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*Weapons Industry***



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WEAPONS INDUSTRY 2007

ABSTRACT: The Weapons Industry includes products that span from munitions, delivery systems, uninhabited vehicles, to sensors. The U.S. government procures these products, which are produced by both government organizations, such as depots, and commercial firms across the globe. Competition is replacing consolidation within the industry and the government needs to maintain domestic weapons production capability to include multiple sources and surge capacity. Action is required to ensure that a qualified and technically capable workforce is available to support the industry. The government must also develop guidelines to ensure the proper balance between safeguarding critical technical data with international cooperative weapons development.

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Fabrique Nationale, Columbia, South Carolina
Marine Corps Warfighting Laboratory, Quantico, Virginia
Marine Corps Weapons Training Battalion, Quantico, Virginia
Raytheon Missile Systems, Tucson, Arizona
Aerospace Maintenance and Regeneration Group, Davis-Monthan AFB, Arizona
General Atomics, San Diego, California
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Urban Redevelopment Authority, Singapore
Singapore Technology Kinetics, Singapore
Police Coast Guard, Singapore
Defense Science and Technology Agency, Singapore
Mitsubishi Heavy Industry Guidance and Propulsion Systems Works, Nagoya, Japan
Kawasaki Heavy Industry Aerospace Company, Nagoya, Japan
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INTRODUCTION

“No part of the industrial base is more critical to the global war on terrorism than the ammunition sector. At its most basic level, the function of the U.S. military is to place fire on targets. Everything else the military does is to create the conditions that will allow sufficient energy to be deposited in a timely manner on such targets, the destruction of which will lead to the defeat of the enemy. It is ammunition that makes the military an instrument of war.”

- Dr. Daniel Goure, Vice President, Lexington Institute

Dr. Goure's comments illustrate the criticality of ammunition and the entire weapons industry to the United States, especially while the nation is at war. Consequently, the weapons industry is a timely and appropriate topic for analysis. The purpose of this analysis is to provide an overview of the industry, which leads to U.S. government policy implications and recommendations. In order to arrive at these recommendations, the Weapons Industry seminar conducted a comprehensive examination of the industry that included literature reviews and domestic and international site visits to key government and commercial organizations that are representative of the industry.

The first step in this analysis is to define the industry by examining the products, producers, and buyers. With the boundaries of the industry defined, the status of the weapons industry is described. Since the industry is so diverse, its description is sub-divided into mature systems and emerging technologies. Mature systems include products such as small arms, and examples of emerging technologies include unmanned aerial vehicles and directed energy systems. The review of developing systems is followed by a discussion on the outlook of future warfare that includes global, regional, and domestic trends. These warfare trends include a discussion of the impact of precision guided munitions on the battlefield and demand for persistent intelligence, surveillance, and reconnaissance. The examination of warfare trends is continued by a review of trends that impact the U.S. government and weapon suppliers. U.S. government challenges include budget uncertainty, defense acquisition transformation, industrial base issues, and a changing workforce. Challenges facing the weapons suppliers include an emphasis on competition and an uncertainty over requirements that are leading them to develop products in advance of firm government specifications. Like the government, commercial firms across the globe are also facing human resource challenges.

All of this background leads to the summary of policy implications for the U.S. government and recommendations for action that will benefit the industry. These issues include: (1) the effect of government regulation on economic efficiency, (2) proliferation and security concerns for weapons technology, (3) the need to maintain a domestic weapons industrial base, (4) promoting research and development in the weapons industry, (5) actions needed to retain a qualified industry workforce, and (6) U.S. relations with its alliance partners.

DEFINING THE WEAPONS INDUSTRY

The aim of this industry study is to examine the weapons industry with an eye toward recommending changes in U.S. government policy to improve the industry's ability to enable and resource national security strategy. The first step in this process is to define the weapons industry to delineate it from other industry studies being performed at the Industrial College of the Armed Forces and to form a basis for analysis and evaluation. To serve these purposes, this study will define the weapons industry based on its products and its buyers.

Other Industrial College of the Armed Forces industry studies address defense-related industries for major combat systems such as aircraft, land systems, and shipbuilding; key technology sectors such as electronics and information technology; foundational capabilities such as manufacturing, transportation, finance, and health care; and areas of current and future interest such as biotechnology and privatized military operations. For this study, the weapons industry will be defined to include the products that fit neatly outside these other groupings.

Traditionally, the weapons industry involves arms and munitions employed by the individual warrior, such as small arms and their ammunition, and man-portable mortars, grenade launchers, missiles, and related munitions. The weapons industry has also included weapons closely related to these individual weapon systems: artillery, crew-served weapon systems, missiles, and munitions mounted on or fired from the various air, sea, and land combat vehicles and systems, including kinetic weapons ranging from simple mortar shells to high-technology Global Positioning System (GPS) guided shells and other precision-guided munitions. This study will address these traditional components of the weapons industry.

Recent developments and military experience have significantly broadened the range of systems that must be considered as part of the weapons industry. Revolutionary kinetic weapons, such as electro-magnetic rail guns and anti-ballistic missile systems, such as the exo-atmospheric kill vehicle, must be considered. Non-lethal and less-lethal systems, from variants of small arms to broad area crowd control systems, are now of interest. Similarly, directed energy weapons, both radio frequency and laser, are of increasing relevance. Experience in Iraq and Afghanistan has demonstrated the need for technologies to detect, remotely detonate, and protect personnel and systems from Improvised Explosive Devices (IED). Finally, advances in robotics, remote control, and sensing capabilities have enabled highly capable uninhabited vehicle capabilities finding use in military and homeland security applications in the U.S. and abroad. Because of the importance of these relatively new classes of weapons and the fact that they don't fit neatly into the other industry studies, they will also be addressed within this study.

In order to recommend changes to U.S. policy regarding the weapons industry, the definition of the weapons industry must be restricted to certain buyers. Specifically, the weapons industry to be examined in this study serves the U.S. government's defense department and related agencies. The definition is inclusive in that it includes all firms and organizations that provide the stated products to the U.S. defense establishment. The definition does not exclude firms that serve both this establishment and others, either foreign defense establishments or commercial or civil uses. Finally, the definition does not distinguish based on geographic location or nationality of producers or suppliers.

The obvious components of the weapons industry are the various firms that develop and produce weapons, such as General Dynamics (GD), Fabrique Nationale (FN) and General Atomics, and the buyers that use the products, including the military services and the organizations that make up the homeland security community. In addition to these producers and consumers, there are a number of other important components of the industry. A variety of firms supply components, subassemblies, and special tools and machines to the industry. Components and subassemblies come from firms that produce weapons as well as those specializing in electronics, information technology, manufacturing, and other areas. Special tools and machines are provided by domestic companies such as Haas Automation and their foreign competitors like Yamazaki Mazak. In addition, a number of concerns sustain and upgrade weapons systems, ranging from private firms such as Raytheon and Singapore Technology (ST) Aerospace to government agencies like the Letterkenny Army Depot. Finally, weapons systems are demilitarized by activities such as the

Aerospace Maintenance and Regeneration Group (AMARG). Together, these various firms and the markets in which they participate constitute the weapons industry.

As the study progressed, it became useful to consider two different segments of the weapons industry. Products, markets and industries progress through a lifecycle, moving from introduction through growth and maturity into decline. The diversity of the weapons industry, both in products and in their lifecycle stages, requires that products early in their lifecycles, herein called emergent products, and those late in their lifecycles, herein referred to as mature products, be treated differently. While there are common challenges facing products and producers in these two classes, there are also important instances where the challenges faced are very different. Policies and resource strategies that are effective in shaping and strengthening the industry's ability to efficiently and effectively provide mature products to the U.S. defense establishment are not likely to be equally effective when applied to emerging products. Policy recommendations that ignore the differences between these two sectors are unlikely to improve the ability of the weapons industry to meet the U.S. defense needs of the future.

This industry study will consider both the mature product and emerging product sectors. Small arms, artillery, crew-served weapons and gun systems, related ammunition and munitions, missiles, and nuclear weapons are generally mature and will be considered within the mature product sector. Uninhabited vehicles, directed energy weapons, non-lethal and less-lethal weapons, and IED defeat capabilities are all relatively new and will be considered within the emerging product sector. Considering both sectors will ensure that the study's conclusions and recommendations are broadly applicable. With a general understanding of the definition of the weapons industry, the current status of the industry can be explored.

THE STATUS OF THE WEAPONS INDUSTRY

The domestic weapons industrial base is composed of a very diverse group of producers. The variation ranges from small independently owned micro unmanned aerial vehicle (UAV) businesses to the large government owned and government operated (GOGO) depots, arsenals and ammunition manufacturing plants. In most segments of the market, there is a strong interdependency between the government buyer and the suppliers. Unlike Japan where Mitsubishi Heavy Industries relies on the government for only 2-3% of its revenue the U.S. weapons industry derives most of its earnings from Department of Defense (DoD) spending and as a result will expand or contract along with the defense budget. The cyclical nature of the defense budget has had a significant impact on shaping the market. As spending increases, there are new entrants into the market, typically in the introduction and growth phases of the life cycle. Conversely, as the budget contracts these late entrants either fold or are absorbed by the larger corporations. If there is an expansion that endures for a significant period of time, such as the Reagan defense build-up or the current Iraq conflict, there will be new entrants into the mature sectors of the market in an effort to increase sales and earnings, especially if the industry has limited excess capacity.

Mature Sectors of the Weapons Industry

The mature sectors of the weapons industrial base are characterized as those products which have been in production for a significant period of time, decade or more. The products are commodities with little product innovation or variation among suppliers. There is widespread technical knowledge of the product and manufacturing processes and as a result, there is typically a de-skilling of workforce (Grant, 2006, p.307). Without product differentiation, corporate strategies

focus on consolidation of facilities, equipment modernization, streamlined production, process improvements, and supply chain management. Most of the competition for the products of the mature sector center on cost; and as a result, there is a tendency towards manufacturing process innovation and capital intensive large scale production. There are few technical or governmental barriers restricting competitive entry into the market. The profit margins are typically small compared to earlier stages of the product life cycle. Foreign suppliers are prohibited from competing for much of the U.S. DoD weapons market due to legal provisions such as the “Buy America” Act and the Berry Amendment. As a result of these market characteristics, narrow margins and high cost entrance barriers, there are few new market entrants. Therefore, the market tends to be highly concentrated; and in addition to cost, high quality products are key success factors (Grant, 2006, p.307).

The mature sector of the weapons industrial base has been on a consistent consolidation since the end of World War II. The number of government and contractor owned plants has shrunk dramatically. A specific example is in the nuclear weapons industry. In the 1960’s there were over twenty companies involved in the missile/reentry vehicle field whereas today that number has consolidated down to three major entrants. Some of this reduction was clearly needed at the end of the cold war, but little was done by DoD to manage or shape the reductions of the contractor facilities. The Defense Contract Management Agency’s industrial base assessment has found that there has been a gradual decline in production capacity to the level necessary to meet peacetime procurement requirements (McAleer, 2006). Notwithstanding, there is still a significant amount of excess capacity for most munitions manufactured in GOGO or government owned contractor operated (GOCO) facilities.

There are no real substitutes for most of the products in the mature sector. Quite frankly because of organizational inertia there is little incentive to innovate or produce substitutes. Currently, there is little capability for a fast large surge in production due to the dormant state of excess capacity. For example, once DoD realized they needed to increase production of body and truck armor for the troops in Iraq, it took two years to procure and deliver the equipment. The government strategy is to fight from the war reserve stocks and replenish during peace time. The excess capacity necessary for replenishment comes at a cost premium. For many of our weapons key components, there is limited excess production capacity available to support a production surge or acceleration.

The private sector has made great strides to reduce, if not eliminate, excess capacity. Just in time supply, long lead focus, and automation are all examples where the private sector has evolved to a lean, agile organization able to compete in the global market. In the private sector, an expense that fails to directly or indirectly generate a future revenue stream is identified and reduced or eliminated. DoD is looking to reduce costs and looks to excess depot capacity as an area that they are willing to accept risk. Donald Rumsfeld’s quote, “As you know, you go to war with the Army you have. They’re not the Army you might want or wish to have at a later time,” is telling in that this highlights a mindset of war material consumption vice material repair (Kristol, 2004). The implication is that modern warfare will be lightning fast and the classic mobilization of the defense industry and depots will never respond quickly enough to factor in this new modern combat. You will simply consume the weapons systems you have on hand.

As suggested by the Army’s employment of software, capabilities increases in conventional weapons will be realized not so much by improvements in the platform but by the employment of software in lieu of hardware. For example, the U.S. Marine Corps is currently working on a concept to upgrade their 120mm indirect fire weapon, XM 326, and their heavy machine gun. The concept advanced here is to take these conventional weapons, an artillery piece or crew served weapon, and

automate the ammunition loading and connect it to a commercially available Panasonic laptop computer equipped with government-owned fire direction control software running on Microsoft Windows Operating System. By doing so, several systems can be controlled by a single operator with the ability to engage numerous preplanned or operationally requested fire missions. Software drives many of the capability increases the U.S. military continues to garner in its current and future weapons systems.

The industrial base for development and sustainment of these systems is shrinking and as this is a true monopsony this situation will not improve. This should lead to discussions at the highest levels of our government because we will eventually reach a point where the weapons on hand today cannot be adequately maintained. This situation coupled with international debates on military capabilities suggests that we are rapidly approaching the time where the debate must address more international weapon systems development and a sharing of key technologies. In addition, this kind of debate and thought process could also expand to emerging sectors of the weapons industry.

Emerging Sectors of the Weapons Industry

The defense industry as a whole and specifically the weapons industry has always been in a constant state of flux. Changes in the weapons industry can be attributed to many factors; technology, doctrinal, or changes in battlefield tactics to react to a thinking enemy. Nothing has upset America's comparative advantage more than war against an enemy that has proven themselves highly adaptive and resourceful creating a comparative tactical advantage against the best military in the world through the use of rudimentary technology. IED's have caused the DoD to change its tactics to fight this battlefield scourge that has pushed the Iraq war into its fourth year.

There are many companies that are supporting the IED effort. The entire industry focus is divided into three predominate areas: armament improvements/vehicle design modifications, electronic defeat network technology, and technology that finds the device. Major players in the defense industry: GD, Raytheon, BAE, and Northrop Grumman appear to be the largest contributors, if not from developed products fielded to date, certainly from total defense money awarded. There is little information on total dollars allocated and even less information on what a particular industry is developing except for armament improvements and new vehicle production. GD, the industry leader of land combat systems, and others are working with the Army and Marines for the next vehicle design and continuation of the up armament process ongoing since late 2003.

Armament

During the Cold War, armor protection for U.S. vehicles was focused to defeat high-velocity kinetic energy projectiles against our armor frontal slopes and vehicle side. There was less armor around the track wheel wells and under belly. The IED's highlighted this vulnerability on the M1 Abrams Tank and Bradley Fighting Vehicle. Industry is catching up by developing IED resistant vehicles and placing reactive type armor plates on the M1's and Bradley's. GD is outfitting the Abrams and British Aerospace Systems (BAE) is upgrading the Bradley. GD has manufactured slat armor for the new Stryker Armored Carrier that deflects the blast away from the vehicle.

With the development of future combat vehicles, the company Force Protection and Protect Vehicle out of Ladson, SC is making mine/IED protected vehicles. These mine-resistant ambush protected (MRAP) armored vehicles have V-shaped hulls which deflects the force of the blast up the sides and away from the crew. "MRAP vehicles will mitigate or eliminate the three primary kill

mechanisms of mines and IED's: fragmentations, blast overpressure and acceleration. From a weapons industry perspective armament protection fits into the defensive category of defining the weapons industry.

IED Sensors and Robotics

There is another battle on the battlefield: the battle of the airwaves or radio spectrum to combat IED's. The defense industry and DoD labs are working feverishly to find devices that can defeat IED's and work friendly within the electro-communication environment. General Atomics, a leader in unmanned aerial vehicles was tapped to help find IED's. U.S. Army Material Commander General Benjamin Griffin, the Research Development and Engineering Command along with Communications and Electronics Command (CECOM) liaison with industry, and integrate findings from the field as quickly as possible (Griffin, 2007). Robotic technology is playing an increasingly important role on the battlefield especially with the defeat of IED's. The U.S. Army Research Laboratory (ARL) has extended its Robotics Collaborative Technology Alliance (CTA) with General Dynamics Robotic Systems with IED as a critical research focus (News Release, 2005. p.1).

Unmanned Aerial Vehicles

Most applications of UAV systems involve intelligence, surveillance, and reconnaissance missions but more recently offensive combat applications have proven an effective tactic. One of the more impressive displays of UAV capability was that of the Predator MQ-9 when it successfully bombed a sports utility vehicle carrying six high profile al-Qaeda operatives during Global War on Terror (GWOT) operations in Afghanistan (Dawkins, 2005, p. 8). This ability to reach out and 'touch' the enemy with minimal potential for the loss of American lives has created a heightened enthusiasm for committing resources to the production of many more UAV's for future military integration.

Military commanders have exceeded 100,000 total UAV flight hours in a variety of successful missions including strike, force protection, and signals collection (Cambone, 2005, p. i). This demonstration of potential has driven the Office of the Secretary of Defense along with all the service Chairs of the Joint Chiefs of Staff to map out a plan for the development and acquisition of a fleet of UAV's beyond the year 2030. Of note, is the myriad types of UAV's currently encompasses approximately 250 craft and is expected to grow to an excess of 1400 craft by the year 2015.

Directed Energy

Directed energy weapons offer multiple advantages over conventional weapons. The effect of the weapon can be almost instantaneous since the energy travels at the speed of light. For many applications, the near instantaneous application of the energy and lack of gravity simplifies the targeting of the weapon. By controlling the amount and form of energy, directed energy weapons can have lethal or non-lethal effects (Bergstein, 2005). While initial costs of the directed energy weapon may be high, the cost per shot of directed energy weapons is significantly less than conventional weapons. For example, the Tactical High Energy Laser (THEL) and Patriot battery can both be used to defeat incoming rockets. However, a shot from the THEL has a cost estimate of \$8K, compared to the \$3.8M cost for a shot by a Patriot battery (Spencer, 2006).

Directed energy weapons also have some disadvantages. They are ill suited for indirect fire, since they are a line of sight weapon. There are currently programs in development to provide mirrors that will redirect the energy, but these are early in development and will not be practical for most applications. Some directed energy weapons have severe logistics and efficiency constraints. Despite these challenges, there is a market for directed energy weapons.

While not all industry analysts agree that directed energy weapons are on the verge of replacing conventional weapons, there is sufficient evidence to defend the statement that directed energy weapons are an emerging subset of the weapons industry that will compliment existing systems. The “long war” generated a domestic and international market within military and non-military organizations for these weapons. Applications include airport defense, ballistic missile defense, rocket, artillery, mortar defense, and non-lethal crowd control. A wide variety of domestic and international suppliers that include both established defense firms and new companies are meeting the demand to develop these systems. This unique class of weapons has both technological and operational challenges. An international cooperative effort needs to investigate methods to increase the power of the weapons while reducing their size and weight. The area denial millimeter wave weapon is technically mature, but has not been fielded due to operational concerns. These concerns include the need to develop doctrine, training, and logistics for the weapons.

Projectile/Ammunition

Metal Storm Limited is among the new wave of emerging technologies. Not requiring any of the intricate firing mechanisms of most conventional arms, Metal Storm devices are capable of firing multiple electronically sequenced rounds from a variety of platforms. The technology allows for these rounds to be ‘stacked’ in a very simple manner within any form of tubular design. Each individual round requires electronic modification to operate in a Metal Storm device thereby limiting its use with other products. Currently Metal Storm is heavily invested in research and development with the idea or concept that ‘if we build it, buyers will want it’ and are heavily recruiting military sponsorship. The potential for very accurate and responsive targeting capabilities are evident within Metal Storm’s products, but mass production of this non-differentiated weapon system is awaiting commercial ‘buy-in’.

Another new weapon which is fast gaining interest amongst the defense forces is the electromagnetic railgun. Capable of launching large caliber projectiles at supersonic speeds up to 200 nautical mile ranges, this new weapon can deliver deadly force comparable to that of the Navy’s Tomahawk missile. Expected to be mission capable and in full production by the year 2014, the railgun has military officials very excited due to its destructive potential at such an extremely low cost. Requiring only electricity for launch, its simple kinetic ‘warhead’ is expected to cost less than a thousand dollars a round and can be directed to a GPS location in less time than its competitor, the Tomahawk missile. General Atomics, a defense contractor in San Diego, now has a \$10 million dollar contract for future production (Zitz, 2007, p.1).

The emergence of ground launched precision guided munitions such as Guided Multiple Launch Rocket System (GMLRS) and Excalibur for artillery, and eventually the Precision Guided Mortar Munition (PGMM) and the tank fired Mid-Range Munition (MRM), are an emerging set of weapons that are providing new capabilities and transforming doctrine and ground operations much like precision guided air launched munitions have done for combined force operations. These weapons enable highly responsive and scaleable kinetic effects, 24/7, in all weather conditions while minimizing collateral damage. They are highly effective against the asymmetric threats the U.S. is likely to face in the future, and as a result, demand is likely to grow even though these

weapons are much more expensive than standard munitions. GMLRS and Excalibur have been effectively integrated into the fire support systems and used with outstanding results in Iraq, yet procurement funding for these munitions remains low. As the face of war changes, the use of ground launched precision munitions may become necessary to avoid collateral damage even though these munitions are much more expensive. This review of emerging weapon systems provides background for the following discussion on the outlook for future warfare, which will shape the next generation of weapons.

IMPLICATIONS FOR FUTURE WARFARE

Current U.S. military operations highlight a growing gap in military power among nations. The lone superpower has in its arsenal not only a huge array of weapons of mass destruction, but a full spectrum of conventional weapons and capability to deal with nearly any military contingency. From long range stealth bombers, the most advanced fighter aircraft, to special forces, to large formations of naval units equipped with the latest aircraft and weapons, anti-ballistic missile forces; the U.S. possesses capabilities in a single unit that surpasses the capabilities of whole nations. A lone U.S. trident nuclear submarine at sea, becomes the 5th largest nuclear power, capable in explosive force in excess of what was expended during World War II ("Call to Nuclear Powers," 2005). How is a small regional nation able to exert any influence faced with this overwhelming capability? Small nations will most likely take a page from Iraq; using cheap unconventional, asymmetrical warfare to counter higher technology. Couple this path with the traditional, modern armed forces path of the modern nations such as China and Russia and the U.S. is faced with having to balance a full spectrum military from insurgent, asymmetrical warfare to global nuclear war, simultaneously. The U.S. can expect small nations in all regions to plan asymmetrical warfare operations, as the U.S. develops more sophisticated weapons technology.

What defense path will the small countries travel in an effort to build to their individual defense needs, given the growth in military capability gap with the industrialized countries? The constant theme heard during the industry international travels was UAV's. Small countries cannot afford a global, space based intelligence, surveillance, reconnaissance (ISR) capability; but UAV's deliver a low cost, regional ISR capability not possessed previously by anyone other than global superpowers. The future will see a proliferation of low cost ISR capabilities across all regions. This low cost ISR capability will allow countries to build smaller more capable and agile forces, to react to ISR information, vice larger less capable forces spread across the entire national borders. Precision information and targeting will allow a nation to increase military effectiveness without the broad cost of large standing forces.

While the term "The Long War" is no longer in favor, the future operations of the U.S. military will be characterized with checking emerging regional powers such as Iran and North Korea, while simultaneously conducting asymmetrical warfare throughout the world. These simultaneous operations will challenge the military force structure, since fiscal constraints will attempt to maximize multi-role weapons systems; reducing weapon's capability for flexibility. A current example was the effort to add ground attack capability to the U.S. Air Forces F-22. Adding bombs and external weapons systems reduces the aircrafts fighter capability, while adding a multi-role capability. Multi-role weapon systems place a burden not only on the designer but on the operator as well. A strike-fighter pilot must be able to perfect the delivery of multiple weapons both precision and non-precision, while maintaining his prowess in air-to-air combat tactics. A common theme from all four service chiefs, is that current military anti-insurgency operations in Iraq and Afghanistan has provided our young leaders with a wealth of knowledge and capability in urban

environments, but at the expense of the U.S. forces ability to operate in the classic maneuver warfare of land combat. Artillery units have been used in supply line security at the expense of their ability to plan and conduct indirect fire missions, critically necessary in modern land warfare. The challenge of the future will not only developing the weapon system to address the largest portion of the spectrum of warfare, but the training necessary for the human operator for these systems.

Finally, not only is future warfare going to be broader in spectrum than previously seen and the weapons systems asked to perform more roles, but the other forms of national power, (i.e., economic, diplomatic, and information) will be strengthened to match the current military dominance. As these other pillars of national power growth, fiscal constraints will logically force a resource shift to accomplish this. A logical tendency may be to reprogram military resources to strengthen these other forms of national power, reducing the military's capability just as it is facing the broadest spectrum of operations. All four pillars must be balanced in capability and power to avoid a strengthening of one pillar at the expense of the remaining pillars. This delicate balance will require all departments of our government to more effectively work together towards the national goal without the traditional inter-departmental friction of years past.

Global Outlook

Center stage in the world today is the threat of terrorism and subsequent measures to defeat it. Asymmetrical warfare has always used unconventional, simple means, to counter a higher technology threat. As the gap continues in monetary resources so too will the proliferation of unconventional threats to modernized forces. While weapon industries aptly respond with elaborate means to defeat the threat (at a price) the result will not ignore the manpower intensive needs to counter the human element of the unconventional threat. The role of the media has exposed a weakness in the strength of the modern civilized society, in its weak stomach for casualties. Precision striking capabilities now expected from today's forces, the weapons industry is aptly suited to provide. The accuracy of today's modern precision guided munitions enables an unprecedented mission success rate while minimizing collateral damage and denying the horrific pictures that otherwise become the insurgent's media weapons. Such high accuracy allows a smaller explosive charge to achieve the same desired effect, further reducing collateral damage, even when prosecuting military targets in the vicinity of civilian populations or friendly troops. Instead of having to estimate the number of sorties required to assure a single target's destruction, the modern war planner can now consider the number of targets destroyed per single sortie. New Concept of Operations (CONOPS) is now possible, allowing extremely close coordination and support of ground troops by friendly air and artillery forces.

The future battlefield will experience a constantly increasing demand for persistent, networked ISR capability and the situational awareness it provides. Timely ISR was once a luxury. Now many battlefield commanders will choose to delay a given mission until a clear ISR picture of the impending engagement is available on the network. Automated tools and decision aides that support intelligent pull of ISR data from the network by battlefield commanders speed the information dissemination process while reducing the risk of information-overload. Similarly, improving tools are allowing strategic planners to provided efficient push of ISR data to appropriate battlefield commanders. Such robust networks are even more important urban warfare where highly dynamic situations can include high-value targets that pop-up unexpectedly with engagement opportunities lasting only a short time. Rapid decision making and short kill-chain timelines are required, followed by near real-time Battle Damage Assessment (BDA) to determine the need for possible re-strikes. Reliable combat identification of contacts is critical but extremely challenging in

such environments. Network-connectivity for weapons will become more prevalent; supporting in-flight retargeting as well as increased ISR back to the network from the weapon's sensors. The difficulty of engaging moving targets in all weather conditions will be greatly reduced with these networked weapons. However, poor interoperability and lack of standards for weapon datalinks may result in platform/weapon stovepipes and impede the development and fielding of such capabilities.

The growing use of networks and timely ISR can have negative consequences if not properly managed. Dependence on the network and data will lead to increasing vulnerability to Information Warfare and erroneous data. Evolving Rules Of Engagement (ROE) that depend on ISR may impede progress on the battlefield when the network fails or experiences jamming. De-congestion of bandwidth in the already crowded RF spectrum will become more challenging as the number of networks and users increases and competition continues with commercial users. Lack of adequate security protections and procedures for multi-level classification may also affect network capabilities if vulnerabilities can be introduced by events such as simply by dropping a networked weapon over hostile territory; commanders may be forced to set the entire network to the lowest level of classification to minimize the vulnerability.

Additional problems created by the gap between U.S. Forces and our allies appear today in the disjointedness of our coordinated operations. Typically, coordination becomes cordoning off areas of responsibility rather than units in coordination with each other. Despite mirrored capabilities, coalition systems are not able to talk to each other, drastically affecting the way we fight and the interoperability of written tactics. The assumption of what our own nation's forces are seeing in their information systems may be drastically different from our allies. This information gap can weaken technology advances as militaries are stymied by the incompatibility of coalition partners. An increasing trend towards international markets and cooperation is aiding the closing of these gaps but they are still present in hardware, software, and legal restrictions on the transfer of technology. This latter trend is becoming increasingly important as defense contractors lay down their strategy for providing stockholder value in the face of forecasted lean times that typically follow a wartime, buildup period. Domestic defense companies may be owned in part by foreign investors or be supplied by international subsidiaries. One example would be BAE Systems, a British company, with subsidiaries in multiple countries and boasts being the number one European defense company, the fourth largest defense company worldwide and the United States 7th largest defense company.

Technological innovations have always happened on the frontiers or through conflict requiring the U.S. to lead the race in such areas like space dominance. Weapons systems heavy in research and development spending have never really been attractive to U.S. taxpayers until the gap becomes critical. The driver in Cold War relations with closed societies was that of fear. While the cold war is over, the future landscape drivers will be what high technology advances our adversaries in closed societies are striving to achieve.

Regional Outlook

Coalition operations and Ballistic Missile Defense (BMD) dictate regional military trends in the weapons industry. We cannot ignore the threats to our neighbors, yet few threats are driving the U.S. Defense industry outside of the areas already mentioned. While BMD when fielded will have many allies wishing for protection under its umbrella such guarantees for total protection are not yet

able to be guaranteed. Thus, either those threatened by the increasing number of ballistic missile capable countries (25 and counting at present) will seek treaty agreements for coverage by more technologically advanced countries or if financially possible, their own version of a Theatre Missile Defense (TMD). There have been an increasing number of countries entering into agreements on stationing of BMD assets like the X-Band radar system to ensure their coverage under the BMD umbrella.

Coalitions marked by increasing roles in "policing" and "peacekeeping" type operations will help drive an industry trend towards non-lethal solutions to these stability type operations. The girth of systems runs from electromagnetic in nature like Raytheon's Project Sheriff, a short-range millimeter wave directed energy non-lethal weapon for use in complex urban environments, to alternate projectiles like those used in FN Manufacturing's FN 303 Less Lethal system. This latter system uses projectiles composed of polystyrene bodies and non-toxic bismuth forward payloads whose effects are non-lethal but disabling and capable of marking targets for later investigations. Some of these systems, although developed, still have scant available information on their long-term effects. More testing, research, and analysis is required to assure new non-lethal technologies do not create lasting detrimental health effects.

Domestic Outlook

Domestic trends within the Weapons industry will center around two key factors. Increasing desire for non-lethal weapons and advanced sensor systems to combat the common criminal. Complementing the currently utilized TASER™ weapons, non-lethal weapon systems involving more powerful, multi-round magazine artillery with projectiles designed as much to tag criminals as to immobilize them are under development as are UAV mounted sensors capable of delivering more precise targeting data. Imagine a thief tagged by a non-lethal highly precise weapon employed from an orbiting UAV before the police on the ground can make their way to the scene. The potential for such non-lethal use of force may bring into question the use of the military in a more domestic capacity to augment police forces when needed, but still stay outside the restrictions of "*posse comitatus*." This is just one example of the potentials which exist that can have a broad impact on future weapons production.

IMPLICATIONS FOR THE WEAPONS INDUSTRY

Trends and Challenges for the U.S. Government

There are numerous challenges for the U.S. government to meet when dealing with the weapons industry. Of these challenges, four critical issues emerge to focus upon: (1) budget uncertainty and investment in science and technology; (2) defense acquisition and business transformation as it relates to weapon system acquisition; (3) health and maintenance of the industrial base; and (4) human resources.

Budget Uncertainty and Investment in the Future

Because the Department of Defense is currently conducting wars in two theatres – Iraq and Afghanistan, the preponderance of our budget is understandably focused on our operational commitments. The challenge of the DoD is how to balance current threats/needs with future investments and foster the innovation needed to stay ahead of our enemies and be ready to counter

undefined threats. To help alleviate and provide alternatives to allay this concern, the Congressional Research Service has performed a formal analysis of this challenge and subsequently identified five long-term challenges for the Defense Budget in FY2006 and beyond. These challenges include: (1) defense budget constraints as a result of projected budget deficits; (2) dramatic increases in military personnel costs – should the Congress restrain future pay and benefits increases; (3) continual increases in defense operation and maintenance costs; (4) ability to afford modernization of military forces in light of continuing cost growth in many new systems; and (5) implications of a changed defense strategy – transformation and potential reallocation of priorities within the defense budget.

At the rate the deficit is currently growing many factors influence our ability to keep up with inflation and/or invest more heavily in technology and foster innovation is becoming more difficult. To maintain status quo defense spending, due to the growth in mandatory entitlement spending in Social Security, Medicaid, and Medicare plus the increasing interest on debt, the United States will have to take radical measures such as an increase in taxes, reduce or postpone availability of entitlement benefits to citizens, or borrow more heavily.

Within the defense budget, because budgets are growing slowly and potentially declining, there must be trade-offs made between paying for personnel and operating costs and the costs of modernizing the force by developing and procuring defense weapons. Historically, the preponderance of the variable spending in the defense budget has been that of procuring new weapons. We have seen large increases and large decreases in the variable spending for new weapons over time depending upon the prioritization placed on the new requirement(s). Conversely, we have seen military personnel and operating costs fall in the mid 1990s after the end of the Cold War but in subsequent years, to meet emerging threats and conflict, increase steadily.

Another budgetary issue of concern is whether the “bow wave” of future acquisition programs in the pipeline can be sustained. Many in DoD are unsure whether projected weapon acquisition budgets are large enough to procure new, technologically advanced systems to replace existing, aging weapon systems given the initial start-up funding has been expended for development and prototyping and that larger investments in the engineering and manufacturing phases are both normal and expected to continue through full scale production.

Changes in the international environment, post 9/11, will also impact the defense budget and priorities. The 2006 Quadrennial Defense Review (QDR) outlines the new strategic framework for DoD and identifies four basic challenges DoD faces as it plans for the future. The reprioritized challenges include an assessment of the likelihood that threats will appear and the perceived vulnerability of the U.S. to such dangers, i.e. traditional challenges from regional competitors, irregular challenges of unconventional warfare, disruptive challenges from a future global competitor that could attack the U.S. military comparative advantage in areas such as space surveillance, satellite communications or networked warfare, and lastly catastrophic challenges to our military might by state or non-state actors with weapons of mass destruction. Each of these challenges could support the need to increase overall percentage and/or dollar increases in the defense budget.

Defense Acquisition Transformation

The Department of Defense is aggressively transforming its institutional acquisition processes and systems to align with 21st century national security requirements and defense budgets. At issue is how to make the acquisition process more flexible and responsive to emerging needs and how to reduce the total time it takes to develop, test and field new weapon systems. The future of weapon systems acquisition is being analyzed as is every aspect of how the DoD does business with

a plan to streamline our processes to deliver improved capabilities to the Nation's warfighters. Additionally, there has been a trend toward international cooperation in weapons systems whereby the DoD and our allies leverage each other's technology, talent, and funding. Notable weapon systems currently employing international cooperation include the Joint Strike Fighter, the Ballistic Missile Defense System, and the Army's Excalibur weapon system.

Defense Acquisition Transformation Initiatives are occurring across the defense-wide acquisition community to affect the entire spectrum of activity. The Undersecretary of Defense for Acquisition, Technology, and Logistics has identified seven formal Defense Acquisition Transformation Initiatives to transform acquisition processes, systems, and management structures to achieve a more integrated, holistic, and cohesive business environment. Because all elements of the acquisition system are involved, the transformation process is intended to be continuous and evolutionary. Anticipated results of the transformation include enhanced workforce productivity, collaborative organizations within the Services, DoD and Interagency stakeholders, realistic and stable budgeting, and well defined requirements and timely delivery of these capabilities to the Combatant Commanders within schedule and cost constraints.

Maintenance of an Agile and Competitive Industrial Base

The 2006 Defense Acquisition Performance Assessment project (DAPA), among other things, confirmed that the industrial environment supporting the weapons industry has changed in many ways. Globalization, commercial item procurement, industry consolidation, and outsourcing have fundamentally altered the landscape of the weapons industry and thereby present a unique challenge to the DoD unlike no other previously experienced.

DoD has recently been faced with industry segment capacity concerns centered on difficulties associated with rapidly increasing the production of "important" (based upon unique operational requirements) items. Problems exist in unique defense "niche" items where limited production occurs during peacetime. Additionally, problems have begun to surface at the second and third-tier subcontractor level necessitating a definition of "important component" which include descriptors such as production by a single source, used by three or more programs, and representing an obsolete, enabling, or emerging technology.

Commercial market and globalization has become challenging because in the mid to late 1990s the DoD began using commercial items and services because they contained the most current and advanced technology available, allow development costs to be amortized among the broader commercial base over time, and are available from numerous commercial suppliers. Fast forward to today when these commercial components are often included in highly classified systems. Because, in most instances, DoD is not the predominant buyer, we have little leverage in these markets. There is little incentive for these suppliers to modify commercial practices or processes to support DoD, and we are often adversely impacted by increasingly global supply chains.

Export control restrictions also impact global markets thereby impacting our U.S. industry partners. This concern has prompted a study by the Institute for Defense Analysis on four major areas affecting the weapons industry – satellite manufacturing, semiconductors, machine tools, and advanced materials. In these four industries, the report found that U.S. companies have not suffered severe economic impacts due to differential U.S. export controls, but that may not be the case going forward. Specifically, large backlogs and long processing times for export control cases have become a serious issue affecting defense trade. Export controls threaten to disrupt supply chain and technology development strategies thereby cutting off market expansion and diversification opportunities.

The DoD has long pursued a policy of competitiveness and promotion of innovation. DoD's interests are normally best served by maintaining competitive markets for products and services. The presence of a sufficient number of capable suppliers in core defense markets foster competition and innovation vital to meeting future warfighting requirements. DoD policy opposes business transactions that severely restrict or eliminate competition or those transactions that may create unfair competitive advantage. As more and more weapon manufacturers consolidate and merge, the ability of DoD to maintain competitive markets becomes increasingly threatened.

U.S. Government Human Resources Challenges

The U.S. government is facing a number of growing human capital issues that include: an aging work force, a small influx of college-age technical and professional workers into the work force, and a lack of high school student interest in math, science, and engineering. In order to carry out the on-going war effort and support the military services' transformation initiatives, there must be a continued strong emphasis on recruiting, training, educating, and retaining a viable, highly skilled workforce. In addition to the current concerns, attention must be paid to the recruitment and retention of the future generation of Federal workers.

Many senior level employees are reaching an age when they are able to retire in the next five years. In FY 2004, 192,100 Federal employees were eligible for retirement (10.4% of the workforce); 303,000 employees were eligible for early-out retirement (16.4% of the workforce) – approximately 1/4 of the Federal workforce could be eligible for retirement during this period. In this same survey, the 50-54 year age group increased 6.1%, while the 30-34 year age group decreased 4.3% and the 25-29 year age group decreased 3.4%. The Office of Personnel Management (OPM) projected retirement losses per year are 61,000 employees from FY 2008 through 2010 (OPM, 2007).

OPM indicated in a 2004 survey that the college-age accessions declined by 3.4% for public service jobs. While there are a variety of reasons for this decline, a Gallup poll conducted in September 2006 indicated that 34% of 2,500 job applicants in the 18 to 29 year age category would be interested in federal employment – the DoD was identified as one of seven agencies of interest. According to researchers, the 18 to 29 year age group desires to make a difference in the public sector and they want to find value and meaning in their jobs. They welcome new technology, want job-related training, willing to take early responsibility for projects, want opportunities to finance their college education through government service, and expect emotional and financial rewards for their efforts (Rutzick, 2006, p.1).

The third major employment related trend is related to the future generation of workers. There is a current downturn in interest among high school students for the math, science, and engineering programs. The nation's defense, space, and economic programs rely heavily upon workers who are training in these specialized and technical fields. These trends and challenges for the U.S. government are only part of the entire picture. The weapons suppliers that support the industry have equally critical trends and challenges that must be examined to ensure complete understanding of the implications for the weapons industry.

Trends and Challenges for Weapons Suppliers

With a diverse industry such as weapons, it is challenging to draw conclusions that apply to all facets of the industry. However, the research uncovered a few reoccurring themes. Raytheon best articulated the first theme, which is current business is good. Their annual report to investors

provides the data to substantiate the Raytheon claim. Net income increased from \$417M in 2004 to \$1,283M in 2006. The company's debt decreased from \$4.6B in 2004 to \$1.5B in 2006 and their return on invested capital increased from 5.2% in 2004 to 7.6% in 2006. General Atomics is example of a privately owned successful weapons firm. As the sole source for the Predator and Reaper class unmanned aerial vehicle, the firm is expanding their production facilities and has a backlog of orders. Some of the other themes include product development, the impact of government sponsored competition and human resource challenges.

Product Development in Advance of Firm Requirements

These companies also serve as examples of the second weapons industry theme, which is the fact that companies are pushing product development in advance of requirements. While Raytheon company leadership is pleased with their current performance, they are not assuming that the status quo will continue indefinitely without active management. They cite the Harvard Business School text, The Innovator's Dilemma by Clayton Christensen that highlights the fact that many of the initially successful personal computer manufacturers, such as IBM, are no longer in the business due to disruptive changes in the technology and business strategies. The Raytheon annual report also cites one of their major risk areas as the need to identify new products and services for current and future markets. One weapons area for future growth identified by Raytheon is directed energy. For example, they are actively marketing their Vigilant Eagle system, which is an airport based high-powered microwave system that provides airliners with a defense against shoulder fired rockets. Raytheon developed their Vigilant Eagle system in anticipation of a future Department of Homeland Security (DHS) requirement for domestic airports or a DoD requirement for security at expeditionary air bases. This system is one of the many projects funded by the \$464M in research and development funds that Raytheon invested in 2006. General Atomics independently developed the Predator B (now Reaper) based on their projection of future requirements for greater payload, higher altitudes, and greater speed.

It should be noted that companies are proceeding at significant risk by developing systems in advance of requirements. While General Atomics already has a buyer for the Reaper, Raytheon has yet to find a buyer for the Vigilant Eagle system. The firm, Metalstorm provides an extreme example of the risk associated with future technologies being developed in advance of requirements. This small firm's future is dependent upon its ability to find a buyer for its unique technology of electronically triggered multiple rounds from a single barrel. While their technology offers the potential for revolutionary increases in rates of fire, the company is struggling since it has not yet found a buyer with a requirement that their technology can address.

Impact of Government Sponsored Competition

Another theme in the weapon's industry is the government's desire to maintain competition. The 1990s saw wide spread defense industry consolidations. In the 2000s, the government encouraged competition. One example is the small arms ammunition manufacturing market. Prior to 2005, the United States had a sole domestic supplier; the government owned contractor operated plant in Lake Charles Army Ammunition Plant, Missouri. In 2005, the DoD, awarded a second source contract to General Dynamics to produce small arms ammunition. This decision provides numerous benefits to the government. The addition of competition provides ATK the incentive to improve efficiency of the Lake Charles Plant. A second manufacturing facility also reduces the possibility of an interruption to the ammunition supply should the Lake Charles plant experience

terrorism or a natural disaster. Finally, the second source will provide increased capacity, which should avoid future ammunition shortages like the ones experienced in 2004. Another example of a government encouraging competition is found in Japan's development of their new cargo aircraft, CX, and maritime patrol aircraft, PX. The Japanese Ministry of Defense development plan requires that the aircraft be developed by three separate companies with each company having responsibility for specific portions of the aircraft.

Weapon Industry Human Resources Challenges

The global weapon's industry human capital challenges are similar to those of the Federal sector. The commonalities are the growing number of aging senior professional and technical workers and the new generation of students that appear to be less interested in the fields of science, technology, engineering, and mathematics than in previous generations.

Singapore and Japan serve as examples of trying to bridge these challenges. They are dedicated to continuous learning and individual development. Singapore is becoming an increasingly mobile society. The city state has no natural resources, but the government and industry sectors team together to leverage continuous learning among their work force population. They constantly update their competencies to broaden their competitive advantage in business and engineering. 80% of the youth attend college and there is a growing interest in science, technology, engineering, and mathematics. Singapore's goal is to establish a community of knowledgeable workers who will deliver the right information to the right people at the right time while protecting its integrity. Enhance knowledge flow requires attention to personnel, work processes, organizations, and technologies. The government and industry have worked together to adapt military technology in creative way to develop first Infrared Fever Screening System – a defense against SARS by setting up information technology infrastructure for monitoring and contact tracing. In addition, defense and procurement expertise facilitated support for last December's tsunami relief efforts by deploying engineers and other professionals with the Singapore Armed Forces to provide technical advice and engineering support for communications setup and construction of air, land, and sea facilities (Singapore DSTA brochure, 2007, pp. 57-59).

Using another approach, Japan provides an informal lifetime employment system in most of its industries. Japan has a Museum of Emerging Technologies that encourages its youth to explore the latest in science and technology. There has always been a heavy emphasis placed on science, technology, engineering, and mathematics within Japan. Sony, Panasonic, Toyota, Kawasaki, and Mitsubishi are world-wide trademark names for electronics and precision equipment. Companies have regularly recruited university graduates for their managerial and technical positions expecting the employees would work until they are 55-65. Guaranteed employment and a secure salary promote employee loyalty, protect the training investment, diminish employee turnover, and create strong colleague relationships. Even in this structured society, there is a slow trend to deviate from tradition and promote ability over age and title. The competitive market is forcing this change in Japanese companies.

Both countries like the U.S. industrial sector recognize the need to supplement their aging work force with highly skilled and educated employees. Women and immigrant workers are being tapped for employment opportunities in Singapore and Japan. Both countries have long standing traditions for women to stay at home to care for their children. In Singapore alone, 450,000 new jobs are projected in the next 5 years for a population of 4.3M people. Women will be recruited to fill most of these employment needs. Both countries use employment incentives similar to the U.S. industrial sector: part-time employment, training courses offered to develop new skills, flexible

hours, work at home, continued skills development, and child care/after school care (Gross, 1998). This discussion of the challenges facing weapon system suppliers along with the remainder of the background on the industry provides the basis for policy implications and recommendations.

U.S. GOVERNMENT POLICY IMPLICATIONS AND RECOMMENDATIONS

Since its emergence as a world leader after World War I, the U.S. has relied on its industrial base to provide the necessary quantity and diversity of war implements. As the U.S. government and policy makers have been reluctant to develop a centralized defense industrial policy and management program, industrial capacity has been maintained through the Defense Production Act (Friedberg, 2000). Consequently, American industry and its relative health has always been a key consideration for U.S. policy makers and so the need to balance arms trade and national security becomes a key consideration and policy objective.

Given the trends outlined in this study, this balancing act has become increasingly difficult due to consolidation of defense suppliers and public demand for reduced defense spending. As the world gets “flatter” through globalization, the threat of asymmetric warfare increases and proliferation of weapons of mass destruction becomes more of a reality, the following issues will need to be addressed: government regulation and economic efficiency; proliferation and security concerns for weapons technology; maintaining a domestic weapons industrial base; promoting research and development in the weapons industry; human resources; and U.S. relations with its alliance partners.

From a stand point of economic efficiency, less government regulation is generally a preferred policy since it allows the free hand of the market to determine the equilibrium point for supply and demand. Letting the free market forces determine this equilibrium point generally allows benefits to exceed costs and leads to more efficiency than arbitrarily having a government agency or a monopoly industry set production quotas. However, there are other factors that responsible governments must consider when setting policies for the weapons market. Maintaining both domestic and international peace and stability is one of these major considerations. Permitting the proliferation of advanced weapons technology to rogue regimes or supplying weapons to fragile regions could be destabilizing and jeopardize world peace, promote terrorism and increase human suffering. Increasingly, governments have instituted controls and restrictions on the use and sale of weapons abroad. These restrictions have become progressively more detailed as the sophistication and lethality of weapon systems increase. Given these limitations on the control and of weapons, most governments nonetheless seek to maintain a robust, responsive, and efficient industrial base to insure the availability of the arms necessary to meet threats to their national sovereignty and interests. The U.S. in particular, given its leadership role in the world today, has a significant incentive to devise and participate in policy initiatives which control the sale and transfer of weapons technology. It is recommended that the United States continue current policies that limit and control the spread of weapons technology to enhance peace and stability throughout the world. Specifically, the Arms Export Act and the International Traffic in Arms Regulation (ITAR) are useful examples of the types of policies that should be followed.

Balancing the need for maintaining technological superiority, the reality of limited budgets and increasing demand for scarce resources, the United States must seriously consider the costs and benefits of maintaining a domestic industrial base for weapons production versus acquiring them from foreign sources. The United States has a long history of operating government owned facilities for the production of weapons and munitions. Government run operations are generally less productive and efficient than privately operated factories and so more recently the DoD has turned

to a hybrid system that tries to leverage the advantages of both systems. This system uses a private contractor to operate a government owned facility and meets the government's requirements through contract incentives. Historically it has been found that a mix of government operated and contractor operated facilities is the best way to meet the varying needs of the DoD. This arrangement works well for small munitions production when surges are encountered during periods of armed conflict. For the larger and more advanced weapon systems, the United States must look to industrial manufacturers. Balancing this between domestic producers and foreign suppliers is a critical challenge that includes many factors such as preservation of the U.S. suppliers to strengthening international security alliances. It is recommended that the United States government provide incentives that maintain and encourage a domestic industrial base for weapons technology and production. Maintaining a mix of government owned and operated facilities along with privately owned facilities is necessary for meeting the needs of the DoD. We should accept that there will be inefficiency with this policy but understand that it is necessary in order to achieve our long term security needs. While ensuring we maintain minimal industrial capability, the DoD should also encourage competition and multiple suppliers when ever possible.

In terms of weapons research and development, the United States' industrial and academic base, since World War II, has arguably succeeded in producing some of the most lethal and operationally effective combat capability the world has ever known. Yet, the capabilities wielded by the United States military did not materialize overnight but, instead, were the product of an extensive, deliberately constructed, research and development infrastructure. "The catalyst that created today's generation of technological advances was a post-World War II decision to create a huge national engine of public science. The foundation of this decision was to fund investigator-initiated projects, largely conducted in academic laboratories, by civilians independent of the military establishment. Under this construct, universities did fundamental research work—the "R" in R&D. Government laboratories and arsenals would then take some of that research and, with the cooperation of industry, develop it into military technologies" (Fountain, Winter 2004-2005, p. 40).

In resourcing this research base, the United States governmental research and development infrastructure operates on a budget of approximately \$13 billion a year (Fountain, Winter 2004-2005, p. 48). In Fiscal Year 2007, basic and applied research consumed the preponderance of funding across all science and technology activities. The robustness of the research and development budget enables DoD to maintain its competitive technological edge but the ability to maintain this level of spending over the long term may prove problematic. Of the roughly \$500 billion Defense Fiscal Year 2007 budget, less supplemental funding for the Global War on Terrorism, science and technology comprised less than 3% of the DoD expenditures and investments. For the foreseeable future, it is probable that science and technology funding for DoD related activities will continue at the 3% or less level. It is recommended that the U.S. government increase the DoD Science and technology budget by 10% over the next five years to ensure we maintain adequate research and development for new and advanced weapons systems and technology.

In moving to personnel considerations, human capital will continue to be integral to a robust weapons industry. However, issues around human capital, aging work force and their replacements, will drive significant adjustments to the way people are managed in support of the weapons industry. In order to meet the human capital challenges, the U.S. government needs to deal with the aging work force issue. There is a need to focus on the retiree population and offer continued employment on a part-time basis. Many retirees seek part-time employment in their respective communities and they do not desire full-time, permanent work. In most cases, retirees retain their retirement benefits and only desire the supplemental income. This group of seasoned and talented employees can serve

as mentors to the 19 to 29 year age group as well as the legacy workforce in the 30 to 49 year age group. The government would receive a substantial return on its investment for the training these employees received throughout the years and it would be an economical method to transfer valuable knowledge and experience to the other employees. Senior employees are motivated when they are involved in mentoring and training situations, so there can be mutual benefit in establishing an arrangement to mentor and train a new generation of employees (Palmer, 2006). This effort would foster a positive environment for continuous learning with far reaching effects.

The U.S. government must diligently pursue avenues to strengthen its ability to attract, train, educate, and retain a diverse and highly skilled work force that is strongly committed to the nation's defense and security. To meet the challenges of the 21st century, our nation must be able to maximize its human capital to have the right personnel in the right place at the right time with the right skills to do the right things for the right reasons. It is recommended that funding for educational programs be maintained with incentives being offered for people to enter the science and technology fields.

A final policy implication that affects the policy for weapons acquisition is the relation of the U.S. with its international security partners. Historically, strong alliances result in enhanced security and increased economic prosperity. The security alliance between Japan and the U.S. is a good example of this. Having commonality of weapon systems between alliance partners also increases interoperability and efficiency. However, this also means that weapons production must be shared between the industrial bases of the security partners. Japan and the U.S. have achieved a working balance in their relationship and this is evident in the current missile defense system that is currently being constructed. It is recommended that the U.S. work closely with its long term security partners to achieve a balance in security concerns and weapons acquisition. The current agreements with Japan and England serve as good models for joint interoperability and fairness.

CONCLUSION

This study examined the weapons industry that develops, produces, sustains, upgrades, and eventually demilitarizes weapons for the U.S. defense community. The range of weapons considered includes everything from traditional individual and crew served weapons and munitions to new classes of weapons such as anti-ballistic missiles, uninhabited vehicles, directed energy weapons, and IED defeat capabilities. This industry was examined through the lens of two sectors, one that concerns mature products and one concerning emerging products and technologies. The industry supporting the mature sector continues to consolidate, driving competitive strategies that reduce infrastructure and production costs rather than spur product innovation and reducing excess and surge capacities. To the limited extent that mature product innovation does occur, it is through increasing integration and enhancement of software in mature weapons. In contrast, the industry supporting the emerging sector is in a constant state of flux, responding to developments in technology, doctrine, and tactics driven in no small measure by the asymmetric strategies and tactics employed by thinking adversaries. Intense product innovation is seen in the development of relatively new weapons like IED survivability and defeat capabilities, robotic and remotely controlled uninhabited vehicles and sensors, and directed energy weapons, and in the development of new capabilities in established weapons such as electronically fired and precision-guided projectiles as well as electromagnetic rail guns.

The defense establishment will require weapons industry support as it faces a challenging future mission environment. The growing gap between modern military powers, including the world's only superpower, and smaller nations with far more modest capabilities presents the need to

balance future force capabilities to meet both emerging regional powers with modern militaries and smaller nations and non-state actors employing asymmetric means with the same forces and capabilities. Individual weapon systems will be called on to perform more roles with fewer friendly casualties and less collateral damage while the defense budget tightens to make room for increased funding for the other instruments of national power. This will require precision strike capabilities backed by and networked with persistent and pervasive ISR capabilities, both implemented with robotic or uninhabited capabilities where possible. The ability to operate effectively and efficiently with coalition partners and to extend security to them will continue to be increasingly important. The weapons industry will also be required to provide the law enforcement and homeland security communities with non-lethal and less-lethal capabilities backed by advanced networked sensor systems.

The government and the weapons industry also face a challenging future. Budgetary pressure will constrain the defense budget, especially funding available for modernization, while defense acquisition transformation will shift the landscape. These factors will combine with pressures from globalization and export controls to further complicate the government's efforts to preserve and enhance the agility and competitiveness of the weapons industry. Government's management of the weapons industry will also be challenged by growing human capital issues. On the industry side, business is currently booming. However, firms are finding it necessary to develop products in advance of firm government requirements, increasing their risk. Government efforts to sponsor competition have resulted in improved efficiency in portions of the industry. The industry also faces a number of human capital challenges. All of these factors bear on the government's ability to ensure the agility and competitiveness of the weapons industry.

This study makes policy recommendations that should enhance the ability of the weapons industry to meet U.S. defense needs into the future. First, it is recommended that the current system to control the sale and transfer of weapons technology be maintained. Second, it is recommended that the U.S. government provide incentives that maintain and encourage a domestic industrial base for weapons technology and production and maintain a mix of government owned and operated facilities along with privately owned facilities. Third, it is recommended that the U.S. government increase science and technology funding by 10% over the next five years to maintain an adequate research and development base for advanced weapons technology. Fourth, it is recommended that funding for educational programs be maintained with incentives for people to enter scientific and technical fields. Finally, it is recommended that the U.S. work closely with long-term security partners to balance security concerns with operational interoperability and efficient acquisition.

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