organizations posses a strong innovative culture. In addition, most Air Force S&T senior leaders acknowledged that considerable improvement efforts were needed to facilitate flexible planning, thereby freeing resources, collaboration, and rewards for creative risk-taking.

6. *Innovative organizations require strong and inspiring leadership and both Air Force S&T senior leaders and company CEOs agree that innovative thinking must be orchestrated from the top***.** Supportive leadership is critical to motivation, strategy, overcoming obstacles, and building an innovative culture. While both Air Force and industry leadership hold themselves accountable for fostering disruptive innovation, complex dimensions of disruptive innovation continue to be challenging regardless of the domain.

7. *Air Force S&T is capable of regaining its prominence as a leader in disruptive technological innovation by applying the emergence model, capturing the relevant best practices of industry, and exploiting the positive attributes of the military domain***.** The research findings combine to establish the proposed model for fostering disruptive innovation in either industry or government organizations. Given an increase in the right motivation, an increase in the right focus of innovation resources, a decrease in the barriers of innovation, and an increase in the characteristics of innovative culture, disruptive innovation will emerge. Although the model is not intended to be an equation for guaranteed success, it does provide a conceptual formula to ensure that all critical elements needed to foster breakthrough innovation are considered.

Recommendations

Based on this thesis research, the followed recommendations are provided to the Air Force S&T community to help foster the emergence of disruptive technology:

1. *Exercise caution with relying on industry to generate relevant disruptive innovation for the Air Force*. Given the differences in motivation, drivers, and resource focus, outsourcing innovation to commercial companies may not provide the long-term relevant technologies needed to dominate the battlespace. While industry is a key collaborative partner, Air Force S&T should invest in enhancing its internal workforce to ensure the emergence of revolutionary military technology.

2. Infuse greater flexibility and innovativeness into AFRL business and technology strategy through the use of discovery-based planning. Discovery-based planning allows experimental results and assumption validation to drive investment strategies. The added resilience in AFRL planning will allow technology breakthroughs to evolve less bounded and foster increased levels of disruptive innovation.

3. *Establish freedom for the scientist and engineering workforce as a priority of Air Force S&T process improvement efforts*. AFRL's greatest asset has always been the intellectual power of its technological workforce. AFRL needs to ensure that all management approaches, supporting activities, and enabling activities place optimization of the scientist and engineer's (S&E) time as the goal of process improvement efforts. In order for AFRL to achieve disruptive technological prominence, the S&E must be given larger amounts of working time free from administrative burden and non-value added work. Even if granting freedom to the S&E increases the responsibilities of management

and support personnel, the long-term benefits of increased disruptive innovation emergence is worth the risk.

4. Utilize successful sustaining innovation to build advocacy and generate resources for disruptive technology innovation. Not all AFRL efforts can or even should be focused on gamechanging ideas. Balanced investments are essential to success. However, AFRL should be careful not to allow incremental improvements in entrenched existing programs in such a way that invention and exploitation of disruptive concepts is neglected. Sustaining technology and requirements-based development play a valuable role as long as they are used to obtain resources for more long-term disruptive breakthroughs.

5. Increase the use of experimental venues to increase technological collaboration with the warfighter and to access the operational impacts of disruptive innovation. While AF S&T's motivation and focus on the state-of-the-art is critical, AFRL can also learn from industry's strong customer focus. More discovery-based experimental venues with the warfighter will increase AFRL's position as a relevant force in helping with operational innovation, especially in the application of technological advancements for disruptive warfighting tactics and techniques.

6. Elevate the innovative culture of AFRL by orchestrating risk-taking from the top. Senior leadership views of innovation play a profound role on the sense of entrepreneurship in the organization. By demonstrating greater risk-taking in approaches to supporting and enabling processes, senior leadership will send a decisive message to the workforce and infuse innovative spirit within the organization. The S&E workforce

will observe the trend in leadership and respond with increases in relevant disruptive ideas.

Limitations of the Research

Although efforts were taken throughout this research to mitigate risks to reliability and validity, sample bias in the survey still arose as a threat to internal validity. As detailed in the methodology chapter, the sample demographics demonstrated some deviations from the population demographics. Volunteerism may have played a role in creating the bias, as the persons who chose to participate in the survey were concentrated in certain geographic sites and directorates. Although the findings were not analyzed based on directorates or geographic demographics, the sampling bias should still be considered when evaluating the generalizations made by the survey portion of this study.

Future Research

Based on the emerging topic and lack of specific literature on disruptive innovation in military organizations, a primarily qualitative research method, supported by some quantitative data, was used in this thesis study. The resulting model for fostering disruptive innovation lends itself well to further quantitative inferential research. The following suggestions for investigative questions examined singularly or as part of a larger research study, would provide the needed quantitative validation of the model for fostering disruptive innovation:

1. How does a military organization's **motivation for innovation** relate to the successful emergence of disruptive innovation?

2. What **focus of innovation resources** in a military organization provide the most successful emergence of disruptive innovation?

3. How does the **elimination of barriers** relate to an organization's ability to foster disruptive innovation? What common barriers to innovation have the most detrimental effect on organizational innovativeness?

4. How do increased levels in the **characteristics of innovative culture** relate to an organization's ability to foster disruptive innovation? What characteristics of innovative culture have the greatest effect on the emergence of disruptive innovation?

5. How can organizational **success in fostering disruptive innovation** be quantified? What organizational metrics and measures can be used to quantify the successful emergence of disruptive innovation?

Summary

This chapter outlined the conclusions, recommendations, limitations, and follow-on studies for this thesis effort. The first section provided a detailed description of the research conclusions. The next section outlined a series of recommendations for the AF S&T community based on the literature review, data results, and research findings. The third section summarized the limitations of this study and provided guidance regarding interpretations and applicability of findings. The last section in the chapter provided some suggestions for future research designed to further enhance the knowledge base in this area of research.

Appendix A: AFRL Organizational Description

AFRL Fact Sheet

U.S. Air Force Fact Sheet

AIR FORCE RESEARCH LABORATORY

Air Force Research Laboratory, with headquarters at Wright-Patterson Air Force Base, Ohio, was created in October 1997. The laboratory was formed through the consolidation of four former Air Force laboratories and the Air Force Office of Scientific Research.

Mission

AFRL's mission is leading the discovery, development and integration of affordable warfighting technologies for America's aerospace forces. It is a full-spectrum laboratory, responsible for planning and executing the Air Force' science and technology program. AFRL leads a worldwide government, industry and academia partnership in the discovery, development and delivery of a wide range of revolutionary technology. The laboratory provides leading-edge warfighting capabilities keeping our air, space and cyberspace forces the world's best.

Personnel and Resources

The lab employs approximately 5,400 people, including about 1,300 military and 4,100 civilian personnel. It is responsible for the Air Force's science and technology budget of nearly $2 billion including: basic research, applied research, advanced technology development and an additional $1.7 billion from AFRL customers.

Organization

AFRL accomplishes its mission through nine technology directorates located throughout the United States, the Air Force Office of Scientific Research and a central staff. The directorates:

Air Force Office of Scientific Research -- With a worldwide exchange program for scientists and engineers, AFOSR is the basic research manager for AFRL at its headquarters in Arlington, Va. AFOSR invests in long-term, broad-based research into aerospace-related science and engineering. To accomplish this mission, AFOSR has formed a strong, productive alliance with other government agencies, U.S. industry and the academic community. Nearly 80 percent of the research is conducted in academia and industry and the remaining 20 percent is conducted within AFRL. AFOSR's investment in basic research programs is distributed to about 300 academic institutions, 145 contracts with industry and more than 150 internal AFRL research efforts.

Air Vehicles Directorate -- With headquarters at Wright-Patterson AFB, Ohio, the Air Vehicles Directorate leads the effort to develop and transition superior technology solutions that enable dominant military aerospace vehicles. The emphasis and vision are on technology investments that support cost-effective, survivable aerospace vehicles capable of accurate and quick

delivery of a variety of future weapons or cargo anywhere in the world. To achieve this, core technology areas focus on aeronautical sciences, control sciences, structures and integration. The directorate targets advanced concepts to direct the development of vehicle technologies that provide future capabilities in the areas of sustainment, unmanned air vehicles, space access and future strike.

Directed Energy Directorate -- With headquarters at Kirtland AFB, N.M., the Directed Engery Directorate develops, integrates and transitions science and technology for directed energy, to include high power microwaves, lasers, adaptive optics, imaging and effects to assure the preeminence of the United States in air and space. The directorate provides research and development for leading-edge space capabilities as well as techniques and technologies to improve and transition optical systems to war-fighting commands. It is the Air Force's center of excellence for high power microwave technology and the Department of Defense's center of expertise for laser development, including semiconductor, gas, chemical and solid-state lasers. The Starfire Optical Range conducts theoretical and experimental research in advanced tracking, adaptive optics, atmospheric physics and imaging of objects in space using large ground-based telescopes. The directorate also assesses potential applications and effects of systems using directed energy technologies.

Human Effectiveness Directorate -- With headquarters at Wright-Patterson AFB, Ohio, and additional research facilities at Brooks AFB, Texas; Mesa, Ariz.; and Edgewood, Md., the Human Effectiveness Directorate develops, integrates and transitions science and technologies for training personnel. The directorate also is responsible for improving the interface between the warrior and the weapon system, and protecting and sustaining Air Force warfighters to assure the preeminence of U.S. aerospace forces. The directorate has eight core technology areas: warfighter skill development and training, training simulation, information display and decision support, crew system design technologies, directed energy bioeffects, toxic hazards effects, crew protection, and logistician effectiveness. The directorate's partnerships with other technical directorates of AFRL impact 28 technology areas across the Laboratory. The directorate has collaboratory relationships, based upon shared interests and mutual benefits, with academia, other military services and government agencies, and commercial enterprises.

Information Directorate -- With headquarters at Rome, N.Y., the Information Directorate develops information technologies for aerospace command and control, and its transition to air, space and ground systems. Its focus areas include a broad spectrum of technologies including information fusion and exploitation, communications and networking, collaborative environments, modeling and simulation, defensive information warfare and intelligent information systems technologies. Directorate scientists and engineers develop systems, concepts and technologies to enhance the Air Force's capability to successfully meet the challenges of the information age. In addition to its primary mission, the directorate has partnered with other elements of the federal government, national intelligence agencies, numerous allied nations, state and local governments, and more than 50 major universities to work problems of common interest.

Materials and Manufacturing Directorate -- With headquarters at Wright-Patterson AFB, Ohio, and an additional research facility at Tyndall AFB, Fla., the Materials and Manufacturing Directorate develops new materials, processes and manufacturing technologies for use in aerospace applications. This includes aircraft, spacecraft, missiles, rockets and ground-based systems and their structural, electronic and optical components. With a host of modern materials and analysis laboratories, the directorate also provides quick reaction support and real time solutions to Air Force weapon system acquisition offices, field organizations and

maintenance depots to solve materials related concerns and problems. The directorate plans, executes and integrates advanced manufacturing technology programs and affordability initiatives addressing manufacturing process technologies, computer integrated manufacturing and excellence through design for military needs. The directorate is also responsible for the Air Force technology programs that address environmental issues and provides materials expertise for airbase assets such as runways and infrastructures and technologies for aerospace expeditionary forces.

Munitions Directorate -- With headquarters at Eglin AFB, Fla., the Munitions Directorate develops, demonstrates and transitions science and technology for air-launched munitions for defeating ground fixed, mobile/relocatable, air and space targets to assure pre-eminence of U.S. air and space forces. The directorate conducts basic research, exploratory development, and advanced development and demonstrations. It also participates in programs focused on technology transfer, dual-use technology and small business development. The directorate is dedicated to providing the Air Force with a strong revolutionary and evolutionary technology base upon which future air-delivered munitions can be developed to neutralize potential threats to the United States.

Propulsion Directorate -- With headquarters at Wright-Patterson AFB, Ohio, and an additional research facility at Edwards AFB, Calif., the Propulsion Directorate develops air and space vehicle propulsion and power technologies. Focus areas include turbine and rocket engines, advanced propulsion systems, and the associated fuels and propellants for all propulsion systems. The directorate is also responsible for most forms of power technology making it one of the nation's leaders in its field. Programs address both future systems and the need to keep current systems competitive, safe, affordable and effective. The directorate has contributed technology to more than 130 military and commercial systems.

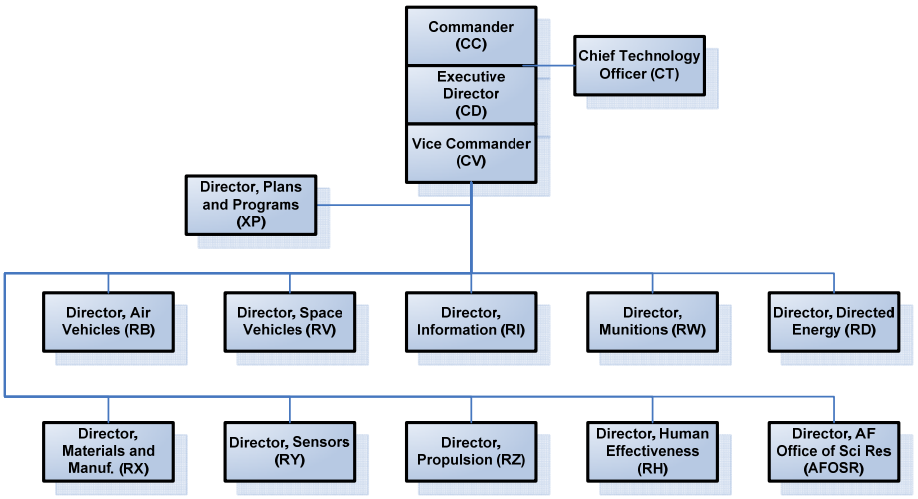
Sensors Directorate -- With headquarters at Wright-Patterson AFB, Ohio, and additional research facilities at Hanscom AFB, Mass. and Rome, N.Y., the Sensors Directorate develops the new technologies that U.S. warfighters need to find and precisely engage the enemy and eliminate its ability to hide or threaten our forces. In collaboration with other AFRL directorates and DOD organizations, the directorate develops sensors for air and space reconnaissance, surveillance, precision engagement and electronic warfare systems. The directorate's vision is to provide a full range of air and space sensors, networked to the warfighter, providing a complete and timely picture of the battlespace enabling precision targeting of the enemy and protection friendly air and space assets. Its core technology areas include: radar, active and passive electro-optical targeting systems, navigation aids, automatic target recognition, sensor fusion, threat warning and threat countermeasures.

Space Vehicles Directorate -- With headquarters at Kirtland AFB, N.M. and an additional research facility at Hanscom AFB, Mass., the Space Vehicles Directorate develops and transitions space technologies for more effective, more affordable warfighter missions. The directorate also leverages commercial, civil and other government resources that ensure America's defense advantage. Primary focus areas include: radiation hardened electronics; space power; space structures and control; space based sensing; space environmental effects; autonomous maneuvering; and balloon and satellite flight experiments.

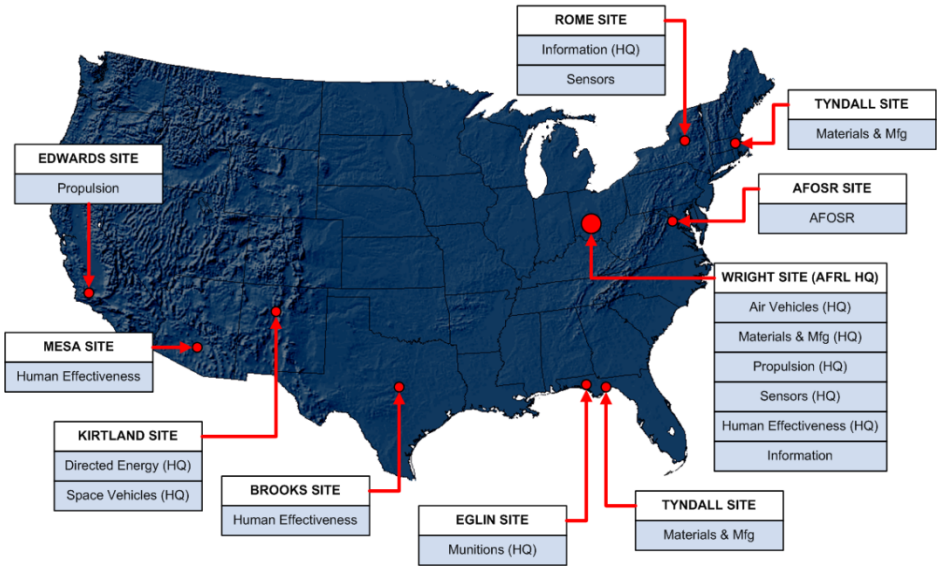
History

The laboratory and its predecessors have overseen more than 80 years of critical research efforts for the Air Force and DOD. Its technology breakthroughs can be found in all of today's modern aircraft and weapons systems, including the F-117 stealth fighter, B-2 bomber, C-17 airlifter and the F-22 fighter. It was contributed to significant advancements in modern communications, electronics, manufacturing, and medical research and products.

AFRL Organizational Chart



AFRL Research Locations



Appendix B: Survey Instrument

AFRL INNOVATION SURVEY

Patterned after *The Quest for Innovation: A Global Study of Information Management - 2006-2016,* American Management Association (AMA)

<u>Demographic Questions</u>

QUESTION 1: In what function do you currently work?

- ❒ Finance
- ❒ Management
- ❒ Contracting
- ❒ HR or Administrative
- ❒ Operations or Support
- ❒ Engineering, Science, and R&D
- ❒ Other

QUESTION 2: What is your current employment type?

- ❒ Military
- ❒ Government Civilian
- ❒ Contractor
- ❒ Other

QUESTION 3: What is your level of responsibility?

- ❒ Section (5-letter organization)
- ❒ Branch (4-letter organization)
- ❒ Division (3-letter organization)
- ❒ Directorate (2-letter organization)
- ❒ Headquarters
- ❒ Other

QUESTION 4: Do you currently supervise personnel?

- ❒ Yes, I am currently in a supervisory position.
- ❒ No, I am currently in a non-supervisory position.

QUESTION 5: What directorate/organization do you work for?

- ❒ Headquarters Air Force Research Laboratory
- ❒ Air Vehicles Directorate
- ❒ Materials and Manufacturing Processes Directorate
- ❒ Propulsion Directorate
- ❒ Sensors Directorate
- ❒ Human Effectiveness Directorate
- ❒ Information Directorate
- ❒ Munitions Directorate
- ❒ Space Vehicles Directorate
- ❒ Directed Energy Directorate
- ❒ Air Force Office of Scientific Research
- ❒ Other

QUESTION 6: How many years of experience do you have with the Air Force and/or Department of Defense (DoD)?

- ❒ 0-5 Years
- ❒ 6-10 Years
- ❒ 11-15 Years
- ❒ 16-20 Years
- ❒ 21-25 Years
- ❒ 25+ Years

QUESTION 7: At what AFRL research site do you currently work?

- ❒ Edwards Research Site
- ❒ Kirtland Research Site
- ❒ Mesa Research Site
- ❒ Brooks Research Site
- ❒ Eglin Research Site
- ❒ Tyndall Research Site
- ❒ Rome Research Site
- ❒ Hanscom Research Site
- ❒ Wright Research Site
- ❒ Air Force Office of Scientific Research Site
- ❒ Other

QUESTION 8: In general, how would you rate your overall job satisfaction?

Not Satisfied (1)	Somewhat Satisfied (2)	Satisfied (3)	Very Satisfied (4)	Extremely Satisfied (5)

QUESTION 9: How would you best describe your directorate/organization's life cycle stage?

- ❒ Newly defined or redefined directorate/organization focusing on introducing new products/services
- ❒ Rapidly growing directorate/organization with increasing responsibility and strong focus on customers
- ❒ Established directorate/organization with strong structure and systems as well as known products/services
- ❒ Directorate/organization focused on increasing quality, cost effectiveness, and continuing improvement in operations
- ❒ Mature directorate/organization with "brand name" recognition and with an established culture
- ❒ Directorate/organization repositioning itself for the future; revitalization efforts are the focal point

Survey Questions

For the purposes of this survey, innovation is defined as follows:

Innovation is the term used to describe how organizations create value by developing new knowledge and/or using existing knowledge in new ways. The term is often used to mean the development of new products or services, but organizations can also innovate in other ways, such as through new business models, management techniques, and organizational structures.

QUESTION 10: How would you rank the importance of innovation to the following activities within your directorate/organization?

	Not Important (1)	Somewhat Important (2)	Important (3)	Highly Important (4)	Extremely Important (5)
Generating S&T knowledge and future technology ideas					
Developing needed products from requirements					
Delivering rapid solutions to urgent needs					
Managing customer relationships					
Process and Policy development					
Recruitment, training, and management of personnel					
Operating and maintaining the organization					
Managing information technology within the organization					
Managing Business (including finance, contracting, etc.)					

QUESTION 11: How important are the following reasons for pursuing innovation in your directorate/organization?

	Not Important (1)	Somewhat Important (2)	Important (3)	Highly Important (4)	Extremely Important (5)
To respond to customer demands					
To increase operational efficiency					
To increase funding levels and cost savings					
To develop new products/services					
To increase AFRL relevance					
To better use new technologies					
To increase speed or time to delivery					
To be state of the art in warfighting					
To define new areas for AFRL relevance					
To diversify funding sources					
To defend against job loss					

QUESTION 12: How important are the following factors for developing an innovative culture in your directorate/organization?

	Not Important (1)	Somewhat Important (2)	Important (3)	Highly Important (4)	Extremely Important (5)
Customer focus					
Teamwork/collaboration with others					
Appropriate resources (time and money)					
Organizational communication					
Ability to select right ideas for research					
Ability to identify creative people					
Freedom to innovate					
Ability to measure results of innovation					
Encouraging both small ideas and big ideas					
Innovation accountability/goals					
Culture of risk-tolerance					
Organizational structures					
Diversity					
Balancing between incremental improvements and breakthrough discoveries					

QUESTION 13: How important are these external drivers of innovation to your directorate/organization?

	Not Important (1)	Somewhat Important (2)	Important (3)	Highly Important (4)	Extremely Important (5)
Customer demands					
Technology					
Pace of change					
Collaborations/alliances with customers					
Availability and cost of talent					
Globalization/increased competition					
Legislation					
Environmental Issues					
Collaborations/alliances with private-sector firms or industry					
Collaborations/alliances with academia/nonprofits/other government research organizations					
Government funding levels					

QUESTION 14: How important are the following ways of measuring creativity and innovation in your directorate/organization?

	Not Important (1)	Somewhat Important (2)	Important (3)	Highly Important (4)	Extremely Important (5)
Customer satisfaction					
AFRL relevance					
New products/services/processes produced					
Financial impact of ideas submitted by employees					
Innovations as a percent of funding					
AF level of spending on research and development					
Spin-offs/new programs based on new products					
Intellectual property (i.e. number of patents)					

QUESTION 15: Please rank-order the three (3) most significant barriers to pursuing innovation in your directorate/organization, with #1 being the highest.

Insufficient resources	
No formal strategy for innovation	
Lack of clear goals and priorities	
Lack of leadership/management support	
Short-term mindset	
Structure not geared toward innovation	
Organizational constraints such as policy	
Too much management control	
Culture of fear about failure	
Lack of rewards for creative behaviors	
New ideas threaten existing programs	

QUESTION 16: Please rank-order the three (3) actions your leaders are taking to support innovation, with #1 being the highest.

Developing an organizational strategy for innovation	
Redesigning organizational structure or work flow	
Increasing employee involvement	
Identifying/attracting more creative talent	
Redefining the organization's values	
Establishing new idea review processes	
Encouraging employees to learn about areas outside their expertise	
Providing training in creative thinking and problem solving	
Creating new incentive programs	

QUESTION 17: Select the one statement that best describes risk taking in your directorate/organization at this time (chose only one).

- ❒ Risk that is well analyzed and aligned with current goals is usually accepted
- ❒ Risk is evaluated carefully to avoid error
- ❒ Intelligent risk-taking is recognized
- ❒ Intelligent risk-taking is rewarded

QUESTION 18: Select the one statement that best describes the evaluation of ideas in your directorate/organization at this time (chose only one).

- ❒ There is no standard policy for reviewing and evaluating ideas
- ❒ There is an independent review and evaluation process for ideas
- ❒ Ideas are reviewed and evaluated by the unit manager where idea was proposed
- ❒ Ideas are reviewed and evaluated by the unit that would impacted by the idea
- ❒ The employee is responsible for starting and managing the review process

QUESTION 19: Select the one statement that best describes the reward and recognition practices in your directorate/organization at this time (chose only one).

- ❒ Innovation is not rewarded in this organization
- ❒ Innovation is recognized with nonfinancial rewards
- ❒ Innovation often leads to more challenging work and/or autonomy
- ❒ Innovation is rewarded by individual bonuses and/or salary increases
- ❒ Innovation is considered in promotion decisions
- ❒ Innovation is rewarded through team bonuses
- ❒ Innovation is rewarded with larger staff and/or budgets

QUESTION 20: Rank the following in terms of the opportunities/competitive edge they give your organization (1=most opportunity, 4=least opportunity).

Collaborate with customers, suppliers, and other firms to design products/services	
Develop new breakthrough products/services that lead warfighting	
Respond quickly and flexibly to the uncertainties of the warfighting environment	
Protect our intellectual property from competition/adversaries	

QUESTION 21: How successful is your directorate/organization at innovation?

- ❒ Very successful
- ❒ Moderately successful
- ❒ Not at all successful

QUESTION 22: Which of the following statements best captures your feelings about innovation?

- ❒ I recognize the importance of innovation, have clear understanding of what innovation means, and how my directorate/organization can become more innovative.
- ❒ I recognize the importance of innovation, have clear understanding of what innovation means, but do not have a clear understanding as to how my directorate/organization can become more innovative.
- ❒ I recognize the importance of innovation, but I do not have clear understanding of what innovation means and how my directorate/organization can become more innovative.

QUESTION 23: In which of the following areas are you currently innovating (Check all that apply)?

Customer experience: how to deepen the customer's relationship with you by generating an engaging experience around your offering	
Service: providing value to customers around your product offering	
Core process: adding value to the central activities of your organization	
Product performance: design and delivery of the core offerings	
Enabling processes: how you support the organization's core processes and workers	
Business model: how the company intends to increase budgets and funding levels	
Brand: how you communicate to differentiate	
Networks and alliances: how you work with other organizations for mutual benefit	
Product systems: widening the range of technology products you offer through linking technologies together	
Channel: how you get your technology products to the warfighter	

QUESTION 24: In which functions within your directorate/organization does innovation currently take place (Check all that apply)?

Generating S&T knowledge and future technology ideas	
Developing needed products from requirements	
Delivering rapid solutions to urgent needs	
Managing customer relationships	
Process and Policy development	
Recruitment, training, and management of personnel	
Operating and maintaining the organization	
Managing information technology within the organization	
Managing Business (including finance, contracting, program/project management, planning, etc.)	

QUESTION 25: In my directorate/organization we…

- ❒ Have a shared definition of what innovation is?
- ❒ Regularly review progress in innovation
- ❒ Have a shared agenda to execute the innovation strategy
- ❒ Have a well-understood strategy for innovation
- ❒ Have well-defined roles and responsibilities

QUESTION 26: Please feel free to provide any additional comments on the information requested in this survey or any other information on innovation which you feel is relevant to this study.

Appendix C: Interview Instrument

AFRL SENIOR LEADESHIP INTERVIEWS

QUESTION GROUP A: View of Innovation

- **A.1.** What is your view of innovation Air Force R&D community?
- **A.2.** Why is it important to foster innovation in the Air Force Research Laboratory?
- **A.3.** How does innovation play a role in the business and technology strategy of your directorate/organization?

QUESTION GROUP B: Innovation Emphasis

- **B.1.** What types of innovation do you as a senior leader place emphasis on within your organization?
- **B.2.** What are the most common categories of product/service innovations emerging in your organization?...and what kind of benefits does the AF gain from those innovations?
- **B.3.** Describe the most common categories of operational/process innovations emerging in your organization?...and what kind of benefits does the AF gain from those innovations?
- **B.4.** Describe the most common types of organizational innovations emerging in your organization?...and what kind of benefits does the AF gain from those innovations?

QUESTION GROUP C: Role of Collaboration in Innovation

- **C.1.** How does collaboration play a role in the innovation of your organization?
- **C.2.** What are the most significant sources of innovative ideas in you organization?
- **C.3.** Do you get the most innovation ideas from external sources or internal sources?
- **C.4.** How does collaboration and partnering benefit your organization?

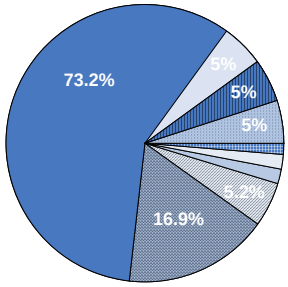
QUESTION GROUP D: Innovative Culture

- **D.1.** Does your organization have strong innovation culture?
- **D.2.** How do you as a senior leader foster innovation in your organization?
- **D.3.** What do you consider the most significant obstacles to innovation in your organization? Are these obstacles internal or external?...and do you have control over them?
- **D.4.** How do you reward innovation in your organization

Appendix D: Survey Demographic Analysis

QUESTION 1: In what function do you currently work?

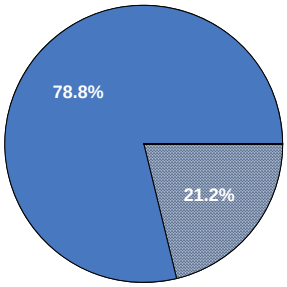
Response Options	*Responses*
Engineering, Science, and R&D	**73.5%**
Management	**16.5%**
Operations or Support	**5.2%**
HR or Administrative	**1.7%**
Other	**1.7%**
Finance	**1.3%**
Contracting	**0.0%**



QUESTION 2: What is your current employment type?

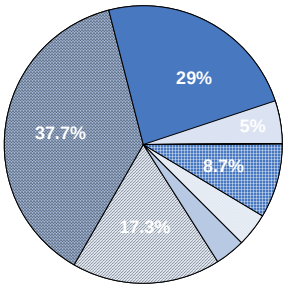
Response Options	*Responses*
Government Civilian	**78.8%**
Military	**21.2%**
Contractor*	**0.0%**
Other	**0.0%**

* Contractors were not included in survey due to contractual policies



QUESTION 3: What is your level of responsibility?

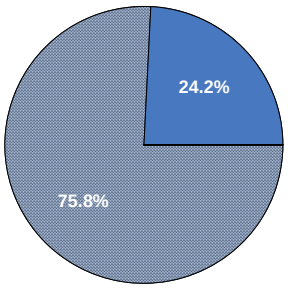
Response Options	*Responses*
Section (5-letter organization)	**29.0%**
Branch (4-letter organization)	**37.7%**
Division (3-letter organization)	**17.3%**
Directorate (2-letter organization)	**3.5%**



Headquarters	**3.9%**
Other	**8.7%**

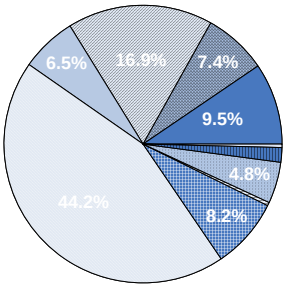
QUESTION 4: Do you currently supervise personnel?

Response Options	*Responses*
Yes, I am currently in a supervisory position.	**24.2%**
No, I am currently in a non-supervisory position.	**75.8%**



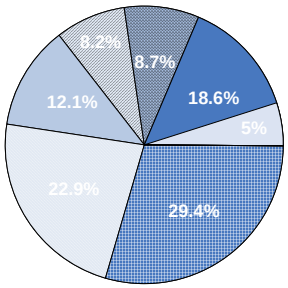
QUESTION 5: What directorate/organization do you work for?

Response Options	*Responses*
Headquarters Air Force Research Laboratory	**9.5%**
Air Vehicles Directorate	**7.4%**
Materials and Manfac Processes Directorate	**16.9%**
Propulsion Directorate	**6.5%**
Sensors Directorate	**44.2%**
Human Effectiveness Directorate	**8.2%**
Information Directorate	**0.4%**
Munitions Directorate	**4.8%**
Space Vehicles Directorate	**1.7%**
Directed Energy Directorate	**0.4%**
Air Force Office of Scientific Research	**0.0%**
Other	**0.0%**



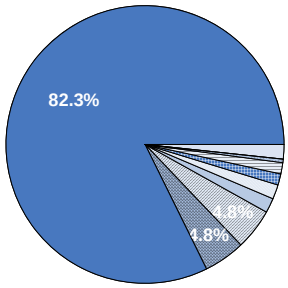
QUESTION 6: How many years of experience do you have with the Air Force and/or Department of Defense (DoD)?

Response Options	*Responses*
0-5 Years	**18.6%**
6-10 Years	**8.7%**
11-15 Years	**8.2%**
16-20 Years	**12.1%**
21-25 Years	**22.9%**
25+ Years	**29.4%**



QUESTION 7: At what AFRL research site do you currently work?

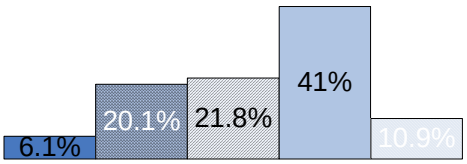
Response Options	*Responses*
Wright Research Site	**82.3%**
Brooks Research Site	**4.8%**
Eglin Research Site	**4.8%**
Mesa Research Site	**1.7%**
Tyndall Research Site	**1.7%**
Kirtland Research Site	**1.3%**
Hanscom Research Site	**1.3%**



	Rome Research Site	**0.4%**
	Edwards Research Site	**0.0%**
	Air Force Office of Scientific Research Site	**0.0%**
	Other	**1.7%**

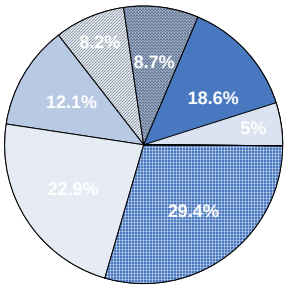
QUESTION 8: In general, how would you rate your overall job satisfaction?

Response Options	*Responses*
(1) Not Satisfied	**6.1%**
(2) Somewhat Satisfied	**20.1%**
(3) Satisfied	**21.8%**
(4) Very Satisfied	**41.0%**
(5) Extremely Satisfied	**10.9%**



QUESTION 9: How would you best describe your directorate/organization's life cycle stage?

Response Options	*Responses*
Newly defined or redefined directorate/organization focusing on introducing new products/services	**18.6%**
Rapidly growing directorate/organization with increasing responsibility and strong focus on customers	**8.7%**
Established directorate/organization with strong structure and systems as well as known products/services	**8.2%**



	Directorate/organization focused on increasing quality, cost effectiveness, and continuing improvement in operations	**12.1%**
	Mature directorate/organization with “brand name” recognition and with an established culture	**22.9%**
	Directorate/organization repositioning itself for the future; revitalization efforts are the focal point	**29.4%**

Appendix E: Survey Question Analysis

The results of the survey data collection and comparisons are provided in this appendix. The AFRL results are shown in **blue bold print**. Where applicable, the results from the AMA/HRI industry survey are provided, in parenthesis, for comparison.

QUESTION 10: How would you rank the importance of innovation to the following activities within your directorate/organization?

Frequency Analysis

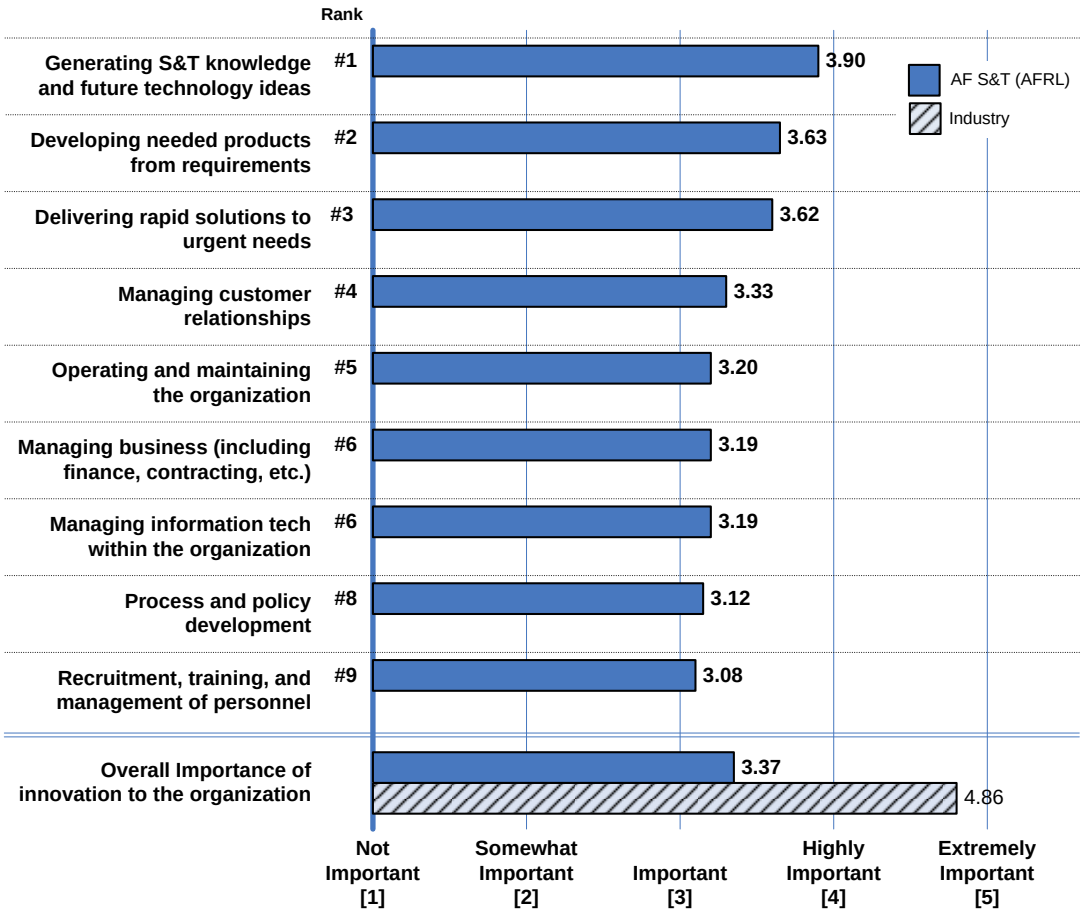
	Not Important [1]	*Somewhat Important* [2]	*Important* [3]	*Highly Important* [4]	*Extremely Important* [5]	*Rank*
Generating S&T knowledge and future technology ideas	**4.8%**	**12.2%**	**13.5%**	**26.5%**	**43.0%**	**1**
Developing needed products from requirements	**2.2%**	**13.0%**	**26.1%**	**37.0%**	**21.7%**	**2**
Delivering rapid solutions to urgent needs	**4.8%**	**12.7%**	**24.5%**	**31.4%**	**26.6%**	**3**
Managing customer relationships	**7.0%**	**17.8%**	**26.1%**	**33.0%**	**16.1%**	**4**
Operating and maintaining the organization	**5.2%**	**20.0%**	**36.6%**	**28.7%**	**10.0%**	**5**
Managing Business (including finance, contracting, etc.)	**4.8%**	**21.7%**	**36.5%**	**23.5%**	**13.5%**	**6***
Managing information technology within the organization	**5.7%**	**22.4%**	**31.6%**	**28.1%**	**12.3%**	**6***
Process and Policy development	**7.8%**	**21.3%**	**35.7%**	**21.7%**	**13.5%**	**8**
Recruitment, training, and management of personnel	**7.8%**	**25.2%**	**33.9%**	**17.4%**	**15.7%**	**9**
Overall Importance of Innovation to Organization	**5.6%** (0.9%)	**18.5%** (7.7%)	**29.3%** (23.2%)	**27.5%** (35.8%)	**19.2%** (51.3%)	

*** = tie**

Comparative Analysis

	Mean	*Sample Variance*	*Standard Deviation*	*Sample Size*	*t-test***	*Statistical Signif***
Generating S&T knowledge and future technology ideas	**3.907**	**1.217**	**1.481**	**230**	**N/A**	**N/A**
Developing needed products from requirements	**3.630**	**1.031**	**1.064**	**230**	**N/A**	**N/A**
Delivering rapid solutions to urgent needs	**3.623**	**1.147**	**1.314**	**230**	**N/A**	**N/A**
Managing customer relationships	**3.334**	**1.151**	**1.324**	**230**	**N/A**	**N/A**
Operating and maintaining the organization	**3.198**	**1.033**	**1.067**	**230**	**N/A**	**N/A**
Managing Business (including finance, contracting, etc.)	**3.192**	**1.073**	**1.151**	**230**	**N/A**	**N/A**
Managing information technology within the organization	**3.192**	**1.092**	**1.193**	**230**	**N/A**	**N/A**
Process and Policy development	**3.118**	**1.129**	**1.274**	**230**	**N/A**	**N/A**
Recruitment, training, and management of personnel	**3.080**	**1.168**	**1.365**	**230**	**N/A**	**N/A**
Overall Importance of Innovation to Organization	**3.365** (4.865)	**1.148** (1.355)	**1.318** (1.835)	**230** (1396)	**-17.763**	**Yes**

** The difference in mean values between AFRL and industry is said to be statistically significant (for a $p < 0.05$) if the t-test statistic is > 1.645 or <-1.645



Importance of Innovation - Comparison of AF S&T and Industry Rankings and Means

QUESTION 11: How important are the following reasons for pursuing innovation in your directorate/organization?

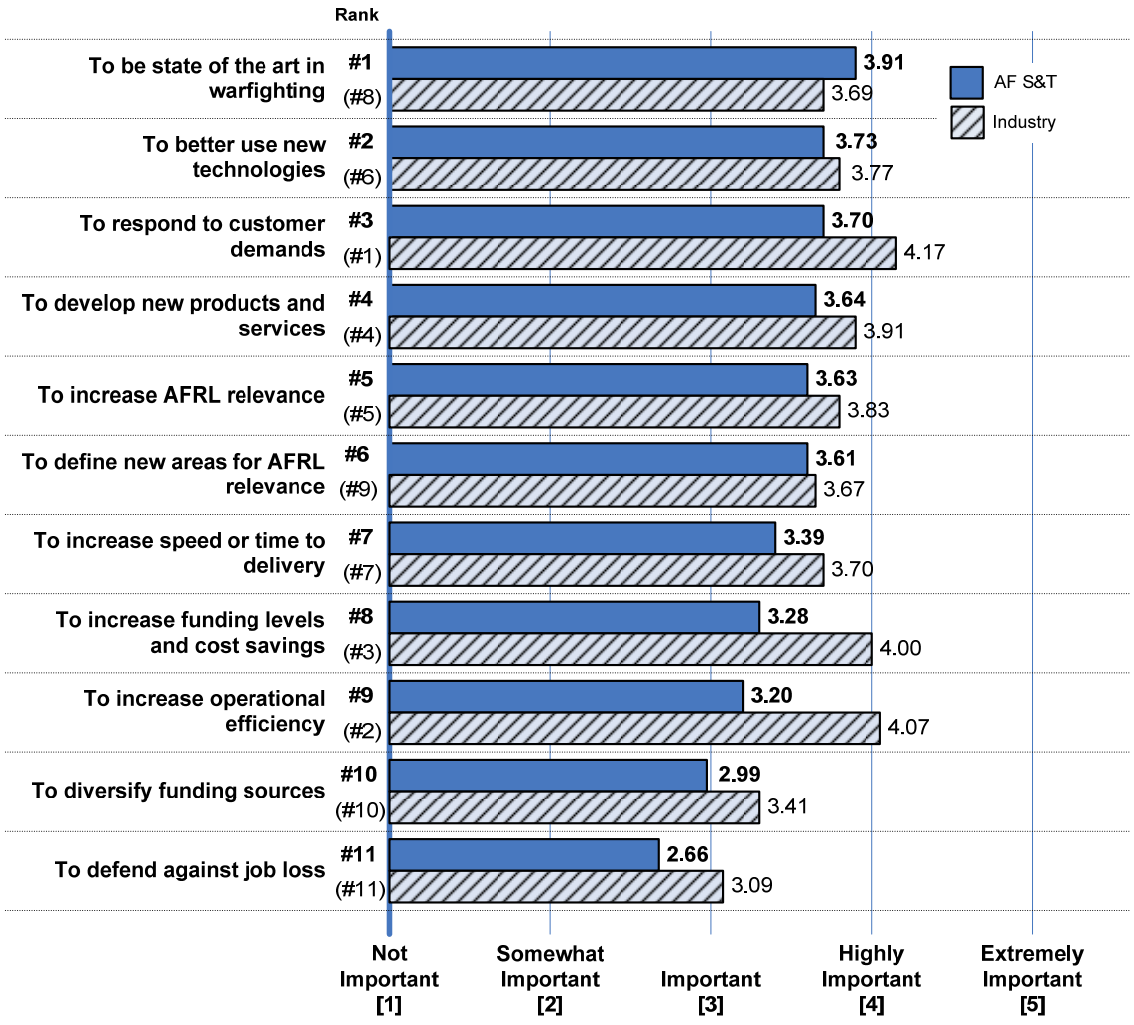
Frequency Analysis

	Not Important	*Somewhat Important*	*Important*	*Highly Important*	*Extremely Important*	*Rank*
To be state of the art in warfighting	**3.1%** (2.2%)	**10.6%** (10.4%)	**18.1%** (29.7%)	**29.5%** (32.0%)	**38.8%** (25.7%)	**1** (8)
To better use new technologies	**3.5%** (1.5%)	**10.1%** (8.8%)	**22.5%** (29.3%)	**37.9%** (32.8%)	**26.0%** (27.7%)	**2** (6)
To respond to customer demands	**2.7%** (1.0%)	**11.5%** (3.4%)	**23.9%** (17.9%)	**36.7%** (33.9%)	**25.2%** (43.9%)	**3** (1)
To develop new products/services	**2.6%** (2.1%)	**14.5%** (7.7%)	**22.4%** (22.3%)	**38.2%** (33.3%)	**22.4%** (34.7%)	**4** (4)
To increase AFRL relevance	**3.5%** (3.6%)	**11.8%** (7.9%)	**25.0%** (23.6%)	**37.3%** (31.8%)	**22.4%** (33.0%)	**5** (5)
To define new areas for AFRL relevance	**3.9%** (3.2%)	**12.3%** (9.9%)	**26.3%** (29.1%)	**33.8%** (32.6%)	**23.7%** (25.3%)	**6** (9)
To increase speed or time to delivery	**4.8%** (3.8%)	**17.1%** (10.0%)	**29.4%** (25.8%)	**32.0%** (33.1%)	**16.7%** (27.3%)	**7** (7)
To increase funding levels and cost savings	**4.4%** (3.1%)	**18.4%** (4.5%)	**36.4%** (20.6%)	**26.3%** (32.8%)	**14.5%** (39.0%)	**8** (3)
To increase operational efficiency	**5.3%** (1.0%)	**26.3%** (5.7%)	**26.3%** (20.7%)	**27.6%** (33.9%)	**14.5%** (39.5%)	**9** (2)
To diversify funding sources	**9.2%** (6.1%)	**24.6%** (13.8%)	**34.2%** (32.1%)	**22.4%** (28.2%)	**9.6%** (19.7%)	**10** (10)
To defend against job loss	**20.6%** (9.4%)	**26.3%** (21.5%)	**28.9%** (34.8%)	**14.5%** (19.7%)	**9.6%** (14.6%)	**11** (11)

Comparative Analysis

	Mean	*Standard Deviation*	*Sample Variance*	*Sample Size*	*t-test*	*Statistical Signif.*
To be state of the art in warfighting	**3.903** (3.686)	**1.125** (1.034)	**1.265** (1.070)	**227** (1396)	**2.727**	**Y**
To better use new technologies	**3.727** (3.767)	**1.067** (1.001)	**1.137** (1.002)	**227** (1396)	**-0.530**	**N**
To respond to customer demands	**3.704** (4.166)	**1.052** (0.905)	**1.107** (0.818)	**226** (1396)	**-6.244**	**Y**
To develop new products/services	**3.632** (3.911)	**1.064** (1.029)	**1.132** (1.059)	**228** (1396)	**-3.693**	**Y**
To increase AFRL relevance	**3.632** (3.824)	**1.064** (1.085)	**1.132** (1.177)	**228** (1396)	**-2.524**	**Y**
To define new areas for AFRL relevance	**3.610** (3.672)	**1.095** (1.058)	**1.095** (1.058)	**228** (1396)	**-0.801**	**N**
To increase speed or time to delivery	**3.386** (3.701)	**1.099** (1.088)	**1.099** (1.088)	**228** (1396)	**-4.019**	**Y**
To increase funding levels and cost savings	**3.281** (4.001)	**1.062** (1.027)	**1.062** (1.027)	**228** (1396)	**-9.538**	**Y**
To increase operational efficiency	**3.197** (4.076)	**1.138** (0.959)	**1.138** (0.959)	**228** (1396)	**-11.033**	**Y**
To diversify funding sources	**2.987** (3.413)	**1.109** (1.131)	**1.109** (1.131)	**228** (1396)	**-5.366**	**Y**
To defend against job loss	**2.662** (3.086)	**1.229** (1.169)	**1.229** (1.169)	**228** (1396)	**-4.859**	**Y**

** The difference in mean values between AFRL and industry is said to be statistically significant (for a $p < 0.05$) if the t-test statistic is > 1.645 or <-1.645



Reasons for Pursuing Innovation - Comparison of AF S&T and Industry Rankings and Means

QUESTION 12: How important are the following factors for developing an innovative culture in your directorate/organization?

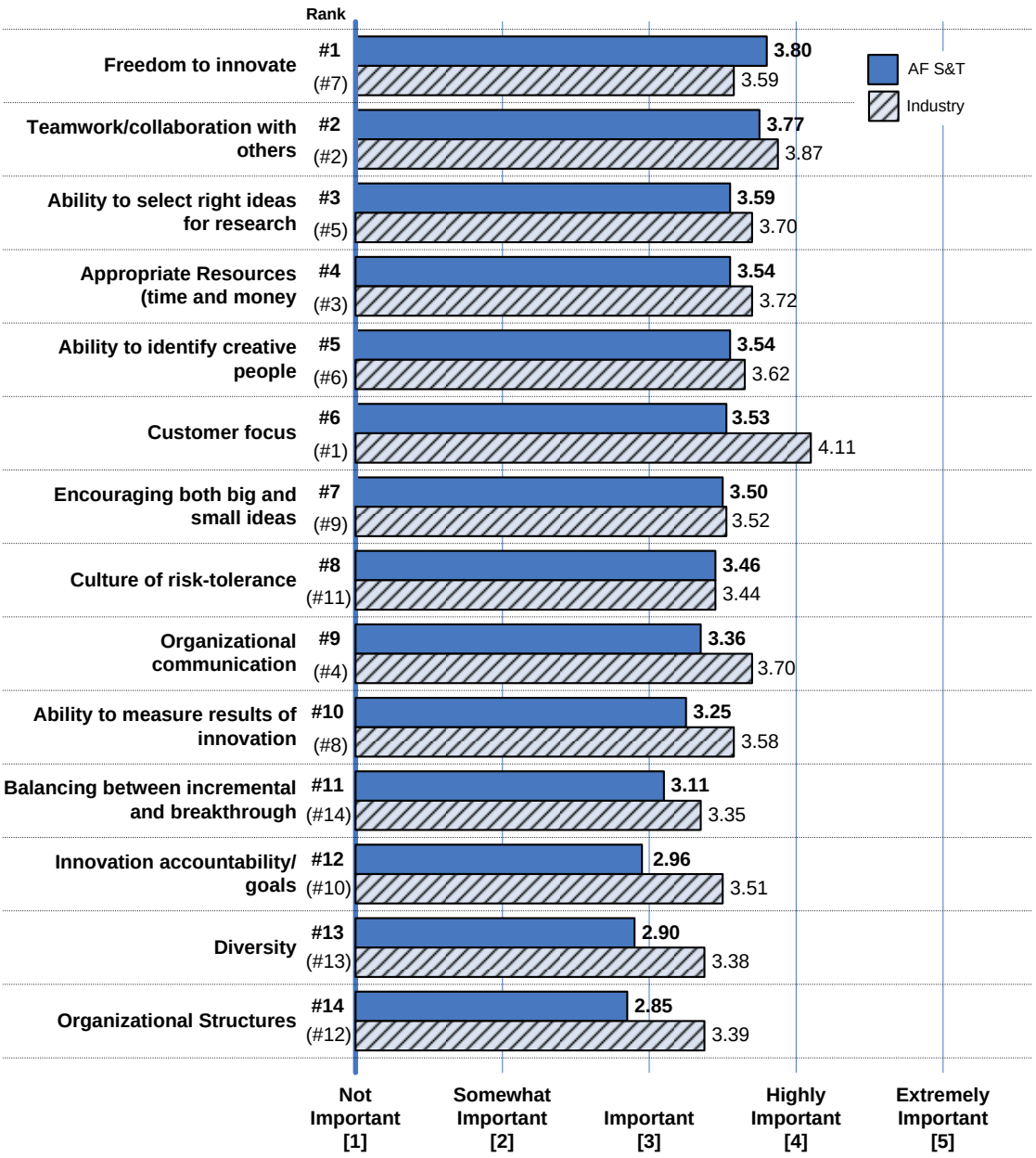
Frequency Analysis

	Not Important	*Somewhat Important*	*Important*	*Highly Important*	*Extremely Important*	*Rank*
Freedom to innovate	**5.6%** (3.6%)	**10.8%** (14.0%)	**18.6%** (26.4%)	**28.6%** (32.3%)	**36.4%** (23.7%)	**1** (7)
Teamwork/collaboration with others	**1.7%** (2.9%)	**9.1%** (7.0%)	**26.4%** (23.4%)	**35.9%** (32.9%)	**26.8%** (33.8%)	**2** (2)
Ability to select right ideas for research	**5.6%** (2.4%)	**13.9%** (10.0%)	**21.2%** (28.4%)	**34.6%** (33.2%)	**24.7%** (26.0%)	**3** (5)
Appropriate resources (time and money)	**3.5%** (1.6%)	**10.0%** (7.7%)	**34.2%** (30.8%)	**33.3%** (37.1%)	**19.0%** (22.8%)	**4** (3)
Ability to identify creative people	**6.1%** (3.4%)	**15.2%** (12.6%)	**22.5%** (28.8%)	**31.2%** (29.3%)	**25.1%** (25.9%)	**5** (6)
Customer focus	**3.5%** (2.1%)	**14.8%** (4.8%)	**27.0%** (18.3%)	**34.3%** (29.4%)	**20.4%** (45.4%)	**6** (1)
Encouraging both small ideas and big ideas	**7.8%** (2.8%)	**13.9%** (13.5%)	**20.8%** (32.1%)	**36.4%** (32.1%)	**21.2%** (19.5%)	**7** (9)
Culture of risk-tolerance	**8.7%** (4.2%)	**16.5%** (14.2%)	**22.9%** (32.1%)	**24.2%** (32.7%)	**27.7%** (16.8%)	**8** (11)
Organizational communication	**5.2%** (3.3%)	**14.3%** (10.9%)	**36.1%** (27.8%)	**29.6%** (28.4%)	**14.8%** (29.6%)	**9** (4)
Ability to measure results of innovation	**6.9%** (2.3%)	**19.0%** (10.7%)	**29.0%** (33.0%)	**32.5%** (33.8%)	**12.6%** (20.1%)	**10** (8)
Balancing between incremental improvements and breakthrough discoveries	**10.0%** (3.9%)	**18.6%** (13.5%)	**32.0%** (39.2%)	**29.0%** (30.6%)	**10.4%** (12.8%)	**11** (14)
Innovation accountability/goals	**10.4%** (4.1%)	**23.4%** (12.2%)	**36.8%** (30.8%)	**18.6%** (34.8%)	**10.8%** (18.1%)	**12** (10)
Diversity	**13.0%** (5.8%)	**27.4%** (13.3%)	**28.7%** (35.1%)	**18.3%** (29.5%)	**12.6%** (16.4%)	**13** (13)
Organizational structures	**9.6%** (4.2%)	**30.9%** (13.6%)	**31.7%** (35.8%)	**20.9%** (31.5%)	**7.0%** (14.9%)	**14** (12)

Comparative Analysis

	Mean	*Standard Deviation*	*Sample Variance*	*Sample Size*	*t-test***	*Statistical Signif***
Freedom to innovate	**3.792** (3.686)	**1.125** (1.034)	**1.265** (1.070)	**227** (1396)	**2.449**	**Y**
Teamwork/collaboration with others	**3.771** (3.877)	**1.002** (1.048)	**1.004** (1.099)	**231** (1396)	**-1.486**	**N**
Ability to select right ideas for research	**3.589** (3.704)	**1.165** (1.036)	**1.356** (1.073)	**231** (1396)	**-1.414**	**N**
Appropriate resources (time and money)	**3.545** (3.718)	**1.020** (0.953)	**1.040** (0.909)	**231** (1396)	**-2.403**	**Y**
Ability to identify creative people	**3.541** (3.617)	**1.193** (1.101)	**1.423** (1.211)	**231** (1396)	**-0.905**	**N**
Customer focus	**3.535** (4.112)	**1.080** (1.003)	**1.167** (1.006)	**230** (1396)	**-7.583**	**Y**
Encouraging both small ideas and big ideas	**3.494** (3.520)	**1.194** (1.038)	**1.425** (1.078)	**231** (1396)	**-0.318**	**N**
Culture of risk-tolerance	**3.459** (3.437)	**1.288** (1.058)	**1.658** (1.119)	**231** (1396)	**0.245**	**N**
Organizational communication	**3.343** (3.701)	**1.077** (1.104)	**1.160** (1.218)	**230** (1396)	**-4.648**	**Y**
Ability to measure results of innovation	**3.247** (3.584)	**1.113** (0.998)	**1.239** (0.997)	**231** (1396)	**-4.326**	**Y**
Balancing between incremental improvements and breakthrough discoveries	**3.113** (3.349)	**1.133** (0.994)	**1.283** (0.988)	**231** (1396)	**-2.988**	**Y**
Innovation accountability/goals	**2.961** (3.506)	**1.128** (1.050)	**1.272** (1.103)	**231** (1396)	**-6.867**	**Y**
Diversity	**2.900** (3.377)	**1.216** (1.085)	**1.479** (1.177)	**230** (1396)	**-5.593**	**Y**
Organizational structures	**2.848** (3.393)	**1.077** (1.030)	**1.160** (1.061)	**230** (1396)	**-7.156**	**Y**

** The difference in mean values between AFRL and industry is said to be statistically significant (for a $p < 0.05$) if the t-test statistic is > 1.645 or <-1.645



Important Factors for Developing an Innovative Culture - Comparison of AF S&T and Industry Rankings and Means

QUESTION 13: How important are these external drivers of innovation to your directorate/organization?

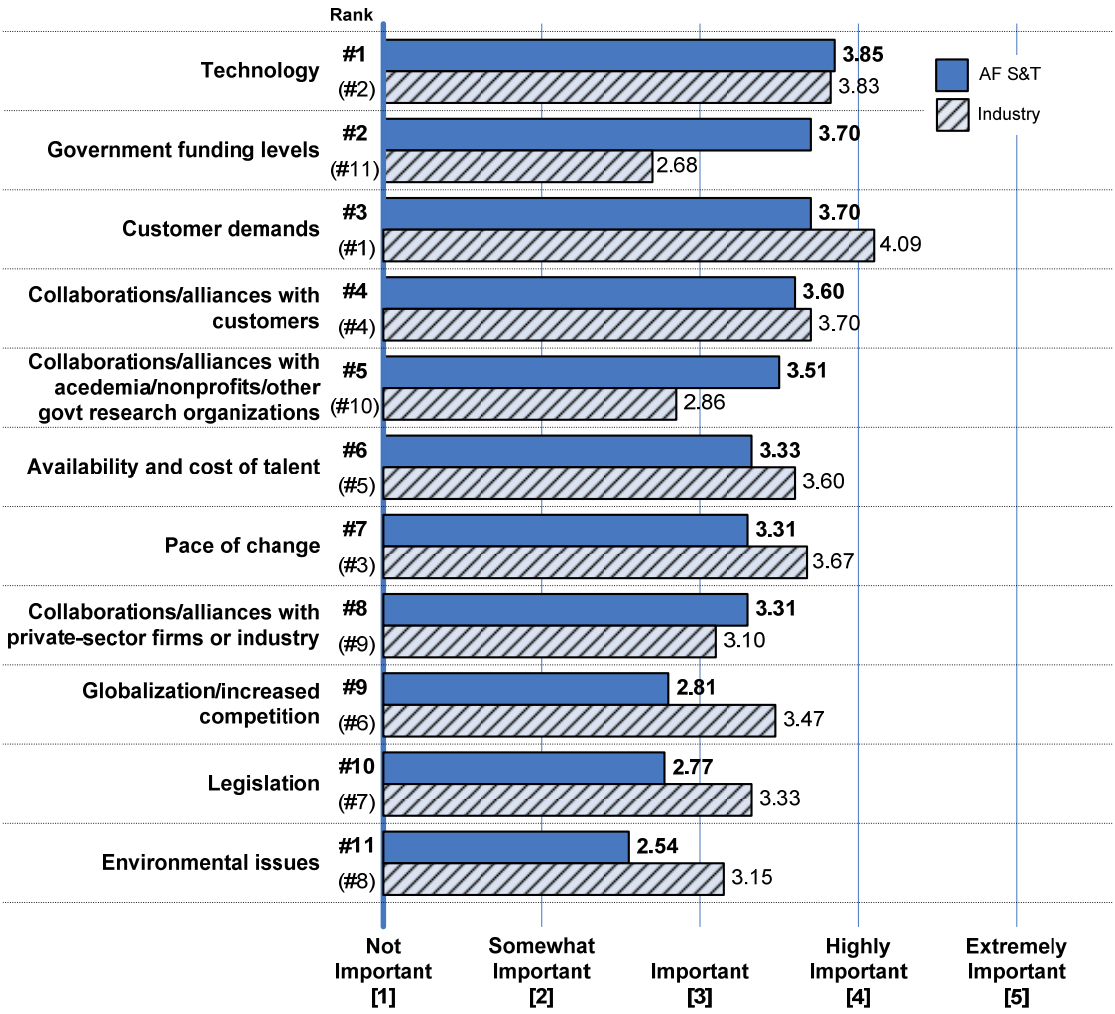
Frequency Analysis

	Not Important	*Somewhat Important*	*Important*	*Highly Important*	*Extremely Important*	*Rank*
Technology	**2.2%** (2.1%)	**8.8%** (7.1%)	**20.6%** (27.1%)	**39.0%** (34.1%)	**29.4%** (29.7%)	**1** (2)
Government funding levels	**3.5%** (22.9%)	**9.7%** (22.6%)	**26.1%** (28.6%)	**34.5%** (15.2%)	**26.1%** (10.7%)	**2** (11)
Customer demands	**1.8%** (1.2%)	**13.6%** (4.1%)	**23.2%** (18.2%)	**36.4%** (37.2%)	**25.0%** (39.2%)	**3** (1)
Collaborations/alliances with customers	**2.2%** (3.8%)	**11.4%** (8.6%)	**29.8%** (28.4%)	**37.7%** (34.8%)	**18.9%** (24.3%)	**4** (4)
Collaborations/alliances with academia/nonprofits/other government research organizations	**4.4%** (15.2%)	**13.7%** (24.8%)	**29.6%** (29.5%)	**31.0%** (20.6%)	**21.2%** (10.0%)	**5** (10)
Availability and cost of talent	**4.4%** (3.2%)	**18.5%** (8.9%)	**33.0%** (33.7%)	**27.3%** (34.1%)	**16.7%** (20.2%)	**6** (5)
Pace of change	**5.7%** (1.7%)	**15.4%** (8.4%)	**36.8%** (33.1%)	**26.8%** (34.0%)	**15.4%** (22.7%)	**7** (3)
Collaborations/alliances with private-sector firms or industry	**4.4%** (8.0%)	**18.7%** (21.5%)	**32.4%** (34.4%)	**30.7%** (25.2%)	**13.8%** (10.9%)	**8** (9)
Globalization/increased competition	**14.5%** (7.1%)	**28.2%** (12.2%)	**29.1%** (28.1%)	**18.1%** (31.6%)	**10.1%** (21.0%)	**9** (6)
Legislation	**14.1%** (9.0%)	**29.1%** (16.2%)	**30.4%** (29.0%)	**18,9%** (24.3%)	**7.5%** (21.5%)	**10** (7)
Environmental Issues	**18.5%** (12.6%)	**35.2%** (16.5%)	**26.9%** (29.5%)	**12.8%** (25.7%)	**6.6%** (15.7%)	**11** (8)

Comparative Analysis

	Mean	*Standard Deviation*	*Sample Variance*	*Sample Size*	*t-test***	*Statistical Signif***
Technology	**3.846** (3.825)	**1.014** (1.005)	**1.029** (1.010)	**228** (1396)	**0.297**	**N**
Government funding levels	**3.699** (2.682)	**1.070** (1.274)	**1.145** (1.622)	**226** (1396)	**12.890**	**Y**
Customer demands	**3.693** (4.088)	**1.046** (0.916)	**1.095** (0.838)	**228** (1396)	**-5.375**	**Y**
Collaborations/alliances with customers	**3.596** (3.669)	**0.991** (1.052)	**0.982** (1.107)	**228** (1396)	**-1.015**	**N**
Collaborations/alliances with academia/nonprofits/other government research organizations	**3.509** (2.857)	**1.105** (1.201)	**1.220** (1.442)	**226** (1396)	**8.129**	**Y**
Availability and cost of talent	**3.335** (3.595)	**1.094** (1.008)	**1.197** (1.017)	**227** (1396)	**-3.359**	**Y**
Pace of change	**3.307** (3.673)	**1.084** (0.971)	**1.174** (0.943)	**228** (1396)	**-4.795**	**Y**
Collaborations/alliances with private-sector firms or industry	**3.307** (3.095)	**1.065** (1.102)	**1.133** (1.215)	**225** (1396)	**2.754**	**Y**
Globalization/increased competition	**2.811** (3.472)	**1.192** (1.158)	**1.420** (1.340)	**227** (1396)	**-7.787**	**Y**
Legislation	**2.767** (3.331)	**1.138** (1.231)	**1.295** (1.517)	**227** (1396)	**-6.850**	**Y**
Environmental Issues	**2.537** (3.154)	**1.130** (1.237)	**1.276** (1.531)	**227** (1396)	**-7.522**	**Y**

** The difference in mean values between AFRL and industry is said to be statistically significant (for a $p < 0.05$) if the t-test statistic is > 1.645 or <-1.645



External Drivers of Innovation - Comparison of AF S&T and Industry Rankings and Means

QUESTION 14: How important are the following ways of measuring creativity and innovation in your directorate/organization?

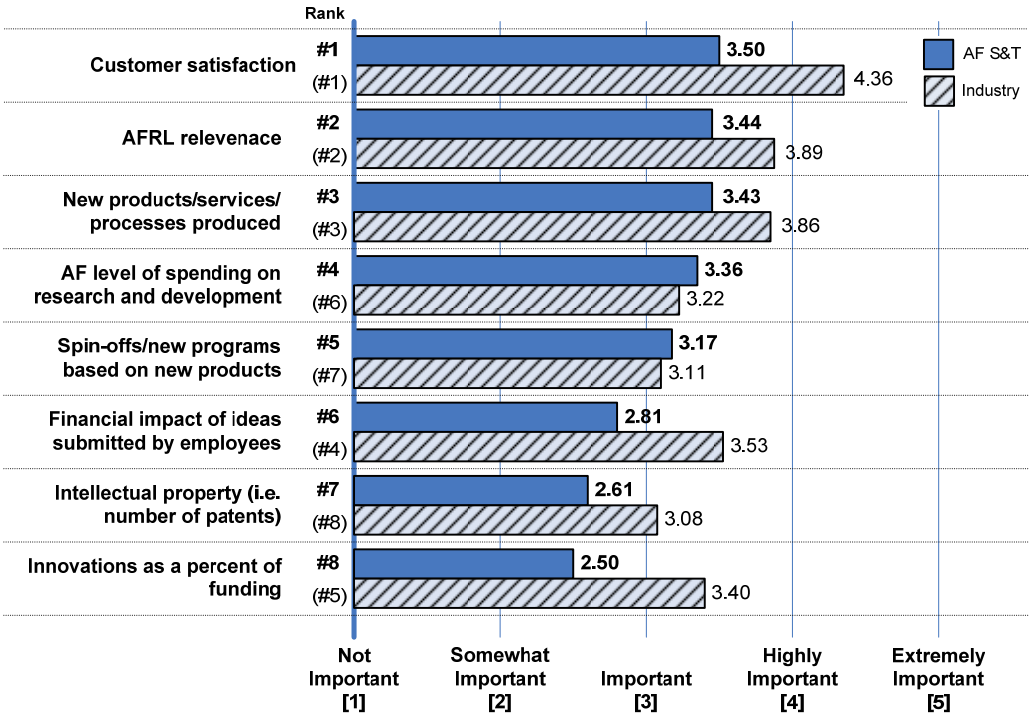
Frequency Analysis

	Not Important	*Somewhat Important*	*Important*	*Highly Important*	*Extremely Important*	*Rank*
Customer satisfaction	**6.1%** (0.7%)	**15.8%** (2.9%)	**24.6%** (11.7%)	**28.9%** (29.1%)	**24.6%** (55.6%)	**1** (1)
AFRL relevance	**8.0%** (4.9%)	**14.2%** (6.6%)	**24.0%** (19.3%)	**33.3%** (33.1%)	**20.4%** (36.1%)	**2** (2)
New products/services/processes produced	**4.4%** (1.9%)	**14.5%** (6.7%)	**32.0%** (23.1%)	**32.0%** (39.9%)	**17.1%** (28.4%)	**3** (3)
AF level of spending on research and development	**8.4%** (7.6%)	**15.9%** (18.5%)	**29.1%** (31.6%)	**25.1%** (29.4%)	**21.6%** (12.9%)	**4** (6)
Spin-offs/new programs based on new products	**7.0%** (12.0%)	**21.5%** (17.3%)	**30.3%** (30.5%)	**29.8%** (27.8%)	**11.4%** (12.4%)	**5** (7)
Financial impact of ideas submitted by employees	**13.3%** (2.4%)	**27.9%** (13.3%)	**33.2%** (30.8%)	**15.9%** (35.6%)	**9.7%** (17.9%)	**6** (4)
Intellectual property (i.e. number of patents)	**21.1%** (15.6%)	**28.2%** (20.2%)	**28.2%** (25.2%)	**13.7%** (23.8%)	**8.8%** (16.2%)	**7** (8)
Innovations as a percent of funding	**22.0%** (6.0%)	**33.5%** (14.4%)	**23.3%** (28.3%)	**15.0%** (35.8%)	**6.2%** (15.5%)	**8** (5)

Comparative Analysis

	Mean	*Standard Deviation*	*Sample Variance*	*Sample Size*	*t-test***	*Statistical Signif***
Customer satisfaction	**3.500** (4.360)	**1.197** (0.850)	**1.432** (0.723)	**228** (1396)	**-10.431**	**Y**
AFRL relevance	**3.440** (3.889)	**1.194** (1.117)	**1.426** (1.248)	**228** (1396)	**-5.311**	**Y**
New products/services/processes produced	**3.430** (3.862)	**1.070** (0.967)	**1.145** (0.936)	**228** (1396)	**-5.729**	**Y**
AF level of spending on research and development	**3.357** (3.215)	**1.219** (1.120)	**1.487** (1.254)	**228** (1396)	**1.646**	**Y**
Spin-offs/new programs based on new products	**3.171** (3.113)	**1.107** (1.190)	**1.226** (1.415)	**228** (1396)	**0.726**	**Y**
Financial impact of ideas submitted by employees	**2.810** (3.533)	**1.152** (1.009)	**1.328** (1.018)	**228** (1396)	**-8.934**	**Y**
Intellectual property (i.e. number of patents)	**2.608** (3.078)	**1.212** (1.308)	**1.469** (1.712)	**228** (1396)	**-5.367**	**Y**
Innovations as a percent of funding	**2.498** (3.404)	**1.152** (1.095)	**1.328** (1.200)	**228** (1396)	**-11.084**	**Y**

** The difference in mean values between AFRL and industry is said to be statistically significant (for a $p < 0.05$) if the t-test statistic is > 1.645 or <-1.645



Measuring Creativity and Innovation - Comparison of AF S&T and Industry Rankings and Means

QUESTION 15: Please rank-order the three (3) most significant barriers to pursuing innovation in your directorate/organization, with #1 being the highest.

Response Options	*1*	*2*	*3*	*Overall Rank**
Insufficient resources	**31%** (21.7%)	**5.9%** (14.1%)	**12.3%** (11.5%)	**1** (1)
Organizational constraints such as policy	**7.9%** (9.5%)	**12.2%** (10.0%)	**13.2%** (11.7%)	**2** (7)
No formal strategy for innovation	**6.9%** (20.6%)	**11.8%** (14.5%)	**10.5%** (12.5%)	**3** (2)
Lack of clear goals and priorities	**11.8%** (16.8%)	**10.0%** (11.6%)	**7.3%** (11.7%)	**4** (3)
New ideas threaten existing programs	**5.4%** (5.2%)	**10.4%** (6.0%)	**11.9%** (8.8%)	**5** (11)
Lack of rewards for creative behaviors	**3.4%** (7.5%)	**11.8%** (15.4%)	**11.4%** (13.1%)	**6** (10)
Structure not geared toward innovation	**8.9%** (11.6%)	**10.0%** (14.3%)	**5.9%** (13.5%)	**7** (6)
Short-term mindset	**5.9%** (12.3%)	**10.0%** (14.9%)	**8.2%** (11.0%)	**8** (5)
Too much management control	**5.4%** (9.4%)	**7.2%** (10.1%)	**6.4%** (10.1%)	**9** (8)
Lack of leadership/management support	**6.4%** (12.6%)	**6.3%** (11.3%)	**5.9%** (7.8%)	**10** (4)
Culture of fear about failure	**6.9%** (9.1%)	**4.5%** (12.8%)	**6.8%** (10.7%)	**11** (9)

* Overall rankings determined based on number of times responses rated in the top three

QUESTION 16: Please rank-order the three (3) actions your leaders are taking to support innovation, with #1 being the highest.

Response Options	*1*	*2*	*3*	*Overall Rank**
Developing an organizational strategy for innovation	**20.4%** (24.9%)	**8.7%** (13.1%)	**15.3%** (9.2%)	**1**** (1)
Redesigning organizational structure or work flow	**18.0%** (17.3%)	**17.4%** (17.4%)	**8.7%** (13.7%)	**1**** (2)
Increasing employee involvement	**13.1%** (14.4%)	**13.3%** (16.3%)	**16.9%** (14.7%)	**3** (3)
Identifying/attracting more creative talent	**13.6%** (12.9%)	**17.9%** (13.1%)	**8.2%** (10.3%)	**4**** (4)
Redefining the organization's values	**12.2%** (12.7%)	**15.4%** (13.8%)	**12.0%** (12.4%)	**6** (5)
Establishing new idea review processes	**6.3%** (9.6%)	**8.2%** (13.0%)	**8.7%** (11.0%)	**7** (6)
Encouraging employees to learn about areas outside their expertise	**12.1%** (8.2%)	**13.8%** (11.2%)	**14.2%** (15.5%)	**4**** (7)
Providing training in creative thinking and problem solving	**4.9%** (6.9%)	**5.1%** (8.7%)	**9.3%** (9.4%)	**8** (8)
Creating new incentive programs	**0.5%** (5.3%)	**0%** (8.1%)	**6.6%** (7.9%)	**9** (9)

* Overall rankings determined based on number of times responses rated in the top three
* tie

QUESTION 17: Select the one statement that best describes risk taking in your directorate/organization at this time (chose only one).

Response Options	*Responses*
Risk that is well analyzed and aligned with current goals is usually accepted	**48.2%** (47.2%)
Risk is evaluated carefully to avoid error	**28.6%** (32.4%)
Intelligent risk-taking is recognized	**19.6%** (14.7%)
Intelligent risk-taking is rewarded	**3.6%** (5.5%)

QUESTION 18: Select the one statement that best describes the evaluation of ideas in your directorate/organization at this time (chose only one).

Response Options	*Responses*
There is no standard policy for reviewing and evaluating ideas	**42.9%** (47.6%)
There is an independent review and evaluation process for ideas	**19.9%** (16.5%)
Ideas are reviewed and evaluated by the unit manager where idea was proposed	**16.8%** (15.4%)
Ideas are reviewed and evaluated by the unit that would impacted by the idea	**7.1%** (12.6%)
The employee is responsible for starting and managing the review process	**13.3%** (7.6%)

QUESTION 19: Select the one statement that best describes the reward and recognition practices in your directorate/organization at this time (chose only one).

Response Options	*Responses*
Innovation is not rewarded in this organization	**25.7%** (26.0%)
Innovation is recognized with nonfinancial rewards	**22.6%** (20.9%)
Innovation often leads to more challenging work and/or autonomy	**24.8%** (19.3%)
Innovation is rewarded by individual bonuses and/or salary increases	**15.9%** (17.6%)
Innovation is considered in promotion decisions	**4.9%** (9.2%)
Innovation is rewarded through team bonuses	**4.0%** (4.4%)
Innovation is rewarded with larger staff and/or budgets	**2.2%** (2.0%)

QUESTION 20: Rank the following in terms of the opportunities/competitive edge they give your organization (1=most opportunity, 4=least opportunity).

	1	*2*	*3*	*4*
Collaborate with customers, suppliers, and other firms to design products/services	**38.1%** (50.9%)	**28.4%** (21.7%)	**26.1%** (16.9%)	**7.7%** (10.1%)
Develop new breakthrough products/services that lead warfighting	**32.7%** (23.3%)	**37.8%** (27.5%)	**22.1%** (31.3%)	**6.8%** (18.0%)
Respond quickly and flexibly to the uncertainties of the warfighting environment	**16.1%** (16.2%)	**27.5%** (34.6%)	**39.6%** (29.6%)	**16.7%** (19.4%)
Protect our intellectual property from competition/adversaries	**13.0%** (9.6%)	**6.3%** (16.1%)	**12.2%** (22.0%)	**68.9%** (52.2%)

QUESTION 21: How successful is your directorate/organization at innovation?

Response Options	*Responses*
Very successful	**N/A** (14.8%)
Moderately successful	**N/A** (70.3%)
Not at all successful	**N/A** (14.6%)

QUESTION 22: Which of the following statements best captures your feelings about innovation?

Response Options	*Responses*
I recognize the importance of innovation, have clear understanding of what innovation means, and how my directorate/organization can become more innovative.	**38.4%** (52.8%)
I recognize the importance of innovation, have clear understanding of what innovation means, but do not have a clear understanding as to how my directorate/organization can become more innovative.	**52.0%** (40.9%)
I recognize the importance of innovation, but I do not have clear understanding of what innovation means and how my directorate/organization can become more innovative.	**9.6%** (6.0%)

QUESTION 23: In which of the following areas are you currently innovating?

Response Options	*Responses*
Customer experience: how to deepen the customer's relationship with you by generating an engaging experience around your offering	**10.8%** (15.2%)
Service: providing value to customers around your product offering	**12.4%** (11.6%)
Core process: adding value to the central activities of your organization	**12.3%** (12.4%)
Product performance: design and delivery of the core offerings	**10.4%** (12.2%)
Enabling processes: how you support the organization's core processes and workers	**12.1%** (11.8%)
Business model: how the company intends to increase budgets and funding levels	**4.4%** (10.6%)
Brand: how you communicate to differentiate	**4.4%** (8.4%)
Networks and alliances: how you work with other organizations for mutual benefit	**15.7%** (8.1%)
Product systems: widening the range of technology products you offer through linking technologies together	**10.4%** (4.7%)
Channel: how you get your technology products to the warfighter	**7.2%** (3.6%)

QUESTION 24: In which functions within your directorate/organization does innovation currently take place?

Response Options	*Responses*
Generating S&T knowledge and future technology ideas	**22.6%**
Developing needed products from requirements	**15.2%**
Delivering rapid solutions to urgent needs	**16.1%**
Managing customer relationships	**10.4%**
Managing Business (including finance, contracting, etc.)	**8.6%**
Managing information technology within the organization	**6.4%**
Operating and maintaining the organization	**7.2%**
Process and Policy development	**7.4%**
Recruitment, training, and management of personnel	**6.1%**

QUESTION 25: In my directorate/organization we…

Response Options	*Responses*
Have a shared definition of what innovation is	**20.8%** (41.3%)
Regularly review progress in innovation	**13.2%** (22.4%)
Have a shared agenda to execute the innovation strategy	**6.9%** (12.3%)
Have a well-understood strategy for innovation	**6.9%** (12.1%)
Have well-defined roles and responsibilities	**52.2%** (11.3%)

Appendix F: Interview Analysis

QUESTION GROUP A: View of Innovation

Definition of Innovation (for the Air Force S&T Community)

	Number of Responses	*Percent of Respondents*
Innovation = Invention/Discovery/Science + Exploitation/Application	7	64%
Innovation is applying existing knowledge in new ways	3	27%
Other	1	9%

Summary of responses

- Innovation is applying existing knowledge in new ways
- Innovation is best defined based on types (breakthrough vs incremental)
- Innovation = invention/discovery + application
- Innovation = invention + exploitation
- Innovation is taking what you know and applying it in new ways
- Innovation = invention + exploitation
- Innovation is out-of the-box solutions to issues and problems
- Innovation is not invention but application of new ideas in ways never before used
- Innovation is the application of knowledge
- Innovation = invention + use
- Innovation is the application of science to solve real world problems

Importance of Innovation (for the Air Force S&T Community)

	Number of Responses	*Percent of Respondents*
Innovation is extremely/highly important	8	73%
Innovation is important, but cannot be applied to all areas	3	27%
Innovation is not important	0	0%

Summary of responses

- Innovation is important but does not apply to everything we do in AFRL
- Innovation is the single core competency of everything we do in AFRL; applies to all core processes
- Importance of innovation is different in AFRL than in the business world
- Innovation (success) is what the AF is paying AFRL to accomplish
- Innovation (in AF S&T) is most important in areas where industry is not doing innovative work
- Innovation plays a role in AFRL, but innovators often lack depth of knowledge needed
- Innovation is what AFRL is for; lead for new technological innovations
- Innovation is in AFRL is essential for national security
- Innovation is very important to AFRL and essential to success in the long-term fight; job of lab
- Innovation is extremely important because AFRL does not lead S&T discovery as much as it did a decade ago; more creativity will help bring AFRL back competitively
- Innovation is critical to AFRL; research can be bought from other places, but application of science is best led by AFRL

Innovation Importance in the Air Force S&T Core Processes

	Number of Responses	*Percent of Respondents**
Innovation important in "Generating S&T knowledge and future technology ideas (Far Term - AFRL Core Process 1)"	9	82%
Innovation important in "Developing needed products from requirements (Mid Term - AFRL Core Process 2)"	6	55%
Innovation important in "Delivering rapid solutions to urgent needs (Near Term - AFRL Core Process 3)"	10	91%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

Summary of responses

- Less innovation benefit in CP2; some innovation possible in CP1; innovation most applicable to CP3
- Innovation applicable in all AFRL core processes
- Strong innovation impacts in CP3; Opportunity for disruptive innovation is the greatest in CP1; Innovation in CP2 is based on process improvement especially in the area of refining systems engineering processes
- Innovation important across the core processes…CP1 demands invention component of innovation; CP2 uses exploitation component of innovation; CP3 involves using existing technology creatively to solve problems
- Innovation is most applicable in CP1; innovation starts with science and is built on based on applied research
- Nature of R&D demands innovation (dramatic revolutionary changes) in all areas; innovation most important in the CP2 and CP3 areas where R&D is transitioned into usable products
- Innovation plays greatest part in CP1 and CP3
- Innovation is important in all the AFRL core processes; best supported right now in the short term CP3 area; need to foster innovation in CP1 and CP2
- Innovation most important in CP1 and CP3; because CP2 is requirements driven, AFRL innovation does not play a strong role here, innovation in not requirements driven
- The forefront of innovation is in CP1 where new knowledge is developed; Innovation also found in CP2 and CP3 where knowledge is put to "use"
- Innovation is important across the spectrum of the AFRL organization

Innovation Importance in the Air Force S&T Core Processes

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Innovation important in "Generating S&T knowledge and future technology ideas (Far Term - AFRL Core Process 1)"	9	82%
Innovation important in "Developing needed products from requirements (Mid Term - AFRL Core Process 2)"	6	55%
Innovation important in "Delivering rapid solutions to urgent needs (Near Term - AFRL Core Process 3)"	10	91%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

Summary of responses

- Innovation needs to considered in building strategy through Future Long Term Challenges (FLTCs)
- Innovation is a repeatable process that can be built into a cohesive investment strategy
- Innovation strategy needs to be better incorporated into FLTCs; foster multi-disciplinary investments

- S&T Business and technology strategy needs to focus on how we exploit invention; current centralized planning is the anti-thesis of innovation
- S&T Business and technology strategy needs to strike a balance between science and engineering.
- Industry innovation strategy seems to be more incremental; AF R&D needs to focus on dramatic
- AFRL should not be afraid of incorporating disruptive/risky innovation into S&T strategy; need to try things outside the norms; need to build strategy for more entrepreneurial research; need to show willingness to invest
- Innovation needs to play better role in S&T business and technology strategy; so focused on planning FLTCs; not strategizing to foster ideas that will make the FLTCs work; AFRL too focused on requirements and not strategizing to foster game-changing (disruptive) ideas
- AFRL S&T business and technology strategy is too requirements focused; long term innovation and disruptive ideas are not being looked at; even FLTCs are too focused on the here and now fight
- I am not happy with how the AF is applying innovation into S&T business and technology strategy; current FLTC planning is merely an administrative burden
- Innovation is an important component of directorate level business and technology strategy; innovative thinking in the larger AFRL picture, especially in FLTCs, is not as encouraging as expected; FLTCs are not being executed as originally intended

QUESTION GROUP B: Innovation Emphasis

Senior Leader Innovation Emphasis (for the Air Force S&T Community)

	Number of Responses	*Percent of Respondents*
Process/Service Innovation (including developing knowledge/technology)	10	91%
Process/Organizational Innovation (including business model innovation)	6	55%
Operational Innovation (including CONOPS development)	3	27%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

Summary of responses

- Emphasis placed on developing science for application, not just for science sake; Some emphasis on process/organizational innovation; not as much emphasis on operational innovation because AFRL not typically involved early enough in capability development processes
- Root to all innovation is not the same, need to have a clear goal regarding what is needed from innovation investment; push for innovation in processes of developing innovation
- Innovation emphasis needs to stay on development of knowledge and technology; limited flexibility on process/organizational aspects; limited control in directing operational aspects
- Service labs are designed to be innovative in the areas of technology products and services; designed for exploitation component of innovation
- AFRL primary focus needs to be in development of technological applications (products); also stress opportunities from emphasis in operational innovation although not applicable in all technology domain areas; operational innovation success more evident in cyber domain than air domain
- Important to emphasize innovation in all areas; innovate new applications (products/services); Potential for AFRL to take advantage of process/organizational ideas although bureaucracy poses a roadblock; AFRL could provide more operational innovation than it does today
- Strongest emphasis is on development of products and services; AFRL transformation efforts are focused on process innovation (covered with CP1, CP2, CP3 concepts); AFRL could put more emphasis on operational innovation

- Most emphasis is placed on innovation in development of products and services (providing new capabilities with existing technologies); Some emphasis placed on operational innovation; not much push for process/organizational innovation…living hand to mouth and lack time/resources to invest further here
- Product/service innovation is largest innovation emphasis area; process and service innovation is getting more important with shrinking budgets…but are we really being innovative here?; organizational innovation has not been emphasized in labs in a while
- Products and services are not the primary focus but generating new knowledge is; I don't emphasize process/organizational nor operational innovation
- Emphasis is on process/organizational innovation; other innovation important but not as much in need of emphasis as process/organizational ideas

QUESTION GROUP C: Role of Collaboration in Innovation

Importance of Collaboration in Disruptive Innovation (for the Air Force S&T Community)

	Number of Responses	*Percent of Respondents*
Collaboration is essential to foster disruptive innovation	11	100%
Collaboration is not essential to fostering disruptive innovation	0	0%

Summary of responses

- AFRL needs to have a mix of ideas from various sources
- Collaborate or die; teams do everything; myth of the lone wolf researcher is not true
- Collaboration is important to everything we do
- Collaboration with industry is essential because most technology transitions occur through industry
- More than half the TDY of this directorate is to conduct collaborations with AF operators
- Innovation only happens by getting a bunch of smart people together
- Collaboration is very important for innovation; without it we are just doing group think
- Collaboration receives tons of emphasis and push within this directorate
- Collaboration is critical; communication is the key
- Collaboration is essential; success though large amount of jointly managed research
- Collaboration is important; there are specific areas of research where AFRL works and blends well with others doing research

Sources of Disruptive Innovative Ideas (in the Air Force S&T Community)

	Number of Responses	*Percent of Respondents**
Government (internal military/civilian personnel)	7	64%
Contractors (in-house contract personnel)	5	45%
Contractors (major industry firms)	4	36%
Contractors (smaller industry firms)	4	36%
Other government agencies/labs	3	27%
Customers/Users/Warfighters	3	27%
Academia (civilian and military)	6	55%
Others	3	27%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

Summary of responses

- Good ideas come from internal resources; not sure if major industry is truly innovative; some doubts on small business innovative research validity; pure acquisition community and warfighters are too focused on cost/schedule/performance metrics to provide innovative ideas; academia (civilian and military) provide good S&T concepts
- There is not a single best source of innovation in AFRL; all players contribute in various ways
- Academia continues to be the best source of new and innovative ideas in technology
- Innovation comes from individuals, it does not matter where they come from
- Best ideas start with a core group of organizational stars (10-20% of the current AFRL scientific and engineering population); need to increase the amount of stars in-house
- I am not really sure where the best ideas come from; we have a mix of in-house and outsourced innovation; need to take better advantage of external innovators
- Innovative ideas come in from across the spectrum; need to take down the artificial walls and allow all to contribute good ideas
- Most ideas come from internal government sources and in-house contract personnel
- Industry has more disruptive ideas because of the availability of resources
- Most of the best disruptive ideas come from external sources; DoD contractors typically don't do discovery/invention research; academia is an investment location for AFRL research dollars
- The most creative (and disruptive) ideas come from the internal junior workforce; not a big enough segment of current AFRL workforce

QUESTION GROUP D: Innovative Culture

Strength of Innovative Culture (in the Air Force S&T Community)

	Number of Responses	*Percent of Respondents*
AFRL has a strong innovative culture	3	27%
AFRL does not have a strong innovative culture	8	73%

Summary of responses

- The innovative culture could be better at AFRL; spending too much on PM; lack of flexibility makes it hard to be innovative
- Innovative culture is an area in AFRL where improvement is needed; people are as good as the pest labs, innovation processes are not the best; AF culture is designed for operations not innovation; lack flexibility; international innovative cultures are better at mustering resources to pursue new ideas
- The innovative culture in AFRL is not strong; we are not good at supporting innovation; as an entity we are not coming to the table with the right mindset
- AFRL has a strong innovative culture; don't need a rigorous approach to innovation; we can be as innovative as we want to be
- AFRL overall does not have a strong innovative culture; too many rules; too many processes; don't spend enough time thinking about the art of the possible
- AFRL does not have a good innovative culture; we have a difficult time fostering innovation, especially disruptive innovation
- AFRL does not have a strong innovative culture; this is something the senior leadership of AF S&T needs to foster
- My directorate and AFRL as a whole does not have a strong innovative culture; you can't direct innovation; capability is there; need to do better at building an environment that will foster disruptive innovation; there are pockets of innovation throughout the lab but we need to build a better environment

- Still opportunities to grow our innovative culture; I would characterize our innovation culture as 40-50% of the level that it should be
- My directorate has a very strong innovative culture; the innovative culture within AFRL as a whole is good too
- The are pockets of innovation within AFRL; we don't have nor need a formal way of nurturing innovation; everyone can't be innovative; wild thinkers need to meld into the rest of the lab; survival leads to innovation

Largest Obstacles to Innovation (in the Air Force S&T Community)

	Number of Responses	*Percent of Respondents**
Government policy and other legal restrictions	5	45%
Lack of tools and training	1	9%
Lack of rewards for innovation	1	9%
Unsupportive culture and climate	3	27%
Limited resources	5	45%
Process immaturity	3	27%
Leadership turnover and management instability	2	18%
Inflexibility in strategic planning and budgeting activities	6	55%
Communication and collaboration difficulties	2	18%
Bureaucracy, administrative burdens, and non-value added work	5	9%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

Summary of responses

- Over-emphasis of standardization in process management is an enemy of creativity; more than one way to accomplish activities; limited amount of time engineers and scientists get to work on S&T; administrative burdens and bureaucracy; too many external influences on business and technology strategy; manpower limits and an over-leaned workforce
- DoD financial (program element) structure is limiting; no flexibility to move money to adjust to changes; lack of cohesive corporate laboratory; tribal culture; big AF culture is not conducive to the S&T innovation mission…built for operational mission; performance appraisal systems seek to put everyone into the same mold…standardized
- Lack of tools and training in innovation; lack of collaboration with organizational/agencies outside lab
- Forcing innovation through data calls and focused processes; excessive oversight and control of activities; too much bureaucracy and administrative burden
- Overdependence on commercial process management methodologies not designed for S&T organizations; excessive and restrictive planning activities
- Highly structured budget/planning environment; less opportunity, flexibility, and freedom to do innovative work; technology transition processes need work; cannot schedule technological breakthroughs; organizational barriers; resource constraints; risk adverse culture is a function of resource limitations; if we made a promise we must keep the promise; force more conservatism; need to make conscience decision to take riskier approaches in some circumstances
- Federal acquisition regulations and policies restrict our innovativeness; artificial organizational barrier; risk adversity; "mine" philosophy of idea ownership; lack of rewards for creative and innovative behavior
- Too much political influence on how we spend our money; fiscal environment forces short-term focus; sacrifice too many great ideas for short-term gains; turnover in senior leadership; lack of organizational stability

- Too much overhead; too many administrative burdens, policies, restrictions, requirements; only fraction on typical S&E's time is spent on actual S&E work; challenges in fitting disruptive innovation for S&T into existing acquisition processes
- Difficulties communicating both externally and internally; growing bureaucracy and over burdensome non-value added work; work might be valuable to someone but in big picture some things need to eliminated to support the larger S&T mission; too much management and leadership turnover; lack of strategic stability; new ideas threaten existing programs
- Cannot plan for technological disruptive innovation; need more flexibility in the AF S&T budgeting systems; too rule based in execution of funding; risk-adversity; resource constraints

Senior Leadership Control Over Obstacles (in the Air Force S&T Community)

	Number of Responses	*Percent of Respondents*
Have control over innovation obstacles and barriers	6	55%
Have some control over innovation obstacles and barriers	4	36%
Have little control over innovation obstacles and barriers	1	9%

Senior Leadership Actions in Fostering Innovative Culture (in the Air Force S&T Community)

	Number of Responses	*Percent of Respondents**
Developing an organizational strategy for innovation	3	27%
Redesigning organizational structure or work flow	5	45%
Advocating for workforce (less admin burdens, greater risk taking)	2	18%
Establishing flexible funding mechanisms to invest in ideas	6	55%
Changes in workplace environment/faculties	1	9%
Establishing new idea review processes	1	9%
Providing training and opportunities to learn about areas outside their expertise	2	18%
Creating new incentive programs	3	27%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

Summary of responses

- Instituted technology review board to break-down stovepipes; changes in organizational structures; capability focused planning
- Innovation is a process that can be learned and repeated; teaching innovation process
- Encouraging rapid improvement event to improve the processes
- Don't need to do anything to build innovative culture; I set aside money to invest in ideas; I give them money and stay out of the way; I bet on people not programs/technology; I run experiments
- Established large director's fund ($1M) to invest ideas and spark innovation; offer $75K grants to individuals for research; sponsorship of graduate and post-doctorate work
- Championing commander's challenge; expanding program to universities as AFRL sponsored research
- Encourage process improvements/environment like TechEdge; facilities and workspace changes to foster more communication; set aside funding for flexible investments
- Sponsorship of tech area leadership symposium
- Try to shield workforce from administrative burdens; encouragement of rapid improvement events to improve innovative processes

- Constant emphasis on risk-taking (let people know we will have 1 breakthrough for every 9 failures); give persons high degree of autonomy to do new things; build business plan to build wedges for new innovative ideas; sponsorship of strategic technology thrusts
- Open up opportunities to fund ideas; establish director's discretionary fund for use as seed money; brokering for risk advocacy on management side of organization; communicate openness to ideas; don't require good ideas to flow through the formal bureaucracy

Innovation Rewards (in the Air Force S&T Community)

	Number of Responses	*Percent of Respondents*
Innovation is rewarded in this organization	3	27%
Innovation is not well rewarded in this organization	8	73%

Incentive currently being used to reward innovation*		
Innovation is recognized with nonfinancial rewards (praise, awards)	6	55%
Innovation often leads to more challenging work and/or autonomy	2	18%
Innovation is rewarded by individual bonuses and/or salary increases	5	45%
Innovation is considered in promotion decisions	5	45%
Innovation is rewarded through team bonuses	0	0%
Innovation is rewarded with larger staff and/or budgets	3	27%

* Percentages reflect the frequency of responses in the interviews; respondents cited multiple answers

Summary of responses

- Performance appraisal systems award financially; awards and recognition programs; freedom to operate
- Reward structure need to be better tailored to individuals; acknowledgement and thank you; salary increases and bonuses under performance appraisal systems
- Innovation is not considered in existing reward structures
- Provide innovators with additional S&T funding
- Innovation is rewarded with the opportunity to show the application of their ideas; I made a difference; opportunity to do something again; performance appraisal systems award financially; bonuses
- Innovation is not considered in existing reward structures
- Rewards for innovation need to be improved; performance appraisal systems award financially; bonuses; education and career development opportunities; simple praise
- Rewards for innovation are lacking
- Not really good at rewarding people for innovation; doing better at recognizing people for innovation…but rewards are still lacking
- Don't have good reward mechanism…only moderately effective; public praise; innovators get more research money
- People who deliver get more influence and program dollars; pockets of financial rewards from pay pool to pay pool

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14. ABSTRACT

Although innovation is widely discussed in both military and industry venues, many organizations continue to struggle with what it means to be creative as well as maintain a competitive advantage. The United States Air Force has specifically struggled with the balance between improving existing technologies and employing revolutionary technologies. The purpose of this thesis research was to study the motivation, focus, barriers, and culture needed to foster disruptive innovation in Air Force Science and Technology (S&T) and to investigate how industry innovation strategies could improve breakthrough Air Force technology emergence. The Air Force Research Laboratory (AFRL), the primary organization responsible for planning and executing all aspects of the Air Force science and technology program, is the ideal study subject to represent the Air Force S&T community at large. Two previous industry research studies, now replicated in an AFRL organizational environment, provided quantitative and qualitative comparisons between the industry and Air Force S&T communities. The study results showed that Air Force S&T is capable of regaining its prominence as a leader in disruptive technological innovation by applying a basic improvement model, capturing the relevant best practices of industry, and exploiting the positive attributes of the military domain.

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