MILITARY INNOVATION
CRITICAL AND DUAL USE TECHNOLOGIES

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ABSTRACT

MILITARY INNOVATION:
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This thesis represents an attempt to explore critical issues in the national military literature and bring up findings for further studies by exploring military innovation, smart management of defense R&D, critical and dual-use technologies concepts in detail. The study has two main components. The first part provides a conceptual and theoretical framework to discuss and understand military innovation, critical technology and dual-use technology. A military that fails to innovate when their contemporaries are innovating is destined to face its dire consequences. So the quest for change within military organizations is a rational and hopefully encouraged behavior. In this thesis the modes of innovation are at the center stage. However, the main intention focus is on technological innovation. As certain technologies are at the core of decisive military innovation, the initial step in innovation is normally to procure the new technology. A country that must purchase technology from abroad is arguably less likely to wield it as effectively as the country that is capable of inventing or manufacturing it, as the latter is usually better equipped to exploit and further refine technology. In order to insure the flow of technological innovations, a sound technology investment strategy must be formulated. A strategy built on a foundation of three integrated building blocks (optimal in-house R&D, expanded collaborative efforts, and smart outsourcing) will enable the military to be an effective smart buyer and smart provider. The thesis proceeds with a brief discussion of critical technologies, specifically the ones that are critical for military and national importance, in order to provide guidance for identifying which technologies harbor the greatest payoff potential. Closely related to this discussion is the question of national economic growth based on technological developments in particular the development of technologies with potential for use in either the civilian or military sectors, and promotion of partnerships among actors; military, industry, academia. Such technologies are referred as dual-use technologies. The dual-use relationships among actors are spin-off, spin-on, venture capital model, and military support/pull model. The second part of the thesis develops a kind of empirical case study analysis based on a rotary-wing upgrade project about the importance of upgrade and system integration technology as a core capability. The last chapter concludes the thesis with the discussion of findings.

Keywords: Military innovation; Military technological and organizational innovation; Military innovation efficiency; Smart buyer; Optimal in-house research; Smart outsourcing; Small business innovative research program(SBIR); Critical technology; Military critical technologies; Dual-use technology; Dual-use relationships; Active Learning; Absorptive Capacity; Core Competence.

ÖZ

ASKERİ YENİLİK:
KRİTİK VE ÇİFT AMAÇLI TEKNOLOJİLER

Yazan, Abdurrahman Mete
Yüksek Lisans, Bilim ve Teknoloji Politikaları Programı
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Bu tez çalışması, askeri alandaki teknolojiler açısından kritik hususları tespit etmeyi hedeflemekte ve daha sonraki çalışmalara ışık tutmak ve teşvik etmek amacıyla askeri yenilikler, savunma alanındaki Ar-Ge faaliyetlerinin akıllıca yönetimi, kritik ve çift amaçlı teknolojiler gibi konuları detaylı bir şekilde ele almaktadır. Tez, iki ana bölümden oluşmaktadır. İlk bölüm, yukarıdaki kavramları tartışarak anlamak için teorik ve kavramsal bir çerçeve oluşturmaktadır. Çağdaşları yenilikler üretirken, bundan yoksun olan ordu, bu durumun kötü sonuçlarıyla yüzleşmek zorunda kalır. Bu nedenledir ki, askeri organizasyonlarda değişim, arzulanan ve akılcı bir şekilde desteklenmesi gereken hareket tarzıdır. Bu tezin temel zeminini, yenilik ve çeşitleri oluşturmaktadır. Fakat, tezin asıl yoğunlaştığı konu, teknoloji içerikli olanlardır. Belirli teknolojilerin askeri yeniliklerin çekirdeğini teşkil etmesi gibi, yeniliğin ilk adımını da doğal olarak yeni teknolojilerin elde edilmesi oluşturmaktadır. Teknolojiyi başka ülkelerden sadece kullanıcı olarak satın alan bir ülkenin, teknolojiyi, üreten veya geliştiren bir ülke kadar etkin kullanamayacağı tartışmasız bir gerçektir. Teknolojiyi üretebilen veya geliştirebilen ülke, teknolojiyi geliştirmek için daha donanımlıdır. Teknolojik yenilikleri sürekli kılabilmek için anlamlı bir teknoloji geliştirme stratejisi oluşturulmalı ve doğru teknoloji seçilmelidir. Silahlı kuvvetler, akıllı bir teknoloji alıcısı olabilmek ve ülkenin teknoloji kapasitesine katkıda bulunabilmek için kendi kontrolünde optimum araştırma ve geliştirme faaliyetlerini gerçekleştirmelidir. Bunun için, gerekli altyapıyı sağlayacak bir teknoloji parkı oluşturmalı ve en az on yıl süreyle, seçilen kritik teknolojilere, karar aşamalarında akıllıca değerlendirmeler yaparak kaynak sağlamalıdır. Sanayi ve akademik çevreyle işbirliğini geliştirmeli, bazı teknolojileri de akılcı bir şekilde kendi dışındaki kaynaklardan sağlamalıdır. Tez ayrıca, hazır bir çözüm önermeden, hangi teknolojilerin ayrılan kaynak ve verilen emeğin karşılığını daha iyi sağlayacağı, hangi teknolojilerin ekonomik kalkınma ve silahlı kuvvetler açısından önemli olduğunu değerlendirebilmek açısından aydınlatıcı bir rehber niteliğindedir. Kritik teknolojiler özet bir şekilde tartışılmaktadır. Tezin kuramsal bölümünün son iddiası ise; hem silahlı kuvvetler hem de ülkenin ticari rekabet gücünü arttıracak çift amaçlı teknolojilere öncelikle kaynak ayrılmalı ve çaba sarfedilmelidir. Bu amaçla silahlı kuvvetler, sanayi ve temel alanlarda araştırma yapan akademik çevreyle işbirliğini geliştirmelidir. Bu işbirliği, değişik şekillerde olabilir, bunlar; askeri amaçla geliştirilen teknolojinin ticari alanda kullanılması, ticari alanda kullanılan teknolojilerin askeri alanda kullanılması, sadece araştırmalara kaynak sağlanması ve askeri altyapının araştırmaları desteklemek için kullanılması vb.leridir. Tezin ikinci ana bölümünde ise, temel bir yetenek olarak sistem entegrasyon teknolojisinin ve modernizasyonun önemini analiz eden, döner kanat teknolojisi ile ilgili gerçek bir projenin gözleme dayalı çalışması yer almaktadır. Sonuç kısmında ise, tespit edilen önemli bulgular ve önerilerim özetlenmektedir.

Anahtar kelimeler: Askeri yenilik; Teknolojik ve organizasyon yenilikleri; Askeri yeniliklerin etkinliği; Akıllı alıcı; Kendi kontrolümüzde optimum Ar-Ge faaliyeti; Dış kaynağı akılcı kullanma; Küçük işyeri geliştirme projeleri; Kritik teknoloji; Askeri açıdan kritik teknoloji; Çift amaçlı teknoloji; Çift amaçlı ilişki modelleri; Aktif öğrenme; Soğurma(özümseme) kapasitesi; Temel yetenek.

To All The Persons Who Have Contributed To My Study

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DISCLAIMER

The views expressed in this academic research paper are those of the author and donot reflect the official policy or position.

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CHAPTER 1

INTRODUCTION

As in the civilian sector, military organizations must display the capacity to change in order to meet the dramatically altered international environment and the challenges of tomorrow. Mc Kinsey analysts Richard Foster and Sarah Kaplan claim that businesses that fail to embrace change and fail to evolve with current markets are doomed to failure (Foster & Kaplan, 2001). Similarly, a military that fails to innovate when their contemporaries are innovating is doomed. So the quest for change within militaries is a rational and hopefully encouraged behavior. Then it makes sense to have the most effective changes possible. In militaries, innovation is more constrained. Unlike most business, a military's strategy, operations and tactics are rarely tested in open battle. This means that while businesses compete every day to make a profit, militaries must wait for an international conflict to fine-tune their strategies and see if they work outside the frame of limited exercises.

The military philosopher Friedrich von Bernhardi claims that each war and every military conflict has its own distinct characteristics and that it is vital to understand as many ramifications surrounding the conflict as possible. While it is important to study recent military history and learn from successes and mistakes made in the past, one can be assured that the next conflict will not be the same as the previous conflict (von Bernhardi, 1913). Then it is important to look ahead towards new developments and create new ideas and principles according to the modern requirements to meet future defense challenges. It is very important for a military to move ahead along with change instead of staying in the past.

The factors that contribute to military superiority are numerous: strategic, tactical quality of commander, numerical advantage, changes in technology and correct application of those changes. But, there are few invariants in the nature of war. The object of the war is always to impose one's will upon the enemy and militaries can act either offensively or defensively to do so. The human factor will always play a role in warfare and individuals or groups can be manipulated to influence the course of war. Yet, aside such few invariant, warfare is a constantly changing art. It becomes dangerous to create rules of war from previous battles as opposed to general lessons of war. So the best militaries can do is make educated guesses during the intermediary periods as to what may or may not be successful in future conflicts (von Bernhardi, 1913).

The options open to militaries to evolve and prepare themselves for the future defense challenges are limited: militaries can either change how they do business, organizational innovation, or change what they do business with, technological innovation. The second chapter of the thesis will examine military innovation and efficiency as a base conceptual framework for further discussions of the next chapters. Organizational innovation defines how the military does business. Organizational innovation may not involve any new technology at all. It simply makes the most effective use of what is available. Technological innovation is easy to understand, but difficult to define. The Organization for Economic Cooperation and Development published the Oslo Manual to define innovation for the purposes of collecting data and further study. Technological innovation is defined in two parts: technological product innovation and technological process innovation. Here, I will use the manual’s definition for technological product innovation: “A technologically new product is a product whose technical characteristics or intended uses differ significantly from those of previously produced products. Such innovations can involve radically new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge” (OECD Oslo Manual, 1996). Also, I will consider the introduction of new technology into organizational innovation as a third type of innovation separated purely from organizational innovation. The focus will be on technological innovation, because technological superiority is one of the most important elements of deterrence in peace. Moreover, in crisis, it provides a spectrum of options to the commanders and authorities. In war, it enhances combat effectiveness, economical termination of conflict and reduces the loss of personnel and equipment. It also contributes to the foundation of the industrial base and improves the global commercial competitiveness. Advancement of technology must be seen as a national security imperative.

However, technological innovation is not something to be approached haphazardly and without a strategy, such as pulling the newest weapons and the most popular, jargon riddled organizational concepts off the shelf. Innovation needs to be approached with care and consistency (Gray, 1997). In order to insure technological innovation and meet the future defense challenges, a sound technology investment strategy must be formulated. Achieving an Objective Force that is responsive, deployable, agile, versatile, lethal, survivable, and sustainable will require the military to have science and technology (S&T) capability through its research and development (R&D) and procurement efforts. To achieve a viable competitor status, there are two key prerequisites: the capacity to acquire or develop the necessary technologies, and the flexibility for related institutions and methods to evolve and exploit the potential. In another effort to explain the nature of successful innovation, Dr. A. S. Hashim (Hashim, 1998), expert on Asian military capabilities and defense policies at the center for Naval Analyses in Washington, D.C., acknowledges a widening military gap between the nations of the west and the rest of the world. He contends that technological infrastructure and financial resources as national level are prerequisites to develop the technology, and then flexibility in organizational culture, structure, and doctrine within a country's armed forces themselves. Differences among countries in this technological infrastructure account for their relative ability to understand, incorporate, and effectively exploit given technologies. Such infrastructure includes R&D facilities and resources, material resources, and access to replenishment. Technological infrastructure considers the knowledge base and institutional capacity to further refine the technology. It comprises, at least, military optimum in-house research, academic research (especially basic research), and industrial facilities for scientific and engineering development, advancement, and finally adaptation in the technological field. In this context, I will review the small business innovative research (SBIR) case in some detail, as it provides a useful example for Turkish readers interested in emerging innovative organizations. The third chapter deals with smart management of technology. A strategy built on a foundation of three integrated building blocks will enable the Army to be the effective smart buyer and smart provider. The challenge to such an accomplishment is the realization of S&T goals that are required to support military transformation. The three building blocks are optimal in-house R&D, expanded collaborative efforts, and smart outsourcing. A government that must purchase technology from abroad is arguably less likely to wield it as effectively as the nation that is capable of inventing or manufacturing it, as latter is usually better equipped to understand and further refine technology.

Not surprisingly, the new technology is itself a prerequisite. Certain technologies are at the core of decisive military technological innovation. However, military advantage can not be achieved without possession of the knowledge to use and manipulate it. Therefore, the initial step in innovation is normally to procure the new technology. The fourth chapter is devoted to identifying which technologies harbor the greatest pay off potential. However, a ready solution for the greatest pay off potential technologies is beyond the scope of this thesis. The thesis emphasizes that the right technology must be developed and the correct technology transition must be executed. A brief discussion of critical and revolutionary technologies is given in this chapter.

It is the intention of this work to emphasize the economic growth of our nation by encouraging the development of technologies with potential for use in either the civilian or military applications. Late comers with limited funds for R&D must rely on innovative catching-up strategies. Therefore, the fifth chapter focuses on dual-use technologies and dual-use relationships in terms of technologies, insertion of commercial components and parts, and employment of dual-use production facilities or manufacturing technologies. However, it is also pointed out that unrealistic expectations from private sector to replace government-funded S&T may also be risky, since the technological requirements of commercial and military also continue to diverge. For example, whereas the commercial marketplace may be able to develop dual-use technologies for electronics and specific aircraft parts, it is unlikely to produce the basic methodologies and technologies for radical new developments in military capabilities, such as those represented by stealth and supermaneuverability. Having experience in selected technology area, especially smart persistence should also be taken into consideration. This requires optimal in-house research.

The sixth chapter of the thesis develops a kind of empirical case study analysis based on a rotary-wing upgrade project about the importance of rotary-wing technology system, upgrade, and system integration technology as a core capability using the concepts and framework. The critics to the project will also be discussed. The last chapter concludes with the findings of previous chapters' discussions and policy implications of the study.

CHAPTER 2

MILITARY INNOVATION

2.1. What is Military Innovation?

When we approach innovation from military point of view, innovation is manifested by new war fighting concepts and new means of integration (e.g. Doctrine, tactics, training, and support). In the scope of this study, innovation is meant to include only those new or novel developments that are introduced intentionally and as a result of rational effort, not on accidental discovery or unintentional changes in capability. Military innovation may not require high technology. Some states cannot afford significant investment in high technology. Low-tech expedients may suffice if coupled with creative operational or tactical concepts. Since the nature of war is always changing, it is important to look ahead towards new developments and create new ideas and principles according to modern requirements.

The options open to militaries to evolve and prepare themselves for the next conflict are limited: militaries can either change how they do business or change what they do business with. In this thesis, these options will be called organizational innovation and technological innovation.

Technological innovation is easy to understand, but difficult to define. This thesis will use the manual's definition for technological product innovation: "A technologically new product is a product whose technical characteristics or intended uses differ significantly from those of previously produced products. Such innovations can involve radically new technologies, can be based on combining existing technologies in new uses, or can be derived from the use of new knowledge" (OECD, Oslo Manual, 1996). It is the tank, machine gun, Stealth bomber, Tomahawk missile, and GPS receivers that fascinate the military. In this thesis, technological innovation will be divided into three categories: weapon technology, transportation technology and information technology. Weapon technologies are the actual weapons deployed, whereas transportation technologies are the platforms that weapons are carried on, such as ships, tanks and aircraft. Information technology allows for both information gathering through sensors and satellites and communication through radios, Internet and telephony.

Organizational innovation redefines how the military does its job. Joyce Wycoff defines organizational innovation as intended change. Innovation is a three piece definition: "having a common direction or vision, recognizing and deciding on opportunities related to the vision and intentionally and effectively moving in a direction to achieve the objective" (Wycoff, 2001). Stephen Peter Rosen, professor of National Security and Military Affairs at Harvard, bends this general framework into a military context. He defines a major military innovation as "a change that forces one of the primary combat arms of a service to change its concepts of operations and its relation to other combat arms, and to abandon or downgrade traditional missions. Such innovations involve a new way of war, with new ideas of how the components of the organization relate to each other and to the enemy, and new operational procedures conforming to those ideas. They involve changes in critical tasks, the tasks around which warplans revolve" (Rosen, 1998). Both of these definitions leave open the possibility of introducing new technology as a type of innovation. Organizational innovation as it is defined for the purpose of this thesis will consider the introduction of new technology into organizational innovation as a third type of innovation separated purely from organizational innovation.

In this thesis, an organizational innovation will be defined as an innovation where one of the primary combat arms of a service adopts new ideas about how the components of the organization relate to each other and to the enemy, abandoning or downgrading traditional missions. Organizational innovation involves recognizing and deciding on new critical tasks. Organizational innovation may not involve any new technology at all. It simply makes the most effective use of what is available.

These definitions distinguish between genuinely new war-fighting concepts (e.g. German Blitzkrieg in the 1930s) and new adaptations of established concepts (e.g., the Israeli shift to full combined arms in the 1970s). But, the effective military modernization need not require inventing new ways to wage war. This is well beyond the reach of most militaries, which may prefer established approaches. Maoist infantry tactics illustrate this point in the narrow sense of the word; these were not considered innovative in the late 1960s. But the North Vietnamese Army executed those tactics with the great skill, rendering U.S. airpowers and armored ground fighting relatively ineffective. In this sense, the NVA's use of tactics was innovative.

2.2. Technological Innovation

A military's ability to establish power in an area of operations increases over time and decreases over space, but the amount of power projected can be affected by the introduction of new technologies. It is important to realize what aspect of this time-space-power continuum will affect new technologies. It is a common mistake to misidentify the nature of a new technology. For example, the French saw the tank only as a weapon during the interwar period of the 1920's and 1930's as opposed to a new form of transportation of weapons. Therefore, the French army strove to create tanks with heavy guns and armor. The Germans, however, saw the tank as both a weapon and a new mobile platform and strove to design tanks that were quick maneuverable, and had great range (Corum, 1992). The result of the conflict between the two allies is well known. Pursuing technological innovation is the most common way that militaries try to improve their effectiveness. Having the largest, fastest, most powerful weapon around gives a distinct advantage to the owner. Militaries that focus on this form of innovation are convinced that science holds the answers to any obstacles that are created, if only the right bits of scientific information can be put together.

Technology is only as effective as the person using it. The machine gun proved its destructive power and military value during the Anglo-Zulu wars and again during WWI (Commins, 2001). However, machine guns were devastated and destroyed eight years prior to the Anglo-Zulu wars, during the Franco-Prussian War (1870-1871). There, misdesignated as part of the artillery instead of the infantry, the machine gun failed to aid the French military efforts. The Montigny mitrailleuse, a crank-operated machine gun, was mounted on an artillery carriage and unveiled as the French army’s secret weapon. The French army then reorganized its artillery into regiments of two six-gun batteries and a third battery of ten mitrailleuses. LTC G.S. Hutchinson, Royal Army, claimed that “the organization of the mitrailleuses was equivalent to a reduction of the French Artillery by one third”. At the battles of Wissembourg (4 August 1870) and Spicheren (6 August 1870), the mitrailleuses were destroyed by Prussian artillery before they had a chance to fire, due to their limited range (Ellis, 1975). The machine gun was also falsely identified as an artillery piece during the American Civil War. There, the machine gun was primarily used to guard bridges and other strategic points far from the primary battlefields. This was also partially due to commanding officers’ lack of familiarity with the weapon (Ellis, 1975). The example of the French army shows that technological innovation can encourage detrimental organizational innovation, which contributed to the French loss during the Franco-Prussian War.

New technology alone can only incrementally improve performance on the battlefield, by creating a weapon that shoots farther, flies faster or has more armament. However, new information technology is often useless without a new organization that allows it to be used to its fullest potential. Colonel John Boyd USAF lectured about the decision-making loop. He claimed that “operating at a faster tempo or rhythm than adversaries” would make the faster force “appear ambiguous and thereby generate confusion and disorder among adversaries" (Boyd, 2002). He, then, examined historical examples from the days of antiquity, Napoleonic wars, German blitzkrieg and modern guerrilla campaigns to illustrate his point. If one's decision-making loop could operate more quickly and efficiently than the opponent's, then the opponent would be overwhelmed because of his inability to keep pace with the latest developments in the conflict. If the organization only requires a certain level of information before acting, new information and communication abilities will either be ignored or slow down the decision-making process by contributing to information overload. By coupling a communication and sensing technology with an incompatible organization, one is either slowing down the decision making cycle by overloading the organization or wasting time and money on an unused technology. In a similar vein, new communication and sensing technology is most likely to illuminate the need for and allow new organizational systems to develop. According to Boyd, by having a faster decision making process than the enemy, one could gain a distinct advantage that could overcome several other weaknesses, such as a smaller number of forces (Boyd, 2002). This faster decision-making loop could be one reason that networked terrorist organizations have been so successful recently. By allowing multiple simultaneous decision cycles at once, the enemy is overwhelmed. The point is this: if advanced technology is not necessary to the mission or how the organization operates, it often becomes a liability.

The advantage now lies with the military that learns how to best manipulate technologies to their advantage and organizes themselves to do so. The ability to reorganize and rethink traditional methods of waging offensive and defensive campaigns is going to be the valuable commodity in today's information-driven, technologically rich battlefield. Conflict in the future will prove the axiom that technology is only as good as the man who uses it. Overall, technology in itself is neutral. It is how it is used that makes the difference.

2.3. Organizational Innovation

It is characteristic of the nature of newsworthy events that the introduction of the Stealth bomber and Tomahawk missiles receive so much more public attention than the usage of these weapons more effectively by the military. Nevertheless, technological innovation is easier to understand, visualize and market than organizational innovation. One possible cause of the resistance to organizational innovation could be the poor definition of organizational innovation; the term is applied to every change in the status quo (Wycoff, 2001). Richard Foster and Sarah Kaplan claim that senior leaders often have emotional attachments to projects and programs that they created or that allowed them to excel and are reluctant to see them go (Foster & Kaplan, 2001). It is natural that stakeholders should be somewhat attached to pet projects and programs. The solution is not to criticize the leadership and label them dinosaurs or retrograde thinkers. The solution is to foster an environment where others are encouraged to pursue and develop ideas. When writing about military effectiveness and about dramatic battles, more focus is placed on tactics and operations than on the organizational changes that allowed these new tactics and operations to be fully developed. However, behind every major tactical and operational change was a dramatic organizational change: either a turn-over of leadership, a new branch forming, division or subdivision of current military structures or the recognition of a new role for a certain branch of the military.

Militaries can choose to modernize themselves purely by means of organizational innovation. New war-fighting capabilities were introduced simply by reorganizing the manner in which the forces fought and technology was used. Organizational innovation may not involve any new technology. It simply makes the most effective use of what is available.

Organizational innovation is sometimes considered the “war of the weak” because it is employed by militaries that have no other options in modernizing their forces. Alvin and Heidi Toffler have noted that organizational innovation has become a much less popular option for military innovation since the industrial revolution (Toffler and Toffler, 1980). As such, militaries that innovated in this manner are considered to have been “forced” into a new organization by their limited financial resources or limited personnel to survive.

This chapter also shows the ability of a few well-placed people in the right place at the right time to effect great changes that greatly improve the effectiveness of their forces. What is most impressive about pure organizational innovation is the relatively small amount of time and resources it requires to create effective innovation.

2.4. Organizational and Technological Innovation

It is unlikely that militaries will innovate technological and organizational innovation simultaneously. Usually, one form of innovation will lead the other, the first creating the demand for the second. The combination of organizational and technological innovation can be the most effective form of innovation.

They are emphasizing that militaries must have compatible technological and organizational systems. If the weapon systems developed and acquired by a military cannot be effectively used by the current organization, then the military will not reach its full potential. Likewise, if the organization creates the need for weapons that are not available, it too, is doomed to failure (Millet et ol., 1986). Granted, technology and organization do not always advance at the exactly the same rate, and simultaneously developing the two is an elusive goal. However, an attainable goal is for new technology and new organization to be developed with consideration towards each other. Sometimes militaries advance technologically first, creating new technology and then considering new ways of employing the technology: new tactics, new operations and new strategy. Eventually new technology via the new strategy creates a demand for organizational innovation to become fully effective.

This bottom-up approach is popular in many militaries. For example, at the Battle of Jutland, radio was available on board vessels. However, the torpedomen (electricians) and not the signalmen were responsible for radio operations and even officers specializing in signaling were not trained in use of the radio (Gordon, 1996). Because of this, radio use was sporadic at best and largely ineffective. Eventually the organization caught up with the new technology to employ the radio more effectively in future wars.

Another, more recent example of organizational and technological innovation is recent American operations in Afghanistan. While the WWII era examples focused on using technology to mass personnel and firepower on target, the more modern variations of this type of combined innovation have used technology to distribute forces while still massing firepower on target.

Futurist Toffler claims that USA is currently poised on the cusp between Second Wave and Third Wave civilizations. Second wave civilizations are defined by industrialization, the standardization of products, routines and education and the centralization of power. Third Wave civilizations take advantage of improved information technologies to break down large bureaucracies and disperse information. The ability to communicate over long distances and the gradual shift of the economy from a production-based system to a service-based system allows people to spread out, and become more independent. This lack of proximity to specialists will also prompt the return of “the-jack-of-all-trades” and workers who are skilled in more than one area (Toffler, 1980). In the same manner, modern military operations have followed suit, which is especially clear in Operation Enduring Freedom.

On 7 October 2001, Secretary of Defense Donald Rumsfeld announced the beginning of Operation Enduring Freedom, while US warplanes were attacking key infrastructure and communications nodes. Operation Enduring Freedom began in what political consultant Dick Morris calls the “Clinton Doctrine that kept military efforts airborne and barred the use of ground troops…until after the aerial bombardment had neutralized the enemy." After a few weeks of strategic bombing returned little in the way of new information or concessions by the Al-Qaeda and Taliban leaders, the operation gradually shifted to the "Rumsfeld doctrine". The Rumsfeld doctrine stresses coordination "among native ground power forces, U.S. Special Forces and commandoes, and American air power" (Morris, 2002).

Ground troops working in small units joined forces with Northern Alliance soldiers and participated in small, packetized attacks. The attacks used a strange combination of high tech and low-tech gadgetry. The American forces that rode horses with the Northern Alliance were Army Special Forces, known as green berets. They are organized into twelve man units, with one officer and eleven senior enlisted personnel. Like the Toffler's third wave jack-of-all-trades, members of the green berets are trained in weapons, communications, foreign languages, combat engineering and combat medicine (Tucker, 2002). The Northern Alliance is a closely linked association of several warlords, each of whom commands the loyalty of several thousand guerrilla fighters. The organizational innovation was not in the either the Northern Alliance or the Special Forces community, but in the collaboration between the two. In recent American military engagements, either large numbers of forces were established on the ground in the area of operations (such as Vietnam or the Gulf War) or no forces were established on the ground at all (retaliatory strikes against Iraq and Kosovo). By sending a small number of troops into Afghanistan, the U.S. military struck the balance between having no ground support and supporting a large military operation. Unlike Somalia, American forces were integrated with Afghan forces as opposed to associated with Afghan forces. This integration allowed for the introduction of American technology and air power into many of the Northern Alliance actions and allowed American forces to guide the Northern Alliance in missions that were important to American interests. After three weeks of operations with ground troops, they controlled two thirds of Afghanistan. At the same time, Operation Enduring Freedom has validated the Predator missile, which made news by being the first independently launched (i.e. launched from platform where no human input was possible) missile. On 27 Feb 2002, the Air

Force's Predator unmanned aerial vehicle successfully aimed and fired a Hellfire-C laser guidedmissile at a stationary target and allegedly proved the viability of this option (Baker, 2002). Previously, Unmanned Aerial Vehicles (UAVs) had been used solely for surveillance reasons, due to the desire to maintain a "human in the loop" in stressful situations where experienced pilot judgment might be necessary. These tests came at the urging of CIA officials who were frustrated with the time delay between surveillance taken by the Predators indicating a viable target and the prosecution of said target. Often, this delay meant the loss of targets of opportunity. Other innovative technologies used were laser-guided munitions, heat signature readers, GPS and portable satellite communications (Jane's, 29 April 2002). This is clearly a case of technological innovation leading organizational innovation. The U.S. military was frustrated that their advanced technologies were not yielding the results desired. By allowing the collaboration between U.S. Special Forces and Northern Alliance troops, modern U.S. military technology was more effectively used. Though the Special Operations Forces had been working on the ability to conduct this sort of operation for a while, military doctrine and hence, organization had not allowed it until Operation Enduring Freedom. So far, this seems to be a successful mix of organizational and technological innovation. By successfully integrating small special operations units into indigenous forces and commanding joint air power, the United States has managed to create an organizational innovation that exploits both the most modern technologies and retrograde technology such as cavalry units. This case is a strong indicator that a properly organized force can exploit a wide radius.

What the past few case studies have shown is that a combination of technological and organizational innovation can yield enormous results. By innovating both technologically and organizationally, military incurs greater risk but could also achieve greater results.

2.5. Measurement of Innovative Success

How, then, should innovative success be measured? Do new war-fighting concepts and/or new means of integrating technology guarantee victory? Innovation does not always win wars. Exogenous factors play a central role; e.g., adversarial size, political landscape, economics. Military effectiveness, rather than victory is a more useful measure of innovative success. An effective military is one that derives maximum combat power from available resources context is clearly important to this measure (Millett, 1986). In this thesis, a new technological innovation will be considered effective if it yields more positive results than could have been achieved with older, more traditional technology. A new organization is effective if it yields more results than older organizations had yielded. The German panzer divisions will be considered effective in this thesis because they captured a territory in weeks that Germany had failed to capture in four years during WWI.

2.6. Conclusion

In sum, there is no ultimate weapon or ultimate organization that will successfully respond to every threat in the future. Organizations and technology have to be continually reshaped to meet the new threats as the future unfolds. No new technology or organization will ever be the last weapon needed or the last organizational change made. It was once claimed that the invention of nuclear weapons had obviated the need for any new military technological innovation. However, militaries have evolved and developed new technologies since that time. Once this is acknowledged, one can recognize that constant innovation, both technological and organizational, is required. Militaries seeking innovation should not invest solely in technology, as this approach has been historically disappointing. While organizational innovation has been more successful, it is often resisted by militaries themselves. The most effective innovations are where technology and organization work in tandem. Sometimes technology will unveil the need for new organization and other times new organizations will allow the development of new technology. Each form of innovation should fuel the other, allowing militaries to advance and adapt to the times and to reach their full potential. In any case, to develop technology and to achieve competitor status, the capacity to acquire or develop the necessary technologies and technological infrastructure are national level prerequisites. Therefore the initial step in innovation is to procure technological innovation. In this thesis, I will focus on technological innovation, because technological superiority is one of the most important elements of deterrence in peace. Furthermore, in crisis, it provides a spectrum of options to the commanders and authorities. In war, it enhances combat effectiveness, economical termination of conflict and reduces the loss of personnel and equipment. It also contributes to the foundation of the industrial base and improves the global commercial competitiveness. The first priority for Turkey should be the establishment of an effective national science and technology base for the development of much needed technological capabilities. In order to insure technological capability and to meet national defense needs, a sound technology investment strategy must be formulated, right technology must be developed, and a plan for technology transition must be implemented.

CHAPTER 3

SCIENCE AND TECHNOLOGY MANAGEMENT IN DEFENSE INDUSTRY

The emphasis of quality over quantity as an operational utility has been adopted by the time. In this respect, in order to ensure that the military will meet future defense challenges, a vision for the Army of the 21^{st} century that involves transforming it into an Objective Force that is responsive, deployable, agile, versatile, lethal, survivable, and sustainable is needed. Achieving the Objective Force will require the military to have superior science and technology (S&T) capability through its research and development (R&D) and procurement efforts. With this strategy, science and technology is vital. The science and technology (S&T) programs exploit scientific breakthroughs and develop a credible array of technologically superior options for weapon systems to support any defense posture. They also contribute to the foundation of the industrial base and improve the global competitiveness of commercial products that benefit from the defense R&D.

The quality of the S&T that emerges from in-house research, from collaborative efforts, and from the military's associations with contractors all depends on age-old tenets of open, direct, and unencumbered communications. The key to a coordinated reform effort will be effective communication between the concept and material developers. This includes communication among strategists, Army Scientists and Engineers (S&Es), other executors of the smart-buyer function, program managers, acquisition experts, users, collaborators, and contractors.

In order to insure technological superiority and meet national defense needs, a sound technology investment strategy must be formulated, the right technology must be developed, and a plan for technology transition must be executed.

3.1. Smart Management of Defense Research and Development and Projects

How should the military sustain superior S&T capabilities to support the army transformation? A strategy built on a foundation of three integrated building blocks will enable the Military to be the effective smart buyer and smart provider it must be to achieve the challenging S&T goals required to support the army transformation. The three building blocks are optimal in-house R&D, expanded collaborative efforts, and smart outsourcing. (1) Optimal in-house R&D refers to the pivotal and supportive research performed solely by military S&Es; (2) expanded collaborative efforts refers to the research that army personnel carry out in conjunction with scientists and engineers from one or more non-military organizations; and (3) smart outsourcing refers to the research performed by non-military personnel with army oversight. This integrated foundation enables an enhanced military smart-buyer capability and military access to top-notch S&T (RAND, Arroyo Center, 2000).

In this context, smart –buyer capability refers to only the technological aspect of the smart-buyer function that includes the integrated efforts to many disciplines (e.g., technological, engineering, legal, procurement, management, and funding expertise). Hence, smart-buyer capability is the military's collective technical expertise that helps the concept and material developers conceive, formulate, and execute material programs (RAND, Arroyo Center, 2000). Optimal in-house research combined with collaborative efforts with technological leaders and well-designed, expertly executed outsourcing will also give the military access to top-notch S&T. With these strengths, the army will be well equipped to acquire the advanced technology it needs for a successful transformation.

All military research is performed in one of these three ways. Normally, these three approaches are mutually exclusive in that research performed using one approach is not performed using either of the other two. However, the approaches are also integrated in that they are all mutually supporting components of a whole. Clearly, then, an important decision that faces the military is to determine which technologies should be researched in-house, which are best suited for collaborative efforts, and which should be outsourced.

Technologies highly specific to army are good candidates for doing in-house because they lack sufficient appeal to attract partners from outside the army and also lack the generic applicability desired by such organizations. Analogously, the technologies which have high military utility and high industry appeal and to a lesser extent those which have more moderate military utility and industry appeal are ideal candidates for collaboration. Similarly, technologies which have high industry appeal and relatively lower army utility indicate that the technological leaders in these areas reside in industry (RAND, Arroyo Center, 2000).

3.2. Optimal In-house Research

In-house R&D is research performed solely by military personnel. The majority of this research is performed at military labs by military S&Es. Hence, it is evident that the research they perform contributes directly to the military's smart-buyer capability and absorbing the advanced technology that in defense projects. The military can manipulate this capability by optimally choosing the types and amount of research performed in-house.

To maintain the quality of in-house research, the military, first, must provide opportunities for S&Es to acquire industry experience, perhaps through industry exchange programs and well-designed collaborative efforts. Second, S&Es must be able to devote a portion of their time to hands-on research. S&Es must also be able to acquire the required level of education in their fields.

3.3. Expanded Collaborative Efforts

Downsizing and budgetary decreases, or limited budget combined with the ever-growing need for cutting-edge technologies, will require the military to look to other government labs and the commercial sector to meet its technologies needs. We believe that in some cases, it makes the most sense to gain the technological capability by engaging in well-chosen, well-designed collaborative efforts.

The hallmark of a well-designed collaborative effort is that the collaborating parties make mutual contributions for mutual benefits. Collaborative efforts call for the sharing of intellectual and material resources to achieve common research goals. Collaborative research efforts involve hands-on participation by military S&Es and by scientists from the collaborating organizations in the research activities. For a variety of reasons, collaboration can be preferable to performing the research in-house or outsourcing it. One reason is that collaboration offers advantages to both the Army and its partners, such as the opportunity to leverage resources and to broaden in-house expertise. Moreover, collaboration offers the military the opportunity to access cutting edge skills, technologies, and products that would otherwise be out of research.

Potential collaborative partners may include other military or civilian government labs, as well as university labs, established private corporations, and small start-up and venture capital firms. Each of these potential partners has unique knowledge and skills to share with the military.

3.4. Smart Outsourcing

Despite the increased opportunities and mechanisms for collaboration, some military research does not lend itself to collaboration. In some cases, firms may have attractive technologies but may lack the will or the staffing to collaborative efforts with the military. In others, the military lacks the technical competence to participate with a partner on an equal footing. Finally, the military is a small market with a need for technological competence in some areas that have little or no civilian application. Outsourcing- in particular, smart outsourcing- is the appropriating strategy to supply those needs that cannot be fulfilled in-house or through collaboration.

To date, however, it has been identified several innovative and unconventional element of the smart outsourcing building block. Below we will cover a little bit one of them: the Small Business Innovative Research (SBIR) program. I think it is a good example and Turkey should focus on such examples.

3.4.1. Small business innovative research (SBIR) program of the United States

The purpose is to increase small business involvement in R&D and to attract small businesses that can potentially contribute to achieving the military's S&T goals. For example, SBIR project funding is provided through contracts with short funding cycles and minimal time lapse between proposal submission and funding decisions. These properties can be very appealing to some small businesses, and the military should use this program to attract and introduce innovative companies with promising technologies to working on military research, in particular dual-use technologies. The military should view the SBIR funding period as a time to evaluate the firm's technologies as well as establish with firms that may have much to offer in terms of meeting the military's S&T goals.

At the end of the SBIR funding period, the projects that are still promising can be eased into more long-term arrangements. Although not all SBIR projects can be expected to be candidates for continued military interest, viewing the SBIR program holds more promise than a piecemeal view that tends to result in missed opportunities. They also contribute to the industrial base and commercial competitiveness of country in the long-term.

This variation encourages SBIR awardees to find additional money from sources such as venture capital firms, angel investors, and large companies to augment their interests in small technology companies. Following is information on the Small Business Innovation Research (SBIR) Program, the Defense Advanced Research Projects Agency's (DARPA) SBIR Program specifically in U.S.

The SBIR Program was created by Congress in 1982 to help small businesses more actively participate in federal research and development (R&D). All Federal agencies with an annual extramural R&D budget exceeding $100M are required to participate in the SBIR Program. These agencies currently include:

- Department of Agriculture
- Department of Commerce
- Department of Defense (Office of the Secretary of Defense, Army, Navy, Air Force, DARPA, Missile Defense Agency, and Special Operations Command)
- Department of Education
- Department of Energy
- Department of Health and Human Services
- Department of Transportation
- Environmental Protection Agency
- National Aeronautics and Space Administration
- National Science Foundation

Participating agencies, including DARPA, are required to conduct an SBIR Program by reserving a percentage of their R&D budget to be awarded to small businesses through a three-phase process. Eligible companies must have 500 employees or less, and must be the primary place of employment of the principal investigator.

The Small Business Administration (SBA) is responsible for setting general policy guidelines, as well as coordinating and monitoring the progress of the SBIR Program. The SBA posts a Pre-Solicitation Announcement that contains information which allows extra planning time for SBIR proposal submissions. In addition to opportunities with DARPA, the document contains valuable information on other SBIR programs within the federal government.

The DARPA SBIR Program:

The DARPA SBIR Program operates with an estimated annual budget of $50M. The Department of Defense (DoD) solicits proposals twice a year through the DoD SBIR Program Solicitation. This solicitation, listing the requirements of participating DoD components, is automatically mailed to those on the DoD SBIR Help Desk mailing list. DARPA participates in this solicitation, and does not maintain a separate mailing list. Proposals submitted under the SBIR Program must comply with the specific criteria and requirements as stated in the appropriate DoD Program Solicitation.

DARPA encourages the submission of SBIR proposals whose technology development will support DARPA's mission of advancing state-of-the-art defense technology, and that have a strong likelihood of being successfully marketed in the commercial marketplace.

Objectives of the DARPA SBIR Program include stimulating technological innovation, strengthening the role of small business in meeting DARPA and DoD R&D needs, fostering and encouraging participation by minority and disadvantaged persons in technological innovation, and increasing private sector commercialization of technological advances developed through DARPA and DoD funded research and development.

The three-phase process of the SBIR Program is as follows:

Phase I - Feasibility Study: A small business may submit a Phase I proposal in response to the topics published in an open DoD solicitation. A Phase I SBIR award, to demonstrate the feasibility of a concept, is typically funded at $99,000. Since DARPA favors commercial potential, companies should begin to pursue commitments for follow-on funding during this Phase. The DARPA SBIR Program is quite competitive with approximately one in ten Phase I proposals being funded.

Phase II – Development: Upon successful completion of a Phase I project, the program manager(s) may invite a company to submit a Phase II proposal for consideration. A separate Phase II solicitation is not issued, and unsolicited SBIR proposals are not accepted. A Phase II proposal should be more extensive than the Phase I proposal and should demonstrate the company's potential to render a product or process. A company that demonstrates a potential for follow-on funding may receive a higher score during the Phase II evaluation process. Phase II proposals are funded for approximately two years at $750,000.

Phase III – Commercialization: Phase III, or commercialization, is the ultimate objective of all SBIR initiatives and a critical part of DARPA's SBIR Program. Small firms may reach Phase III through private sector commercialization or by obtaining non-SBIR government follow-on contracts for additional technology development.

3.5. Technology Transition Planning

Doing the right technology is only one-half of the equation. In order for technology to transition, a plan for transition must be developed and implemented. The overall concept for technology transition and the framework in which technology transition planning takes place must be described. The focus is on orderly, phased transitions to give the user the technology option to satisfy part of his needs quickly, at an acceptable risk, in addition to having comprehensive quality technology available. Three aspects necessary for successful technology transition planning are organizational commitment (teamwork), technology availability for transition (timeless), and operational requirements (Prizemieniecki, 1991).

Teamwork among laboratories, program offices, and development planning and engineering organizations, is the key to success in expeditiously transitioning technology into future weapon systems. If all parties are comfortable with the risks involved and are in agreement with the overall technical performance parameters, transition is smooth. In some instances, the special capabilities of the laboratories and the urgency of an operational requirement make it appropriate for the laboratory to develop products for direct delivery to other user. In these cases the laboratory makes an agreement directly with the technology user. This teamwork approach assures technology transition by obtaining user/developer commitment to a transition plan and by completing the technology demonstration on time for a scheduled transition opportunity.

3.6. Conclusion

In order to insure technological superiority and meet national defense needs, a sound technology investment strategy must be formulated, the right technology must be developed, and a plan for technology transition must be executed. Expeditiously transitioning the right technology into our future weapon systems requires regular interaction with operational users as well as teamwork across product divisions, program offices, development planning and engineering organizations, and the laboratories.

How should the military develop and sustain superior S&T capabilities to support the transformation? A strategy built on a foundation of three integrated blocks will enable the military to be the effective smart buyer and access to advanced S&T. These are; optimal in-house R&D, expanded collaborative efforts, and smart outsourcing. All Army research is performed in one of these three ways. Clearly, then, an important decision that faces the Army is to determine which technologies should be researched in-house, which are best suited for collaborative efforts, and which should be outsourced. The objective of any defense S&T program is the continuing discovery, exploitation, demonstration and, rapid transition of technology into quality weapon systems to meet operation needs.

From the point of view of Turkey, I think the first priority is to create the enabling infrastructure (research apparatus, laboratories, expenditures, and infratechnologies) necessary for optimal in-house R&D to foster long-term innovation, smart outsourcing, and to absorb advanced technology in defense projects. The second priority is to build new foundation for innovation that is responsive to technological changes and emerging challenges. One of the endeavors of governments, enterprises and societies of late industrializing countries in their struggle to overcome their usual backward technological economic development is to build capable institutions and create the type of environment that induces active learning that focuses on the mastering and improving of the absorbed technologies to create an active learning system. The expanded collaborative efforts should be based on partnerships among academia, industry and military. The goals should catalyze partnership for innovation that will enable the transformation of knowledge created by the national research and education enterprise into innovation. I think Small Business Innovative Research Program is the vital innovative element of smart outsourcing for increasing small business involvement in R&D, to stimulate technological innovation, to strengthen the role of small business, to attract small businesses that can potentially contribute to achieving the military's S&T goals and to the industrial base and commercial competitiveness of country in the long-term. Such an approach will contribute to developing the foundations needed to support a technology driven transformation, including a skilled technical work force research and development base, and available investment capital. Overall, learning, absorption, and incremental innovation should be the main focuses. We should focus on the militarily critical technologies that will provide maximum war fighting capability for money invested and improve the commercial competitiveness, which brings us to the identification of militarily critical technologies and dual-use technologies. Selecting the right technology, instead of just following the fashion is crucial. The next two chapters will deal with these issues.

CHAPTER 4

CRITICAL TECHNOLOGY

The aim in this chapter is to provide information on the direction of future science and technology research and education in response to the projected critical technology needs for national defense. Discussion covers twenty critical defense technologies which have been identified by comparing the 1990 Department of Defense (DOD) Critical Technologies Plan submitted and the 2001 Department of Defense (DOD) Militarily Critical Technologies List (MCTL). It is expected to address the needs of senior managers in charge of science and technology programs, as well as for those who direct the development of weapon systems.

4.1. Why Look Ahead?

Envisioning the future helps to understand the contribution of science and technology to meeting future needs. It may provide:

- Solving societal problems with science and technology,
- Anticipating ethically or environmentally objectionable outcomes,
- Help to manage the allocation of limited resources,
- Determine when a nation should seek to cooperate internationally or when government industry partnering is appropriate,
- Identify national or regional strengths,
- Help to contribute to the foundation of the industrial base and improve the competitiveness of commercial products,
- Determine critical technologies that has defense and commercial potentials,
- Insure technological superiority and meet national defense needs.

The objective is to bring information to the technology management process that attempts to reduce some of the uncertainty about future developments and to understand potential future impacts. We look ahead to predict the future characteristics of useful machines, procedures or techniques and to set the tasks which emerge in connection with medium and long-range planning.

4.2 What is Critical Technology?

"Critical" materials-resources without which the military forces of a nation would cease to function effectively- has long been a factor in the thinking of strategic planners in the industrial age. As the focus on sources of military advantage has shifted to more-technical realms, certain technologies have come to be identified as "critical" in the same sense. Beginning in the 1980s, the term "critical technology" began to be applied to the civilian industrial arena as well. The technological sources of the material wealth of modern industrial economies are becoming paramount. Further, the increasing concern during the 1970s and 1980s with competitiveness between trading nations added an apparently rivalries element, viewed by many as not unlike a military effort.

In the modern age, assessing the status of the nation's technology base and considering the issues that relate to its well-being have been important concern. To be successful and meaningful, any such effort would need to be conducted in a symbiotic relationship with the private sector, where technological capabilities are developed and employed. Precisely because of the multiplicity of goals and purposes that makes the critical technologies issue far more complex in the civilian sector than in the military raising questions and seeking answers must be conducted as a conversation between private-and public-sector institutions- as well as with those in universities who have addressed these issues.

After all these discussion, it is possible to identify several different meanings of the term implicit in its use (Popper et ol., 1998).

- Technology which is the “state-of-the art” or “high technology”,
- Technology which is a component of national self-sufficient,
- Scientific or technical capabilities that are the “pace setter” for other applications,
- Capabilities or tools that are generic or pre-competitive and therefore, contribute to many fields.

Though similar in their goal of identifying technologies important to the future, each country undertaking a forecasting or technology identification exercise has crafted its own approach to defining and identifying critical technologies. Each of these national efforts reflects the system of innovation and technology development in that country. Criteria for listing technologies cross a range of factors (RAND, 1998).

- Economic benefits sought (i.e., contributes to industrial competitiveness, essential for future innovation, support a rapidly developing sector, improves foreign exchange),
- Scientific benefits expected (i.e., improves the builds the national science base, builds generic technology capabilities),
- Social benefits needed (i.e., improves the environment, builds human capital, contributes to health and safety),
- National security imperative.

4.3. The Characteristics of Contemporary Critical Technologies?

Beyond the agricultural and industrial revolutions of the past, life in 2015 will be revolutionized by the growing effect of multidisciplinary technology across all dimensions of life: social, economic, political, and personal. But, the actual realization of these possibilities will depend on a number of factors, including local acceptance of technological change, levels of technology and infrastructure investments, market drivers and limitations, and technology breakthrough and advancements. Since these factors vary across the globe, the implementation and effects of technology will also vary, especially in developing countries.

Some of advanced technologies are listed as critical for national development: Information technologies, Biotechnology, Advanced Materials, and Nanotechnology. These are revolutionary new technologies whose potential for changing the fundamentals of economic life are such that no country can afford to ignore them (Miller, 1992). Typically, they will be based on scientific discoveries, possibly carried out by pure scientists in non-industrial settings, for example "basic research" in universities and specialized laboratories. In particular, we see that the important development in these technologies is the ability to control phenomena at incredibly detailed levels, the bit of information, the gene, and the atom in a new material.

Some have predicted that whereas the 20th century was dominated by advances in chemistry and physics, the 21st century will be dominated by advances in biotechnology. We appear to be on the verge of understanding, reading and controlling the genetic coding of living things, affording us revolutionary control of biological organism and their deficiencies. Other advances in biomedical engineering, therapeutics, and drug development hold promises for a wide range of applications and improvements.

On another front, "the emerging fields of nanoscience and nanoengineering are leading to unprecedented understanding and control over the fundamental building blocks of all physical things. These developments are likely to change the way almost everything—from vaccines to computers to automobile tires to objects not yet imagined- is designed and made.

In a third area, materials science and engineering is poised to provide critical inputs to both of these areas as well as creating trends of its own. For example, the cross-disciplinary fields of biomaterials and nanomaterials are making promising developments. Moreover, interdisciplinary materials research will likely continue to yield materials with improved properties for applications that are both commonplace (such as building construction) and specialized (such as reconnaissance and surveillance, or aircraft and space systems).

Although the examination of trends can yield a broad understanding of current directions, it will not include unforeseen technological breakthroughs. Unforeseen complex economic, social, ethical, and political effects on technological development will also have a major effect on what actually happens in the future. For example, although many computer scientists and visionary government program managers saw the potential for the Internet technology, it was practically impossible to predict whether it would become globally significant, the pace of its adoption, or its pervasive effect on social, political, and economic systems. Nevertheless, this trend study can yield a broad understanding of current issues and their potential future effects, informing policy, investment, legal, ethical, national security, and intelligence decisions today.

4.4. Critical Technologies of National Importance

This section provides views on critical technologies that may yield public benefits, and that are critical to the nation. On national-level, critical technologies are those that are seen to make critical contributions in the domains of national security, health and the environment, transportation, education, and economic growth. The National Critical Technologies fall into six broad areas (Przemieniecki, 1991):

Materials with properties that promise significant improvements in the performance of items produced and used by every sector of the economy.

- Materials synthesis and processing,

- Electronics and photonic materials,
- Ceramics,
- Composites,
- High-performance metals and alloys.

Manufacturing processes and technologies that can provide the basis for industry to bring a stream of innovative, cost-competitive, high-quality products into the marketplace.

- Flexible computer integrated manufacturing,
- Intelligent processing equipment,
- Micro-and nanofabrication,
- Systems management technologies.

Information and Communications technologies which continue to evolve at a breath-taking pace, permanently changing our approaches to communication, education, and manufacturing.

- Software,
- Microelectronics and optoelectronics,
- High-performance computing and networking,
- High-definition imaging and displays,
- Sensors and signal processing,
- Data storage and peripherals,
- Computer simulation and modeling.

Biotechnology and Life Sciences advances that will permit unconventional approaches to major problems in such diverse fields as medicine, agriculture, manufacturing, and the environment.

- Applied molecular biology,
- Medical technology.

Aeronautics and Surface Transportation systems that enhance our civilians and military capabilities and increase the ease and safety of travel.

- Aeronautics,
- Surface transportation technologies.

Energy and Environment related technologies which have the potential to provide safe, secure, and enduring sources of energy and ensure that a healthy environment is preserved for the use of future generations.

- Energy technologies,
- Pollution minimization, remediation, and waste management.

4.4.1. National security

More than perhaps any other factor, technology is widely seen to be the key enabler of military capability. The implication of this is that the civil technology base will increasingly become the primary strategic resources in the context of military as well as economic security. If the countries with accumulated strength in civil markets develop more effective institutional mechanisms for transferring technology between civil and military activities, they could in time challenge the established military industrial powers. Countries that today have large commitments to defense R&D are faced with a shrinking market which has become a relatively inefficient developer and user of technology. Unless the balance of resources is successfully shifted in favor of civil activities, a loss of industrial output and technological capability will result along with a weakening of firm previously propped up by defense spending.

Another conception of criticality in national security terms involves energy-related technologies; energy-conversion and energy-storage technologies. We can look at energy prices to increase and energy resources to decrease. Thus, this is not only an economic security issue, but also a national security issue.

4.4.2. Health and environment related technologies

These technologies encompass a range of activities and products from biological and medical research, to genomics and biomaterials, to medical devices, food, nutrition, to waste management and recycling.

Among the health-related critical technologies are again biotechnology (genomic technologies), technologies for preventive medicine and diagnosis. Imaging and other information sciences applications, food and nutrition, implants of medical device, and tissue engineering. Among the environmental-related critical technologies are waste-management, and recycling technologies.

4.4.3. Transportation related technologies

Changes in the basic technologies of transportation, furthermore, are seen to have widespread implications for energy needs and related industries. Among the technologies that are seen to be critical in this area are:

- high-speed ground transportation and mass transportation,
- embedded information systems for real-time control and communications in transportation, which can greatly increase its efficiency,
- telecommuting, which can obviate the need for physical commuting.

4.4.4. Economic growth

Technology has been the critical factor in the long-term economic growth of modern industrial societies. The rate of technological advance is widely viewed as a key factor in both productivity increases and economic growth. In fact, the most common criterion is its potential contribution to economic growth or competitiveness. In the same way that the Japanese do, the state should recognize that the economy today is its battlefield, and national security stems from economic security. In order to prepare Turkey for a secure future, there is a need to have a stabilized economy. Our warriors should be business enterprises. The government really needs to consider technology as their new military endeavor as the new foundation for security heading into the 21st century. What the government needs to do is to use the same discipline as used in the military in war.

In general, the technology’s contributions to the nation’s economic welfare are:

- Technological leadership conferring economic leadership,
- Technology conferring high productivity and employment.

Technology leadership provides continuing economic strength and a positive feedback that could confer long-term benefits to the societies and create technological breakthrough. The technologies that are identified as having a major effect on the economic growth of the nation, or that are seen as keys to future competitiveness are:

- Manufacturing, and industrial-efficiency technologies, including robotics, computers, and sensors,
- Computer-based and other technologies that can speed up the transition of technical concepts to commercially available capabilities, from design and

product engineering through manufacturing, distribution, and life-cycle management,

- Scale-reducing technologies that also reduce barriers to entry and exit, and facilitate scale-up manufacturing processes,
- Information technologies and software that will foster telecommuting, education and training, and other activities,
- New-material processing technologies,
- Electronics technologies (integrated circuits with higher speeds),
- Those that can foster energy independence,
- New manufacturing technologies.

4.5. Military Critical Technologies

These technologies represent a judgment as to the most important weapon-related technologies which support the long term military goals and are used to design the defense science and technology investment strategy for the future.

4.5.1. Military goals

The military goals can be divided into three categories: (A) deterrence, (B) military superiority, and (C) affordability, as shown below (Przemieniecki, 1991).

4.5.1.1. Deterrence goals

Goal 1: Weapon system that can locate, identify, track, and target strategically relocatable targets.

Goal 2: Worldwide, all-weather force projection capability to conduct limited warfare operations (including special operations forces and low intensity conflict) without the requirement for main operating bases, including a rapid deployment force that is logistically independent for 30 days.

Goal 3: Defense against ballistic missiles of all ranges through non-nuclear methods and in compliance with all existing treaties.

4.5.1.2. Military superiority goals

Goal 1: Affordable on-demand launch and orbit transfer capabilities for space-deployed assets with robust, survivable command and control links.

Goal 2: Substantial submarine warfare advantages.

Goal 3: Worldwide, instantaneous, secure, survivable, and robust command, control, communications, and intelligence (C3I) capabilities within 20 years, to include: (a) on-demand surveillance of selected geographical areas; (b) real-time information transfer to command and control authority; and (c) responsive, secure communications from decision makers for operational implementation.

Goal 4: Weapon systems and platforms that deny enemy targeting and allow penetration of enemy defenses by taking full advantage of signature management and electronic warfare.

Goal 5: Enhanced, affordable close combat and air defense systems to overmatch threat systems.

Goal 6: Affordable “brilliant weapons” which can autonomously acquire, classify, track, and destroy a broad spectrum of targets (hard fixed, hard mobile, communication modes, etc.).

4.5.1.3. Affordability goals

Goal 1: Operations and support resource requirements reduced by 50 percent without impairing combat capability.

Goal 2: Manpower requirements reduced for a given military capability

Goal 3: Enhanced affordability, producibility, and availability of future weapon systems.

4.5.2. Technology thrusts

The demands being placed on the S&T program by the users' most pressing military and operational requirements are (Przemienecki, 1991):

1. Global Surveillance and Communications
2. Precision Strike
3. Air Superiority and Defense
4. Sea Control and Undersea Superiority
5. Advanced land Combat
6. Synthetic Environments
7. Technology for Affordability

4.5.3. Defense critical technologies

Military Critical Technologies are essential to ensure technological superiority which is a fundamental element of military power. It should, however, be pointed out that the advanced technology by itself does not equate to military power which can only be achieved by the capabilities of industry to translate advances in critical technologies into affordable, high-quality, high-performance military systems. Therefore the development of these capabilities must remain an important national priority.

The U.S. Department of Defense (DOD) Militarily Critical Technologies List (MCTL) is a product of the militarily critical technologies program (MCTP) process (http://www.dtic.mil/mtcl). This process provides a systematic, ongoing assessment and analysis of technologies to determine those that are critical to military forces. It assigns values and parameters to the technologies and covers the worldwide technology spectrum... Thus the list is a detailed reference to start with. Technologies are selected for the MCTL through the deliberation and consensus of Technology Working Group (TWGs). TWG chairpersons continually screen technologies and nominate items to be added to or removed from the MCTL. Working within an informal structure, TWG members who come from government, industry, and academia strive to produce precise and objective analyses across the technology areas. The MCTL contains:

- Weapons Systems Technologies; which details critical technologies with performance parameters that are at or above the minimum level necessary to ensure continuing superior performance of systems used by the military and supporting entities (http://www.dtic.mil/mtcl):

1. Aeronautics System Technology
2. Armaments and Energetic Materials Technology
3. Chemical and Biological Systems Technology
4. Directed and Kinetic Energy Systems Technology
5. Electronics Technology
6. Ground Systems Technology
7. Guidance, Navigations, and Vehicle Control Technology
8. Information Systems Technology
9. Information Warfare Technology
10. Manufacturing and Fabrication Technology

11. Materials Technology

12. Marine Systems Technology

13. Nuclear Systems Technology

14. Power Systems Technology

15. Sensors and Lasers Technology

16. Signature Control Technology

17. Space Systems Technology

18. Weapons Effects and Countermeasures Technology

- Developing Critical Technologies; which lists technologies that will produce increasingly superior performance of military systems or maintain a superior capability more affordably. It focuses on worldwide technologies that will become available in the future (http://www.dtic.mil/mtcl) :

1- Aeronautics

2- Armament and Energetic Materials

3- Biological Technology

4- Biomedical Technology

5- Chemical Technology

6- Directed and Kinetic Energy Technology

7- Energy Systems Technology

8- Electronics Technology

9- Ground Systems Technology

10- Information Systems Technology

11- Lasers and Optics Technology

12- Manufacturing and Fabrication Technology

13- Marine Systems Technology

14- Materials and Processing Technology

15- Nuclear Technology

16- Positioning, Navigation, and Time Technology

17- Sensors Technology

18- Signature Control Technology

19- Space Systems Technology

20- Weapons Effects Technology

4.6. How Business Views Technology and Its Critically?

The discussion in this section is based on an interview in U.S. in 1995; the U.S. federal government has sponsored reports at regular intervals to identify critical technologies. Most recently, the White House Office of Science and Technology Policy turned to the RAND Corporation to help define critical technologies from an industry perspective:

The presidents, CEOs, and Chief Technology Officers from 39 firms representing a cross section of industries were asked, “What technologies are critical to your firm/industry?” Responses to the question fell across a wide spectrum yet had certain striking regularities (RAND, 1998).

Many of the interviews explicitly commented that they needed to restate the concept in the terms they are more used to dealing with-most often “core” or “enabling” or “value-adding” or “distinguishing” technologies. Illustrating that few technologies are, by themselves, viewed as critical. Those technologies from which high economic value flow, either in the production of these technologies and subsequent sale, or in the application of these technologies. The issue is not technology but technology- in use, and its use is to serve business purposes. Technologies are employed within a context and toward ends that alone raise their importance and value. Many firms stated their position on technology. They think of critical technologies as having three possible meanings:

1. The base technology- the know-how that the company needs in order to stay in business.
2. Pacing technology- essentials that give the firm an edge among the competition; and,
3. Radical, new technology- innovation that places a firm on a different footing from others in the industry puts them way ahead.

Generally, only the smaller firms were looking for breakthrough technologies. Most firms were centering technology plans on widening the gap with competitors, creating a competitive advantage, and seeking means that would make them distinctive. But the common denominator across these variations on the theme of critical technology is to think of value creation- on company terms. What dominate industry thinking about technology are sources of competitive advantage. Most often, the interviews suggested a view of technology as either a cost-reducing mechanism within a larger business process or a means of providing advantage by conferring new capabilities and functionality.

The main technology areas and the first three for each are listed below (RAND, 1995):

1. Energy

- Storage, conditioning, distributing, transmission
- Generation
- Energy efficiency

2. Information and communication

- Software, toolkits
- Communication
- Sensors, components

3. Manufacturing

- Discrete product manufacturing
- Micro-Nanofabrication
- Continuous materials processing

4. Materials

- Polymers
- Composites, Ceramic
- Structures

5. Living systems

- Biotechnology
- Medical technology
- Agriculture, food technology

6. Transportation

- Avionics-controls
- Propulsion& power
- Aerodynamics

7. Environmental Quality

- Monitoring
- Pollution control
- Restoration, remediation

4.7. Conclusion

Rather than providing a long detailed look, a brief description of critical technologies with potentially significant effects are provided. On the nation-level, critical technologies are those that are seen to make critical contributions in the domains of national security, health, the environment, transportation, education and economic growth. Criteria for listing such technologies cross a range of factors; economic benefits sought, scientific benefits expected, social benefits needed, and national security imperative. Some of the advanced technologies are revolutionary. New technologies whose potential for changing the fundamentals of economic life and national security are such that no country can afford to ignore them. These are Information Technologies, Biotechnologies, Advanced Materials and Nanotechnology, and these are critical for national development and national security.

The following important step is to identify a definition of what is critical and to determine those that are critical to military forces. The military critical technologies program process should provide a systematic, ongoing assessment and analysis of technologies, and screen technologies continually and nominate items to be added to or removed from the list. Thus, the process must be flexible to accommodate the changing needs. First, the program should represent the assessment of the demands, technology thrusts, being placed on the S&T program by the user's most pressing military and operational requirements. As national security requirements, operational needs, and technology evolve, additional thrusts can be added and existing thrusts can be modified. Second, the program should assign values and parameters to the technologies and cover the worldwide technology spectrum to determine military critical technologies. Third, the program should identify key technology areas (each key technology area supports one or more technology thrusts) which are essential for achieving the goals and objectives of the technology thrusts. Finally, the program should prioritize technology needs and opportunities based upon their potential to provide critical battlefield capabilities.

In short, the military critical technologies program should identify and focuses on selected critical technologies that will provide the maximum war fighting capability for the money invested, and contribute industrial base. Therefore, advancement and protection of the right technology must be a national security obligation. This demands a significant dual commitment to in-house army applied research and to the expansion of cooperative efforts with the other services, academia and industry. Civil and military R&D policies will need to be more closely harmonized than in the past.

The critical technologies and their priorities will naturally change in the future. Generally, the identified critical technologies are intended to implement major long term goals derived from requirements statements of needed military capabilities 15 to 20 years in the future. These technologies represent a judgment as to the 20 most important weapon-related technologies which support the long term military goals and are used to design the defense science and technology investment strategy for the future.

CHAPTER 5

DUAL-USE TECHNOLOGIES AND RELATIONSHIPS

The link between economic growth, competitiveness and technological development is a major research topic. In this chapter, the development technologies with potential for use in either the civilian or military sectors or the dual-use relationships between the government and the private sector firms is taken up. Our discussion of dual-use technologies begins with its definition as those technologies which have both commercial and military use (Alic, 1992).

What is a Dual Use Technology? It is a technology that has both military utility and sufficient commercial potential to support a viable industrial base. The objectives are to partner with industry to fund the development of dual use technologies needed to maintain technological capability on the battlefield and for industry to remain competitive in the marketplace (http://www.dtic.mil/dust/faq.htm).

5.1. The Promise of Civil-Military Integration

After World War II, the Military's unique regulatory and oversight requirements, combined with its specialized and highly demanding military technology needs, led progressively to the emergence of two separate industrial bases, one for military research and development (R&D) and production, and one for the civilian market. Throughout much of the Cold War, the most advanced technology developments in many areas arose in the highly regulated military R&D sector. Beginning in the 1970s, however, civilian technology in electronics and other areas began overtaking and even surpassing developments in military R&D. In the 1980s, there was a growing interest in developing strategies for more effectively exploiting commercially developed technologies for defense applications. By the mid-1990s, the problems of declining defense budgets and growing weapon system procurement costs combined with these technology trends to lead some officials in government and industry to advocate the integration of military and civilian industrial bases, a concept commonly referred to as Civil-Military Integration (CMI), (Lorell, 2000).

According to its advocates, CMI concept would (Lorell, 2000);

- Reduce costs of acquiring and supporting weapon systems,
- Improve performance at Initial Operational Capability and throughout the life cycle of a weapon system.
- Shorten development times.
- Improve reliability and maintainability.
- Help to maintain the defense-relevant portion of the industrial base.

The advocates of CMI base their arguments on two sorts of assumptions. First, they assume that there is an extensive “dual-use” overlap between commercial and military process and product technologies. Second, they believe that military, in the context of the incentives and constraints provided by a more commercial –like market structure, will spur the development of high-performance weapon systems at lower costs than can be achieved under the current heavily regulated military acquisition process (Lorell, 2000).

Critiques respond that even extensive acquisition reform will not result in the benefits promised by advocates of CMI. They argue that, in fact, there is little dual-use overlap between civilian and military products and processes in many crucial technology areas, so that integration of the defense and commercial industrial bases is simply not possible. They who critics also believe that without regulatory safeguards, competitive incentives and constraints will be inadequate to access to high-performance weapon system at a reasonable price. They argue that a specialized cadre of defense-oriented firms operating under close governmental supervision is the best solution. Further, even those who believe in the basic promise of CMI have concerns about the effectiveness of its implementation. One worry is that acquisition personnel may not receive adequate training and support to make the often-difficult decisions required of them in a commercial- like environment. For example, managers may find it difficult to separate “must-have” system requirements from those that are only “nice to have” so that appropriate cost performance tradeoffs are not made. They may also be reluctant to surrender control over weapon system configuration to contractors, but their failure to do so would reduce contractors’ ability to make the changes necessary to provide many of the benefits promised by CMI (Lorell, 2000).

Is the civilian market driving technology at a rate and in a direction that meets national security requirements? Can CMI provide the necessary and desired performance capabilities?

First of all, we should identify candidate technology areas to examine the dual-use applicability of commercial technologies and potential relationships between government and industry. For example, the U.S. administration provided close to $1 billion per year from 1993 to 1995 for its dual-use technology initiatives to encourage an increase in the overlap between defense and commercial production and promote the development of dual-use technology. The program defines dual-use as broadly encompassing products, services, standards, processes, and acquisition practices that are capable of meeting requirements for military and nonmilitary applications. It provides funding to overcome perceived barriers to dual-use production, including lack of access to capital, high risks, and onerous federal regulations governing contractual requirements. According to the findings based on the interview with the firms, firms fell into two groups: (1) they make products for both commercial and defense aerospace or (2) they make products for nonaerospace commercial applications in addition to producing for defense and commercial aerospace industry. The electronics and materials firms (they already had commercial experience and demand for high-tech was strong) were more successful than machine shops and aircraft parts firms(a cost structure and machines that do not lend themselves easily to more competitive and larger volume applications, lack of knowledge of commercial market and no commercial experience). Avionics, because of its growing importance and cost for combat aircraft, and because the size and vitality of the nonmilitary electronics market should provide ample opportunities for CMI (RAND, 1998).

5.2. Dual-use Technologies: Implications for Cost, Schedule, and Contractor Configuration Control

Possibly the single most important claim of CMI advocates is that closer integration of the military and commercial industrial bases will lead to significantly lower-cost weapon systems that will be developed more quickly (Lorell, 2000). Chastely, this is an assertion that needs case studies to decide whether equal or better performance is obtainable through the use of commercially derived parts and technologies in military systems. Here, I provide some examples, but a detailed study is well beyond the scope of the thesis. An examination of the cases provided in the chapter indicates that risks are incurred in moving toward a full-blown CMI strategy, particularly with respect to durability and reliability. These risks are at least partially offset by the promise of much reduced weapon system costs. The uses of commercial-grade parts will probably increase dramatically even without a CMI strategy. The market for these technologies is already driven by such commercial products as wireless communications, television broadcasting hardware, and automotive sensors, where production may reach millions of units. Military demand is comparatively so much smaller that often only dual-use components will be available. Using the civilian industrial base is, thus, an important national priority.

In addition, to help the military continue to exploit leading-edge technologies, use of the civilian industrial base can substantially cut costs. Reducing the use of military-specification (Mil-Spec) parts is a major source of savings. Mil-Spec parts are more expensive than similar civilian products, and generally slower to procure. The additional costs come from two primary sources. First, Mil-Spec parts are often produced in much smaller lots, resulting in higher unit prices. Second, even when Mil-Spec parts are manufactured on the same line as commercial equivalents, they are rigorously screened to ensure reliability, durability, and consistently high-level performance (Lorell, 2000).

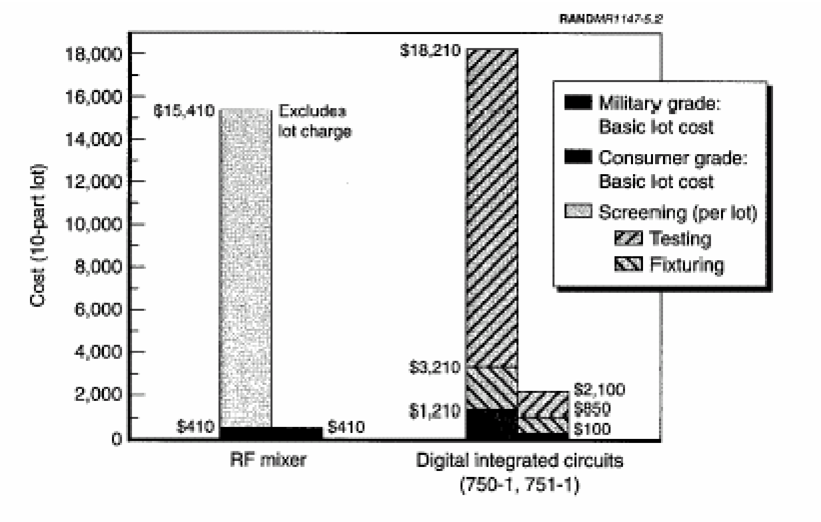


Figure 1- Large Cost Premiums Are Paid for Mil-Spec Parts Screening

Source: RAND

U.S. Wright Laboratory has sponsored various radar technology demonstration and pilot programs that encourage the incorporation of commercial technologies and techniques into military aircraft radars. Two such programs are the advanced low cost aperture radar program (ALCAR) and the radar system aperture technology program (RSAT). One purpose of these two programs is to promote the development of much lower-cost technologies for phased- array fire-control radars. The participating contractors have examined a wide variety of strategies to reduce costs while maintaining system performance. These strategies include assessment of different technical approaches based on commercially developed technologies “Dual Use Technologies” (Lorell, 2000).

As mentioned above, a key cost driver in new-generation fire-control radars is the high cost of transmit/received (T/R) modules for electronically scanned antenna array. Pilot programs are examining different techniques and design approaches to solving this problem. On the RSAT program, Raytheon has developed a completely new low-cost antenna architecture and technology that was originally developed for commercial applications. Another approach examined by Northrop Grumman for a low-cost ESA was to exploit rapidly evolving commercial technology developments in MPMs to develop a lower-cost MPM-based transmitter as an alternative to expensive solid-state transmitter or low-reliability traditional traveling wave tubes. As a result of such efforts, the cost of military T/R modules has declined dramatically since the beginning of the 1990s.

Two other examples are of particular interest in regard to T/R modules. In one case, a contractor's military division worked closely with an automotive commercial electronics division to improve manufacturability and yield. As a direct result of the interaction with the high-volume commercial electronics division, the military division redesigned its T/R module to reduce the number of wire bonds, decrease the number of chips on a single substrate, and separated the GaAs and Si chips onto separate substrates.

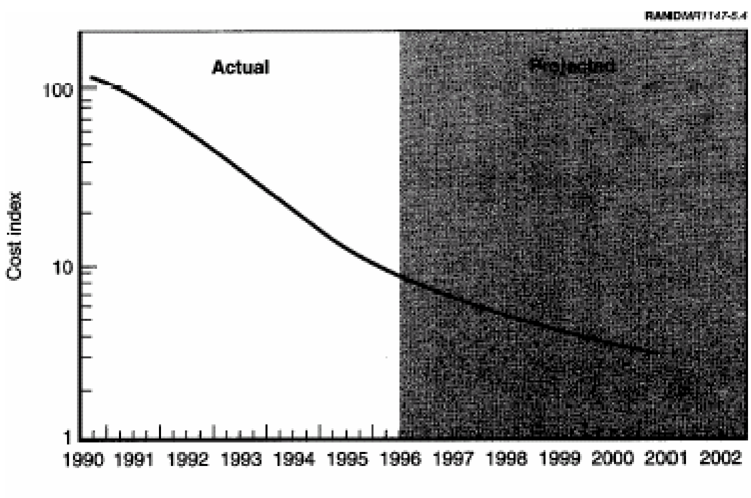


Figure 2- Typical T/R Module Cost History and Projection

Source: RAND

In another instance, a defense division, after interacting with a commercial electronics division, decided to adopt "flip chip" technology for military high-power microwave applications. This technology is common in the consumer electronics world in various straight digital logic applications, but had not been used before in military microwave applications. The advantage of attempting to apply commercial flip chip technology to microwave applications was an increase in the thickness of the chip and elimination of wire bonding to permit manufacture on high-speed automated equipment and to increase yield and reliability (Lorell, 2000).

Similar savings were found in developing modules for fighter and helicopter communication, navigation, and identification (CNI) systems. After maximum insertion of commercial parts, the modules are estimated to cost only about 60 percent of the original baseline cost protection. Cost would probably be even lower if the modules had been designed from the start to use non-Mil-Spec parts. Only 10 percent of the module's components remain Mil-Spec, but they account for 50 percent of its cost (http://www.rand.org/paf/highlights01/civilian2.html).

More broadly, systematic use of commercial parts, technologies, and processes is likely to reduce the cost of typical avionics modules by 20 to 50 percent and also to shorten R&D schedules. But two important caveats are:

- Civilian contractors may need authority to make changes throughout the system's life. This helps to achieve the right component mix and avoid dependence on obsolete (and paradoxically expensive) parts in a world of very short product life-cycles. It can also motivate contractors to continuously insert the more effective, lower-cost technologies that inevitably emerge.
- Concerns remain about the log-term reliability and durability of systems that include non-Mil-Spec components. Early evidence is mostly encouraging, but such hybrid systems require continued testing for long-term resistance to the extremes presented by military environments.

The cases related here are just a few examples among many. As a result of analysis of the case study evidence, we can conclude that: The systematic insertion of commercial parts, technologies, and manufacturing processes, combined with dual-use automated manufacturing, is likely to reduce the costs of typical military avionics modules by roughly 20 to 50 percent, and to shorten R&D schedules. Cost-saving potentials appear to be greater in digital avionics than in high-end RF/microwave applications, but this may change as commercial microwave applications more widespread (Lorell, 2000).

In sum, many factors are responsible for these enormous decreases in average unit cost, including increased automation in assembly, reduced MMIC costs, new technology insertion, and greater use of commercial parts and technologies. For example, costs have been reduced through insertion of commercially developed parts into T/R modules such as low-noise amplifiers drawn from direct broadcast television systems. Closer adherence to commercial design rule practices have contributed to cost reductions. Insertion of new technologies developed for dual-use applications, such as aluminum nitrate substrates and silicon germanium wafer processing, have helped to bring costs down.

5.3. Dual-use Technologies: Comparison of the Critical Technologies

Comparison of the National Critical Technologies, the Commercial Emerging Technologies, and the Militarily Critical Technologies in Table 5.1 demonstrates the substantial degree of overlap that exists between those technologies essential for national security and those that contribute to economic competitiveness (Przemieniecki, 1991). Most of the defense technologies are “dual-use” in nature, and potentially are as important for their nondefense applications as they are to military applications. The critical technologies which are dual-use in nature should receive appropriate emphasis within the military science and technology program. The technologies with potential for use in either the civilian or military sectors are being listed here.

Table 1: Comparison of National Critical Technologies with Department of Commerce Emerging Technologies and Department of Defense Critical Technologies:

Critical technologies	National critical	Commercial critical	Military critical
Materials			
Materials synthesis and processing	+		
Electronic and photonic materials	+		
Ceramics	+		
Composites	+		+
High-performance metals and alloys	+		
Advanced materials		+	
Semiconductor materials and microelectronic circuits		+	+
Superconductors		+	+
Manufacturing			
Flexible computer integrated manufacturing	+	+	
Intelligent processing	+		
Micro and nano-fabrication	+		
System management technologies	+		
Machine intelligence and robotics			+
Artificial intelligence		+	

Information and Communication			
Software	+		+
Microelectronics and optoelectronics	+	+	
High-performance computing and networking	+	+	
High-definition imaging and displays	+	+	
Sensors and signal processing	+	+	+
Data storage and peripherals	+	+	+
Computer simulation and modeling	+		+
Advanced semiconductor devices		+	+
Optoelectronics	+	+	
Digital imaging	+	+	
Sensor technology	+	+	+
High-density data storage	+	+	+
Parallel computer architecture			+
Data fusion	+	+	+
Signal processing			+
Sensitive radars			+
Machine intelligence and robotics			+
Photonics			+
Computational fluid dynamics			+
Biotechnology and Life Sciences			
Applied molecular biology	+		
Medical technology	+	+	

Biotechnology materials and processes		+	+
Medical devices and diagnostics		+	
Aeronautics and Surface Transportation			
Aeronautics	+		+
Surface transportation technologies	+		
Propulsion technologies; Air-breathing propulsion			+
Energy and Environment			
Energy technologies	+		
Pollution minimization, remediation and waste management	+		

Source: Przemieniecki, (1991).

5.4. Dual-use Relationships

Dual-use relationships can take several forms and each one has its own unique characteristics. This section will focus on the potential relationships between government and industry during the conduct of the research (Barattino, 1994).

Four distinct dual-use models are defined as:

1. Spin-off
2. Spin-on
3. Military/Industry Joint Ventures
4. Defense Infrastructure Support
    a. Military Pull
    b. Military Support

5.4.1. The Baseline: Spin-Off Model

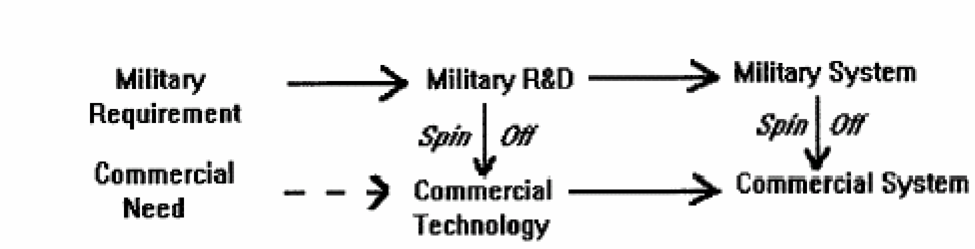


Figure 3- Spin-Off Model Interrelationship

Source: Barattino, 1994.

The military requirement, as defined by war fighting needs, is translated into performance requirements. Assuming that existing systems cannot meet this need, the acquisition community responds with a program to develop a new system to provide this capability. The military research and development effort then proceeds through the standard defense acquisition cycle to produce the military system. Spin-off occurs when either the military technology or system is used by the commercial market (see Figure 3). However, the commercialization potential was not a factor in allocating defense resources. The acquisition program survived or failed bases solely its merits in developing a military system.

Single objective is to satisfy military need. The military requirement provides the basis for all research under spin-off. Because the primary focus of the spin-off model is to produce military systems, the defense acquisition regulations discourage commercial application of defense R&D. The most appealing aspect of spin-off to the defense manager is that it provides the most control for the acquisition community over meeting program cost, schedule, and performance requirement, as compared with the other models. A frequent problem with defense acquisition has been a lack of self-control in defining the requirements as 'must-have' or 'nice to-have'. Often, this leads to performance requirements beyond those dictated by threat, squandering the value of the lower risk premium.

5.4.2. Spin-On Model

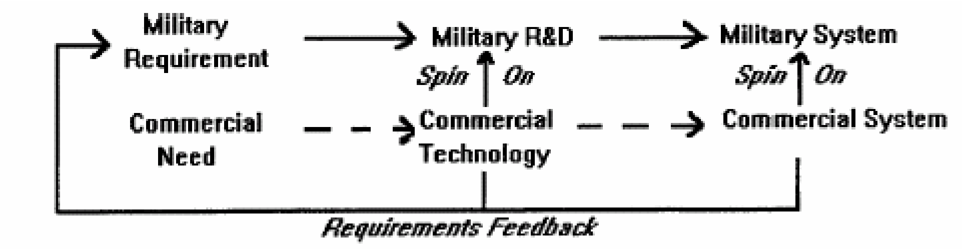


Figure 4- Spin-On Model Interrelationship

Source: Barattino, 1994.

The concept here is that military acquisition programs use technology developed for commercial markets to the maximum extent possible. The belief is that commercial products can satisfy most acquisition needs at the component and subsystem level, even for the major weapon systems that have no commercial counterpart.

The two major reasons often cited for considering the spin-on model are:

1. To focus more attention on commercial technologies that will boost the competitive position in world trade.
2. To enhance the use of the latest technologies in selected areas such as electronics and computer software.

The first goal of saving money with commercial items must be considered on a life cycle cost basis. If savings achieved with lower R&D costs are exceeded by higher operations and maintenance costs, then the intent of the dual use thrust will have been violated. Therefore, the performance trades must factor in the support tail required during the lifetime of the system. The second goal of tapping into the best new technologies must be conditioned by the requirements regarding the environment in which the system will have to operate during its life time. These kinds of detailed performance-cost-logistics-requirement trade must be conducted at the beginning of a program’s life. This is the fundamental difference between spin-on and spin-off models.

A fundamental ingredient to implement spin-on within defense acquisition is the flexibility to relax military standards at the component level and military requirements at the system level. The barriers inhibiting companies from operating in a dual use mode have to be removed. The key ingredient to making spin-on a viable concept is the availability of commercial products and a willingness of the commercial vendors to sell these goods. The spin-on model requires major revision of requirements generation process. A major advantage of spin-on often cited is that it allows for updates of technology on a regular basis. In contrast to the rapid upgrades to commercial technology, multi-year procurements for major weapon programs results in new systems coming off the assembly line with fairly old technology being deployed into the field. However, the disadvantage of fielding old technology conversely has the advantage of less risk in supportability requirements for the logistics community. Wide use of commercial technology at subsystem levels may result in a host of new headaches from a supportability viewpoint.

The U.S. Army's precision lightweight GPS receiver program provides an excellent example of spin-on acquisition in use (Sweeny, 1993). GPS receivers became an important staple for the fighting soldier during Desert Storm. As a result, the U.S. Army decided to purchase tens of thousands of these receivers over the 1993-97. In 1990, the government's receiver weighed over 17 pounds and cost $40,000 each. However, the rapid development of circumstances required the Army to purchase about 8,000 commercially available receivers in a hurry. These systems were not as accurate as the military ones, but cost only $4,000 each and weighed only 4 pounds. Location accuracy provided by the receiver was sufficiently improved by operational procedures, specifically by adjustments in the transmitted signals of the GPS satellites. The great success with these commercially available versions led the Army to adopt a spin-on acquisition strategy for the follow on.

5.4.3. Military / industry joint venture model

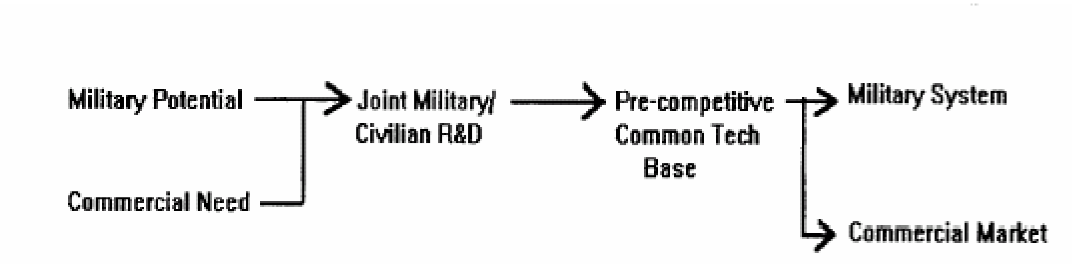


Figure 5- Military / Industry Joint Venture Model Interrelationship
Source: Barattino, 1994.

The key emphasis here is a common belief between both parties that a joint relationship has more benefits than either party trying to undertake the research effort alone. The motivations of both parties will differ in their final objective. The relevance of these varying interests will play a key role in structuring a successful joint venture. The government should balance the opposing perspectives by providing the opportunity to the joint venture partner to limit access of the research results.

The military labs and research centers within the S&T community will be the key player for joint ventures and will have to operate as technical marketers in developing potential industrial partners. The key attributes of the joint venture model relates to the risk associated with counting on two partners with very different objectives continuing their support through project completion. A strong reason for teaming is to pool the limited resources of the participants. This implies that either the project is too large for any single party to fund or it doesn't have sufficient organizational support to muster enough internal resources. Sharing of costs can also have benefits to both parties in that a critical mass may be achieved by pooling resources that may not have been possible before. Joint ventures are more likely to be pursued for higher risk projects with a basic or exploratory research focus. The structure of the project will vary with each teaming arrangement, with any combination of facilities and people possible. The key factor required here is flexibility at the local level to establish the venture conditions. It requires wide latitude in establishing joint venture agreements.

An era of wide scale joint ventures within the defense S&T community will require a number of cultural changes at levels within the organization. The lack of cooperation among peers which typifies the labs sometimes leads to less than optimum technologies offered by the government to the joint venture. The industry partners should have co-equal status in a successful joint venture relationship. Joint ventures will require a new level of commitment within the S&T management structure, as well as the military operating commands.

One of the major examples is a joint venture arrangement between COMSAT, the Phillips Lab, and the Department of Energy’s Sandia Lab. The U.S. DOD has been funding research since the mid-1980s to project a laser beam generated on the ground through the atmosphere onto a satellite in space. Military interest in this technology is based on the need to negate hostile satellites during conflict or generate high resolution images of either friendly or hostile satellites during peacetime and wartime. The Air Force Phillips Lab in New Mexico has been performing risk reductions experiments to demonstrate the enabling technologies to perform these missions. A concept called power beaming has been discussed within the satellite community, led by the quasi private company COMSAT. The basis of this idea is that the primary cause for removal of their satellites from an operational status has been failure of the battery system providing power during periods when the satellite’s solar cells are not exposed to sunlight. If a laser beam could be used during these shadow periods to reduce the drawdown of the batteries, COMSAT estimates that the satellite lifetime could be extended by years. This, in turn, would extend the revenue produced by the satellite, as a replacement satellite would not have to be launched on the current time interval of about ten to twelve years. The long term objectives of each of the parties involved differ dramatically. Air Force researchers need to satisfy the military missions. COMSAT representatives have a viable commercial interest in extending satellite lifetime. Sandia Lab engineers are trying to find an application for their nuclear pumped laser concept that has to find a sponsor.

At this stage, each team member brings a unique capability that would cost the other more resources than they could muster alone. This type of joint venture arrangement between government and industry can be repeated on a wider, more repetitive way.

5.4.4. Defense infrastructure support model

5.4.4.1. Military pull model

Figure 6a- Military Pull Model Interrelationship

Source: Barattino, 1994.

This model based on using defense assets to support a higher national need. The military pull model, represents a derivative in which defense is used to infuse capital into a targeted industry with the primary goal of stimulating a new commercial technology for the private sector. The military may also gain from use of the product, as well.

The Technology Reinvestment Project (TRP) managed by DARPA is an excellent example of the military pull model. The program was generated to meet the nation's need of converting a large portion of the defense industrial base to commercial products in the Post Cold War era (Gregory, 1993).

5.4.4.2. Military support model

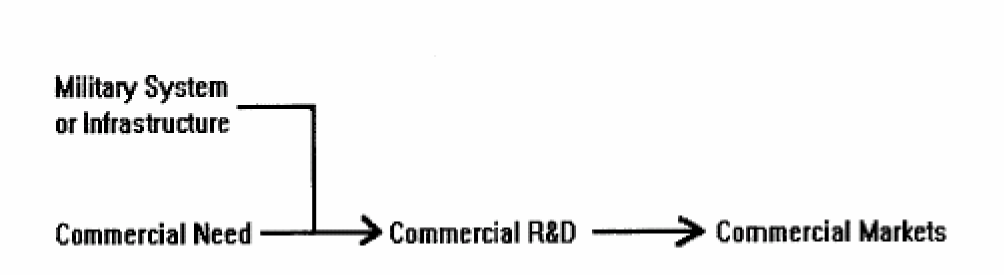


Figure 6b- Military Support Model Interrelationship

Source: Barattino, 1994.

The military support model is a second offshoot in which some operational capability within the defense infrastructure is directed to assist in the development of a new commercial product or service. Impacts on the operational readiness of these support units will have to be considered when committing to dual-use projects. While economic competitiveness is critically important to the nation's prosperity, the military's primary role is still maintaining preparedness to fight, even in the Post Cold War environment.

An example of the military support model in practice is the active role that the Air Force Space Command is taking in supporting the U.S. Space Launch Industry. Until the Challenger disaster, the U.S. mistakenly curtailed its support for expandable launch vehicle capability, with almost blind reliance on the shuttle for getting our satellites deployed. During this period, the European consortium, Arianespace, capitalized by capturing over 70 % of the international space launch market (Thomson, 1993). The government has been very vocal in its support for recapturing a large share of this market for U.S. companies. The open effort by the government to maintain a domestic space launch capability represents a partnership with U.S. industry that typifies dual-use relationships under the military support model.

The military pull model can be considered as a limited form of a national industrial policy, with some higher national economic objective as the driver behind the thrust. The key here is that the assets of our defense infrastructure are used to achieve this national need. The military support model supports projects requiring infrastructure beyond industry’s capabilities. The use of launch facilities to support commercial space satellites is a clear example. Opportunity costs regarding military readiness must be factored.

The high level support for this type of dual-use interaction almost guarantees the best efforts by defense personnel. The responsiveness of government people to industries needs must be improved.

5.5. Conclusion

Dual-use technology is a technology that has both military potential to provide technological superiority on the battlefield and commercial potential to provide competitiveness in the market place. The past twenty years has made it clear that innovations based on scientific and technological advances have become a major contributor to national well-being. Global competition and emerging challenges require building new foundations for innovation and a more cooperative government-industry-academia relationship than previous times. From the point of Turkey, with limited resources, dual-use technology should be the first priority, and the main issue to discuss in detail.

Thus, this thesis intends to promote the economic growth, enhances technological capability and maintains war fighting capability in loop, of our nation by encouraging development of technologies with potential for use in either the civilian or military sectors and deals with dual-use technologies which have both commercial and military use.

To encourage an increase in the overlap between defense and commercial production and promote the development of dual-use technology, the program should define dual-use as broadly encompassing products, services, standards, processes, and acquisition practices that are capable of meeting requirements for military and nonmilitary applications. Moreover, it should provide funding to overcome perceived barriers to dual-use production, including lack of access to capital, high risks, and regulations governing contractual requirements.

We know that dual use technology development with industry can work. It is clear that many of the technologies being actively pursued by industry to commercial marketplace will also provide a military advantage on the battlefield.

CHAPTER 6

ROTARY-WING UPGRADE AND SYSTEM INTEGRATION TECHNOLOGY AS A CORE COMPETENCE: A CASE STUDY

6.1. Rationale Choosing the Rotary-Wing Technology System, What is Its Military Importance?

To meet varied challenges of the 21st century, Army Aviation, envisions the family of systems, systems Upgrades and Advanced concepts. If you ask why? Let me discuss a little.

Table 2 of 26 shows the strong close correlation between Rotary Wing Technology and Battlefield Dynamics. Rotary Wing Technology system has also the capabilities for the military main functions (C4ISR, Operations, Logistics), and sub-functions. The system is annotated to reflect its applicability across all sub-functions: C4ISR collection, transmission, and user systems; operations mobility, lethality, and survivability; logistics deploy ability and supportability. This large, diverse group of dynamics and functions illustrates Rotary Wing Technology System's ability to support a wide range of combat operations. In short, Army Aviation is an integral part of all Battlefield Dynamics.

The primary mission of the Rotary Wing Technology System is to base as a good platform to support a wide range of combat operations. The system can be configured to carry out troop, logistical support, medical evacuation, command-and-control, search-and-rescue, armed escort, electronic warfare, executive transport, anti-armor capability, air-to-air capability, and area target capability.

Table 2a. Rotary-wing and Battle dynamics

System Type	BA TTLE D YNAMICS					
	Early Entry	Depth and simultaneous Attack	Mounted Battle space	Dismounted Battle space	Battle Command	Combat Service Support
AH-64 Apache Longbow	*	*	*	*	#	
UH-60 Blackhawk	*	*	*	*	#	#

* Provides Significant Capability #Provide Some Capability

Table 2b. Rotary-wing and Military Functions

	MILITARY MAIN FUNCTIONS							
	C4 ISR			**Operations**			**Logistics**	
	Collection	Transmission	User Systems	Mobility	Lethality	Survivability	Deploy	Support
AH-64	*	*		*	*	*		
UH-60	#	#	#	*	#	*	*	*

* Provide Significantly Capability #Provide Some Capability

In short, when we consider the above tables, advanced concepts and capabilities together, Rotary Wing Technology System will continue to be versatile and deployable. It will combine speed, mobility and fine power in the attack/reconnaissance and assault forces, while moving and sustaining combat power at decisive points on the battlefield in its cargo/utility helicopters. With the evolution of combined Arms Operations and Nonbattlefield Operations, Rotary Wing will be even more important in the faster, paced battles of the future, and the humanitarian-aid operations. Then it is clear enough that the technological system has a national importance and it is a military critical technological system. Furthermore, Rotary Wing Technology System has a huge potential for upgrade and system integration technologies. Thus, we should discuss and evaluate technology system from dual-use point of view.

6.2. What is the System Integration and Upgrade Technology, What is Its Importance from Point of Turkish Economy and Army?

When we consider a new era in a rapidly changing world and as the nations move toward a smaller defense force, the establishment of future defense challenges should be responsive, mobile, deployable, lethal, survivable and sustainable. The forces have to accomplish their missions quickly and effectively than before. This needs the integration of mission requirements that include the ability to hunt and kill (mobility, navigation, lethality), to communicate, to deploy and to ensure the safety of the system and its crew (survivability). To support these kinds of requirements, we must have a specific technological capability that means the ability to integrate the subsystems, system integration technology.

The system integration technology includes three main capabilities. It has to define the operational requirement specifications by getting feedback from user to meet future defense needs, and to provide an initial base to engineering side. Based on this specification, a system structure design considering safety, the aim, applicability, redundancy, efficiency shall be made. For specific Rotary Wing Technology safety, redundancy, structure, aerodynamic meeting the requirement, weight and balance, power electrical wiring, etc. should be run by software. The algorithm should meet the user requirement. Besides these, the system integration technology requires an appropriate infrastructure, not only research apparatus and seal labs, but also infra technologies that support; basic scientific and engineering data needed to conduct R&D and control; the technical data of platform subsystems, interface change documents; research test, measurement, and analysis of new systems compatibility with older systems; and process technologies.

The number of major weapon systems new starts will decrease substantially the rest of this decade while increased reliance will be placed upon technology insertion into existing systems via such upgrading mechanisms as engineering change proposals (ECPs), product improvement proposals (PIPs), pre-planned product improvements, and block improvement and multistage improvement programs. For example, the military aircraft upgrades sector of the Cold War ended a major arms race and had a profound effect on military aircraft contractors. Defense budgets in the west began to fall. This adversely affected the military aircraft industry. In addition, to save costs, the aircrafts already in the inventory began to be outfitted to undertake more diverse missions and to customize of platforms for military clients.

These upgrade efforts may be intended to achieve one or a combination of the following objectives.

1. Improve performance, such as power, more cargo, efficiency, and quick response,
2. Extend useful life,
3. Reduce operating and support costs,
4. Improve safety/survivability,
5. Create a new major/revolutionary combat,
6. Reduce crew workload,
7. Overall be able to integrate subsystems technology development into system.

A good example is the US Army Blackhawk Upgrade program. In April 2001, the US Army approved an upgrade program for more than 1,500 Black Hawks to UH-60

M standard. First flight of the UH 60 M is scheduled for end of 2003 with entry into service in 2006. The program will extend the service life of the helicopter until 2025. The upgrade will include new wide chord composite spar main rotor blades (which will provide 500 lb more lift than current UH-60 L blade), digitized 1553 bus based glass cockpit and avionics suite with four multi-strengthened fuselage and advanced infrared suppression. A new General Electric T 700- GE-701 D engine is also being developed (The website for Defense Industries-Army).

Generally, the aircrafts, which are subjected to upgrades, will often be configured with new avionics packages. Avionics improvements and system integration are also necessary because many upgrade programmers required military aircraft to be fitted with new munitions, offensive capabilities, defensive counter measures, integrated cockpit for reduced crew workload, aided target recognition, air-to-air capability, all weather pilotage, precision navigation, situational awareness, mission planning, secure com and data transfer, etc.

The net result of this trend from our country point of view is a heightened requirement for modern, multi-role platform and system integration technological capability as core competency. When we consider the characteristics of future conflicts, the geographical location, the national sources and the national importance priorities, we should try to extend the service life of platform. However, there is a strong requirement that we must have the capability to deliver highly accurate precision guided munitions, to navigate preciously in all weather, to recognize targets from a long distance and, to deploy troops anywhere, and to have new anti-aircraft systems, at least as much as the other side. Otherwise, there is no meaning to have such platforms. We have to follow subsystem technologies trend. If we keep the platforms to operate more than 30 years, we have to upgrade them at least every ten years because of emerging technologies to keep deterrence. This means that we have to learn actively and absorb system integration technology as a key technology for our country.

6.3. Avionics and Software Development Process in the Project

A rotary-wing avionic upgrade project that I explain here is an undergoing project. The project is different from traditional acquisition cycle. It has two main goals. The first goal, short-term, is to satisfy user operational requirements, and the second goal, long-term, is to provide an environment for domestic main contractor to be able to learn actively the core technological capability which is system integration technology. The way to transfer technology is hand-on working together with the main subcontractor that is responsible for system integration from beginning of the development process, top-level design, to the end of project, system integration lab (SIL) tests and platforms' flight tests. The user is in the loop from beginning to the end of project development process.

The project organization consists of teams from the different engineering disciplines that are organized into an integrated program team. The operational requirement specification (ORS), in other terms the pilot-vehicle interface (PVI) team is responsible for the definitions of the operational requirements and producing and maintaining of the PVI document that is basic for development process. It defines system concept, operating logic, and particularly in this project cockpit layout, man-machine interface and everything the pilot see/touch. It is one of the major milestones. The team is a bridge between the end user and the developers. The system engineering team is responsible for the definitions of the requirements for software, hardware and test equipment, integration in lab and on platform, and testing. The team performs and coordinates all tasks related to the system engineering process. The software team is responsible for the development of the codes of software, files, implementing any required changes, software testing, and maintaining software development files.

The major milestones of the project development process are system requirement review (SRR), preliminary design review (PDR), critical design review (CDR), and system integration. The purpose of the SRR is to reach mutual agreement between the developer and the user to the development of the requirements for the system.

The purpose of the PDR is to define base-line PVI definitions and system SIL requirements. At CDR, specification details from graphics to algorithms and man-machine interface functions shall be completed. The purpose of the system integration is SIL tests, evaluating the requirements, operational sequence testing and platform integration.

The major phases of the system integration and software development process are:

- Analysis of user need (operational concept, system requirements)
- System analysis
- System design (the important document is ICD (interface control document)
- Software requirement analysis
- Software preliminary design
- Software detailed design
- Software coding and unit test
- Software host integration
- Software target integration
- Software integration
- Avionics system integration
- Avionic system formal tests

The main actor in the project is a foreign subcontractor which is responsible for system integration and software development. The other subcontractors are just providing product itself or product and related technology. The main contractor is a domestic aerospace company and it is supposed to learn system integration technology actively. Thus, let us look at the organization features of the main subcontractor briefly. The main subcontractor's organization features are summarized hereinafter:

- The project is run by the program manager, belonging to the Aircraft and Helicopter Upgrades & Systems.

- The technical project is run by the technical manager,
- The system engineering activities are run by the system engineering team,
- The software engineering activities are run by the software engineering team,
- The hardware engineering activities are run by the hardware engineering team, belonging to the engineering division,
- The integrated logistics (ILS) activities are run by the ILS team leader,
- The reliability activities belong to the chief technology office,
- The quality assurance activities belong to the Aircraft and Helicopter Upgrades & Systems and chief technology office.

My main criticisms to the project are:

- There is not a well organized preplan to monitor the long-term goal, learning system integration technology, of the project,
- There is not a well organized replan to absorb and maintain core technological capability,
- The subcontractor's interest considerations have a negative effect at the development process,
- There is not a well organized preplanned criteria to measure the efficiency of the technology transfer.

On the other side, the outstanding advantages are:

- The end user is in loop throughout project and the eedbacks of user are input for development process,
- There is a close communication and collaboration between actors,
- The way to transfer technology, hand-on working from the beginning that means learning actively, is very attractive and I think will

be

very efficient.

6.4. Conclusion

It is so clear that Rotary Wing is a good platform to support a wide range of combat operations and Rotary Wing Technology System has a huge potential for upgrade and system integration technologies. We have to upgrade our platforms to keep deterrence. This means that we have to absorb system integration technology as a key technology for our country. It is obvious that the user inputs are so critical for those kinds of projects.

CHAPTER 7

CONCLUSION

Technology is a driving force today and impacts the ways in which we live and do business. Over the next decade, technology will become even more pervasive. The aim of this study was to explore the concepts of military innovation, critical and dual use technologies and to bring up findings for further studies. Main findings can be summarized as follows:

1. As it is the case in the civilian sector, military organizations have to change to meet the dramatically altered international environment and the challenges shaping tomorrow. There is no ultimate weapon or organization that will successfully respond to every future threat. The options open to militaries to successfully evolve and prepare themselves for the future defense challenges are limited: militaries can either change how they do business,(organizational innovation) or change what they do business with, (technological innovation). Military innovation is manifested by new war fighting concepts and new means of integration (e.g. Doctrine, tactics, training, and support). The most effective innovations are where technology and organization work in tandem.

2. In this thesis, I focused on technological innovation, because technological superiority is one of the most important elements of deterrence in peace. In a crisis situation, it also provides a spectrum of options to the commanders and authorities. In war, it enhances combat effectiveness, economical termination of conflict and reduces the loss of personnel and equipment. In any case, in order to develop technology and to achieve competitor status, the capacity to acquire or develop the necessary technologies and technological infrastructure are national level prerequisites. A government that has to purchase technology from abroad is less

likely to wield it as effectively as the nation that is capable of inventing or manufacturing it.

In order to insure technological capability and meet national defense needs, a sound technology investment strategy must be formulated, the right technology must be developed, and a plan for technology transition must be executed. How should the military develop and sustain S&T capabilities to support the transformation? A strategy built on a foundation of three integrated blocks will enable the military to be the effective smart buyer and access to advanced S&T. These are optimal in-house R&D, expanded collaborative efforts, and smart outsourcing. The objective of any defense S&T program is the continuing discovery, exploitation, demonstration and, rapid transition of technology into quality weapon systems to meet operational needs.

3. One of the struggles of governments' enterprises and organizations of late industrializing countries in their struggle to overcome their usual backward technological development is to build the adequate institutions and create the type of environment that induces active learning and absorptive capacity. Absorptive capacity is the ability to recognize the value of new external information, learn, assimilate and apply it. Another important determinant is active learning strategy. A strategy of learning that also focuses on the mastering and improving of the absorbed technologies of production through by imitation, reverse engineering, and copying (Viotti, 2002). To separate the concepts of science technology and technique are the crucial elements for an active learning system. We have to accumulate technological capabilities that mean the design of a project starting from the generation of an idea, passing through a multilevel and hierarchical complex web of skill, knowledge relationships, to the realization of an artifact. Competence building is also a critical success factor. It contributes both to the generation of innovations and to the utilization of innovations.

Innovation is the transformation of knowledge into products, processes, systems and services. The key elements of innovation are: knowledge, skilled workforce, infrastructure, and smart persistence with long-term vision. There is a broad support for the proposition that innovation drives manufacturing and other productivity growth, which in turn driving economic growth and national well-being. University-industry-government relations provide a knowledge infrastructure to innovation systems in terms of overlapping institutional spheres, with each taking the role of the other and with hybrid organizations emerging at the interfaces. The common objective is to realize an innovative environment consisting of university spin-off firms, trilateral initiatives for knowledge based economic development and strategic alliances among firms, government labs, and academic research groups.

I think absorptive capacity is one of the two important factors that we have failed to have. The other one is smart persistence with long-term vision. Absorptive capacity is ability to recognize the value of new, external information, assimilate it and apply it. Then, how can the company develop absorptive capacity? This requires a substantial amount of scientific knowledge and basic research. To keep track of scientific developments the firms should establish links with academia. The company should develop the technological capability and have a very active and effective R&D system. And it should be recognized that the efficacy of a R&D unit does not depend entirely on the amount of money spent on the R&D function. The organizational structure of an R&D system and the quality of its staff may in fact prove to be more important.

4. From Turkey's point of view, I think the first priority is to create the enabling infrastructure (research apparatus, laboratories, expenditures, infra-technologies and foundations) necessary for optimal in-house R&D to foster long-term innovation smart outsourcing, and to absorb advanced technology in defense projects. Within this context, military may construct at least one high-tech development zone with strong incentives based on partnerships among academia, industry and military. The aim is to absorb foreign technologies and produce a large labor pool with technological skills. Military may also build a new foundation for innovation like DARPA in U.S. based on our realities. Then, this foundation should focus on small business innovative research program (SBIR) and fund these programs to increase small business involvement in R&D, to stimulate technological innovation and to

attract small creative businesses that can potentially contribute to achieving the military's S&T goals and to the industrial base and commercial competitiveness of country in the long term. The aim is to improve understanding of the central importance of technology for power and welfare by the general public.

5. Becoming a learning organization, accumulating core technological capability in selected areas (in case upgrade and system integration technologies), and successfully developing or improving new technologies must be the aim of the main contractor for the sake of project's long-term goal. Smart user inputs and establishing management practices that support innovation are also critical success factors. For the project that is undergoing I have some remarks to discuss. The flows of technology and information among people enterprises and institutions are key to the innovative process. There are interactions among enterprises, public institutes and user. The project provides an environment as a long-term goal for domestic main contractor to be able to learn actively. However, this does not mean that it is enough. The main contractor should approach this project as a chance to create core competence that will provide a future in long-term different from traditional attitude. The visionary leadership should support and encourage core competence communication, involvement and a deep commitment to working across organizational boundaries. Core competencies do not diminish with use, even, they are enhanced as they are applied and shared. Core competencies are built through a process of continuous improvement and enhancement that may span a decade or longer. Firms can develop core competencies either in-house or by strategically incorporating capabilities in the marketplace into their existing activities. When we consider competence, we focus on a higher order of skills. These generic skills include higher levels of education, creativity, risk taking, and initiative (Heitor, 2002). However, the effective utilization of external capabilities also requires absorptive capacity.

On the other hand, learning system integration technology will not be completed with this project. The government side should be aware of this reality. Creating core competence takes time and this environment should be provided. I think we need two more steps. At the second step, main contractor should upgrade the same type of platforms with the same configuration without subcontractor contribution. At the third step, it should also upgrade other platforms and integrate new system to the configuration. Then, I think that the process will be completed. Another point is that technology transfer is not something to happen itself. Checking absorptive capacity, monitoring technology transfer process and giving feedback and measurement of the technology transfer efficiency are very crucial to the success of goals.

In relation to the aero-technology reviewed in Chapter 6, I believe that the main contractor should accumulate cooperative capability for upgrading and modification of fixed wing and rotary wing aircraft selecting as a long-term core strategic business section. It is evident that Rotary Wing is a good platform to support a wide range of combat operations and Rotary Wing Technology System has a big potential for upgrade and system integration technologies. We have to upgrade our platforms to keep deterrence, which implies that we have to absorb system integration technology as a key technology for our country. Clearly, the user inputs are very critical for this kind of projects.

6. This thesis also aims to promote the economic growth of our nation by encouraging development of technologies with potential for use in either the civilian or military applications as we are a late comer country and with limited founding for R&D. Dual use technology has both military potential to provide technological superiority on the battlefield and commercial potential to provide competitiveness in the market place. Global competition and emerging challenges require building new foundations for innovation and a more cooperative government-industry-academia relationship than previous times. Civil and military R&D policies will need to be more closely harmonized than in the past. The civil technology base will increasingly become the primary strategic resource in the context of military as well as economic security if they develop more effective institutional mechanism for transferring technology between civil and military activities. However, this thesis also points out that a strong dependence on the commercial sector to replace government-founded S&T may also be risky, because the technological requirements of commercial and

military also continue to diverge. For example, whereas the commercial marketplace may be able to develop dual-use technologies for electronics and specific aircraft parts, it is unlikely to produce the basic methodologies and technologies for radical new developments in military capabilities, such as those represented by stealth and super maneuverability.

What are the impacts of the dual use technologies and relations on the defense acquisition strategies? When we study lessons from history, one significant observation over the past fifty year is the cyclical nature of moving from cost to fixed price contracting centralized control to decentralized control and separated commands to unified commands for acquisition.

We do not know where we will be in this process in the next decade, but one thing that can be guaranteed is that the acquisition climate will continue to change, and the ability to adapt to these changes will be crucial to success in program management.

Major acquisition programs should be managed from a structure that is separate from the normal operational chains. Management of major weapon system acquisitions requires efficient implementation. The process of acquisition starts with a logical means of progressively translating broadly stated mission needs into well-defined system-specific requirements. The process can be divided into two distinct areas; those that are considered preparatory and those that make up formal acquisition. The preparatory area of acquisition consists of the requirements definition process and the concept exploration and definition phase. The formal acquisition area of the process consists of the demonstration and validation phase, the Engineering and Manufacturing Development phase, the production and deployment phase, and the operations and support phase. I think demonstration and validation phase is the most important milestone to decide.

The impacts of the dual-use relations on the new defense acquisition strategies are sure and it is undergoing major revisions, such as:

- Selective upgrading of weapon systems or sub-systems.
- Low-rate procurement of systems. The potential for spin-on at the component level may still be a credible option for minimizing the system of the industrial base having to be bankrolled with defense dollars.
- Prototypes are cycled through several development iterations before even being sent to production.
- Procurement of limited quantities of new weapons that provide revolutionary improvements in our warfighting capabilities.

APPENDICES

APENDIX A

THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY (DARPA)

The Defense Advanced Research Projects Agency (DARPA) is the central research and development organization for the Department of Defense (DoD) in the US. It manages and directs selected basic and applied research and development projects for DoD, and pursues research and technology where risk and payoff are both very high and where success may provide dramatic advances for traditional military roles and missions.

The Defense Advanced research Projects Agency (DARPA) was established in 1958 as the first U.S. response to the Soviet launching of Sputnik, and to ensure technological superiority for fostering innovation and pursing high-payoff, frequently high-risk projects. Since that time DARPA's mission has been to assure that the U.S. maintains a lead in applying state-of-the art technology for military capabilities and to prevent technological surprise from her adversaries. Each conflict has demonstrated the wisdom of having an entrepreneurial technical organization unfettered by tradition or conventional thinking. For example, in Operation Desert Storm, the Persian Gulf War of 1990, some of the revolutionary capabilities, such as the F-117 stealth fighter, the joint surveillance and target attack radar system (JSTARS), and the precision guided munitions were the direct result of initiatives of this small agency in the preceding years. The DARPA organization was as unique as its role, reporting directly to the Secretary of Defense and operating in coordination with, but completely independent of, the military research and development (R&D) establishment. Strong support from the senior DoD management has always been essential since DARPA was designed to be an anathema to the conventional military and R&D structure and, in fact, to be a deliberate counterpoint to traditional thinking and approaches.

The success of DARPA has been measured historically by the transition of its technologies and concepts into military capabilities in the hands of U.S. forces. By that measure, the agency has been phenomenally successful, considering its size; scanning the examples will demonstrate that success. Some of the most prominent technologies are stealth fighter, stealth bomber, phased array radar, joint STARS, uncooled IR sensors, head-mounted displays, M16 assault rifle, army tactical missile system, tomahawk cruise missile engines, endurance unmanned air vehicles, cermets materials for armor, unmanned undersea vehicle, information technology, DARPAnet.

Some of the more important founding characteristics are listed below. Over the years, DARPA has continued to adhere to these founding principles:

- Small and flexible;
- Flat organization;
- Substantial autonomy and freedom from bureaucratic impediments;
- Technical staff drawn from world-class scientists and engineers with representation from industry, universities, government laboratories and Federally Funded Research and Development Centers;
- Technical staff assigned for 3-5 years and rotated to assure fresh thinking and perspectives;
- Project based- all efforts typically 3-5 years long with strong focus on end-goals. Major technological challenges may be addressed over much longer times but only as a series of focused steps. The end of each project is the end. It may be that another project is started in the same technical area, perhaps with the same program manager and, to the outside world; this may be seen as a simple extension. For DARPA, though, it is a conscious weighing of the current opportunity and a completely fresh decision.

- Necessary supporting personnel (technical, contracting, administrative) are “hired” on a temporary basis to provide complete flexibility to get into and out of an area without the problems of sustaining the staff. This is by agreement with Defense or other governmental organizations.
- Program Managers (the heart of DARPA) are selected to be technically outstanding and entrepreneurial. The best DARPA Program Managers have always been freewheeling zealots in pursuit of their goals;
- Management is focused on good stewardship of taxpayer funds but imposes little else in terms of rules. Management’s job is to enable the Program Managers;
- A complete acceptance of failure if the payoff of success was high enough.

The Agency looks very similar today. Other than the reporting chain, there have been only minor changes in approach. Each Director recognized the wisdom of the agency’s historical approach and defended the organization from outside influences that would constrain its freedom and flexibility. In addition, the Department of Defense’s senior management seeing the value of an agile, forward-looking R&D group unconstrained by conventional thinking and able to investigate ideas and approaches that the traditional R&D community finds too outlandish or risky, has consistently protected the independence of DARPA. Failure to keep the bureaucracy at bay would have doomed the value of DARPA and this has been consistently recognized over the years.

The freedom to act quickly and decisively with high-quality people has paid handsome dividends for DoD in terms of revolutionary military capabilities. Factors contributing to a successful transition are vision of need, good technology, persistence of technologists, good working relationship with partners, jointly supported programs, strong user support, transition planning.

Today, DARPA is an organization of 240 personnel (approximately 140 of which are technical) directly managing a budget of about $2 billion. A typical technical project might be structured as follows:

- $10-40 million over 4 years;
- Single DARPA Program Manager with direct control of the efforts and the funding;
- A SETA contractor or contractors to support the Program Manager in his or her primary roles of managing the efforts and representing the program with Congress, the Office of the Secretary of Defense, the military Services and/or involved Unified Commander;
- An Agent (furnishing from a fraction of a person to several people) in a military R&D laboratory to provide technical and contracting support (paid from program funds to provide this support);
- Five to 10 contractor organizations and two universities executing tasks focused on a specific aggregate goal.

Obviously, there are wide variations to this “typical” case. Some projects are under $1 million and a few are in the hundreds of millions of dollars. However, the management paradigm is the same; the variations in the amount and type of “hired” assistance. Regardless of size, a single DARPA Program Manager is in charge and must manage and represent the project internally and externally.

DARPA’s original operating philosophy has changed over the years in only three ways- its relationships with the commercial marketplace, its business practices, and its emphasis on joint systems.

First, the DoD has gone from dominating the market in such areas as microelectronics, computing and network communications, each of which was driven by DARPA in past years, to the current situation where the DoD is able to somewhat influence the directions of a much-larger-than-DoD market. DARPA has played one of the key roles in assuring that DoD's long-term interests are served in this new situation.

Second, in past decade, DARPA has pioneered revolutionary R&D business practices reform. With the support of the Congress and DoD senior management, DARPA has led the way in adopting commercial practices and innovative contracting arrangements. Congress provided the authority for "Other Transactions" and "Section 845" agreements to DARPA on an experimental basis, and, because of DARPA's success, has conveyed the same authorities to the rest of DoD.

Third, since the Goldwater- Nicholls Act, DARPA has focused considerable attention on solutions to Joint-Service systems and problems.

Some Major DARPA Accomplishments;

Over the past four decades, DARPA and its management methodology have been very successful at "filling the gaps" in Figure 3.8 Figure 4 illustrates some of DARPA's preeminent accomplishments since the early 1960s. DARPA was borne of the space age. The launch of Sputnik in 1958 also launched DARPA, so the Agency's initial projects were all space-related. However, the Agency nearly ceased to exist when DARPA's space programs were transferred over to the National Aeronautics and Space Administration and the National Reconnaissance Office. But a new mission came along to counter a threat that no Service or agency was tackling:

ICBMs. From approximately 1960 to 1970, DARPA was the driving force behind the U.S.'s technology advancements in Ballistic Missile Defense. In 1968, the Army Ballistic Missile Defense Agency (ABMDA) was created and the ballistic missile defense mission was moved from DARPA to ABMDA. In the 1960s, DARPA's Project AGILE pursued a modification of the Colt AR-15 rifle to develop what is now known as the M-16 assault rifle, the standard-issue shoulder weapon in the U.S. military. DARPA began developing the technologies for stealthy aircraft in the early 1970s under the HAVE BLUE program, which led to prototype demonstrations in

1977 of the Air Force's F-117 tactical fighter that proved so successful in Operation Desert Storm. After the successes of the DARPA HAVE BLUE Stealth Fighter program, DARPA launched the TACIT BLUE Technology Demonstration, which contributed directly to the development of the B-2 bomber deployed by the Air Force. DARPA's stealth technology has also gone to sea: the SEA SHADOW, built in the mid-1980s, employs a faceted shape similar to that of the F-117 to achieve reduced radar cross section, while the twin hull construction contributes to wake reduction and increased sea-keeping capabilities. The Global Hawk and Predator Unmanned Aerial Vehicles have been prominent in Operation Enduring Freedom in Afghanistan and other parts of the world. DARPA began working on Global Hawk in the 1970s as the TEAL RAIN program; the Global Hawk high altitude endurance unmanned aerial vehicle (UAV) transitioned from DARPA to the Air Force in 1998.

Development of Predator began in 1984 as DARPA's AMBER program. The Tier 2 Predator, medium-altitude endurance UAV evolved directly from DARPA's AMBER and Gnat 750-45 designs, and was operationally deployed in the mid-90s. And the most famous of all of DARPA's technology development programs is the Internet, which began in the 1960s-1970s with the development of the ARPANet and its associated TCP/IP network protocol architecture. DARPA's development of packet switching is the fundamental element of both public and private networks, and it spans the Department of Defense, the federal government, the U.S. industry, and the world. A crucial characteristic to note about several of these accomplishments, which holds true for many DARPA programs, is that it took a long time from when the idea was first conceived to when it actually bore fruit and was used by the U.S. military. DARPA has shown itself very willing to tackle hard technical problems repeatedly, even in the face of previous failure, if the technology offers revolutionary new capabilities for national security. Patience and persistence are required attributes for those who pursue high risk technology, but they are often rewarded with extremely large payoffs.

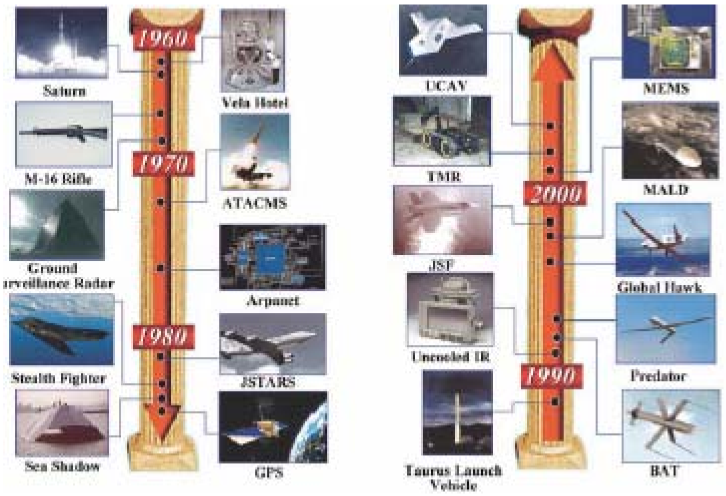


Figure 1: A summary of key DARPA accomplishments spanning more than four decades.

Transitioning DARPA Technologies

Transitioning technology – getting technology from research and into use – is a difficult challenge, partly because so many different types of organizations may need to be involved, i.e., S&T organizations like DARPA, the acquisition community, the warfighting/requirements community, and the firms that actually produce the product. And the very nature of a technology strongly shapes how it transitions. For example, a component technology, like a new material or microchip, is likely to get to the warfighter when a prime contractor incorporates it into a system, without the Service acquisition program necessarily having decided on it per se. This means the key decisions are made by industry – prime contractors and subcontractors. On the other hand, a large system development program, such as Global Hawk, requires the warfighting community to establish a formal requirement for the system, thereby charging the acquisition community with actually purchasing mit. New systems simply do not "diffuse" their way into military use, like a new material might. The transition challenge is exacerbated for DARPA because its focus is on high-risk, revolutionary technologies and systems, which may have no clear home in a Service, are Joint, or threaten to displace current equipment or doctrine. All these factors tend to create resistance, or at least barriers, to the use and adoption of a new technology. Figure 2 is a simplified illustration of three methods DARPA uses to transition technology to the warfighter. The first "bar" illustrates a significant part of DARPA's strategy. DARPA invests about 90 percent of its funds at organizations outside the federal government, primarily at universities and in industry. Over time, this investment leads to new capabilities in industry and steadily reduces the risks of the underlying technology. At some point a company finally becomes confident enough of its ability to make a new technology for a predictable cost and schedule that it will propose the technology to someone other than DARPA. DARPA's investment reduced the risk of a technology to the point where firms themselves are willing to make it, use it, or otherwise bid it back to the rest of the DoD. However, companies will not propose a new technology to a Service customer if they are not confident that the Service customer will accept it. The second bar in Figure 5 shows how DARPA removes this impediment. To build potential Service customers for DARPA technology – someone to whom these companies can bid with confidence – DARPA deliberately executes about 80 percent of its funding through the Services. That is, a Service organization acts as DARPA's agent and is the organization that actually signs the contracts with the research performers and monitors the day-to-day technical work. This creates a cadre of people inside a Service who are familiar with a DARPA technology, who can vouch for it, and who can shepherd it into a Service acquisition program. Once the company is confident that it can build a technology and a Service is willing to accept it, the technology then transitions and DARPA is, typically, forgotten. DARPA occasionally builds prototype of a large, integrated system such as Global Hawk. Such programs reduce the risks in a new system to the point where the warfighting community can be confident that it will get a new and cost-effective capability. However, without proper planning such programs can run into a two-year "funding gap" between the time when the Service is convinced it wants the system and the time when the DoD's financial system can effectively respond. To prevent these and other problems, DARPA tries to ensure transition of prototypes by negotiating a Memorandum of Agreement with the Service adopting the system. The earlier the Memorandum of Agreement is negotiated, the better it works, since it is easier to plan the needed outyear funding ahead of time instead of trying to find it later. In addition, to strengthen its connections with the Services, DARPA has military officers on staff who serves as "operational liaisons." These liaisons keep DARPA informed about what the Services might want, and they keep the Services informed about what DARPA is developing.

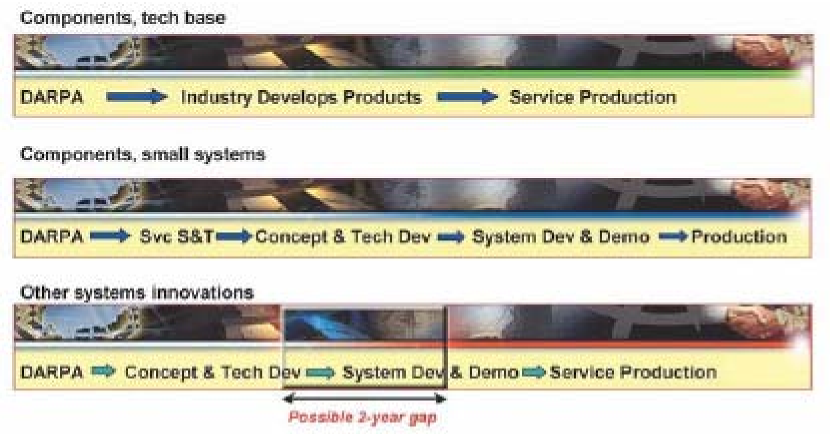


Figure 2: DARPA transition methods.

In summary, DARPA's ability to adapt rapidly to changing environments and to seek and embrace opportunities in both technology and in processes, while maintaining the historically proven principles of the Agency, makes DARPA the crown jewel in Defense R&D and a unique R&D organization in the world.

APPENDIX B

U.S. DUAL-USE SCIENCE AND TECHNOLOGY PROGRAM (DUST)

Dual-Use Technology is a technology that has both military utility and sufficient commercial potential to support a viable industrial base.

Objectives:

- To partner with industry to jointly fund the development of dual use technologies needed to maintain technological superiority on the battlefield and for industry to remain competitive in the marketplace. This is accomplished through:
- The use of streamlined contracting procedures, and
- Cost sharing between the Program, the Services, and industry.
- However, just as important is making the dual use development of technologies with industry a normal way of doing business in the services.

Benefits to Industry:

- Leverage of scarce S&T funding.
- Provides vehicle to form beneficial partnerships with other firms, defense labs, or universities.
- Access to advanced technology through these partnerships.
- Increased potential for transition of technologies into defense systems which can lead to increased markets.
- Development of “win-win” partnership with the DOD should lead to increases probability of a successful development program and commercialization.

Process:

- The Military Services issue a joint BAA and projects that meet the minimum requirements identified below are evaluated based on selection criteria
- Quantity and quality of industry cost share
- Military benefit.
- Technical & management approach.

Minimum Requirements for DU S&T Projects:

- Project is developing a dual use technology,
- At least 50% of project cost is paid by non-federal participants, one of which is a for profit company,
- Awards are based on competitive procedures and solely on merit,
- Project awarded using cooperative agreements or other transactions,
- Project resulting in technology development not its application.

Project Evaluation Criteria:

- Military benefit,
- Commercial viability of technology,
- Transition of technology into military or commercial programs,
- The quality of cost share.

Sample: Second Annual DUS&T Achievement Award Winners

The DUS&T achievement award recognizes successful dual use projects and honors those individuals in the military responsible for their initiation and execution. The winner and runner-ups are below: This was the second year the award was presented. A total of 12 nominations were received. From those nominations one winner and two runner-ups were chosen. The responsible individual(s) identified from the winning project received a $5,000 award and the runner-ups received $2,500.

Any science and technology (S&T) project that has developed or is resulting in the development of a dual use technology and meets the following criteria was eligible to compete for the award:

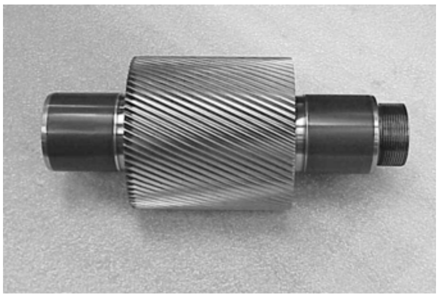
- The project developed, or is developing, a dual use technology that will meet a military need and has sufficient potential commercial application to support a viable production base.
- At least half (50%) the cost of each proposed project must be paid by non-federal participants, one of which must be a for-profit company.
- Projects must have been awarded competitively, using Technology Investment Agreements (TIAs), i.e. Cooperative Agreements or Other Transactions.
- The project must have developed or will result in the development of a technology, not the application of a technology.

Projects that met these criteria were evaluated based on military benefit, commercial viability of technology, transition of technology into military or commercial programs, and the quality of cost share.

Winning Project:

Thermal Spray Nanostructured Coatings:

The winner of the second annual Dual Use Achievement Award is a Navy project titled Thermal Spray Nanostructured Coatings. The Project developed a highly wear and corrosion resistant ceramic composite coating that can be applied using existing industrial equipment and standard thermal spray processes.



The primary benefit of this technology is a reduction in life cycle costs through increased corrosion and wear protection. In addition, thermal spray coatings are superior to hard chrome plating and are about 60% less expensive due to the cost of complying with environmental regulations. Navy applications for this technology are well underway and include air intake and exhaust values for submarines that is expected to save $400K/ship or $20M over the next ten years. It was also used on the USS George Washington’s electric motor and oil pump shafts and will be used for the main propulsion shaft for mine countermeasure ships resulting in a $1M/year savings per ship.

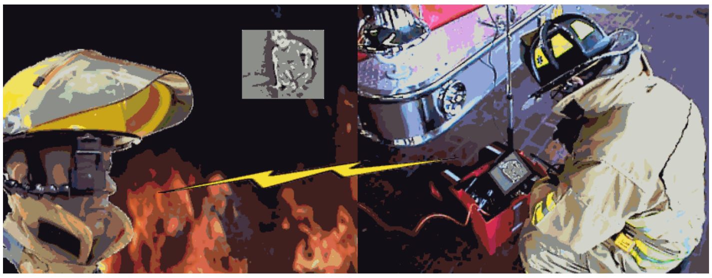
The technology is also transitioning into commercial products. Warren Pump is using the technology to manufacture screw pump rotors for commercial gas turbines and fuel feed pumps and the technology is also being used on water pan rolls for the printing industry. Inframat - the contractor for the project - has formed a new company Nanopac, to pursue new opportunities to include its possible use in diesel engines. The military benefits of this technology are realized by reduced total ownership costs for submarines, surface ships, and aircraft.

Runners-Up

UL3 - The Worlds Smallest Imaging Infrared Camera

This project designed, fabricated and tested a low cost, low power, uncooled infrared camera that weights approximately 1 and three quarter ounces and is only two cubic inches in size.

The small size and reduced cost of the camera makes it ideally suited to be mounted on a helmet or rifle, as a battlespace sensor, and for micro air vehicles. The 10th Mountain Division is currently testing the camera in an Unmanned Arial Vehicle and the technology developed under this program has generated the Warrior Extended Battlefield Science & Technology Objective and a follow-on Advanced Technology Demonstration, which will ultimately result in this technology being employed into the field.

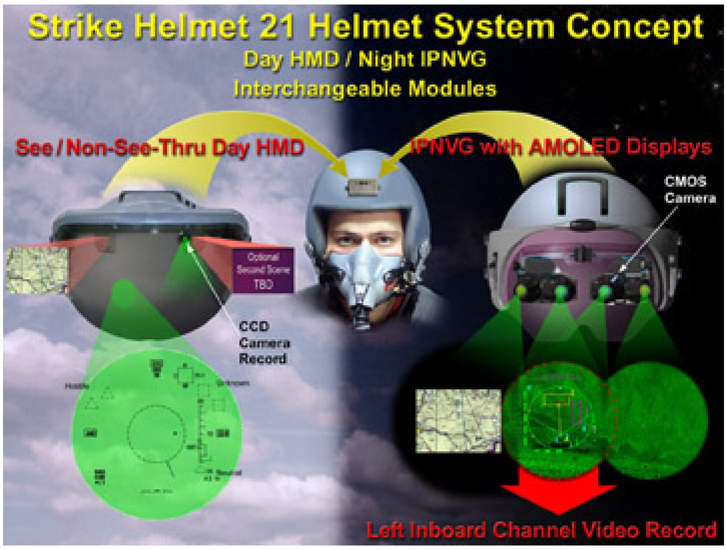


The camera also has tremendous commercial potential. Two applications are underway. The OMEGA, the commercial name for the UL3, is the enabling technology for a new generation of handheld fire fighting cameras. A total of 1,200 units are expected to be delivered in 2002. In addition, Indigo — the contractor for this project - and Autolite are introducing a new night driving system in 2003 that is based on the Omega camera. The units are expected to cost $500 and projected 5 year sales are $400 million. These commercial sales are essential to drive down the cost of the technology and make it more affordable for military applications.

High Brightness Emissive Miniature Displays

The project developed the first full color, high luminance, monochrome active-matrix organic light emitting diode display. The display characteristics make it ideal for helmet display optics and it was designated by the Society for Information Display and information Display Magazine as the display technology of the year for 2000.

The technology is expected to meet all military needs for helmet mounted displays and was selected for several Air Force and Army helmet programs including the Joint Strike Fighter and the Land Warrior program, which will require about 3,000 units per year over the next 10 years.



The low cost, and power consumption rates make this display technology also ideally suited for commercial applications. Magin Corporation — the contractor for this project - has shipped over 20 evaluation kits to customers and their micro display is considered the best on the market. The technology is already finding applications in cell phones, computer-connected eyeglass displays, and head mounted instrumentation displays. Future applications include medical and computer gaming and video.

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