Through a Glass, Darkly:
Innovation and Transformation in the Twenty-First Century Air Force

Christian C. Daehnick, Lt Col, USAF

April 2001

Report Documentation Page

Report Date	Report Type	Dates Covered (from... to)
01APR2001	N/A	-

Title and Subtitle Through a Glass, Darkly: Innovation and Transformation in the Twenty-First Century Air Force	**Contract Number**
	Grant Number
	Program Element Number
Author(s) Daehnick, Christian C.	**Project Number**
	Task Number
	Work Unit Number
Performing Organization Name(s) and Address(es) USAF	**Performing Organization Report Number**
Sponsoring/Monitoring Agency Name(s) and Address(es)	**Sponsor/Monitor's Acronym(s)**
	Sponsor/Monitor's Report Number(s)

Distribution/Availability Statement
Approved for public release, distribution unlimited

Supplementary Notes
The original document contains color images.

Abstract

Subject Terms

Report Classification unclassified	**Classification of this page** unclassified
Classification of Abstract unclassified	**Limitation of Abstract** UU

Number of Pages
107

DISCLAIMER

Opinions, conclusions, and recommendations expressed or implied within are solely those of the author, and do not necessarily represent the views of Air University, the United States Air Force, the Department of Defense, or any other US government agency. Cleared for public release: distribution unlimited.

Contents

Illustrations

Tables

Abstract

Innovation and transformation are the words of the moment in the defense community. Faced with an uncertain threat, limited budgets and at least the potential for major technological changes in the way some military missions are conduction, many outside the military have demanded major, even revolutionary change, and the military Services are each moving to frame their plans in suitable terms. The Air Force, both recognizing the potential for the use of space as an operating environment and facing increasing external pressure to show that it is a "space service" has proposed transforming itself into an "aerospace force." But all this talk hides the fact that innovation is a complex process, that there are important differences between "innovation," "transformation," and "revolutions," and that using the words interchangeably is more likely to cause confusion than make incremental improvements become radical. One objective of this paper is to clarify what each of those terms mean and better explain what is required to innovate in and transform a military service.

This paper reviews theories of innovation from both the military-historical perspective and from the business perspective, and attempts to identify common elements. It also reviews the record of the Air Force (and its predecessors) in creating, adopting and implementing innovations, and in transforming (or being transformed) over the years. Finally, the paper proposes some of the things that should happen in order for the Air Force to become a truly "aerospace" force, and assesses the prospects of this transformation occurring.

Introduction

The very act of historical reconstruction imposes a clarity and coherence on events that was neither present nor possible at the time.[1]

Consider the irony. A new century, a world power as yet unchallenged militarily, regional rivals, some of them with worryingly high economic growth, but relative peace, with no military conflict between major powers having taken place for decades, a high degree of recent technological progress, and growing economic interdependence. And yet, the world is on the brink of the most destructive wars in its history. The *way* wars are fought is on the verge of massive transformation; in fact, at least two transformations in each of the established realms of warfare. And in addition, an entirely new dimension of warfare is about to open up.

This is not the world today, but a very brief summary of the world as it existed 100 years ago. Of course, there are many differences and it would be a mistake to try to draw either too many parallels or lessons. But consider what military professionals a century ago were about to face.

Within a few years, the concept of a capital ship would be revolutionized by the all big gun *Dreadnought*—a ship that rendered its predecessors obsolete and redefined the terms of the naval arms races before World War I. At the same time, improvements in gunfire accuracy were dramatically extending the ranges at which naval combat would take place. Heavier-than-air flying machines were about to take to the skies. Within 40 years of the first flight, these machines would evolve from curiosities to weapons that

[1] Murray, Williamson, and Allan R. Millet, *Military Innovation In The Interwar Period*, Cambridge University Press, 1996, p 380; emphasis in the original.

would make even the most modern, powerful, and fast battleship obsolete as a weapon for control of the seas. In parallel to these developments, submarines would evolve from crude coastal defense weapons to oceangoing platforms that could threaten anything on the surface.

On land, armies would first witness the culmination of developments of the second half of the 19th century—the use of repeating rifles, machine guns, and rapid fire artillery, along with the use of railroads to mobilize and supply masses of troops—that would seem at first to shift the balance of strength on the battlefield in favor of defensive operations. And yet even as land warfare was transformed from a more mobile, Napoleonic ideal to something industrial and immensely destructive, the seeds of yet another transformation were planted. In the tanks of Cambrai, the infiltration tactics of the German March 1918 offensive, and the incorporation of the rapidly evolving airplane, visionaries could already see the potential for a more mobile and decisive form of land warfare which would nonetheless astonish the world in Poland in 1939 and again in France in 1940.

The airplane, a key to later transformations in both land and sea warfare, would emerge as a weapon in its own right. To a remarkable degree, many of the concepts basic to air warfare were demonstrated even in the first World War[2]. Building on that experience, air power pioneers would in the space of half a century transform what was once considered a dream—manned, powered flight—into an instrument of unparalleled destructive power (especially with nuclear weapons) and global reach.

[2] Very well described in Kennet, Lee, *The First Air War, 1914-1918*, The Free Press, New York, 1991.

These are only some of the most obvious elements of the transformation—or multiple transformations—of warfare in the twentieth century. The development of radio, radar, and other uses of the electro-magnetic spectrum, nuclear weapons, the introduction of rockets, guided weapons, space-based sensors, communications, and navigation devices, and many other technological advances add further layers of complexity.

Thinking about the number, the type, and the degree of changes that would take place within the span of one (long) human life, how could anyone but the most visionary come close to anticipating the direction of these developments? Even during the span of one military career—picking almost any segment of the 20th century—it would have been difficult for anyone to have the mental agility to adjust to, let alone anticipate, the changes that were taking place.

Which brings us to the present. It is indeed hard to imagine that the next century holds as much change as the last one, at least in military affairs. But considering the changes, or the potential for changes, in geopolitics, economic developments, and technology—things which undoubtedly affect military capabilities and the demand for them—it would be foolish indeed to think that we were embarking on an era of stability or stagnation.

The immediate problem for the United States is how to build on success and avoid complacency. No military in history has possessed the range of capabilities and ability to dominate its opponents that ours does. But this is not something that comes cheaply or could be easily rebuilt if allowed to fall into disrepair. Following what some have termed

a procurement holiday[3] the U.S. military faces the prospect of "recapitalizing" virtually the entire force over the next 30 years[4] something that is not possible given current and projected defense budgets; either some capabilities will have to be sacrificed or the military will have to be used less.[5]

Some defense analysts do argue that the situation is not so dire, and that with modest force reductions and selected investments the U.S. military can maintain or even improve its capabilities without demanding additional money.[6] Others, reviewing the same facts, maintain that the United States cannot continue on the path that it is going but will need to make some significant strategic choices about how we engage with the world and further, significant strategic and operational choices about the shape of our military.[7] From a slightly different perspective, those who believe that rapidly advancing technologies— particularly information technologies—will radically change the way wars are fought, argue that only by reshaping the military to take advantage of this "revolution in military affairs" will we avert disaster.[8] In a slightly different vein the argument has also been made that we should not try to predict the ultimate shape of the future military but instead accelerate the cycle of developments, prototyping, introduction of operational

[3] Goure, Daniel and Jeffrey M. Ranney, *Averting the Defense Train Wreck in the New Millenium*, The CSIS Press, Washington, DC, 1999, page x.
[4] Ibid., page x.
[5] Ibid., pp 124-131
[6] O'Hanlon, Michael, *Technological Change and the Future of Warfare*, Brookings Institution Press, Washington, DC, 2000
[7] Williams, Cindy, ed., *Holding the Line: US Defense Alternatives for the Early 21st Century*, MIT Press, Cambridge, MA, 2001, introductory article.
[8] Owens, William A., with Edward Offley, *Lifting the Fog of War*, Farrar, Straus and Giroux, New York, 2000

systems, and experimentation and doctrinal development to ensure that we are always the innovators and always in the lead in the use of significant military technology.[9]

Complicating all of this is the ambiguous nature of the threat. Most people would assume, as the 1997 National Defense Panel did, that future adversaries will "have learned from the Gulf War."[10] Those lessons are typically taken to be: don't allow the US unimpeded access to a theater, don't allow the US time to build up forces, and don't try to fight symmetrically.[11] Beyond that, who and where we might be engaged is somewhat debatable. Some believe the Pacific and Asia is the theater we have to prepare for.[12] More generically, some argue that we should not expect to have access to bases in any theater of operations.[13] Others believe the main threat will be urban operations. Recently there has been increasing concern about "homeland defense" against terrorist activities and electronic attack.[14] In every case, however, this is no more than extrapolation and informed speculation, and unfortunately, the assessed threat is difficult to disentangle from an author's preferred solution (in terms of military hardware and doctrine). The future is of course unknowable in detail, and current facts and trends are subject to

[9] Warden, John A., " The New American Security Force, " *Airpower Journal*, Fall 1999
[10] National Defense Panel, Transforming Defense: National Security in the 21st Century, Executive Summary, December 1997, page 1
[11] "Asymmetric" threats should certainly be taken seriously, but it's worth considering first that the US has more "asymmetric" options than anyone else, and second, that few if any countries will design their militaries only, or perhaps even primarily, to fight the US. They have local and regional adversaries to worry about first. So I suspect it is unlikely that any nation-state will completely give up fixed wing aircraft, tanks, or certain kinds of ships. There is also the question of resources. MG (ret) Robert Scales suggests (conversation, 19 Mar 2001) that those countries which can afford it will try to create a two-tier military: one to attempt to deny the US its objectives, the second to achieve local or regional goals.
[12] For example Cohen, Eliot A., "Defending America In The 21st Century," Foreign Affairs, December 2000
[13] Cote, Owen R Jr., "Buying '…From the Sea': A Defense Budget for a Maritime Strategy," in Williams, op. cit.
[14] United States Commission on National Security/21st Century (Hart-Rudmann commission), *New World Coming: American Security in the 21st Century; Major Themes and Implications*, September 15, 1999.

different interpretations even by reasonable and disinterested parties. The bottom line is that the threat to plan against, given the global nature of US interests and the current lack of a peer competitor, is perhaps less predictable than ever.

One thing most commentators are prone to agree on is that the US military, though currently unchallenged in most regards, is woefully unprepared for the new (uncertain) challenges. Too heavy, too slow, locked in Cold War thinking, attached to outdated weapon systems and doctrine—nothing short of a "transformation" is needed. And while many of the details are debatable, one thing seems certain: in the absence of a clear and imminent threat to US security, despite our global commitments, the resources available for defense will not increase dramatically.[15] The Air Force cannot even afford to replace its current inventory of aircraft, satellites and other equipment as they wear out, given current funding projections.[16] Of necessity, something will have to change. At the same time, technological advances will create opportunities to perform the same missions more efficiently, or to add capabilities that were previously impossible—but not without investment up front to develop the new capabilities.

In the context of this paper, how do all these issues relate to the concept of the U.S. Air Force becoming an "aerospace force?" Specifically, what is the need for this change, how much of a transformation will it involve, how long will it take, how much will it cost, can we afford it, and what kind of changes—hardware, people and their skills, culture, doctrine, etc.—will be necessary?

[15] Williams, op. cit., pp 12-18.
[16] "Settling in for the 107th Congress," *Aerospace America*, March 2001, p10.

This paper will address these questions by focusing on peacetime innovation, for two reasons. First, we are at least in a period of "semi-peace"[17] and are likely to remain so for the foreseeable future. Even if a conflict does break out, it is hard to imagine given the current world situation that it will last long enough for any significant changes, except perhaps the modification of an existing weapon or the development of new tactics, to take place. Also, even with years of fighting in previous wars (World War II, Korea, Vietnam) the most significant innovations were often either in the planning stages before the war started or took years afterwards to complete. In other words, far-reaching innovation that will lead to the apparently necessary transformation of the military will take time and will not have the incentive of immediate combat risk (or even the implied risk of the Cold War) to drive it.

The remainder of this paper will address several issues: first, what are the phenomena called innovation and transformation: how can they be described and what do they imply? Second, by reviewing various studies, can we learn something about how innovation and transformation happen: the conditions for success, obstacles, organizational and other strategies that at least improve the chances of innovating successfully? Third, is the Air Force an innovative organization, and how can it improve its ability to innovate in the future? What kind of a strategy might the Air Force adopt in transforming to an aerospace force? And finally, what are the prospects for success?

[17] Cohen, op. cit.

What are Innovation and Transformation?

This paper will propose some approaches to understanding the mechanisms of innovation, and some areas for the Air Force to emphasize if it wishes to transform itself into an aerospace force. The examples given below mix military and industry experiences. Adding the business perspective helps to separate generally applicable truths about innovation as a human endeavor from more specific concerns about military innovation. Of course, there are differences in the environments, risks and rewards, but the parallels in the process are also remarkably strong.

A. Describing innovation

Definitions of innovation vary from fairly narrow and specific to almost all encompassing. At one end of the spectrum, almost any sort of change might be considered an innovation, regardless of its scope or significance. Webster's says it's: "the act of innovating;" i.e. "to make changes or alterations in; bring in new ideas and methods."[18] At the other end, Rosen defines it as a change in how a military "combat arm" fights, the emergence of a new combat arm, or a change in the relative value or prestige of a combat arm.[19] Some might agree that "by innovation we mean revolutionary change, change that alters significantly military doctrine, the combat role of particular technologies, and the status of groups within the military who specialize in the use of the

[18] Landau, Sidney I., ed, *Webster Illustrated Contemporary Dictionary, Encyclopedic Edition*, J.G. Ferguson Publishing Company, Chicago, 1982

[19] Rosen, Stephen Peter, *Winning the Next War: Innovation and the Modern Military,* Cornell University Press, Ithaca, 1991, p 7.

technology…not incremental improvement in weapons or doctrine."[20] Yet the later definition is certainly too restrictive for most uses; in fact, it sounds more like a definition of "transformation" (see below).

In fact, innovations come in many forms: incremental and breakthrough, equipment and "process" (manufacturing, doctrine, tactics, etc), isolated and synergistic. All of these are relevant in some way to the overall description. Military innovation offers some unique challenges, as does innovation in business, but at the root, is there really any difference in *what happens*?

At its core, innovation is an active change, to achieve a conscious objective, involving something new. There are three key elements of this definition. First, *active* change implies that the innovator is seeking to do something better. Accidental discoveries of a technique or phenomenon are not in and of themselves innovation; they must be interpreted, at least some of the implications grasped, and an effort made to apply that knowledge toward a goal (the second element) for innovation to take place. Third, although innovation often involves synthesis of existing ideas, either one of the elements of the approach or the combination of elements itself should be new; this is partly semantics, because of the word "innovation" itself, but also logical. Returning to a previous doctrine, force structure, strategic posture, or in a business sense trimming back to a core product line, may be wise strategically and even essential, but it is not innovation.

The purpose of innovation depends on the goals of the individual or organization. It may be to make money through the creation of a better (or less expensive, but in any case

[20] Sapolsky, Harvey M., "On the Theory of Military Innovation," *Breakthroughs*, Spring 2000, page

more profitable) product in the business world. A more far-reaching innovation might create an entirely new market or industry. In a military sense, the goal is usually either improved effectiveness or reduced cost or risk for a certain type of operation. The analog to creating a new market would be the creation of an entirely new method of fighting (and winning) wars.

Innovation is also inevitably a process involving humans in every step, from recognizing (or creating) an opportunity, to developing and "selling" the idea, to implementing it and exploiting its benefits. Also, humans will ultimately feel, interpret and in many ways shape the effects of the innovation, often in ways that can't be foreseen by the original innovators. The unintended (or perhaps barely foreseen) consequences of an innovation—think of the original intent of the internet as a means of file sharing and e-mail among researchers—are often more significant than the original goal.[21]

None of the above makes any judgment of whether innovation is always good. Certainly in a moral sense, if it involves the creation of more destructive weapons, the answer is ambiguous. But in a more practical sense there is ambiguity as well. For example, the development of nuclear weapons (clearly an innovation) fueled a belief that all future wars would be nuclear. This shaped service doctrine and capabilities—particularly those of the Air Force in the 1950s—and resulted in less capability to fight the wars that actually occurred in the mid-to-late 20th century.

38

[21] Albert Hirschman believed, as described in Sapolsky, op. cit., that most real benefits from an innovation are in fact unplanned, since the original innovators tend to overstate benefits and underestimate costs, making their initial goals unachievable. "Redemption" comes in the form of unplanned benefits. However, Hirschman studied development projects (dams, infrastructure development, etc), so this is a skewed view.

B. Describing transformation

Recognizing that innovation alone might not seem sufficiently dynamic after the end of the Cold War, defense pundits and the Pentagon have begun talking more and more about "transforming" the military. Again, definitions vary. Certainly transformation involves change. Senator Joseph Lieberman believes that it is "change on a scale sufficient to effect a revolution in both thought and deed, and rapid enough to outpace our rivals…"[22] More pragmatically, it has been defined as "taking the advances in various technologies and using those to alter how the military is organized trained and structured for future conflict."[23]

Both those definitions make assumptions that go beyond the dictionary definition of the word "transform: to change the form or appearance of; to change the nature or character of; convert." In the case of Senator Lieberman, he adds a time element, insisting on rapidity. And the second definition assumes that the change is not only technologically inspired, but almost entirely dependent on technology. As mentioned earlier, innovation and transformation seem to have become almost synonymous in some people's minds, a fact which I believe hinders understanding of the processes of change.

So what is transformation? As it applies to organizations, it certainly involves change, and sweeping change at that, in equipment, procedures, organizational structures, the type of personnel skills demanded, career paths, and ultimately capabilities. But in and of itself, transformation does not have to be rapid or based on a single driving force. An accumulation of small changes over time—some planned, some fortuitous and some

[22] Lieberman, Joseph I., "Transforming National Defense for the 21st Century," Opening address before the US Army Conference on Strategic Responsiveness, November 2, 1999
[23] "Transformation Must Leap Many Hurdles," *Defense News*, March 19, 2001, p 4

initially unrecognized—can lead to a dramatic transformation. Also, recognizing that a transformation has taken place can be exceeding difficult. The "*blitzkrieg*" form of mobile warfare, for example, might fit this pattern.[24]

Nor is transformation necessarily an active, self-directed event. Unlike innovation, changes forced on an organization may transform it, even against the organization's wishes. Arguably, the Air Force change from a SAC (and bomber)-dominated nuclear force to a theater oriented, fighter-dominated force had far more to do with politics, DOD budget decisions and the results of the Vietnam War than any plan developed by the Air Force itself. However, just as Clausewitz described war as a struggle between two living, thinking, adapting entities, transformation can never be entirely passive; an organization's response to the external forces will shape the pace and direction of change.

In any event, planning and conducting a fully controlled transformation, which most advocates seem to want the military to do, is extraordinarily difficult. Partly this is because of the scope of change. New technologies must not only be introduced, but they must be refined and in many cases significantly improved (submarines and airplanes for example) before they can have a major impact. At the same time, doctrine, tactics and procedures must be developed to take advantage of the new capabilities. Sometimes doctrine may be a driving force behind the development of new capabilities. In parallel with this, organizational structures will change to accommodate the new weapons and their operators—and of course, this is not always done gladly. Many of these developments necessary to consolidate a transformation—that is to make it truly

[24] Murray argues in Murray and Millet, op cit, p 44, that even the architects of the "blitzkrieg" on the eve of the campaign against France in 1940 had no way of being certain their efforts would transform land warfare.

effective—will have to be innovations themselves. But those innovations may open up new and unexpected paths, either forcing the organization to revise its initial plan or resulting in a foolish persistence down a dead-end.

So it seems that "transformation" toward a specific end is at least in part an illusion. Although in hindsight, one might pick start and end points, it is really a continuous process[25] during which goals must be regularly reevaluated in light of evolving and emerging opportunities and requirements. Transformation is also both broad and deep: whereas an innovation could be very focused in terms of a change in technology, tactics, doctrine, or organization, a transformation will likely involve all of these. Further, transformation implies some significant changes in organizational culture, to include which skills are most valued by the organization, who gets promoted and ultimately who leads the organization, and even the image of the organization to itself into the outside world. Some writings on military innovation[26] have argued that these factors are necessary for an innovation to be successfully adopted. These are two sides of the same coin; while it is certainly true that adopting a major innovation (such as the development of carrier aviation in the U.S. Navy) requires the development of an associated "community," I believe it is also true that this defines an organizational transformation.

Another aspect of transformation is its thoroughness. Does it utterly destroy the old ways or the preceding "order?" The advent of mechanized warfare was a transformation for land forces--but that has not ended the utility non-mechanized forces in certain

[25] Highlighted by Gen (ret) Ronald Fogleman in "The New American Way of War: Continuous Transformation," *USNI Proceedings*, January 2001, p 112, though he doesn't elaborate on the concept.
[26] Rosen, Stephen Peter, *Winning the Next War: Innovation and the Modern Military*, Cornell University Press, Ithaca, 199op. cit.

circumstances. The advent of the aircraft carrier as an offensive weapon certainly transformed previously battleship-dominated navies--but not all navies have aircraft carriers. It appears that there are different kinds of transformations: some, which appear to be mainly technological and are not high cost,[27] are almost universally adopted. Others, which certainly include technological elements, and confer a significant competitive advantage in some situations—such as aircraft carriers—may only be adopted by major "players." In this case, countries seem to have decided to have fewer and smaller ships; strangely no country seems to have gone completely for an asymmetrical strategy, e.g. of buying only submarines.

However, transformation takes a long time to complete. An innovation is hardly ever completely abandoned in favor of its predecessor—except perhaps for cost reasons, if a country finds itself having to retrench—but it may catch on slowly. Legacy capabilities have considerable staying power, and few things disappear entirely from an arsenal, though they may be relegated to niches.[28] Organizational structures can be even more persistent. This results in a system with layer upon layer of structure (especially in terms of organization and culture), something like a city built up on the ruins of its predecessors, and this in turn often shapes the direction of future innovation.[29]

---

[27] Such as the use of automatic rifles for infantry combat.

[28] For example, horses and sabers still have a ceremonial role in the military, just as it is still possible to purchase gas lighting fixtures for decorative use. Some militaries still operate the An-2, a cloth-covered biplane. On the other hand, catapults, broadswords and "iceboxes" used before electric refrigeration are museum pieces; an indication that even ceremonial use of old technologies dies out eventually.

[29] In some ways, old technologies may "preconfigure" the shape of things to come. Utterback (*Mastering The Dynamics Of Innovation*, Harvard Business School Press, Boston, 1994, pp 52-53) highlights this in a business context. In a military sense, armor for individual soldiers might be one example. In a broader sense, the use of balloons, the airplanes and space as surrogate "high ground" for observation before anything else could be another illustration of this phenomenon.

Earlier, I noted that innovation is not always an unqualified good. What about transformation? In this case, if an innovation (or group of innovations) is so widely adopted as to transform a military or an industry, there is usually no longer a question of good or bad. In a business sense, if the market no longer exists for a certain product, it will disappear regardless of the nostalgia people might feel. For the military, the inherent conservativism of doctrine and institutions will tend to resist change, thus a case for transformation must be compelling. When it happens, chances are it was simply necessary.

C. *Military innovation and transformation*

The premise of this paper is that innovation and transformation are different, but intricately entwined. Before reviewing the theoretical approaches to how innovation is done, it's worth describing how military innovation and transformation are related.

Innovations can be very specific and narrow in their effects, or they may be broad and far reaching. Collectively, several innovations may have a synergistic effect that is more far-reaching than the individual elements might imply. Also, the widespread adoption of an innovation will certainly enhance its impact. One way to think of the difference would be to relate innovation to different levels of warfare:

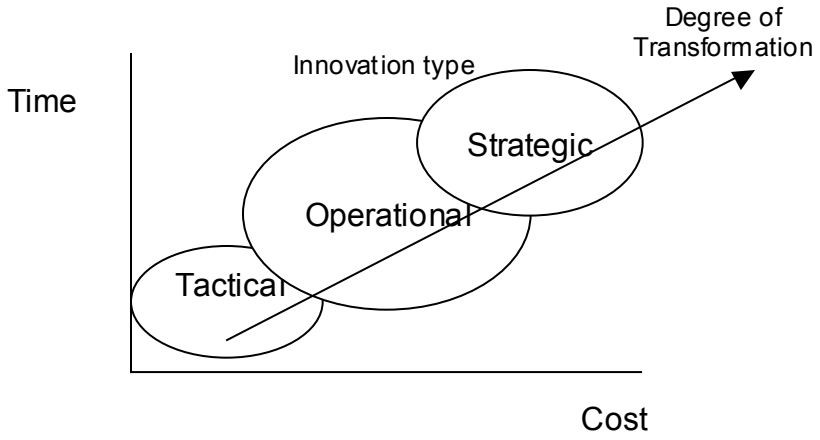

Figure 1: Innovation Associated With Levels Of Warfare

In this construct, the type of innovation (technological, doctrinal or organizational) is not depicted; what matters is the effect of the change. Some illustrations of what would be included and each level are:

-tactical innovations: in general, these use existing technologies or minor modifications to existing technologies, or involve--or respond to--the introduction of the new tactical technology; for example, the introduction of the guided air-to-air missile, the repeating rifle, or infiltration tactics. A tactical change can quickly produce higher level effects, *if* it is adopted across an entire military.

-operational level: these innovations require combinations of new technological developments, or different integration of existing military elements at the operational level of war. Some examples: development of air-land battle doctrine, development of the aircraft carrier as an independent striking weapon, amphibious warfare, and the deployment of the Global Positioning System (GPS) with associated user equipment.

Clearly, these begin to shade into the strategic realm, again depending on the degree to which the innovation penetrates and is successfully exploited (through a synergy of equipment, doctrine, procedures and trained personnel) by a military organization.

-strategic level: these innovations make use of either an extremely successful operational innovation, or more likely a combination of operational innovation with other factors; perhaps a sociological change (such as the French Revolution and the creation of a "nation in arms"), new external factors (perhaps the sudden acquisition of American overseas possessions following the Spanish-American War), or (rarely) the appearance of a transformational or revolutionary technology. Some further examples: unrestricted submarine warfare, strategic bombing, the Eisenhower doctrine of massive retaliation or more generally the concept of nuclear deterrence.

This drawing is of course very qualitative; depending on circumstances, time could vary from weeks to years. The dollar cost of innovations is even more difficult to be precise about, especially if one were to try to include factors such as savings from retiring obsolete equipment or abandoning outdated concepts--or even worse, to try to estimate a net cost if the probable success or failure in a conflict were factored in.[30]

Intuitively, the more an innovation tends toward the strategic end of the spectrum the greater the degree of transformation that a military will undergo. Note that this does not imply cause and effect; rather, the two go hand-in-hand. As a strategic innovation is fully exploited—and in order to exploit it—the structure, doctrine, and even the mix of skills required of people in a military organization will change, as will the hardware.

[30] For example, consider the combined bomber offensive in World War II; its actual costs are calculable, its opportunity costs can be estimated (in terms of what else could have been done

A couple other features of Figure 1 are worth comment. First, although a given innovation could probably be categorized as tactical, operational, or strategic, the areas overlap—distinct boundaries don't exist. In fact, I would argue that innovations at a higher level are usually the result of an accumulation of innovations at the lower level. For example, the use of relatively fast-moving mechanized formations, infiltration tactics on an operational level, dedicated air support (to include mounting sirens on dive bombers for psychological effect), and radios to better coordinate maneuver and fire support were all operational level innovations that produced the German "blitzkrieg." Clearly, the combination of these innovations could also be termed the strategic level innovation, especially when combined with Guderian's vision of striking at and crippling the nervous system of an opposing army—and this in turn transformed land warfare.

Alternatively, a single innovation might qualify as a "breakthrough," so far-reaching in its inherent capability that its effects reach beyond the level of its application. Development of the GPS constellation or the US underwater tracking system (SOSUS) might fall into this category. But it is still likely that some collateral assets (guidance kits for using GPS signals to provide precise, all weather munitions, for example) will be needed to fulfill the potential of the innovation.

---

with the money), but it would be impossible to do more than guess at the overall cost or outcome of the war had the strategic bombing campaign not been conducted.

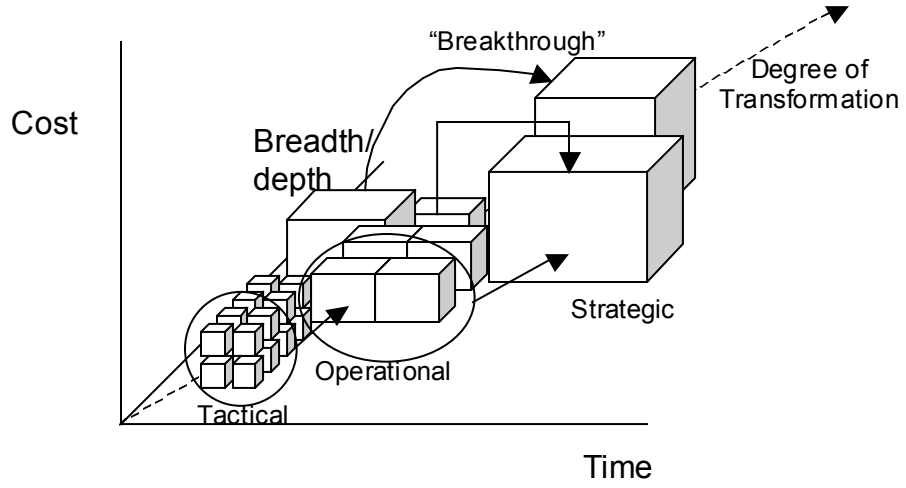

Figure 2: Cumulative Effect of Innovations

Adding a third axis to the drawing, labeled breadth/depth, is an attempt to capture both the possibility of the cumulative effect of several innovations at one level, and qualitative affect of breakthrough as opposed to incremental technology change. The development of continuously aimed naval gunfire and supporting fire control systems in the years prior to World War I[31] and the development of electric lighting and later the electricity infrastructure[32] both are cases that show how an accumulation of relatively small advances, combined with either an insight or a significant new technological development, produce more all-encompassing transformations. Another excellent example is from the ongoing developments in semiconductor fabrication. Although the basic technology—photolithography—has not changed since 1962, continuing, evolutionary, advances in equipment and techniques have allowed for previously unimagined increases in resolution, and consequently an exponential increase in the

[31] Morison, Elting E., *Men, Machines and*, *Modern Times* MIT Press, Cambridge, MA, 1966, Chapter 2.

density of circuits which can be packed on a chip. This in turn has fueled "Moore's law" and led to revolutionary changes in the capabilities of computers and how they are used.[33]

This raises the question of the difference between an evolutionary transformation and a revolution in military affairs. The word revolution is certainly more dramatic, and some might argue that it conveys a sense of profound change that is qualitatively different from that produced by "ordinary" innovation and transformation.[34] I believe the main distinction is the time element, though classifying any specific time scale as "revolutionary" vs evolutionary is arbitrary, and probably would vary in different eras of warfare. Qualitatively speaking, a rapid transformation that leaves others behind because they are simply not able to keep up (we are operating inside their strategic "OODA loop," so to speak), as opposed to lacking the resources or collateral assets to exploit the new capabilities, could be termed revolutionary.

As with the extent of transformation, the pace of change is often unpredictable. Because not all elements required for a transformation will change at the same rate, predicting a coming revolution is even trickier than predicting a transformation. This could rightly lead to some skepticism about the potential for a "revolution in military

---

[32] Utterback, op. cit, Chapter 3.

[33] Henderson and Clark, "Architectural Innovation: The Reconfiguration Of Existing Product Technologies And The Failure Of Established Firms," *Administrative Science Quarterly*, March 1990, pp. 19-27. They argue that the core design concepts of photolithography have not changed, although the available performance has improved dramatically due to equipment and process innovations.

[34] For example, Dr Barry Posen offers the definition of a revolution as "an innovation so potent it spreads throughout the system, forcing others to adapt or perish." (From discussions in his graduate course on military innovation.)

affairs" due to communications and computer technologies.[35] But one of the main points of the preceding discussion should be this: that revolutionary change across the board is not needed to produce a dramatic transformation in capabilities. It often accrues from a synergistic combination of new technologies in one or two areas, existing capabilities that can be modified, and an insightful recognition of the potential new applications.

Another key point is that transformation will happen—the question is how rapidly, what direction it will take, and whether an organization will lead the way or be forced into a change not of its own choosing. Without claiming that something as sweeping as a transformation can be fully anticipated or planned in detail, is it possible to recognize the opportunities for change, commit an organization early to the change, and guide the direction of the change in some way?

With those issues in mind, the next section will attempt to create a framework for understanding the conditions that can stimulate innovation, the elements that distinguish small changes from tremendously significant ones, the obstacles that innovative efforts must overcome, and some ideas on how this can all be done.

[35] This is O'Hanlon's argument in *Technological Change and the Future of Warfare*; he doubts that even the complementary technologies (in sensors, weapons, structures, propulsion, etc), let alone doctrine and organizational changes, are available to realize the RMA.

Theories of Innovation and Transformation

As mentioned above, the definitions various writers use for innovation and transformation overlap, with some definitions of one essentially meaning the other. Consequently, there is little explicitly written on the theory of "transformation," and most of the references below will be to writings on innovation. However, preceding sections have argued that innovation and transformation are intertwined, with innovations accumulated in a particular field and/or over time producing transformations. Also, the factors involved: environmental, organizational, and so forth, are the same. Keeping this in mind, it should be possible to develop an overall framework.

Curiously, although many theories of military innovation, especially those which emphasize organizational factors, pay homage to some of the pioneers of the study of innovation in the business world (notably Schumpeter), little attention seems to have been paid to work over the last 20 years. This is unfortunate for two reasons. First, as the Cold War ended, and especially since then, research in many key technical areas has been driven less and less by requirements of the military and more by demands of the market place. Thus, it seems useful to try to understand as much as possible about what factors are driving innovation in the commercial world; this may be the primary source of new technological ideas for the military for the foreseeable future. Second, there are many parallels between innovation in the business world—especially in large, successful firms—and innovation in the U.S. military. Further, since the life cycle of business products tends to be quite short compared to the life cycle of military doctrines or

weapons systems, perhaps the experiences of the business world can serve as a useful laboratory to better understand military innovation.

Given the conditions that the United States currently finds itself in and the significant potential of emerging technologies, I believe there is a very good general analogy to be drawn to a firm that is dominant in its industry but faces the possibility of a major technological shift. Although there are certainly differences—the level of risk for example, since failure in business means a loss of jobs, money, and prestige, whereas failure in war could mean the defeat and subjugation of the nation—in both cases the organization must balance the potential risk and cost of innovation with the prospect that a failure to innovate could be equally disastrous. If so, the studies of industry that attempt to explain business innovation may be helpful in explaining what the US military must do.

Some general comments: first there seem to be two major questions in studying innovation. One is why an organization generates and adopts an innovation. In historical studies of military innovation, this is often linked with the question of why one country either more successfully or energetically pursued a particular innovation when its competitors did not. Case studies of business innovation also often seek to explain why one company succeeded where others did not.

In some ways, this is almost an archeological question: looking at the past, asking why one military evolved in a certain way while another failed to. It is important for understanding boundaries and constraints for the future. Why did only the US and UK vigorously pursue an air force capable of strategic bombardment during the 1930s, when virtually all existing or nascent air forces believed that this was the way to go, and all

established military arms worked to keep the fledgling air services in supporting roles? Undoubtedly each country's geopolitical situation—location, perceived threat and the role of the military—and available resources were critical. These factors may be decisive in a negative sense if the objective of a proposed innovation runs counter to a country's basic needs or capabilities. But saying that a factor is necessary falls short of determinism, and doesn't help explain *how* new capabilities actually get developed.

The second question, which gets relatively less attention in studies of military innovation than in those which examine business cases, is the question of how an organization innovates. Are there specific procedures, mechanisms, organizational structures, practices, doctrines, etc., that enable or inhibit innovation? Can an organization improve its ability to innovate successfully?

Students of military innovation, although they have used many historical case studies, have focused to a remarkable degree on the period between the world wars, ostensibly because of parallels between those years and today's conditions[36]. Some notable works include books by Posen[37], Rosen[38], and Murray and Millet.[39] While there are lessons to be learned from this era, I would argue that the parallels can be overdrawn and it would be dangerous to use those analogies exclusively.[40]

Before proceeding with the framework, some general comments on the main themes of writers on military and business innovation are in order.

---

[36] The parallel is often attributed to Andrew Marshall, see for example Murray and Millet, op cit, p 377. I argue below that this parallel, and therefore the lessons to be learned from an excessive focus on those years, can be overdrawn.
[37] Posen, Barry R., *The Sources of Military Doctrine*, Cornel University Press, Ithaca, 1984
[38] Rosen, op. cit.

D. *Theories of military innovation*

In the study of military innovation, there seem to be two main schools of thought. The first focuses on factors external to a military organization as being the key drivers of the innovation. These factors include a country's civilian leadership,[41] technology,[42] perceived external threat,[43] and inter- (and intra-) service rivalry.[44] The second school of thought is that organizational factors may be a primary determinant. Rosen argues that innovation requires the development of intellectual and organizational foundations before it can be incorporated, hence the key is the development of new career paths, rewards and incentives.[45] Murray sees the process as an extremely complex interaction of various factors, but states that institutional processes for exploring, testing and refining conceptions of future war are "literally the *sine qua non* of successful military innovation in peacetime."[46]

Most authors seem to agree that there is a difference between peacetime and wartime innovation. Peacetime innovation tends to be more deliberate process, perhaps with farther -reaching effects, if only because the changes have had more time to work their way into the system.[47] Also, innovation in wartime is often much more related to a military or nation's need and ability to adapt quickly. Looking at the problem in another

---

[39] Murray and Millet, op. cit.
[40] For more detail see the last part of this section.
[41] Posen, op. cit.
[42] The RMA advocates would strongly argue that technology opportunity or push is—or should be—a source of innovation, while Rosen (op.cit. pp 39-52) argues that the evidence is contradictory.
[43] Posen, op. cit.
[44] Sapolsky, op. cit.
[45] Rosen, op. cit., pp. 18-20
[46] Murray and Millet, op. cit., p 410.
[47] Rosen, op cit., pp 57-60.

way, Cohen and Gooch argue that the sources of "military misfortunes" are a failure to learn, failure to adapt, failure to anticipate, or some combination of the three.[48]

E. Theories of business innovation

Innovation in business has been studied for decades, but it has gotten increasingly greater attention in the past 20 years. The original inspiration for much of the study was Joseph Schumpeter's seminal concept of "creative destruction."[49] The essence of this idea, which inspired many modern management theorists as well as Colonel John Boyd, was that by its nature capitalism was a system which could not stand still--that this system was in fact "an evolutionary process."[50] Schumpeter proposed the idea that there was a process of "industrial mutation ... that incessantly revolutionize is the economic structure from within, incessantly destroying the old one, incessantly creating a new one,"[51] process for which he coined the phrase creative destruction.[52]

Since Schumpeter developed this idea, numerous students of the business world, refined and attempted to better explain the mechanism by which creative destruction takes place. Although much of this has been inspired by the computer industry, its spinoffs and related enterprises, the case studies and examples used in most of the work

---

[48] Cohen, Eliot A. and John Gooch, *Military Misfortunes*, The Free Press, New York, 1990
[49] Schumpeter, Joseph A., *Capitalism, Socialism and Democracy*, Harper & Row, New York, 1976
[50] Ibid., p 82.
[51] Ibid., p 83, emphasis in the original.
[52] Interestingly, and in fact something seldom noted by those who quote him, Schumpeter (writing in the 1930s and 1940s) believed that capitalism was doomed by this: that large enterprises with committee and bureaucratic processes would come to dominate and stifle the original individual entrepreneurial spirit of capitalism; that capitalism would erode the institutions of earlier society that were essential for stability, and that capitalism would "inevitably" be replaced by a socialist form of society. (See the introduction to Schumpeter, op. cit, by Tom Bottomore, and Utterback, op. cit, p 192.) I mention this at length as a cautionary note: visionaries usually get some critical details about the future wrong, and also, ideas—like innovations—are often put to much different uses than their creators imagined.

also include older industries. As I discuss below, many of the theories have relevance to military innovation as well.

As with theories of military innovation, there is no single agreed upon framework to describe how innovation works in the business world. However, there are a number of useful concepts that help describe the process of innovation and what it takes to be successful.

F. Developing a framework

Rather than review writings about innovation in detail, this section will attempt to bring a number of concepts together in a framework to aid thinking about innovation in a systematic manner. The pieces of this framework are:

- impetus for innovation
- critical elements and concepts
- obstacles to innovation
- mechanisms
- strategies

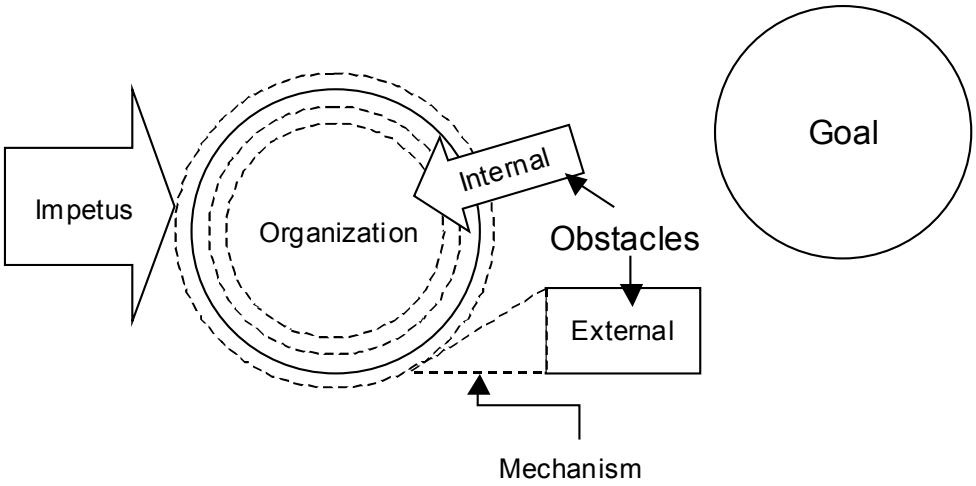

Figure 3: Components of the Innovation/Transformation Process

Although very simplistic, this cartoon may help to visualize the process of innovation and transformation. At the center is the organization, which could be construed as the entire US defense establishment, just the uniformed military, a single Service, or a community within that Service. In reality, it is all of these, further layered with the rest of the government and society on the outside, and further subdivided within even warfare communities (for example along generational lines). The key concept is that the "organization" is not monolithic, creating challenges and opportunities to form coalitions and generate support for change at many levels. A range of external forces create the impetus for change *through the perceptions* of those within the organization. At the same time, perceptions and attitudes within various parts of the organization create an institutional inertia—internal obstacles to change. External obstacles also exist. The challenge is to move the organization forward; to do this, innovators need to understand the critical elements of the situation and develop both mechanisms to overcome the obstacles and a strategy to use those mechanisms effectively.

With this model in mind, what do all the pieces consist of?

1. The impetus—creating the opportunity

Several things have the potential to inspire innovation.

- defeat in war or a major battle[53]
- lack of success in a key mission[54]
- advances (technological, force structure or organizational changes) by a rival

[53] Though often seen as a key factor, historically it is neither necessary nor sufficient to initiate innovation, as Rosen (op. cit, p 9) argues.
[54] For example the ability to destroy key bridges in Vietnam, to find mobile missiles during the Gulf War, or to satisfactorily conduct urban military operations in Somalia)

- a threat to institutional survival or independence[55]
- availability of new technologies
- geopolitics[56]

As mentioned earlier, the key to any of these is not necessarily the reality of the situation, but the perception by a sufficient coalition within the organization that a new response to the situation is needed. What constitutes "sufficient" will vary of course, depending on circumstances: how much change is required, what resources will be needed to effect it, and so forth.

Another point to consider is that these factors seldom work in isolation; usually, perception of a threat of some sort will generate a search for a new approach to the problem. Although this can involve non-materiel solutions, chances are that some sort of technological opportunity will line up with a given organizational interest, resulting in a proposed solution that involves both technological and organizational change.

2. Critical elements and concepts—laying the foundation

Attempting to understand what happens next involves sorting through a large array of factors. While the exact relationships and linkages will always be difficult to quantify, awareness of the possible influences on the process of innovation is at least a start.

[55] Challenging the very existence of an organization (a military Service for example, or a "community" within that Service) may be a spur to find new and creative ways of fighting wars—or it may leave the organization to adopt a defensive crouch and resist all attempts at change both good and bad.

[56] Such as threatening actions by a rival; potential lack of or unreliable access to facilities in a possible theater of operations; restricted freedom of operations. This also includes the geography of a country; limited access to the oceans will limit maritime options, for example. Little strategic depth (e.g. Israel) will also shape requirements.

a) Environment

The first of these influences is the strategic environment. This will overlap with the factors listed above as potential inspirations to innovation. However, not every part of the environment will be an impetus. Some may act as obstacles, but in general they will provide the context in which the debate over whether to support the innovation will take place.

The first issue is primarily a politico-military one relating to the nature of the international system and its direction over the next several years. Without the ability to foresee the future, this will necessarily be based on many assumptions. The components of the question on the strategic environment are: which rivals will we face? Peer competitors? Regional powers? Non-state type organizations? And in what mix and timing? Where does this imply that military forces will have to be used? What kinds of capabilities will these competitors have? What form will the conflict take?

A subset of this question concerns the functions that the U.S. military will be asked to perform. For example, will these continue to follow the outlines of the current national military strategy, or will they be modified to a more restricted set (such as those suggested by Eliot Cohen: defense against WMD, conventional dominance, short-term contingencies, and peace maintenance?[57]

Another part of the strategic environment concerns questions about technology. Are we in fact on the verge of a technology-driven revolution in military affairs? How much of the implementation should we pursue now—i.e. is the technology ready? What supporting technologies might be needed? Are these available? How much do we still

[57] Cohen, op. cit.

need to learn and understand before we're prepared to begin acquiring systems? What are the implications, and how do we explore them, for organizations and doctrine?

One business concept that may be helpful in thinking about technology readiness is that of the technology S Curve.[58] This idea, illustrated in Figure 4 below, proposes that during the early stages of the development of a technology--or more generally an approach to a given problem--the return on investment will be relatively small. At some point, additional effort begins to yield more dramatic returns; this continues until the technology matures and a point of diminishing returns is reached.

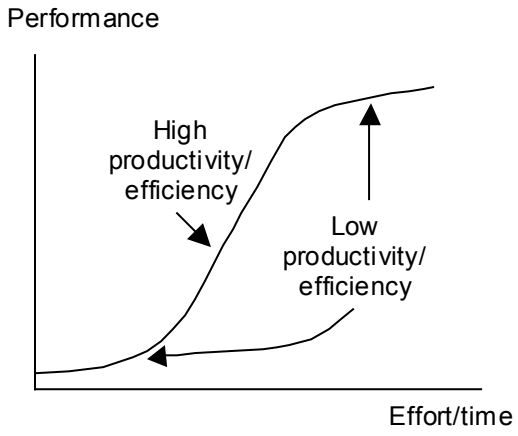

Figure 4 The Technology S-Curve

More significantly, a firm that is on the steep part of the curve will be seeing a good return on its investment and will be operating at a relatively high efficiency. This makes it naturally reluctant to switch to a different technology or approach which, though it

58 Foster, R (1986), "The S- Curve: A New Forecasting Tool," Chapter 4 in *Innovation: The Attacker's Advantage*, Summit Books, Simon And Schuster, NY, p 102.

might offer the potential for greater performance in the long run, is at present still on the lower part of its S Curve, as shown below in Figure 5.

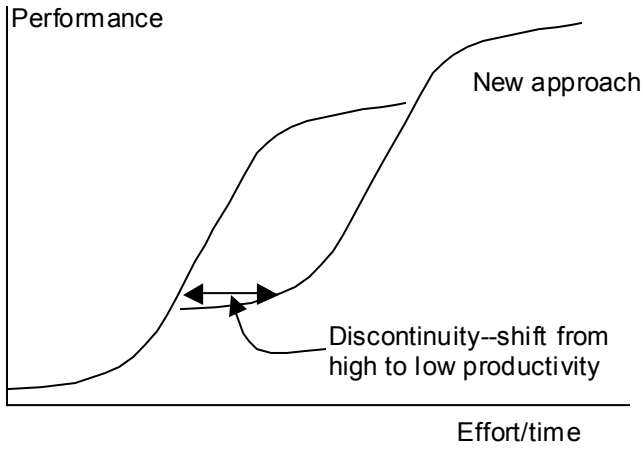

Figure 5 A Second S-Curve and Technological Discontinuity

Even if a company is not the first to switch to this new approach, it will almost certainly not be as productive initially using the new technology as it was with the old, since achieving better performance will require new equipment, people in the company learning new skills (and possibly forgetting old ones), and may also require changes in organization. This "discontinuity" is one reason why firms—especially those which are established and successful—may have difficulty adopting innovations.

Another major issue is risk. Specifically, how much risk is the country willing to take? How much current capability—and which types of capabilities—can be sacrificed to prepare for the new? As for timing, when is the right time to take risks? How rapidly do the changes have to proceed to ensure the country does not face an unacceptable window of vulnerability? This of course relates to the first general question about the

strategic environment, as does the question of exactly what risks will be incurred. And naturally, one must also ask—and answer—the question of how the risks will be managed.

The risks mentioned above primarily concern threats to U.S. interests. Other risks are more associated with internal costs—questions related to the internal strategic environment. What sort of investment cost is acceptable to the nation? Assuming that the resources available are finite, and thus constrain the rate and amount of change, and the number of existing capabilities that can be kept intact, how can an acceptable cost be balanced against an acceptable security risk? What about opportunity costs, either in terms of mission capabilities forgone, or expertise that will be lost?

This is turn raises the issue of resources. The amount of resources made available will have an affect on how innovation is pursued. Although some might use the historical "argument" based on the interwar years that resource deprivation is a spur to creativity, it should be obvious that without sufficient resources even the best ideas cannot be adequately tested or implemented.[59] At the same time, a surplus of resources could very well make an organization too comfortable and unlikely to challenge existing ways of doing business.[60]

All of the above suggests that policy makers, in business or national security, need to develop an understanding of the environment and a vision of the future, including where and how the country or company fits. This has its own risks. Policy makers clearly should

[59] For example, Holger Herwig, in Murray and Millet, op. cit., p 261, argues that lack of resources impeded development of submarine capabilities in the US before World War II.
[60] Rosen, op. cit., p 4 cites a study by Lawrence Mohr that showed almost no correlation between resources available and innovation in public health agencies. In a somewhat more germane example, one could argue that the tremendous resources devoted to the Air Force, and SAC in

not choose a vision of the future so specific that it will drive the organization to a configuration that is useless if the vision turns out not to be correct. This argues for retaining some degree of flexibility and "slack" in our military system. As long as there is no certainty or consensus about how and where the American military is to be used, and against whom, the strongest case that can be made is one of retaining a broad spectrum of proven capabilities—with appropriate modernization—in order to be prepared for a wide range of contingencies.

Nonetheless, having a focused vision of both the challenges and opportunities is ultimately necessary, since it will be very difficult to transform the American military in any meaningful way if there is a continuing cacophony of divergent strategic visions. This is a recipe for great deal of unfocused effort, and ultimately a prolonging of the status quo.[61]

b) Elements of a strategy

Implicitly, strategy is about balancing capabilities (available means) and constraints to produce a desired outcome at acceptable risk. In a military sense, this means ensuring that a nation's strengths are used to advantage and its weaknesses protected. Technological sophistication, force structure, and operational and technical procedures should be well balanced to ensure that there are no vulnerabilities that the enemy can exploit, and that the nation can achieve its objectives by unbalancing or overwhelming the enemy. Ideally,

---

particular, in the 1950s produced innovation mainly in narrow technical areas, such as flying aerodynamic vehicles higher and faster.

[61] Although this might be a good way to generate potentially useful ideas, it is unlikely to produce the resources or political support to implement, exploit and sustain them—in other words, to turn them from ideas into capabilities.

the nation's military might pursue "full spectrum dominance" as our joint vision documents say we will,[62] but this is a luxury the few countries have ever been able to afford. Increasingly, it appears likely that the United States will not be able to afford it either.[63] In any event, it appears that we will have to establish some priorities for future developments—and to do that a strategy is indispensable.

In creating a strategy, policy-makers must have the aforementioned appreciation of the environment and vision of the objective, and also an understanding of what is possible. In many cases, this involves the capabilities and limitations of innovations. To put this into perspective, some management ideas may be useful.

One concept with some bearing on the prospects for successful innovation is that of "appropriability." This refers "to the environmental factors, excluding firm and market structure, that govern an innovator's ability to capture the profits generated by an innovation."[64] In the commercial world, appropriability is generated by things such as intellectual property protection (patents and copyrights), secrecy, and the ability to act more quickly on perishable information or opportunities that a competitor. Appropriability can be either loose, meaning the information is generally available and usable by others, or tight, meaning the opposite. In a military sense, this goes to the issue raised by Warden's New American Security Force article:[65] can we maintain secrets and proprietary information long enough to keep our weapon systems effective for 30 years,

[62] "Joint Vision 2010," *Joint Forces Quarterly*, Summer 1996, pp 34-50, and "Joint Vision 2020," *Joint Forces Quarterly*, Summer 2000, pp 57-76.
[63] Williams, op. cit, O'Hanlon, op. cit., and Goure, op. cit.
[64] Teece, David J., (ed), *The Competitive Challenge*, Cambridge MA, Balliger Publishing, 1987, p 188.
[65] Warden, op. cit.

or do we need to generate changes more rapidly to ensure that others can never develop countermeasures?

A second concept is that of "complementary assets." In the business world, these consist of capabilities in marketing, sales, manufacturing, distribution, post-sales service and related product lines (computer operating systems and product software, for example).[66] Complementary capabilities in a military sense could be logistics and supply systems, transportation, C4ISR systems, or the use of one branch of the military to support or enable operations by another. In both cases, the point is two-fold: complementary assets are often indispensable to introducing an innovation and making it successful. At the same time, the existence of a large amount of infrastructure and established capabilities creates inertia and vested interests that must be taken into account in planning for change.

Another concept builds on the technology S-curve idea. In the business example, an established market is disrupted by the appearance of a new approach—a technological discontinuity. This generates an "era of ferment" as a variety of different designs or concepts are tried; this is a period of potentially great "product" innovation. Ultimately, a "dominant design" emerges, and the focus of innovation shifts to more incremental improvements in the product, with process (e.g. manufacturing) innovation becoming increasingly the focus of effort—until the now mature market is once again disrupted. The different phases of a product life cycle can be depicted as shown below in Figure 6. This representation highlights the fact that the process is continuous, and that in fact it is

[66] Class notes from "Managing Technological Innovation," MIT Sloan Business School Course 15.351.

the technological discontinuities mentioned above that disrupt the specific phase—the era of incremental change—and set in motion the search for a new dominant design.

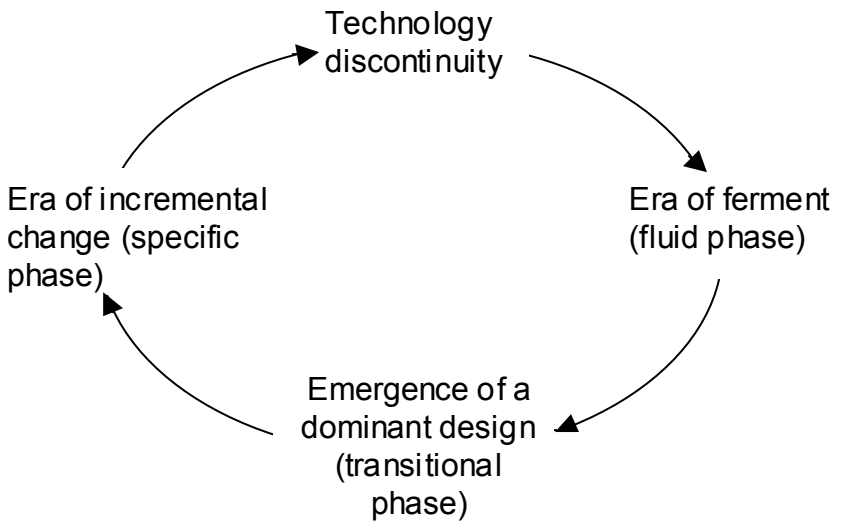

Figure 6 Dominant Design Life Cycle

The dominant design is defined by Utterback as "the one that wins the allegiance of the market place, the one that competitors and innovators must adhere to if they hope to command significant market following. The dominant design usually takes the form of a new product (or set of features) synthesized from individual technological innovations introduced independently in prior product variants." Collateral or complementary assets such as market channels, brand image, costs of switching (by customers), efficient manufacturing and distribution capabilities, etc. can often player role or give a firm an advantage in establishing the dominant design.[67] This tends to give an advantage to established firms, but those firms are seldom the ones to lead a shift to new technologies;

in fact, those firms may respond to the threat of a new approach by putting a burst of energy and creativity into improving their existing product, as shown below in Figure 7.

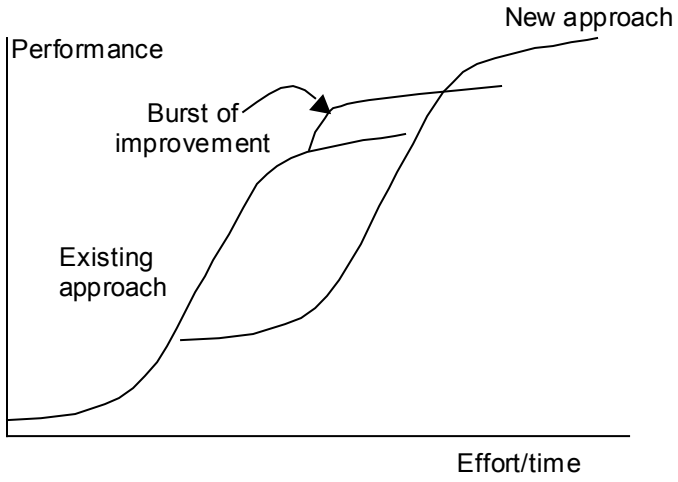

Figure 7 Performance of Established and "Invading" Technologies[68]

The result of this effort, although it may temporarily preserve market share and the company's existing way of doing business, is generally doomed to fail. As Utterback says "a pattern emphasized in the cases in this study is the degree to which powerful competitors not only resist innovative threats, but actually resisted all efforts to understand them, preferring to further entrench their positions in the older products. This results in a surge of productivity and performance that may take the old technology to unheard of heights. But in most cases this is a sign of impending death."[69]

---

[67] Utterback, op. cit, p 27.
[68] Ibid, p 160.
[69] Utterback, op. cit. p xxvii.

The flip side of this coin is that once a dominant design has emerged and competition shifts into incremental product improvement and process innovation, established firms have an advantage and barriers to entry increase.[70] Innovations at this stage tend to be "competence enhancing."[71] Although outsiders may produce this sort of innovation, they are unlikely to benefit from it--because of the established firms' advantages. They have every incentive, on the other hand, to pursue radical innovations that overturn the existing order.

Military parallels are not hard to illustrate. The *Dreadnought* was an example of dominant design in the capital ship area that put an end to the "era of ferment" begun with steel-hulled ships and lasted until a new approach—aircraft carriers—displaced the battleship entirely. Aircraft offer several examples: biplanes emerging as a dominant (though not unchallenged) design for "pursuit" aircraft during World War I, until the development of all-metal fuselages, better wing designs and more powerful engines produced a new dominant design by the late 1930s. World War II saw the emergence of jet engines, which eventually resulted in a new dominant design (exemplified by the F-86 and the MiG-15) in the 1950s. Innovation in submarines, though certainly not confined to one country, was led by Germany until the end of World War II—a case of a disruptive technology being pursued by an outsider that had difficulty competing with the dominant "firm" in the established "market."

Another useful approach is to categorize innovation by what changes. This recognizes that technological change can be either "competence enhancing" or "competence

[70] Ibid., p 89.
[71] Ibid., p 183.

destroying"[72] in the sense that they either reinforce the competences of the existing, dominant firms or undermine them. The latter, disruptive, technologies[73] may affect either components of an existing dominant design or the linkages among those components. If the linkages are affected, the change is termed "architectural innovation." These "change the way components are arranged into a system, essentially changing the rules of the game without necessarily changing the components" (at least at first).[74] In fact, an architectural change is often triggered by the change in a component, although this may not be a major change in and of itself. [75] A way to visualize this concept is shown below in Figure 8.

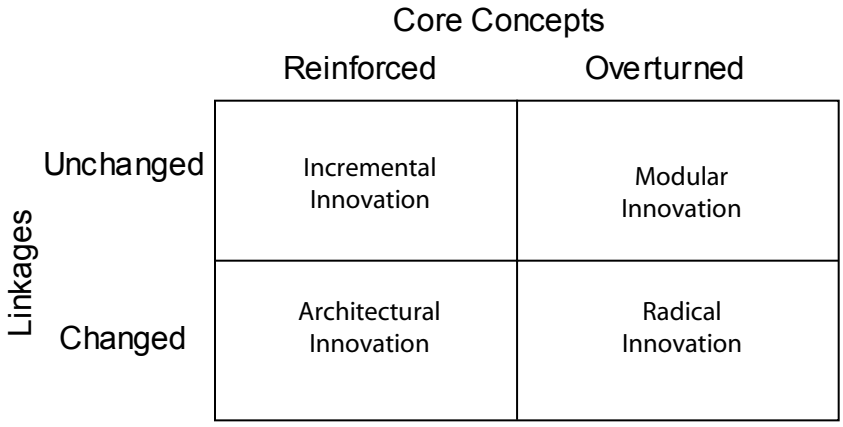

Figure 8 Architectural Innovation Matrix

Henderson and Clark argue that it is the change in linkages, rather than any specific change in component technologies, that produces a dominant design. Once the dominant

[72] Utterback, op cit p 207.
[73] Christensen, Clayton M., *The Innovator's Dilemma*, Harper Business, 1997, p xv.
[74] Henderson and Clark, op. cit., p 9.

design emerges, firms spend less time learning about alternative configurations, so the competition shifts to more incremental change. This produces another way of looking at what has been called a "the attacker's advantage"[76] First, "an organization's communication channels will come to embody its architectural knowledge of the linkages between components" and second, the same is true for the "informational filters" which affect what an organization learns.[77] In other words, in institution's success may not only makes it resistant to trying new approaches, but could in fact blinded to the very emergence of these approaches.

Taking these thoughts further, Christensen[78] argues that major change in an industry is in fact due to architectural innovations which he says involve an intense degree of market innovation in addition to technological innovation. Further, he suggests that devices that are components of one architecture have architectures of their own; in other words, architectures are nested. This implies in turn that there are many different approaches—changes in system and component technology—that are levers to pull in pursuit of improved performance;[79] another explanation of Utterback's observation that existing firms are often able to boost performance of their established technology when faced with a threat. Also, Christensen observes that architectural innovations typically *underperform* the dominant architecture at first, when performance is measured using the parameters that are important at the time.[80] Because of this, the innovator has to seek a

---

[75] Ibid., p 12.
[76] Christensen and Foster, *Innovation: The Attacker's Advantage*, New York, Summit Books, 1986, cited in Utterback, op. cit, p 161.
[77] Henderson and Clark, op cit., p 15
[78] Christensen, "The Limits Of The Technology S Curve," *Production And Operations Management*, Fall 1992, pp. 334-366, and also in the book *The Innovator's Dilemma*.
[79] Ibid., p353.
[80] Ibid., p360.

new or niche market in which the performance disadvantages are not as significant. However, when the pace and ultimate potential of improvement in traditional performance measures of the new architecture exceed that of the old architecture, the old architecture is doomed to disappear, and change occurs rapidly.

Christensen cites the example of steam power for ships: initially it was used on rivers and lakes where the direction and strength of the wind was unreliable so steam, although slow, expensive, and dangerous, could outperform sail. By the traditional measures—speed, cost per ton, and reliability—steam continue to underperform sail power for 75 years.[81] Initially, the markets that steam and sail power served were different and even complementary, but when steam power matured to match the performance of sail for oceanic travel, sailing ships were replaced with remarkable speed.[82]

These observations have interesting implications for military innovation. First, as a large, successful operation, the US military possesses a number of "dominant designs" and architectures, with the corresponding cultural and information filters. The danger that these theories suggest is that we could be blinded by our success; of course, this is hardly a new concept, but an explanation in these terms removes the unproductive judgmentalism of the "stupid generals always fighting the last war" school of thought and suggests ways to deal with the problem.[83]

Second, those who wish to see a successful innovation through should be prepared to be patient. In comparison to existing systems, using traditional measures of performance, the innovation may at first offer less capability—unmanned air vehicles are a possible

[81] Ibid., p363
[82] In *The Innovator's Dilemma*, Christensen gives a much more detailed example of this phenomenon in the computer disk drive industry.

example. Competition from the innovation may spur the existing approach to new heights of capability (sophisticated, even "active" tank armor in response to increasingly capable antitank weapons might be an example here). It may not be clear for some time whether in fact the new approach will ultimately be superior; sponsors of the innovation should also realize that considerable investment will have to be made to realize the promise of a new approach.

Finally, the concept of architectures as the real secret to developing a new dominant design offers hope that a wholesale rebuilding of the components of US military power is not necessary; finding the right new linkages and making selected advances might produce all the improvements required.

c) People, culture and organization

One of the critical factors in how organization responds to opportunities for innovation is a "the ability of the firm to recognize the value of new, external information, assimilate it, and apply it." Cohen and Levinthal called this "absorptive capacity," [84] and say that is largely a function of the firm's level of prior related knowledge. It depends on the knowledge and expertise of individuals within an organization, both the depth and diversity of their knowledge structures, and an organization's communication systems—how well it both gathers and disseminates knowledge.[85] Because this concept includes both an organization's ability to gain new

[83] Mainly by increasing "absorptive capacity"—see below.
[84] Cohen and Levinthal, "Absorptive Capacity: A New Perspective On Learning And Innovation," *Administrative Science Quarterly*, March 1990, p 128.
[85] Ibid., pp 132-133. By diversity of knowledge structures they mean that the organization should have individuals and sub organizations capable of understanding the implication of advances in a

knowledge as well as to apply it (i.e. problem-solving skills), Cohen and Levinthal maintain that it is absolutely critical to invest in this capability: "once a firm ceases investing in its absorptive capacity in a quickly moving field, it may never assimilate and exploit new information in that field, regardless of the value of that information."[86]

Absorptive capacity is related both to the skills of the individuals in an organization as well as the institution's structure, particularly how information enters and is filtered by the organization. This argues for high levels of education, interaction with others in the same or related fields, and effective means for sharing lessons learned.

From a different perspective, writers on military innovation have also noted the significance of organizational climate, or culture in creating an innovative organization. Murray praises the German interwar army for tolerating outspoken officers and a high degree of debate within the officer corps, "connecting the intellectual drive within their army to the operational world," and in general using a system of competition for schooling to raise the intellectual "tone" of the organization.[87] Likewise, Beyerchen[88] says there is a need for technical talent within the military, access to outside talent, and "permeable boundaries" between the technical and operational worlds.

The need for "first rate thinkers" goes beyond technology; one author has decried US military educational institutions as "relics of the Cold War," and saying "never has thinking been more necessary" calls for an overhaul of the professional military education system so the schools can serve as "incubators of military change.[89] He further calls for a

---

wide variety of fields, relating that knowledge to the mission of the organization, and communicating it effectively to others in the organization.

[86] Ibid., p 136.

[87] Murray and Millet, op. cit, pp 47-48.

[88] "From Radio to Radar" in Murray and Millet, op. cit., p 298.

[89] Cohen, op. cit.

change in personnel structures to increase career flexibility, similar to what is available in the civilian world.

A complicating factor is that military services have a culture that is different from the rest of society.[90] From Samuel Huntington's characterization of the military ethic as "corporative" and "fundamentally anti-individualistic,"[91] through Brodie's statement that military officers tend to be "means-oriented rather than object oriented,"[92] to the importance of "traditional loyalties,"[93] scholars in the field have consistently concluded that military organizations are more conservative and slow to change than other institutions. In addition, there seems to be a tension between this institutional conservativism in times of peace and the boldness and dynamism expected of the military during war. This may stem from the need to deal with uncertainty by having a stable doctrine prior to entering a conflict,[94] and does not imply a culture that is extremely open to new approaches.

The military is also a bureaucracy, and bureaucracies by their nature oppose innovation.[95] Some of the most useful insights on organizational structure can still be found in James Wilson's study of bureaucracies. Among other things, he observes that the prospects for innovation increase with the diversity of an organization, both the task

[90] Most observations tend to focus on officers, since they will be the senior uniformed policy-makers. However, as the literature on business innovation makes clear, there are many similarities in the problems of innovating.
[91] Huntington, Samuel P., *The Soldier and the State*, Harvard University Press, Cambridge, 1967, p 64. Huntington's work is dated in that it ignores the increasing professionalism of the enlisted force since the creation of the all volunteer force. He also seems to ignore differences in Service or warfighting community cultures.
[92] Brodie, Bernard, "Technological Change, Strategic Doctrine, and Political Outcomes," in *Historical Dimensions of National Security Problems*, University Press of Kansas, Lawrence, 1976, p 301. The implication is that someone who flies a bomber of drives a tank will see only that means—not some new way of doing things—as the solution to achieving objectives.
[93] Janowitz, Morris, *The Professional Soldier*, The Free Press, New York, 1964, p 35.
[94] Sapolsky, Harvey, from class notes for *Military Innovation*, MIT course 17-462.

structure and the incentive system.[96] In other words, having a structure that inherently applies different perspectives to a problem should generate more potential solutions. Some believe that this favors an organization such as the Navy, with its three warfighting communities with overlapping capabilities; additionally, this argues against promoting too much "jointness," because least common denominator solutions rather than truly innovative approaches will predominate.[97] At the same time, Wilson suggests that an organization with a great deal of diversity will adopt proportionally fewer of the innovative proposals than a more monolithic one, because decisions in general are harder to implement.[98] He also points out that it is easier to increase an organization's ability to generate new ideas than to increase its "capacity to ratify" any given proposal.[99]

Military culture is also determined by the nature of the leaders. In the Army and the Navy, the dominant branch or community has changed over the years as one "combat arm" gains or loses influence relative to the others. This also may affect the willingness to accept innovative solutions, especially as the "guard" changes; one of the reasons for the decline of the "bomber generals" within the Air Force was their inability to think in other than absolute terms. With the rise of the more "pragmatist" fighter generals, the Air Force became more able to expand the capabilities of air power outside the realm of strategic

---

[95] Max Weber as cited in Rosen, op. cit, p 2.
[96] Wilson, James Q., "Innovation in Organization: Notes Toward a Theory," *Approaches to Organizational Design*, University of Pittsburgh Press, Pittsburgh, 1971, p 198.
[97] Sapolsky discussions; also, see Eliot Cohen, "Defending America in the 21st Century"
[98] Wilson, op. cit., p 200.
[99] Ibid., p 207.

nuclear warfare.[100] Ironically, the fighter pilot mentality or "mafia" is now seen as an obstacle to progress in building a true 21st century Air Force.[101]

Because of all these factors, a common observation is that outsiders innovate, or at least are far more likely to perceive the need for innovation.[102] This is not limited to the military. Relating the concepts of architectural innovation and absorptive capacity helps to explain why outsiders are more likely to pursue changes, especially those that are likely to undermine the existing order of an organization, market, or form or warfare. How an organization can overcome the barriers to innovation will be addressed below.

d) Summary

The point of this (rather long) section has been to highlight some key concepts that should be kept in mind as one plans a strategy. These are summarized in Table 1. While this is neither an exhaustive list nor a checklist for strategy development, the ideas presented will hopefully help illuminate the situation an organization finds itself in, and allow it to be better prepared for upcoming challenges.

[100] Worden, Mike, *Rise of The Fighter Generals: The Problem of Air Force Leadership 1945-1982*, Air University Press, Maxwell AFB, AL, 1998
[101] For example, Murray, Williamson, "Drifting Into the Next Century: The USAF and Air Power"
[102] Janowitz, op. cit., pp 25-26, Wilson, op. cit., p 300, Utterback, op. cit. p 161.

Environment	Strategic/geopolitical Military missions Technology Risk and timing Resources Vision
Elements of Strategy	For innovation itself Appropriability Dominant designs Architectural innovation Complementary assets
People and culture	Absorptive capacity Military culture and organization Bureaucracies

Table 1 Key Concepts for Innovation

A quick look at the factors on the right side of the table might also illustrate why it can be misleading to draw too much from historical parallels. Specifically, although some of the factors might align, many others will not. In the case of equating the present to the "interwar" years (1919-1939), it is fairly clear that the geopolitical situation is not the same, nor is the nature and role of the American military. There is no nascent combat arm (the air service in those days) that promises to alter the physical dimension of warfare. Space has not yet had air's equivalent of World War I. Information, though its advocate's promises sound eerily like those of early (also pre World War I) air power advocates, is pervasive and furthermore has always been present in warfare. Drawing parallels between technological advances in the interwar years and today is also tenuous at best. This is not to say that valuable lessons cannot still be learned, but to sound a cautionary note about how directly applicable they are.

3. Obstacles—what makes innovation difficult

Innovation involves change, so clearly any factor that argues against change could be an obstacle. Some of these factors have already been mentioned but deserve a brief review.

One such factor is exemplified by the S-curves shown in Figure 5. An organization may be pursuing one approach or technology that is not only successful but appears to be returning investment at a great rate. The alternative approach may promise higher performance in the long term, but initially will produce smaller rates of return for a given level of effort; it may even provide worse performance initially by traditional measures of merit than the established approach.[103]

Also, the members of an organization that is accustomed to doing things one way will have become fairly good at understanding the costs and benefits of the existing approach. They can make convincing, rational arguments that the new approach will not be good for the "bottom line," whether that is profits[104] or military effectiveness. Would-be innovators must appeal to something other than traditional measures, or else exaggerate their claims; the latter approach in turn leads to the potential that they will be discredited when, almost inevitably, initial performance of the innovation falls short of expectations.

Aside from the rational arguments, both military and business organizations may suffer from the "not invented here" syndrome. Outsiders[105] may in fact come up with some of the best ideas, but no matter how promising these are, they may be suppressed or rejected if there is a somewhat similar effort (even if demonstrably inferior) underway "in

[103] Christensen, *Limits of the Technology S-Curve*, p 363.
[104] Christensen, Clayton M., *The Innovator's Dilemma*, p 226.

house." Development of fire control computers in the Royal Navy in the first decade of the 20th century offers an example of such a problem.[106]

The case of naval fire control highlights a cultural issue as well. Traditionally, the ultimate measure of merit for an officer has been his performance in combat or combat-related skills. With the advance of technology, those traditional skills have become steadily less important. In the fire control case, not only did the computer largely replace the judgment of the gunnery officer, but the increased size of guns meant combat would take place at longer and longer ranges. This made the skills required less "manly," and seemed to cheapen those things that traditionalists held dear. It also meant that the traditional ways of measuring an officer's worth would change—patterns of incentives and rewards shifted.

This is a common theme in the evolution of military capability. From the time the longbow devalued armored knights through the resistance to the machine gun, the resistance to the demise of horse cavalry and the saber, the resistance to air-to-air missiles and PGMs, to some current arguments against information warfare, UAVs and space-based capabilities, the desire not to undercut the warrior skill and ethos of the military has been a constant, if often unstated, influence. The resistance is not only to new weapons, but also to changes in doctrine that would devalue more traditional combat arms, and thus potentially change the leadership of the institution. This issue is recognized by some

---

[105] "Outsiders" can mean a variety of things: civilians relative to the military, one Service relative to another, one community relative to another, and so forth.

[106] See Sumida, Jon Tetsuro, *In Defense of Naval Supremacy:, Finance, Technology and British Naval Policy, 1889-1914*, Unwin Hyman, Boston, 1993, pp 146-176.

current military thinkers as an obstacle that needs to be overcome, but the way to do it is not at all clear.[107]

This is not to say that resistance to the new methods is always misplaced. A precipitous and premature shift to a new way of doing things could be disastrous for an organization. The stubborn resistance of the old guard can in fact make sure that a new idea is both valid and needed,[108] but it must be carefully monitored to ensure that new ideas aren't simply stifled. Sometimes, the military may even be right to resist pressure from outsiders.[109]

Organizationally, bureaucratic politics presents another obstacle to innovation. Since innovation requires some resources, there will be a competition among the Services or even within a Service for what is after all a finite allocation. This can hinder a Service (or community) doing things that would benefit the larger institution but might lead to a loss of prestige, influence or autonomy for itself.[110] Similarly, even if a proposed innovation could ultimately enhance the position of the organization, it may be difficult to compete for resources in an environment where more traditional, valued missions are going short.

---

[107] For example, Maj Gen (ret) Charles Link (Developing Aerospace Leaders briefing) has suggested that the Air Force needs to consider a future in which traditional piloting skills no longer matter, and MG (ret) Robert Scales ("Warfare in the 21st Century: A Strategic View," speech at the MIT Lincoln Lab Defense Technology Seminar, 19 Mar 2001) argues that the Army must come to grips with the fact that the days of traditional infantry combat, "closing with and destroying," the enemy are numbered.

[108] An observation made by Thomas Kuhn in his *Structure of Scientific Revolutions*, cited in Lambeth, Benjamin S., The Transformation Of American Air Power, Cornell University Press, Ithaca, 2000, p 394.

[109] For instance, in the case of the "military reformers" of the 1980's who argued that US weapons were becoming too few and complex, and that the US military should shift to simpler, cheaper weapons. Had this advice been followed, Desert Storm may have been a much more costly operation.

[110] The history of air support to ground forces, in which lessons learned during wartime were repeatedly forgotten afterwards, partly because it did not serve Air Force institutional interests to improve its capabilities in what was essentially a subordinate role, might be a good example.

Another manifestation of the cultural obstacles to innovation in the military is a doctrinal rigidity brought about through selective interpretation or outright misuse of historical[111] and operational[112] evidence. To some extent, this could reflect intellectual dishonesty, as individuals choose to ignore evidence that does not fit their preconceived agenda. But it may also be a reflection of the problem of absorptive capacity: individuals who are not capable of understanding what they are seeing or recognize the potential of an alternative approach. The answer to this is to increase the capacity of individuals in key positions to assimilate new information, think critically, and be willing to change their minds in the face of objective evidence. This in turn could create some inherent tension, as military culture prizes (and experience often vindicates) those who get tough when the going gets tough, who persist in spite of the odds, and who don't change plans on a whim. Resolving this tension will be a major challenge in a world of rapidly changing technologies and concepts.

4. Mechanisms—how to make things happen

It's worth noting that "product" and "process" innovation follow separate paths. This is depicted by Utterback as shown in Figure 9.[113]

[111] See, for example, Murray in Murray and Millet, op. cit, pp. 319-322. Murray also accuses the Air Force in particular of this sin in his article "Drifting into the Next Century." His own use of evidence however is selective and often biased (for example, citing New World Vistas—a Science Advisor Board report, as evidence of overall AF technological "monism," claiming the AF ignored PGMs post-Vietnam while failing to acknowledge that a) the Navy did much worse and b) that the AF stubbornly persisted with "smart" weapons in the face of opposition from civilian "military reformers."

[112] Watts, Barry D., "Unreported History and Unit Effectiveness," *The Journal of Strategic Studies*, Vol 12, No 1, 1989, pp 88-98.

[113] Utterback, op. cit., pp 82-83.

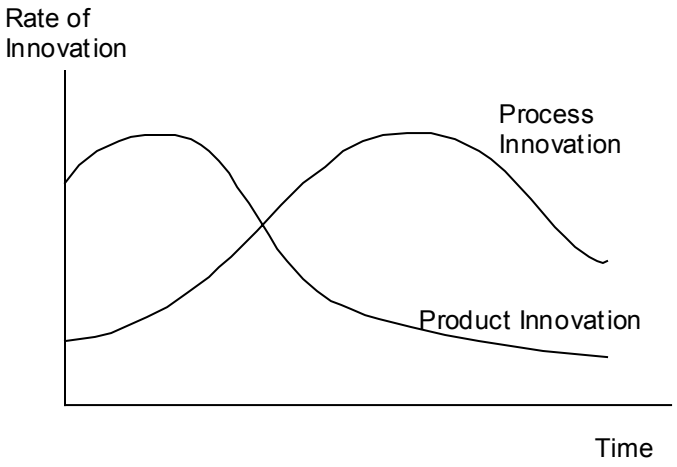

Figure 9 Changing Rates of Product and Process Innovation

The type of skills required is different for the two types of innovation; in product innovation, more creativity and a looser organization is required. When process innovation is important, efficiency and tighter control is needed. Paralleling the arguments presented by Foster, it's worth noting that to be successful in the various stages of a technological approach's life cycle requires a different strategy. The type of innovation needed in each stage is different: a more creative, breakthrough-oriented approach to come up with the technological discontinuity; the ability to come up with an "architectural" or perhaps platform-oriented solution (discussed below) that takes into account more than just technology but a number of other factors in order to develop a dominant design; and perhaps an increasingly more organized and disciplined approach during the era of incremental change to refine the process and create maximum efficiencies. Again, all these imply different skills in the workforce and probably different organizations. Further, as Utterback argues, success in one generation breeds

established methods, generates infrastructure and sunk costs, and even creates patterns of thinking that can blind a company to the possibilities of a new approach.

This corresponds to some extent to Wilson's theories about generating innovative ideas versus implementing them, and suggests that different organizations may be needed at different phases of development. Christensen[114] concludes that the established firms that were most successful in entering new "disruptive technology" markets, were those that created spin-offs or semi-independent subsidiaries to pursue the innovation.

If military equipment is considered the product, and doctrine the process, there would be a straightforward parallel here. This is probably true on the tactical level, thinking about the employment of a new weapon, for example. But at the operational level and higher, the interactions or linkages between systems become important, and the dynamics of architectural innovation come into play. Here, the lessons for organizing are less clear, and it's likely that only experimentation and the willingness to explore new combinations of capabilities will lead to successful innovation.

Along those lines, the use of simulations, exercises and wargames is seen by some, as "essential to innovation and transformation."[115] Watts and Murray argue that these must be based on sound institutional processes and real-world evidence.[116] This is of course difficult when some systems that are proposed for a future, transformed force do not yet exist, even in prototype form. The key here seems to be to hold as objective, unbiased simulations as possible to explore the potential of different approaches. Again, this is much easier said than done: except in hindsight the correct answer is unprovable. One

[114] Christensen, *The Innovator's Dilemma*, p 217.
[115] Krepinevich, Andrew, "Military Experimentation—Time to Get Serious," Center for Strategic and Budgetary Analysis background paper, 31 Mar 2001

person's biased exercise might be another's objective proof that a new concept does or doesn't work. And it is also not clear, despite the arguments of some[117] that *joint* experimentation is the way to go.

5. Strategies—putting it all together

How much should an organization try to innovate? What organizational structure should it adopt to encourage innovation? How can it get the necessary resources? How far should innovation go? How useful is innovation that falls short of a complete transformation, and what is required to consolidate innovations into a transformation? Is any significant transformation of a large organization likely to be successful without a well articulated a vision from the top? These and other questions are the challenge for a strategy of innovation and transformation.

Many business innovation theorists seek to explain how an innovator or company can overcome the obstacles to innovation, pick a successful strategy, and implement it. One approach to bringing order to complexity is to think of the various projects a company has undertaken not in isolation, but in terms of how they relate to an overall strategy. This involves categorizing projects according to their relationship to a company's core products and processes. Wheelwright and Clark propose the following terms: breakthrough, platform, derivative, or R & D.[118] The cornerstone of this framework is the concept of a "platform." This would be a core product line, in which components and

---

[116] "Military Innovation in Peacetime," in Murray and Millet, op. cit, pp 410-411.
[117] Krepinevich, op. cit., and Macgregor, Douglas A., "Transformation And The Illusion Of Change," *National Security Studies Quarterly*, Autumn 2000, pp. 1-8
[118] Wheelwright and Clark, "Creating Project Plans To Focus Product Development," *Harvard Business Review*, March-April 1992, pp. 70-81

processes are shared to a great degree but which produces a variety of different options for customers. Derivative projects could be thought of as branches from this main trunk, while breakthrough projects are needed to make significant changes to existing products or processes. Research and development is "the creation of the know how and know why of new materials and technologies that eventually translate into commercial development."[119]

Although the concept of focusing a company's business around core product lines—its platforms—hardly seems revolutionary, both the study of businesses and my own experience with government research and development projects indicate that it is both easy for an organization to suffer from a proliferation of unrelated projects and difficult to reorganize those or trim them down to a more focused set. The reasons for this are many: pet projects of highly regarded individuals, projects with outside sponsorship (e.g. congressional interest), or just a proliferation of "good ideas" for which an organization lacks objective ways of of comparison. Regardless of the sources, this proliferation has tremendous costs in terms of diluting the effort of the individuals in the organization, the resources which in organization has to spend, often without much realistic hope of producing a viable product (or in military terms, delivering a useful war fighting capability). It may be difficult, but organizing the projects—for example, around a company's core competencies—will pay off in improved results. Just as importantly, "possibly the greatest value of an aggregate project plan over the long term is its ability to

[119] Ibid, p. 72.

shape and build development capabilities, both individual and organizational," or in other terms, to increase an organizations relevant absorptive capacity.[120]

One problem innovators will always face is that of gaining acceptance for new idea. In attempting to sell a new product, a company must transition from the early market which is "dominated by a few *visionary* customers to a *mainstream market* dominated by a large block of customers who are predominantly *pragmatists* in orientation."[121] Moore represents the different market segments as a sort of bell curve (Figure 10 below) and says in fact that the gap between early adopters and the mainstream market is a "chasm" that must be bridged. While he does not offer an exact prescription for how to do this, he does makes several useful observations about the difference between visionaries and pragmatists that have a direct bearing not only on selling to the public but probably on "selling" an idea within the organization itself .

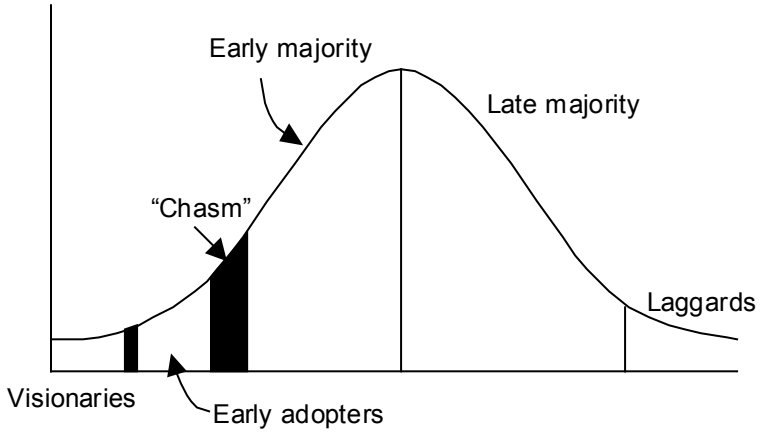

Figure 10 Technology Adoption Life Cycle

[120] Ibid., p 75.
[121] Moore, G. (1999), "High-tech Marketing Illusion" and "High-tech Marketing Enlightenment," Chapters 1 & 2 in *Crossing The Chasm*, HarperCollins New York , pp. 3-59; emphasis in the original.

Building on this and other concepts Gans and Stern have developed a matrix that helps illuminate the choices for commercial innovators. This diagram, shown below in Figure 11, ties together several of the ideas mentioned above.[122] The question on the left side deals with appropriability: can an innovator keep his idea from development by the incumbent? The question of the top deals with how important the incumbent's complementary assets are in making the new innovation successful. Although the four quadrants shown do not have sharp boundaries--it's usually very difficult to answer a definitive yes or no to the questions--this construct could be of use to an innovator trying to decide whether to start his own company, license his idea, or take some other approach.

		Do incumbents complementary assets contribute to extracting value from the new technology?	
		No	Yes
Can innovator preclude effective development by the incumbent?	No	Head-to-head competition--attacker's advantage	Favors internal developments by the incumbent.
	Yes	"commodified ideas" and "standard setting"	"Idea market," licensing

Figure 11 Technology Development Strategies

[122] Gans, Joshua S. and Scott Stern, "The Product Market And The 'Ideas' Market: Commercialization Strategies For Technology Entrepreneurs," unpublished draft, August 2, 2000

Looking at the problem from the perspective of the incumbent or dominant firm (or a military sense, from the perspective of the United States) this diagram suggests a framework for thinking about the threat. What technological or other advances might a competitor pursue to gain an advantage over the incumbent? What sort of developments would render the "complementary assets" of the dominant firm either obsolete or less relevant? By the same token, this diagram could suggest areas, or ways, in which the dominant firm can further extend its advantage.

Finally, innovation will not happen without the right sort of insightful, aggressive people to pursue it. Education is absolutely critical.[123] An organization must be prepared to tolerate and even encourage debate, and as Rosen recommends, if a military is to transform itself there must be career paths that lead to the top of the organization, otherwise the innovators will seek independence. At the same time, would-be innovators, transformers and reformers must have some connection with the traditional values of an organization. It would be unrealistic to expect the leaders of a military service (or a company) to promote people into positions of authority who held everything the old guard had done in contempt.

G. Lessons from theory

One key observation is that innovation does not always involve breakthrough technologies or ideas. Often, a new combination of existing elements, or a new capability to link elements can produce dramatic effects. Thinking in terms of "architectures" to

[123] Cohen, op cit., Murray and Millet, op. cit., Peter Hay, and Karl Mueller, "Going Boldly—Where?," *Aerospace Power Journal*, Spring 2001, pp. 34-49 and others all make this point. The idea is generalized by Cohen and Levinthal, op. cit., as "absorptive capacity."

accomplish military mission areas rather than in terms of point solutions to specific requirements may help spark truly revolutionary ideas. But it is unlikely that a final, complete concept will spring full blown from anyone's mind; rather, exploring many alternative possibilities is a better way of ensuring that the ultimate choice is the most effective. And of course, how effectiveness is defined and evaluated will have a major impact on that outcome.

Change is inevitable, but any given change is not always necessary. There are usually alternative solutions, and a good organization can make old methods more effective long after their time has supposedly passed. Sometimes this is the best approach; "skipping a generation," whether in hard disk drives or fighter aircraft might save an organization some effort and investment. But it is a risky strategy: predicting and timing markets is notoriously difficult, and forgoing the learning that goes on with the production, introduction and modification of a generation of systems might lead to shortfalls in "absorptive capacity" that are hard to even recognize.

At the same time, an organization must be willing to experiment, even at the cost of some near-term capability. Simulations can only go so far; at some point, prototype systems need to be created and tried under operational conditions. This might apply to organizational structures as well.

There is no magical lever which can be applied to a military organization to make it become innovative. The process of innovation is inherently complex, especially if that innovation will be of a significant enough nature to transform an organization. What may be possible is to create a climate, culture, and institutions that recognize the possibility, desirability and even necessity of change, that are capable of objectively evaluating

potential new approaches, and that are able, once the decision to proceed is made, of rapidly embracing the innovation and developing it to its fullest potential.

To achieve this, individual skills are at least as important as any organizational structure. The military must seek to recruit, retain, educate, productively employ and reward people who understand both the implications of new technologies and the operational context in which they will be used.

One particular type of individual that the military will continue to need is the visionary. Visionaries are often, in fact usually, wrong—at least in the details. However, they still bear close attention because at the core their ideas have tremendous power. They are also more attuned to new outside ideas because of their outlook, and can use their powers of persuasion to get the ideas heard and evaluated. Institutionally, the military must find ways to stimulate and reward this kind of thinking, but at the same time the visionaries must understand the gap, or "chasm" in thinking that separates themselves from the pragmatists, and find ways to overcome it. This suggests that visionaries, especially if they wish to lead change themselves and not simply become martyrs for a cause, must find ways to secure their place and reputation in the institution—in other words, show that they value the culture and can master traditional skills—as well as look for opportunities to push their new ideas.

Would-be military innovators must also learn to build coalitions with key civilian decision-makers, both in Congress and the executive branch of government, and with specialists outside government, including industry and, for lack of a better word, think tanks. In different circumstances one side or the other (the military or the "outsiders") might need to take the lead role in promoting and pursuing change. But neither can

succeed without the other; the military cannot generate the resources or technology on its own for most changes, and outsiders cannot force lasting change on the military if there is no institutional buy-in.

This raises the complicated issue of *who* needs to be appropriately educated. As mentioned above, the military must ensure that it improves its own absorptive capacity, specifically through increasingly sophisticated and comprehensive education of officers. But what about the professional civilians in the Department of Defense? And the political appointees? And Congress? And industry, academia and the numerous defense think-tanks and consultants? It is easy to think of those outside the military as sources of ideas and information, but the fact is that they also need to be educated on the realities of military missions, and they need to be open to ideas coming from the military. This implies a fairly complex process of communication and interaction that may produce a climate of intellectual ferment and many good ideas on one hand, or rapid implementation of an idea on the other—but is unlikely to do both at the same time. In other words, I would argue that Wilson's model of a bureaucracy is not limited to a single organization, but can apply to the overarching national defense community as well.

Finally, the US military should recognize that its wealth of complementary assets are source of strength and not just a potential hindrance to innovation. The possibilities for using relatively minor technological advances in conjunction with existing capabilities to create a new architectural approach need to be explored, as well as the more "revolutionary" concepts that claim to overturn basic principles of warfare.

Is the Air Force an Innovative Service?

The history of innovation in the Air Force is a paradox. Conceived because of a technological innovation, born of a doctrinal innovation at the strategic level, and dependent on both technological and tactical innovations to achieve any of the early promises of air power, the Air Force is in many ways the most innovative of services. However, the very efforts to convince others of the promise of air warfare and the drive to fulfill those promises has also at times led to a single-minded focus on one part of the mission to the exclusion of others and at the expense of real innovation. On several occasions, the Air Force has been reluctant to adopt innovations that today are seen as essential to its capabilities.

Because of this history, there is a distinct difference between how many in the Air Force see current efforts to innovate and how outsiders view those same endeavors. To some, the Air Force remains mired in the past—but only the past it prefers to remember—and unwilling to consider necessary changes.[124] This view is too harsh, but not entirely without basis.

Although the 20th century was filled with change for all military services, it would be difficult to argue that any changed more than the Air Force. Leaving aside the fact that the Air Force--or any form of air service--did not exist at the turn of the last century, the changes in capability from the days of the earliest airplanes to today are truly phenomenal. From the Wright flyer to the B-2 aerial platforms have changed almost beyond recognition. The first powered flight was shorter than the wingspan of the 747—

[124] Murray, "Drifting into the Next Century"

which can fly thousands of miles—and the change in speed from then until now is equally dramatic. Propulsion changed from tiny engines generating a few horsepower and driving wooden propellers to gas turbines generating tens of thousands of pounds of thrust. Weapons evolved from nonexistence to nearly autonomous devices that can work their destruction at ranges of hundreds of miles. And that's just the evolution of atmospheric flight; rockets have evolved from firecrackers to missiles capable of intercontinental ranges or of placing artificial satellites in orbit. Those satellites in turn provide capabilities that were almost literally unimaginable a century ago. Advances in radio and electronics have allowed the creation of extremely capable "uninhabited" air vehicles, which are just now being developed to their full potential. And given recent advances in technology, the Air Force can foresee further dramatic advances in capability.[125]

The history of the development of air power however, is as much one of a constant drive by air power advocates to increase capabilities to a level that would fulfill the earliest promises of the visionaries as it is one of a military service struggling to keep its doctrine up to date with advancing technology. Debates over the proper use and control of aviation assets, the relative importance of the different missions, as well as the overall effectiveness and morality of air power surfaced early and would take decades to resolve; indeed, many continue today.[126]

The early history of the United States and aviation was not auspicious. Although the U.S. Army Signal Corps ordered a Wright airplane and flying instruction for two officers

[125] In contrast, although there have been massive changes in capabilities, ships for the most part are still recognizably ships. They are still made largely of steel and still driven by rotating propellers. Infantrymen still carry rifles whose capabilities have not changed nearly so radically, and even the vehicles of ground warfare (except for helicopters) would probably be relatively well understood and soldiers of a century ago.
[126] Kennet, op. cit.

in February of 1908,[127] by the time of World War one the U.S. had fallen well behind European powers; in fact it had half as many aircraft as Belgium, a total of eight.[128] During the war the U.S. relied mainly on European aircraft and weapons. Although the United States did produce the successful "Liberty" engine, this was a mixed blessing: so many surplus engines were produced that there was actually a mandate to use these engines exclusively in new designs after the war. Liberty engines, despite being obsolete, were still in use on American warplanes two decades later.[129]

In the years following the first World War, men whose ideas of air power had been shaped by the war sought to create a new and separate service. Visionaries like Mitchell saw air power not only as a new and decisive form of warfare but as the new basis for national power. Due to his strident advocacy Mitchell was arguably not as effective in developing the actual capabilities as, for example Admiral Moffett was in developing naval aviation, but the publicity and interest generated by Mitchell and the air service[130] was enough to ensure continued development funding despite overall low military budgets throughout the 1920's and 1930's.

This period saw a great deal of innovation in the technology of flight and in some operational concepts. For example, the development of accurate on board instrumentation allowed a demonstration of "blind" flying, pioneered by Jimmy Doolittle. Aircraft construction changed dramatically, with all metal single wing aircraft eventually replacing canvas covered biplanes. Speed and endurance records were broken regularly,

[127] Ibid., p 7.
[128] Ibid., p 21.
[129] Ibid., p 95.
[130] For example the bombings of captured German warships, the initiation of airmail service, and a series of Congressional aviation commissions.

driven by a desire for prestige and excitement and the general public enthusiasm for aviation as much if not more than by military requirements. Still, the air service did demonstrate some unique concepts, including aerial refueling, and worked hard at developing the doctrine that would take it into World War II and ultimately toward its goal of becoming an independent service: strategic bombardment.

The history of the Air Corps Tactical School (ACTS) offers decidedly mixed lessons on institutionalizing innovation. Despite its name, ACTS quickly became associated with the concept of using strategic bombardment to cripple an enemy's war fighting capability. Although not explicitly rejecting Douhet's concepts, the ACTS believed that the best way to force an enemy to submit was not the indiscriminate bombing of civilian population centers, but through directly attacking vital industrial capabilities. This would ultimately destroy the enemy's ability to wage war.[131] Although there was an attempt to do a "scientific" analysis of the enemy target systems to cause this collapse,[132] there were also numerous shortcomings. Extremely—and in light of World War II experience one could say wildly—optimistic assumptions were made about bombing accuracy and the destructiveness of aerial bombs. Equally optimistic assumptions were made about the survivability of large, fast bomber aircraft. While these assumptions were not completely unfounded given the technology of the time,[133] and there was some effort made to test the assumptions, the tests themselves were not realistic, and evidence that didn't accord with the prevailing "ideology" was disregarded.

---

[131] Faber, Peter R., Interwar US Army Aviation and the Air Corps Tactical School: Incubators of American Airpower," in Meilinger, ed., *The Paths of Heaven: The Evolution of Airpower Theory*, Air University Press, Maxwell AFB, AL, 1997, p 217.

[132] Key systems included electricity, transportation, and fuel refining and distribution.

Not all participants in the process were convinced by the logic, analysis, or experiments. Chennault was a notable critic, arguing that fighter aircraft were a threat to bombers and were also necessary to gain air superiority—but ultimately he was ignored. Although it could be said that the bomber advocates won the debate "fairly,"[134] there would be a tremendous price to pay in terms of bomber losses over the skies of Europe in World War II.

In World War II, as in the first World War, the capabilities of air weaponry advanced dramatically. Air power showed during the blitzkrieg that it could be used to strike at the nerve centers of an enemy in both a physical and psychological sense. During the campaigns in North Africa, Italy, and Europe, learning and adapting along the way, air forces showed increasingly greater affects on the land battle. The observation of Erwin Rommel is telling: "Anyone who has to fight, even with the most modern weapons, against an enemy in complete command of the air, fights like a savage against modern European troops, under the same handicaps and with the same chances of success."[135] Massive production of aircraft[136] (the strategic bombing campaign alone consumed approximately one-third of U.S. wartime production [cite source]) eventually overwhelmed the opposing force. Following the Normandy invasion, with the Luftwaffe essentially defeated, the combined bomber offensive was finally able to unleash its planned force against German industry and. 72% of all the bombs dropped on Germany

---

[133] Bombers were as fast as fighters, making intercepts difficult; also, quite accurate—when used under ideal, daytime conditions—bombsights were being developed.
[134] Murray and Millet, op. cit., p 124.
[135] From B.H. Liddell Hart, *The Rommel Papers*, cited in Hallion, Richard P., *Strike from the Sky*, p 161.
[136] Aircraft production was roughly 25%--or perhaps as much as 40%--of the overall US war effort. It was a much greater part of Britain's: their strategic bomber offensive alone consumed 30% of

were dropped after July 1944[137] with the result that Germany's industry, oil production and transportation system did ultimately collapse—but not before the war on the ground was also essentially over.

Massive production of aircraft and pilots also resulted in sufficient numbers to provide as much ground support aviation as the army could use. The later years of the war would see the development of effective coordination between air and ground forces that unfortunately would fall into disuse and ultimately be forgotten in only a few years.

Finally, World War II saw the emergence of the "ultimate weapon." Although arguably the bombing raids on Hamburg, Dresden, Tokyo and other Japanese cities using only conventional fire bombing were even more destructive in terms of damage and loss of life, the demonstration of what a single weapon could do over Hiroshima and Nagasaki powerfully affected developments in air power for the next 20 plus years.

The closing days of the war had one further influence on the future direction of U.S. air power: the capture and exploitation of numerous advanced German weapons and their designers. Through Project Paperclip, the United States was able to evaluate and begin exploring numerous advanced concepts. Perhaps just as significantly, the Soviet Union acquired many of the same technologies and many skilled scientists. This set the stage for the technologically driven arms race of the Cold War. Among the technologies with the most far-reaching implications were rocket technologies and the A4 (V2) rocket itself--the basis for the first intermediate and later intercontinental ballistic missiles as well as the first space launch vehicles.

---

all wartime production. Werrel, Kenneth P., "The Strategic Bombing of Germany in World War II: Costs and Accomplishments, in *Journal of American History*, December 1986, p 707.

[137] Ibid.

Following the war the U.S. military immediately and rapidly downsized, and the advocates of an independent Air Force finally prevailed. Ironically, the first test of the new service was not combat but the Berlin airlift; an extremely potent example of the strategic use of air power,[138] but not exactly what some visionaries had in mind. After initially running the airlift operation General Curtis Le May became the second commander of the newly formed Strategic Air Command, a position he would hold for almost 10 years. LeMay's history, his personality, and—following the Korean War—the Eisenhower administration's desire to reduce defense expenditures and doctrine of massive retaliation, would have enormous impact on the new Air Force.

The Korean War bears mentioning for two reasons: first, because of a general lack of preparedness among U.S. conventional forces, and in the Air Force the need to relearn many of the lessons of World War II about cooperation with ground forces and the right way to interdict enemy forces; and second the fact that as soon as the war was over, many of these lessons seemed to be immediately forgotten again. In part, this was due to an immediate refocusing of the Air Force on the strategic nuclear mission to the point that by the late 1950's development of conventional weaponry had all but ceased.[139] Development of bombers that flew faster, higher, and farther was the service's main priority. Fighters were either designed to intercept bombers or to carry nuclear weapons themselves. The senior leadership of the Air Force was dominated by "bomber generals"

[138] Requiring several innovations of its own in scheduling, maintenance, air traffic control and cargo handling.
[139] In 1958 the Air Force apparently informed its major commands that "development of non-nuclear weapons was to be terminated." Worden, op. cit., page 127 note 21.

and Tactical Air Command struggled to justify its existence let alone get adequate funding.[140] The culture of SAC dominated the Air Force.[141]

During these years, when the Air Force share of the defense budget approached 50%, in some ways the doctrine of massive retaliation hung like a dead hand over the prospects of innovation in the service. With the manned bomber the primary means of carrying out the nation's chosen strategy, one perceived threat to SAC's primacy (the development of the Navy " super carrier " in the early 1950's) avoided, and the "anomalous" Korean War dismissed as a one time occurrence, doctrinal rigidity set in. Air Force doctrine documents, never a particularly high priority, went unrevised for years. Only the threat of losing ballistic missile programs to the Army, the Navy's development of Polaris, and later the insistence of Secretary of Defense McNamara, led to the Air Force putting significant effort and resources into this new type of weapon.

Sputnik in 1957 shocked the nation out of its complacency regarding technical superiority, and prompted an accelerated science and technology program. The Air Force, with an undiminished commitment to going higher, faster, and farther, began proposing itself as an aerospace force.[142] It pursued satellite development programs and other efforts such as the Dynosoar space plane and Manned Orbiting Laboratory, however, these developments seemed to some heavily influenced by SAC requirements and mentality. The resulting suspicion led to competition, and then forced collaboration in the National Reconnaissance Office with the CIA[143] on satellite reconnaissance

[140] Ibid., pp 55-131
[141] Ibid., p 62.
[142] The word was first used by Chief of Staff Thomas White in 1958; Hays & Mueller, op. cit., p36.
[143] "Establishment and Early History of the NRO," briefing by Jeffrey Richelson to the MIT Security Studies Program; 13 Sep 2000.

programs, and later the cancellation of the Air Force's manned space efforts and designation of NASA as the sole government agency for these efforts.

During this time, the United States became involved in Vietnam, a war for which once again the United States Air Force was unprepared. Lacking an effective air superiority fighter, and further, having allowed its air-to-air combat skills to atrophy, the Air Force first had to adopt the Navy F-4, and despite some efforts[144] suffered a relatively miserable air-to-air combat exchange ratio throughout the war. The Navy adapted more quickly, setting up its Top Gun training program and improving its exchange ratios. Only after the war did the Air Force finally get serious about learning lessons, establishing the aggressor squadrons, Red Flag and other "flag" exercises, and developing the F-15 as a premier air superiority fighter.[145] These changes coincided with the terminal decline of the influence of the bomber generals and rise to the most senior ranks (Chief of Staff and Chairman of the Joint Chiefs) of officers who had more well-rounded experience (Generals Brown and Jones), and the rising influence of TAC under General Creech. This trend culminated in 1982 with the naming of a "pure fighter" general, Charles Gabriel, as the Chief of Staff.[146]

In many ways, the Vietnam years were watershed for the Air Force. SAC's operating methods were shown to be overly rigid and dangerous in the skies over Hanoi in December 1972. The initial losses of B-52s to surface-to-air missiles, in part due to inflexible and predictable tactics, would make any student of military history wonder if the command remembered any lessons of World War II. The division of control of air

[144] Lambeth, op. cit., p 46.
[145] Ibid., pp 59-65.
[146] Worden, op. cit. p. 226.

assets—not only between the Air Force and Navy in the "route pack" system, but between SAC for its bombers and 7th Air Force for all other aircraft—violated principles which airmen claimed to hold vitally important. Within the Air Force, SAC pilots suffered relative to tactical air force pilots in that they did not receive combat performance reports or similar consideration for decorations--vital factors in future promotions.[147] Also, military necessity and technological opportunity drove the Air Force to use precision guided munitions (PGMs), and it slowly began to dawn on some thinkers that these weapons might be a more effective way of attacking certain targets.[148]

Following the Vietnam War there was both a refocusing on the Soviet threat in Europe and a movement away from the doctrinal emphasis on strategic nuclear warfare. The expansion of nuclear forces, at first constrained by budgets, now also acquired treaty constraints. The operational level of war was rediscovered in military writing, and there was a renewed emphasis on theater level operations. In 1988 John Warden wrote the first significant theoretical book on air power[149] to come from an American military officer since, probably, Billy Mitchell. Although Warden's theory and his priorities remain controversial, this book signified a significant shift in Air Force thinking to now focus on the operational level war.

The late 70's and early 80's saw several weapon system developments that would determine future Air Force capabilities. The tactical forces received the F-15, F-16 and A-10. For many years, SAC had been trying to get a replacement for the B-52. The B-1

[147] Ibid., p 177.
[148] Resistance was not limited to Air Force officers; civilian system analysts in McNamara's Pentagon also opposed them based on faulty assumptions; see U.S. Government, *Commission On The Organization Of The Government For The Conduct Of Foreign Policy*, Chapter 8: " Smart Bombs, " pp. 191-198.

had initially been canceled by the Carter administration because of its expected vulnerability to Soviet air defenses as a high altitude bomber, and because of the development of low observable, or stealth, technology and a follow-on bomber program (the B-2) then shrouded in secrecy. The Reagan administration resurrected the B-1, changing the design to be a low altitude penetrator (with some significant performance compromises). The B-2 program continued as well. However, in a triumph of the old SAC mentality neither program initially contained provisions for the aircraft to drop conventional, let alone precision, weapons. At the same time nuclear forces were being modernized with both the Navy's Trident missile and the MX or Peacekeeper. There was intense controversy over the Peacekeeper missile—its size, capabilities, and basing mode (but relatively little discussion of the dramatic leap forward in accuracy that the Trident was offering, and its implications)—debates that occupied much of the Air Force leadership's attention. In the case of both the bombers and the Peacekeeper, the Air Force never seemed able to articulate a coherent strategic concept behind the replacement systems—evidence that doctrine had not kept pace with requirements or technology.

The development of stealth aircraft deserves some additional attention. Widely touted now as one of the keys to current and future capabilities, stealth was not initially heartily embraced by the Air Force. Part of this may of been due to skepticism about the technology, part of it due to compromises in performance (particularly for the F-117) necessary to produce low observability; probably some was due to the impression that this new technology was being pushed by engineers and scientists unfamiliar with real war fighting requirements. The situation almost exactly parallels the problems facing

[149] Warden, John A. III, *The Air Campaign*, Pergamon Brassey, Washington, 1989

innovators in industry who try to convince an existing and successful company to adopt a completely new product. In this case, only the forceful intervention by DOD civilians with substantial credibility and political clout (most notably William Perry) kept the programs on track and convinced Congress to keep funding them.[150]

Other significant efforts of the 70's and 80's include development and deployment of the AWACS system, the Global Positioning System satellite constellation, the Air Force/DARPA Pave Mover experiments which led to the Joint STARS aircraft, and the initiation of the advanced medium-range air-to-air missile program. Each of these programs could be a case study in itself of how innovations are generated and adopted.[151]

Precision-guided munitions (PGMs) also found greater acceptance. Although the Air Force is often accused of focusing more on platforms than weapons, the fact remains that by the time of the Gulf War the Air Force had significantly more capability to employ PGMs than the Navy or our allies.[152] It's also quite interesting in the aftermath of the Gulf War to look back on the debates of the "military reform movement" of the 1980's. Claiming a high-tech weapons were too expensive, unreliable, and ineffective, the "reformers" pushed for larger quantities of simpler, cheaper platforms and munitions. These included not just civilian outsiders but also current or former members of the military (such as Colonel John Boyd). LANTIRN, a system allowing laser designation and night time navigation and targeting came in for particular criticism. Their arguments

[150] Interview with William P. Delaney, Director's Office Fellow at MIT Lincoln Lab and participant in the analyses and debates over the adoption of stealth.
[151] See for example, Williams, George K., "AWACS and JSTARS," In *Technology and the Air Force*, J. Neufeld et. al., eds., US Air Force, Washington, 1997, pp 267-287.
[152] In Desert Storm, 10, 468 guided bombs were dropped. The US dropped 89% of those, and the Air Force dropped 90% of that number. 5,508 air-ground missiles (excluding HARM) were fired, 99% of which were by the US. 96% of those were from Air Force platforms. *Gulf War Air Power Survey*, Unclassified Summary Volume, Table 7-3, Chapter 7, p 19.

overlapped with some in the military who argued that it was better to have "a smart plane dropping dumb bombs that dumb plane dropping smart ones." This debate can easily be used by both sides in arguing how receptive to innovative the Air Force is. On the one hand it has been cited by Murray[153] as evidence of Air Force intransigence, closed-minded-ness and fixation on technology. Also, one could make the point that the Air Force could not have persisted in pursuing advanced weapons without significant support from outside parties—notably industry, which had a clear interest in developing these new weapons. On the other hand, one could reasonably praise Air Force leadership for persisting in the development of high-tech weapons despite the external criticism. In the end, the innovations were adopted, and adequate if not universal capability was in place by the time of the Gulf War.

Since the Gulf War, and I believe contrary to some assessments[154] the Air Force has worked to address numerous shortfalls in capability. For example, almost all aircraft including bombers are now capable of delivering PGMs, the advent of GPS-aided munitions has removed the last sanctuary (weather) for fixed targets, and UAVs are of vital part of almost all operations. Indeed, the Air Force has recently conducted successful tests of launching a Hellfire missile from Predator UAV using both remote and on board laser designation.

[153] Murray and Millet, op. cit., p410.
[154] Murray, in "Drifting into the Next Century" claims that the Gulf War Air Power Survey was "deep sixed" and its lessons essentially ignored. He cites no evidence for this; in fact, munitions developments would seem to directly contradict him. From my own experience in the acquisition system, citing a need from the Gulf War was nearly a requirement for any program during the mid-1990's.

However, there are still many things to criticize. Both Murray[155] and Worden[156] make the argument that perhaps the pendulum has swung too far in the "tactical" direction; the Air Force seems to focus almost exclusively now on theater warfare, perhaps to the exclusion of its ability to achieve strategic effects at long range.[157]

Another source of criticism is that the Air Force, in adopting innovations, has been too quick to discard useful older capabilities. Some critics believe the Air Force has now placed too much faith in stealth technology with the resulting neglect of electronic countermeasures and air defense suppression assets. Although this is a complex budgetary, political, and technological issue, the Kosovo campaign and the potential to encounter more advanced surface-to-air missiles in future campaigns certainly suggests that this is an area the Air Force cannot afford to ignore.

Another development is worthy of attention although its real military utility is still unclear, and that is the airborne laser. The development of this system could almost be seen as a case study in architectural innovation. First, directed energy weapons have yet to be proven in traditional military applications. In boost phase theater missile defense, the ABL is pursuing a "market niche" and thus is neither a threat to established systems

---

[155] Ibid.
[156] Worden, op. cit., p 228.
[157] This usually takes the form of criticism about service advocacy for the purchase of "short range" F-22's and, and the limited number of bombers, especially the B-2, but is probably more valid in a doctrinal sense. Curiously, many of the arguments against the currently planned mix of aircraft are ahistorical. Although there have been occasions (such as the El Dorado Canyon raid or operation Desert Fox) in which countries have denied the United States overflight rights or the use of in country bases if they did not agree with the military action the United States was about to take, these were not large scale applications of force. A more pertinent example may be the Italian government's refusal to allow the basing of F-117's for the Bosnia operation. Again, however, this was not an operation in which either vital U.S. interests or the security of the host nation were threatened. Nor has any potential enemy yet developed the capability to deny the U.S. access to theater bases. This is not to say that it is not a potential future threat, nor that we can be complacent. But it is still only a postulated future threat, thus it is not valid criticize the Air Force for ignoring historical evidence on this count.

nor does it suffer by comparison in traditional measures of performance with kinetic energy weapons. If the system works as planned, it does have the potential to provide a breakthrough capability—and not solely against ballistic missiles. This effort is an example not only of technology push, in which years of earlier laser development and a breakthrough in adaptive optics made such a system conceivable, but of a requirements driven process—a "strategy to task" methodology—that was seeking answers to the problems posed by theater ballistic missiles during the Gulf War. For the most part, the Air Force has funded this program "out of hide," meaning that other requirements were not met. In terms of the willingness of the Air Force to innovate, it is difficult to see this program as anything but encouraging. In terms of the Air Force's ability to innovate successfully, time will tell.

In addition to development of new technologies, the Air Force has made substantial organizational changes since the Gulf War. Air Force Systems Command and Air Force Logistics Command were merged into a "Materiel Command," ostensibly to improve "cradle-to-grave" management of weapons. More traumatically, SAC disappeared, merging with TAC to become Air Combat Command (ACC). Responding to a changed strategic environment, the Air Force is moving toward an "expeditionary" concept, with deployments away from home station a more regular, but also more predictable, event. The ICBM force, after a brief stay in ACC, was transferred to Space Command, giving the latter its first actual weapons.

In the mid-1990'sthe Air Force created the space weapons center, an organization whose purpose is to make existing space capabilities more accessible and relevant to terrestrial war fighters, and to develop new concepts for space capabilities. To foster in-

house innovation, in 1997 the Air Force established six “battle labs” in the area of UAVs, command-and-control, force protection, and expeditionary operations, space and information warfare.

In terms of some of the critical elements of creating a culture of innovation, I believe it is still too early to judge the depth of change in the Air Force. But there has been positive change. Under General Fogleman the Air Force created a “Chief of Staff's reading list” with a large number of books recommended at different times during an officer's career. The list is heavily oriented toward history (partly to address the concern that Air Force officers do not know history well) and certainly is not a collection of party line propaganda. In 1991 the Air Force established the School of Advanced Air power studies (SAAS), a yearlong follow-on to Air Command and Staff College. The curriculum, which includes intensive reading, debate, and classes taught by a distinguished faculty, is heavily focused on history, military theory, and the development of critical thinking . The 10th class will graduate this year; coincidentally this year is the first time a SAAS graduate has been selected for Brigadier-General.

Many questions remain, however. Although some institutions have been established and organizations changed, it remains to be seen how strongly career paths will be affected, whether sufficient incentives have been created for operational leaders, planners, and program managers to be innovative, and most importantly whether individuals who have the right mix of a desire to innovate and a pragmatic ability to get things done will rise to positions of influence.

The history of the Air Force shows the successful adoption of many innovations. One analyst has suggested that the Air Force has already transformed itself twice and is

embarking on a third transformation.[158] However, many of the most significant advances in Air Force capabilities do not seem to have been generated—or at least to have had strong constituencies—inside the service initially. Often, bureaucratic politics or intervention by civilian leaders seems to have been required to force the Air Force to pursue innovations (such as ballistic missiles or stealth technology). In other cases (development of effective air combat training after the Korean War or the adoption of PGMs) the process of adoption of the innovation has seemed remarkably slow and his sometimes lagged other organizations. Innovations made at the tactical level have sometimes been suppressed or even reversed by higher levels (for example aerial tactics developed in Vietnam). And yet...one way or another the Air Force has managed to create overall capabilities well beyond those of any competitor or ally, and even to come much closer to realizing the early promises of the prophets of air power than any "realistic" thinker would have expected. Although there were periods in history of the Air Force in which doctrine, tactics, and organization stagnated, the almost relentless march of technology seems to have eventually forced changes.

The patterns of the past do suggest three things. First, the Air Force, and air power advocates in general, have a history of overpromising and then having to work very hard to deliver. In the end, except for the still-open debate of what sort of national strategic objectives air power can achieve on its own, those promises have virtually all been realized. The ability and willingness of the Air Force to adopt the necessary innovations on its own however is questionable. Outside influences, particularly of the technology push variety, seem critical.

[158] First to a strategic nuclear force, then to a focus on tactical proficiency. Benjamin Lambeth

The second lesson is that the Air Force usually responds when it feels a part of its mission is threatened by an outside organization. Army and Navy ballistic missile programs in the 1950's, Army attempts to develop their own close air support aviation in the early 60's, and Navy developments in space programs might be some examples. Sometimes, the Air Force response is more of bureaucratic consolidation that of innovation. The course of the next few years, particularly in regard to space, will depend on how strongly the Air Force sees a potential threat to its institutional survival—i.e., how seriously it regards the possibility of the creation of a separate space force—and what actions it takes.

The third potential lesson of the history of Air Force innovation is that the Air Force does not innovate effectively when one community is allowed to indulge the belief that there is a single answer to all military problems: specifically during the 1930's when the concept of strategic bombardment crowded out development of other doctrine and capabilities, or in the 1950's when SAC's nuclear bombardment doctrine was paramount.

Conversely, one could also argue that it was the obsession with institutional independence—gaining it in the 1930's and consolidating it in the 1950's—that led to such an exclusive focus on the independent mission. In some ways this may come down to an issue of matching resources and requirements. Reducing available resources, or justifying the resources based on a single mission (as in the 1950's) will probably cause the organization to focus on those missions that it most closely identifies with or sees as the most critical.

---

speech on Air Force transformation, 1 Dec 00, Pentagon.

Is the Air Force an innovative service? Judging by progress and the results, the answer is yes. But past innovations have perhaps been too dependent on outside impetus and too seldom directed by a coherent internal vision. On the other hand, during times when one version of air power doctrine dominates—for example that of the strategic nuclear forces and SAC in particular during the 1950's—rather than innovating, the service tends to consolidate its gains, and in fact stagnates. The challenge is to create and sustain a vision of the future that is not dogmatic, but in fact promotes the development and exploration of new concepts. At the same time, this vision and its supporting doctrine must be convincing enough to generate the resources needed to create the aerospace force of the 21st century. Otherwise, developments will likely be taken out of the hands of the Air Force once again and directed by either Congress or the DOD leadership.

Transforming to an Aerospace Force

The ability of the Air Force to innovate will be challenged by the very concept of becoming an "aerospace force." For reasons already discussed, resources will be limited, and there is a need to replace (recapitalize) portions of the existing force. Further, there is no single obvious technological device (an aerospace vehicle that could perform a variety of missions equally well in space or the atmosphere) or doctrinal concept (analogous to strategic bombardment) that can serve as a rallying point. Hence the need for institutional innovativeness—the ability to cleverly combine a variety of ideas into a synergistic concept—has never been greater.

The Air Force says that its transition to an aerospace force is a "process not simply an objective."[159] Recognizing that the strategic environment, technology, and demands on the military are unlikely to be static, a philosophy that encourages continuous innovation seems appropriate.

A direction is also necessary however. Both business case studies and military historical studies suggest that this must come from a country's national strategy, resources and geopolitical situation, and in the case of a military service from an appreciation of its core competencies.

The Air Force faces several challenges in its goal of transforming into an aerospace force. The first are external to the institution. The motivation, or the threat, is not terribly clear. Because there is no immediate challenge or issue forcing the development of true aerospace capabilities, there is no clear picture of how urgent this transformation

is. On the other hand, the timeline for consideration of a potential separate space service mentioned in the Rumsfeld report is five years.[160] Absent a war, that is an exceedingly short time to transform an institution, or even to set processes in motion given the delayed action of the U.S. programming and budgeting cycle. The significant, and at this point unknown, issue is just how significant the "threat" to Air Force control of space assets really is.

Another obstacle to a rapid transformation is the existing acquisition system. The cycle of research, development, test and deployment simply takes too long to produce rapid changes in force structure, even if the costs were to be reduced. And perversely, the longer it takes to develop and deploy a new capability, the more "man-years" of human effort are involved, and the higher the costs. This is an external challenge for two reasons: first, the official rules of the acquisition system are determined by DOD and Congress, and are difficult to change; second, the unofficial rules—the lobbying and advocacy required to ensure congressional funding—impose a certain deliberateness on the process that seems to be overcome only in "black" programs. Between the Air Force, DOD and Congress, there must also be an increased acceptance of developmental risk, a recognition that programs will not always achieve their objectives initially, and a willingness to do two almost contradictory things: stick with a concept that has potential through the difficult early years, and ruthlessly abandon—or at least shelve—projects that are not working out. The latter requirement demands both better objective simulation and

---

[159] United States Air Force, *The Aerospace Force: Defending America in the 21st Century…a white paper on aerospace integration*, Washington, DC, 2000, p iv

[160] Scott, William B., "Commission Lays Foundation for Future Military Space Corps," *Aviation Week & Space Technology*, January 15, 2001, p 433.

evaluation tools than we now have, and a forceful and visionary sort of leadership that is difficult to achieve.

Another external challenge—at least mostly external—is the question of technology. Clearly, some technologies (such as a truly revolutionary propulsion system that would enable easy access to space) are not yet available. However, there many other technologies which are "on the shelf" and could be assembled into a new architectural concept that might radically change how we use space.[161] The challenge is less one of finding a technological silver bullet and more one of imaginatively assembling the pieces—and then improving the performance of the individual elements.

But in any case, the process will take money. Absent a decision to give the Air Force more resources to pursue this transformation--a decision that is unlikely to be made without a compelling vision of the future—the Air Force will have to find developments internally at the expense of existing programs and plans.

This in turn means taking on several internal challenges. The Air Force needs to understand and probably improve its processes for generating and implementing innovations. This includes coming to grips with the question of whether doctrine (i.e. the pull of requirements) or technology opportunities should drive the development of new capabilities. Of course this is not an either-or choice; but the process for educating those who write doctrine and operational requirements on technological opportunities—and on the other hand in educating technologists about the directions the operational force would like to pursue—is not well developed or understood. In addition, the Air Force needs to decide if its doctrine will be forward-looking or simply codify existing capabilities. If the

latter is the case, there is a crying need for something to bridge the gap between what is in the official programming system and the "Vision Force" that the planners have postulated.

The Air Force must take a close look at existing organizations and decide if these are really capable of producing innovative concepts and capabilities, or if they're too closely tied to the status quo. To some extent, this may be done by external forces; if the recommendations of the Rumsfeld Commission are fully implemented, Air Force Space Command will have significant influence over the development of new capabilities, and the corporate Air Force will have increased executive agent responsibilities for Department of Defense space programs.[162] It remains to be seen however, how quickly and smoothly those recommendations will be implemented.

Implementing any changes or recommendations of course requires people. And people, including organizational attitudes and culture, can be among the slowest things to change. The Air Force is making efforts on several levels to develop an "aerospace" culture[163] but most of these will take some time to show results, and even the question of whether they will produce results will not be answerable for years. To me it seems very difficult to develop a culture by fiat; we have air capabilities and we have space capabilities. It is possible to take people with expertise in one area and give them exposure to the other, but while that may produce knowledgeable individuals and increased understanding between the communities it does not necessarily follow that it will produce a common culture. That requires shared experiences and identity for all

---

[161] This was the basic premise for my School of Advanced Airpower Studies thesis: "Blueprints for the Future. Comparing National Security Space Architectures"
[162] Scott, op. cit, p 433-435

members of the service, starting with basic training (or the Aerospace basic course for officers).[164]

Developing a viable career path for officers to be considered "aerospace" experts is also vital. The Air Force has such an effort (called Developing Aerospace Leaders) underway. However, this will be a difficult issue to tackle. Naval aviation gained status in the Navy when it was mandated that only aviators command aircraft carriers;[165] this created a path to senior rank and responsibility for the new specialists. The Air Force has a similar problem; it is trying to integrate two cultures, thus has to make it possible for at least some people to have a career path that touches both worlds. Given the requirements (age, eyesight, lengthy training) to become a pilot (or navigator) it is clearly easier to take those who are initially flight qualified and give them exposure to—and command in—the space world. But where does that leave those who start on the space "side?" There is some option with the decision to make air battle managers rated officers and allow them to command certain flying units (such as AWACS and Joint STARS), but this is unlikely to create a large number of opportunities. And the increasing use of UAVs may also offer new opportunities for command. But the divide will remain between those who participate (or at least might participate) directly in combat and those who do not. This divides even the flying world, was one of the factors in the rise of fighter generals to leadership of the Air Force, and remains an obstacle to having a significant percentage of

---

[163] US Air Force, *The Aerospace Force*, pp 21-22.
[164] Although it is not clear to me from interviews with lieutenants who have gone through the Aerospace Basic Course that is either challenging enough or coherent enough to produce the sort of institutional identification that comes, for example, from the Marine Corps basic course
[165] A Morrow Board (1925) recommendation. See Murray and Millet, op. cit, p 211.

non-fighter pilots at the most senior levels of the service. This cultural obstacle, which is certainly not unique to the Air Force, will be difficult to overcome.

A clear requirement, and an obstacle if it does not exist, is a strategy on how the institution will be transformed. Actually, the absence of a strategy is not so much an obstacle as an indication of a lack of direction. As the saying goes, if you don't know where you're going, any way will get you there. Changes in technology, society, budgets, and requirements for use of the military will eventually reshape and transform the Air Force. The question is, to what extent can the institution itself foresee and shape that transformation?

Should the Air Force pursue these efforts alone or as part of a joint project? Certainly many authors would insist on the latter as a requirement.[166] While the Air Force should pay attention to joint requirements, it should neither rely on this for justification nor be deterred by a lack of joint support. Plans should include making maximum use of other capabilities, but the goal of innovation is to produce a better way of doing things; this will necessarily mean competing with other concepts. Further, if the Air Force has systems, operational concepts and doctrine that will make aerospace capabilities a reality, it has an obligation to pursue them and not wait for the bureaucratic joint doctrine process to justify them.

Finally, transformation to an aerospace force requires, I believe, some sort of physical capability that can truly be classified as "aerospace." At the risk of being accused of focusing on hardware to the exclusion of doctrine and ideas, the following is an outline of

[166] For example Macgregor, op. cit., Libermann, op. cit., and Krepinevich, op. cit.

some of the capabilities the Air Force might consider pursuing—and the rationale—if it wants to become an aerospace force.

The Air Force has identified a set of core competencies and held to them since 1996. These are:

-Aerospace (formerly Air and Space) superiority
-Global attack
-Rapid global mobility
-Precision engagement
-Information superiority
-Agile combat support[167]

This is actually a good starting point, although by themselves the categories and capabilities they suggest cover too broad an area to properly focus technology and doctrine development efforts.

In better defining the areas to focus on, the Air Force should ask where the greatest challenges and opportunities lie. This could entail placing bets on potential technology breakthroughs, working to address key vulnerabilities or gaps in existing capabilities, and planned improvements in existing core capabilities.

Examples of this line of thought follow. In evaluating ideas in deciding priorities the so-called "attributes" and "tenets" of air or aerospace power need to be kept in mind: speed, range, and perspective in particular.[168] The list focuses on capabilities that would lead to a more recognizably "aerospace" force. Of Course, the Air Force has other requirements; how to prioritize and balance them will be a key question.

---

[167] USAF, *The Aerospace Force*, pp 11-13.

[168] There is some inconsistency in describing exactly what the attributes of air, space and aerospace forces are, and some disagreement about whether the same attributes can be correctly assigned to all three; see Hays & Mueller page 37, Air Force Doctrine document 2-2, *Space Operations*, August 23, 1998, and the *Aerospace Force* white paper.

Virtually all air forces consider it axiomatic--with valid historical reasons--that little is possible in air operations without control of the air. Consequently, the Air Force has invested enormous effort in developing and procuring the F-22. This aircraft will undoubtedly go a long way to ensuring that American forces are unchallenged by enemy aircraft either over our air space or theirs.

The space part of Aerospace superiority presents a much different challenge. Most discussions recently have talked about in need for space control—always with the caveat that national policy will drive this decision—with an emphasis on the use of offensive or defensive weapons in space. The *Aerospace Force* white paper makes mention of the fact that enhancing our space surveillance capabilities is the first depth in space control.[169] However, it is not self-evident that efforts to improve space situational awareness are receiving enough attention or emphasis. The "space-based visible" sensor and the MSX experimental spacecraft (launched in 1996) has dramatically demonstrated the potential for improving our capabilities; however the mission of space-based space surveillance will only be implemented as a secondary function of the SBIRS Low missile tracking constellation, which will not be deployed for years at best. This should be one of our highest priorities;[170] given better situational awareness (which would also include better space object identification capabilities) the United States will be in a far better position to recognize and react to future threats. Needless to say, a sophisticated surveillance,

[169] USAF, *The Aerospace Force*, p 12.
[170] Making space surveillance and situational awareness a top priority has now been explicitly endorsed by two members of the National Space (Rumsfeld) Commission: retired Generals Fogleman and Moorman; "Space Commission: Space Surveillance Deserves Funding Priority," Aerospace Daily, March 29, 2001

tracking, and damage assessment capability is virtually a prerequisite for intelligent employment of weapons in space should it ever come to that.

Considering the core competencies of global attack and precision engagement, the Air Force must improve its ability to attack mobile, dispersed, and concealed targets, in all weather conditions. Destruction, rather than suppression, of enemy air defenses needs more effort . Hardened and deeply buried targets may also be an issue. In both cases, weapons that arrive at hypersonic speed from an aerospace platform could provide unique capabilities.

Some new weapons developments are in order but most would agree that our greatest shortfalls now are in the speed of operations and the responsiveness and quality of our surveillance and reconnaissance systems. Even when assets are in place and theoretically capable, the agility of our system leave something to be desired.[171] And the fact is that the assets are often not sufficient. Our intelligence, surveillance, and reconnaissance platforms are almost all "low density, high demand" platforms. They are also expensive to operate and aging. In general, we need in improved surveillance capability, and the ability to have persistent regional surveillance with improved resolution in time, space, and different parts of the electromagnetic spectrum . In studies, exercises, and war games the value of a space-based radar has been repeatedly shown[172] and yet the Air Force institutionally has not been able to make even a demonstration project happen in over 10 years of trying. This also must be a higher priority.

---

[171] During the Kosovo campaign it took General John Jumper's personal involvement to redirect surveillance and strike assets to deal with a high priority mobile target. Jumper, John P, "Transformation and Integration," briefing at the Unified Aerospace Power in the New Millenium Conference, Arlington Virginia, 8 Feb 2001

[172] Most recently in the "Schriever 2001" wargame, held in January 2001.

Aside from the deploying sensors, improved communications, data fusion, and command-and-control capabilities are needed both to better exploit the capabilities of the assets that we have and to better deal with future threats. These certainly fall into the realm of information dominance, an enabler for the other capabilities but also an emerging war fighting option itself. The Air Force must stay on top of these capabilities, recognize its own vulnerabilities, and work to exploit new techniques, but not assume that the physical realm will become irrelevant. A transformation to an aerospace force is impossible without incorporating information technologies, but those technologies are not sufficient by themselves to allow full exploitation and control of the "aerospace medium" in pursuit of national objectives.

In the areas of global mobility and agile combat support increased speed is again a primary consideration. Much of the work here depends on reducing the amount of equipment and the number of personnel that actually must be deployed into a theater of operations. Reduced logistic support requirements and improved communications links that allow "reach back" will provide high payoff. There is one area, however, where our lack of a suitable platform or physical capability directly and dramatically affects our ability to operate: space lift. Study after study on future space operations has concluded that reliable, rapid, assured and inexpensive access to space is absolutely critical. A vehicle that allowed routine, aircraft-like, access to space would make the concept of an aerospace environment a real operational medium instead of just a slogan, opening entirely new vistas for deployment of space assets and rapid global operations.[173] It would also be a visible symbol that the Air Force does in fact possess aerospace capabilities and

would do far more to silence the critics than any number of white papers or briefings. Support for this kind of project has been minimal however. Although this is partly a political issue outside of the control of the Air Force (presidential decisions during the Clinton administration to assign reusable launch vehicle development the NASA and to veto funding for the Air Force space plane project for example), and there are requirements on the books, a true sense of advocacy and urgency is lacking.[174]

[173] I strongly disagree with the unsubstantiated assertion—footnote 23 in Hays and Mueller, op. cit—that this type of operation would be a relatively minor adjunct.
[174] Scott, William B., "Is USAF Sandbagging Spaceplane Project?," *Aviation Week & Space Technology*, November 20, 2000, p 60

The Prospects for Air Force Transformation

The military, and the Air Force in particular, has been accused both of ignoring history[175] and of failing to prepare for a future which does not have a clear historical precedent. In addition, there is a struggle between the advocates of a RMA, who believe that the fog of war can be permanently lifted, and the traditionalists who deny that anything has changed since Clausewitz. With all the differing opinions, one can find an academic "expert" to back almost any proposed course of action. And amid this cacophony of voices and undeniable technological change and budget realities, the Air Force is trying to become something new—an aerospace force. What are the chances?

The prospects for Air Force transformation—at least one in which the Air Force has some control over the pace and direction—are not entirely clear. While some commentators[176] believe the transformation is underway and others[177] seem to think that the Air Force is pursuing at least some of the right ideas, other observers both in and outside the Air Force are more skeptical. Hays and Mueller believe that the Air Force is falling short in discussions of strategy, vision statements, and the development of "enduring military space leadership."[178] Murray[179] is even more critical, saying that "clueless about the past, arrogantly sure of its technology, and largely ignorant of real war, the Air Force is drifting into the next century."

---

[175] Murray, "Drifting into the Next Century."
[176] Lambeth, Benjamin S., "Air Force Transformation," speech to HQ USAF/XP, 1 Dec 00.
[177] Scales, Robert H. Jr, "Warfare in the 21st Century: A Strategic View," speech and follow-on discussions at the MIT Lincoln Lab Defense Technology Seminar, 19 Mar 2001
[178] Hays and Mueller, op. cit., p 46.
[179] Murray, op. cit.

The Air Force has produced visions of the future, but they either fall short on foreseeing major changes or lack specifics about path that must be followed to get to a future capability.[180] What the Air Force needs is a description of a plausible future objective capability,[181] with a date attached—a stake in the ground if you will—an achievable road map that describes how the service will put these capabilities in place, and a convincing strategic rationale that will enable the service to compete successfully for funding. Part of this process includes determining if there is a sequence of events in developing capabilities that will work best in producing the objective force, identifying long lead or critical path items, and getting started on them.

One of those items is certainly people. Skills must be developed, the "absorptive capacity" of the organization must be improved and probably redirected, career paths and incentives must be established so that the right sort of leaders will emerge, and efforts must be made to create a new organizational culture.

In some ways, culture is a chicken and egg question. As the capabilities of an organization change, as the leadership changes, the culture will change also. This is certainly what happened to the Air Force between the 1960's and 1980's, as the previously dominant SAC bomber culture was eclipsed by the rising "fighter mafia." Regardless of conscious efforts to change, the balance of power in the organization will shift as the

[180] US Air Force, *Global Engagement: A Vision for the Twenty-First Century Air Force*, 1997. Following publication of *Global Engagement*, the Air Force set about creating a long range plan to implement the vision, but that plan itself suffered from major disconnects with the reality of ongoing budgeting and programming. Also, *The Aerospace Force* lacks specifics about how changes might be implemented.

[181] For example, the Schriever 2001 force was described as "unrealistic" in the time frame the game was to have taken place; Eberhart, Ralph E., "Aerospace Integration and the Air Force," speech at the Unified Aerospace Power conference, Alexandria, VA, 8 Feb 01.

proportion of people—especially officers—in different specialties changes.[182] As the Air Force moves into the future, the number of piloted aircraft (i.e. with the pilot on board), and the number of pilots as a percentage of Air Force officers will continue to decrease. At some point, this "gene pool" will not be sufficient to provide the right kind of Air Force leadership. Officers with different backgrounds will begin to take over. More and more of the mission will be performed by non-rated officers, and the culture will change. The challenge is to hold on to the valuable parts of the old tradition while embracing the new.

I would argue that if the Air Force is to actually become an aerospace force it will have to transform itself; if external actors or advancing technology are allowed to drive the direction of changes it is highly unlikely that the current vision will come to pass. More likely, space capabilities will increasingly become more separated from the Air Force mainstream, and possibly eventually from the service itself.

One way of glimpsing potential futures is through simulations and war games, but to be valuable these must be open ended, not attempts to prove a particular point. The Air Force has conducted its Global Vigilance war games, in which space assets play an increasing part, and recently held the Schriever 2001 war game which focused on space capabilities. The question remains to what extent the Air Force (and Congress) is willing to let lessons from those war games drive the development of future systems.

Difficult development decisions need to be made. Will the Air Force begin to pursue the migration of certain surveillance capabilities to space-based platforms or will it

[182] In 1966, the number of fighter pilots exceeded the number of bomber pilots for the first time since 1955, and was rising while the number of bomber pilots was declining. Worden, op. cit., p 189. This generation of officers is now the Air Force leadership.

acquire a new airborne platform? Because of the potential life span of a new aircraft this could clearly affect the composition of the force for good portion of the 21st century. Essentially, this parallels a business decision about switching technology S curves. Clearly, airborne platforms still have significant potential capability, especially if the endurance of a UAV is factored in. Just as clearly, a space-based system offers both even greater potential performance in some areas as well as significant risk and cost. Visionary leadership will be required to make the right mix of choices, and those choices will directly affect the future of the organization.

To aid in making those decisions leadership of the Air Force needs to have not only some idea of where it wants to go but the path to take to get there. For example, should the Air Force place its bets on a few potential high payoff projects, with the idea that those capabilities will stay in the inventory for many years, or should pursue something like John Warden's proposed New American Security Force which would a deliberately to deploy only small numbers of rapidly evolving capabilities. Considering the uncertain nature of the threat and the potential for its rapid evolution (for example, rapidly adapting air defenses which could significantly erode the value of stealth over the life span of an aircraft) should the Air Force continue to plan for systems to stay in the inventory for 30 years or more with incremental modifications and improvements? Even our space systems have long lives, to the point that some of the designs may be dated before launch and obsolescent long before the spacecraft ceases functioning.

Considering the process of innovation itself, how much effort should the Air Force put into institutionalizing a process[183] versus fostering a climate where innovative ideas

[183] Murray and Millet (op. cit. p 326) believe this approach will have little success.

are encouraged and rewarded. As a rhetorical question, one might ask where more progress is being made: in the command-and-control battle lab or in Air Combat Command's efforts to establish a prototype operations center, the so-called CAOC-X? In the UAV battle lab, or in the skies over Bosnia and Kosovo where real world requirements drove the integration of a laser designator on the Predator, and most recently the testing of that platform with Hellfire missiles?

And what of advancing our capabilities in space and developing a true aerospace force? Judging by resources and programs, as opposed to power point briefings and white papers, little progress has been made so far. The loss of the Discover II program and the lack of significant funding for the Space Operations and Space Maneuver Vehicles is disheartening. It is encouraging at least that there is an ongoing debate—and in the pages of the Air Force's professional journal no less, not in some outside publication—over exactly what aerospace integration means and what direction it should take. The report of the Space (Rumsfeld) Commission has given the Air Force both an opportunity and challenge. It should not assume that it has more than five years to show at the very least a change of direction that points towards a service with recognizably different capabilities and career patterns than exist today.

The argument in the Aerospace Force white paper that integration means "achieving the mission rather than focusing on a particular medium or weapons system"[184] and that leaders will make resource decisions "based on capabilities that produced the desired military effects"[185] is legitimate but inadequate. First, it ignores one of the basic reasons that the Air Force claims a special competency for air warfare over the other services,

[184] USAF, *The Aerospace Force*, p 9.

mainly of the concept of "air-mindedness." Second, the simple criterion of achieving desired effects ignores both the opportunity to achieve better effects and the possibility of changing the way operations are conducted—the ultimate outcome of a real transformation. If the Air Force chooses to pursue only those options which meet currently understood needs, we reduce our chances of developing truly revolutionary capabilities. This is the same trap that companies fall into by paying too much attention to current customers and not enough to emerging markets. Further, if the solutions the Air Force chooses do not involve new uses or further exploitation of space we leave ourselves open to Senator Bob Smith's accusation that we are in really not a space service. Indeed, although education about existing capabilities is good, how will we ever develop a sense of "space-mindedness" (or aerospace mindedness) if we do not expand our operations in that environment?

The study of businesses suggests that it is very difficult for an established firm to a) produce breakthrough or architectural innovations as well as a new firm, and b) pursue a dual strategy of continuing a product line in which it is successful and at the same time adding in or starting up a second product line using new technology. This suggests that the Air Force faces substantial challenges in making the transformation it has proposed, that the prospect of an "attacker" in the form of a new Service or nominally subordinate "Space Corps" could be justified on more than bureaucratic or political grounds, and that to avoid this, the Air Force must be willing to make radical and perhaps painful decisions about what "product lines" to pursue if it wants to stay in the space business.

---

[185] Ibid., p 22.

Bibliography

Articles/Speeches

Brodie, Bernard, "Technological Change, Strategic Doctrine, and Political Outcomes," in *Historical Dimensions of National Security Problems*, University Press of Kansas, Lawrence, 1976, pp 263-306

Christensen, "The Limits Of The Technology S Curve," *Production And Operations Management*, Fall 1992, pp. 334-366

Cohen, Eliot A., "Defending America In The 21st Century," *Foreign Affairs*, December 2000

Cohen and Levinthal, "Absorptive Capacity: A New Perspective On Learning And Innovation," *Administrative Science Quarterly*, March 1990, pp. 128-152

Eberhart, Ralph E., "Aerospace Integration and the Air Force," speech at the Unified Aerospace Power conference, Alexandria, VA, 8 Feb 2001

Fogleman, Ronald R., "The New American Way of War: Continuous Transformation," *USNI Proceedings*, January 2001, p 112

Foster, R (1986), "The S- Curve: A New Forecasting Tool," Chapter 4 in *Innovation: The Attacker's Advantage*, Summit Books, Simon And Schuster, NY, pp. 88-111

Gans, Joshua S. and Scott Stern, "The Product Market And The 'Ideas' Market: Commercialization Strategies For Technology Entrepreneurs," unpublished draft, August 2, 2000

Hays, Peter and Karl Mueller, "Going Boldly—Where?," *Aerospace Power Journal*, Spring 2001, pp. 34-49

Henderson and Clark, "Architectural Innovation: The Reconfiguration Of Existing Product Technologies And The Failure Of Established Firms," *Administrative Science Quarterly*, March 1990, pp. 9-30

Jumper, John P, "Transformation and Integration," briefing at the Unified Aerospace Power in the New Millenium Conference, Arlington Virginia, 8 Feb 2001

Krepinevich, Andrew, "Military Experimentation—Time to Get Serious," Center for Strategic and Budgetary Analysis background paper, 31 Mar 2001

Lambeth, Benjamin S., "Air Force Transformation," speech to HQ USAF/XP, 1 Dec 2000

Lieberman, Joseph I., "Transforming National Defense for the 21st Century," Opening address before the US Army Conference on Strategic Responsiveness, November 2, 1999

Macgregor, Douglas A., "Transformation And The Illusion Of Change," *National Security Studies Quarterly*, Autumn 2000, pp. 1-8

Moore, G. (1999), "High-tech Marketing Illusion" and "High-tech Marketing Enlightenment," Chapters 1 & 2 in *Crossing The Chasm*, HarperCollins New York , pp. 3-59

Murray, Williamson, "Drifting Into the Next Century: The USAF and Air Power," Center for Strategic and Budgetary Analysis web site

Richelson, Jeffrey, "Establishment and Early History of the NRO," briefing to the MIT Security Studies Program; 13 Sep 2000

Roberts and Berry, "Entering New Businesses: Selecting Strategies For Success," *Sloan Management Review,* Spring 1985, pp. 3-16

Sapolsky, Harvey M., "On the Theory of Military Innovation," *Breakthroughs*, Spring 2000, pp 35-39

Scales, Robert H. Jr, "Warfare in the 21st Century: A Strategic View," speech and follow-on discussions at the MIT Lincoln Lab Defense Technology Seminar, 19 Mar 2001

Scott, William B., "Is USAF Sandbagging Spaceplane Project?," *Aviation Week & Space Technology*, November 20, 2000, p 60

Scott, William B., "Commission Lays Foundation for Future Military Space Corps," *Aviation Week & Space Technology*, January 15, 2001, p 433-435

"Settling in for the 107th Congress," *Aerospace America*, March 2001, p10

"Space Commission: Space Surveillance Deserves Funding Priority," Aerospace Daily, March 29, 2001

Teece, David J.. (ed), *The Competitive Challenge*, Cambridge MA, Balliger Publishing, 1987

"Transformation Must Leap Many Hurdles," *Defense News*, March 19, 2001, p 4

U.S. Government, *Commission On The Organization Of The Government For The Conduct Of Foreign Policy,* Chapter 8: " Smart Bombs, " pp. 191-198

Warden, John A., " The New American Security Force, " *Airpower Journal*, Fall 1999

Watts, Barry D., "Unreported History and Unit Effectiveness," *The Journal of Strategic Studies*, Vol 12, No 1, 1989, pp 88-98.

Werrell, Kenneth P., "The Strategic Bombing of Germany in World War II: Costs and Accomplishments, in *Journal of American History*, December 1986

Wheelwright and Clark, "Creating Project Plans To Focus Product Development," *Harvard Business Review*, March-April 1992, pp. 70-81

Williams, George K., "AWACS and JSTARS," In *Technology and the Air Force*, J. Neufeld et. al., eds., US Air Force, Washington, 1997, pp 267-287

Wilson, James Q., "Innovation in Organization: Notes Toward a Theory," *Approaches to Organizational Design*, University of Pittsburgh Press, Pittsburgh, 1971, pp 195-218

Books/Reports/Studies

Christensen, Clayton M., *The Innovator's Dilemma*, Harper Business, 1997

Cohen, Eliot A., and Gooch, John, *Military Misfortunes: The Anatomy of Failure in War*, The Free Press, New York, 1990

Goure, Daniel and Jeffrey M. Ranney, *Averting the Defense Train Wreck in the New Millenium*, The CSIS Press, Washington, DC, 1999

Gulf War Air Power Survey, Unclassified Summary Volume, March 1993.

Huntington, Samuel P., *The Soldier and the State*, Harvard University Press, Cambridge, 1967

Hallion, Richard P., *Strike from the Sky: The History of battlefield Air Attack, 1911-1945*, Smithsonian Institution Press, Washington, 1989.

Janowitz, Morris, *The Professional Soldier*, The Free Press, New York, 1964

"Joint Vision 2010," *Joint Forces Quarterly*, Summer 1996, pp 34-50

"Joint Vision 2020," *Joint Forces Quarterly*, Summer 2000, pp 57-76

Kennet, Lee, *The First Air War, 1914-1918*, The Free Press, New York, 1991

Lambeth, Benjamin S., *The Transformation Of American Air Power*, Cornell University Press, Ithaca, 2000

Landau, Sidney I., ed, *Webster Illustrated Contemporary Dictionary, Encyclopedic Edition*, J.G. Ferguson Publishing Company, Chicago, 1982

Meilinger, Phillip S., ed., *The Paths of Heaven: The Evolution of Airpower Theory*, Air University Press, Maxwell AFB, AL, 1997

Morison, Elting E., *Men, Machines and Modern Times*, MIT Press, Cambridge, MA, 1966

Murray, Williamson, and Allan R. Millet, *Military Innovation In The Interwar Period*, Cambridge University Press, 1996

National Defense Panel, *Transforming Defense: National Security in the 21st Century*, Executive Summary, December 1997

O'Hanlon, Michael, *Technological Change and the Future of Warfare*, Brookings Institution Press, Washington, DC, 2000

Owens, William A., with Edward Offley, *Lifting the Fog of War*, Farrar, Straus and Giroux, New York, 2000

Posen, Barry R., *The Sources Of Military Doctrine: France, Britain and Germany Between the World Wars*, Cornell University Press, Ithaca, 1984

Rosen, Stephen Peter, *Winning the Next War: Innovation and the Modern Military*, Cornell University Press, Ithaca, 1991

Sumida, Jon Tetsuro, *In Defense of Naval Supremacy:, Finance, Technology and British Naval Policy, 1889-1914*, Unwin Hyman, Boston, 1993

Schumpeter, Joseph A., *Capitalism, Socialism and Democracy*, Harper & Row, New York, 1976

United States Air Force, *Global Engagement: A Vision for the Twenty-First Century Air Force*, 1997

United States Air Force, *The Aerospace Force: Defending America in the 21st Century…a white paper on aerospace integration*, Washington, DC, 2000

United States Commission on National Security/21st Century, *New World Coming: American Security in the 21st Century; Major Themes and Implications*, September 15, 1999

Utterback, James M., *Mastering The Dynamics Of Innovation*, Harvard Business School Press, Boston, 1994

Warden, John A. III, *The Air Campaign*, Pergamon Brassey, Washington, 1989

Williams, Cindy, ed., *Holding the Line: US Defense Alternatives for the Early 21st Century*, MIT Press, Cambridge, MA, 2001

Worden, Mike, *Rise of The Fighter Generals: The Problem of Air Force Leadership 1945-1982*, Air University Press, Maxwell AFB, AL, 1998