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Weapons Industry

The Industrial College of the Armed Forces
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WEAPONS INDUSTRY 2012

ABSTRACT: The Industrial College of the Armed Forces Weapons Industry Seminar analyzed the domestic and international industries that support the development and sustainment of current and future weapons systems. This analysis assessed the current conditions, critical challenges, and five- and fifteen-year outlook for the U.S. defense industrial base within the international environment. The seminar concluded that certain sectors of the U.S. weapons industry may be severely challenged by planned Department of Defense (DoD) budget cuts starting in 2013, the January 2012 U.S. DoD strategic guidance to "rebalance" its forces and capabilities toward Asia, as well as ongoing decline due to years of insufficient sustainment. Maintaining the current U.S. technological edge and workforce expertise, developing and sustaining current and future requirements, and managing an increasingly global defense industry are critical challenges for the industry and policy makers.

Mr. Rick Bennett, Department of the Air Force
Col David Cohen, U.S. Air Force
Lt Col Anthony Cotto, U.S. Air Force
Mr. Mark Danburg, Department of the Air Force
Lt Col Thomas Dodds, U.S. Marine Corps
CDR George Landis, U.S. Navy
CDR Christopher Moss, U.S. Coast Guard
Lt Col Thomas Nicholson, U.S. Air Force
Mr. Charles E. Peartree, Department of State
COL Quenton Rashid, U.S. Army
COL John M. Scott, U.S. Army
LTC Gerard Vavrina, U.S. Army
Mr. Peter Wheel, Raytheon
Lt Col Raymond Wier, U.S. Air Force

Dr. Shannon Brown, Faculty
CAPT Janet Florey, U.S. Coast Guard, Faculty
Col Brian Collins, U.S. Air Force, Faculty

PLACES VISITED

Domestic:

BAE Systems Inc., Electronic Systems (Nashua, NH)
Beretta USA (Accokeek, MD)
U.S.Congress (Washington, DC)
Colt Defense LLC (Hartford, CT)
Esterline Defense Technologies (East Camden, AR)
FLIR Systems (North Billerica, MA)
Heckler and Koch USA (Ashburn, VA)
Kirtland Air Force Base (Albuquerque, NM)
Defense Nuclear Weapons School (Albuquerque, NM)
Lockheed Martin Missiles and Fire Control (Camden, AR)
Los Alamos National Laboratory (Los Alamos, NM)
National Technical Systems (Camden, AR)
National Ordnance and Ballistic Test Center (Camden, AR)
Naval Surface Warfare Center (Dahlgren, VA)
Raytheon Integrated Defense Systems (Andover, MA)
Smith and Wesson, Inc. (Springfield, MA)

International:

Alp Aviation (Eskisehir, Turkey)
FNSS (Ankara, Turkey)
Havelsan, Inc. (Ankara, Turkey)
METU-MEMS (Ankara, Turkey)
Office of Defense Cooperation (Ankara, Turkey)
Savunma Sanayii Müsteşarlığı (Undersecretariat for Defense Industries) (Ankara, Turkey)
Turkish Aerospace Industries (Ankara, Turkey)
Tusas Engine Industries (Ankara, Turkey)
U.S. Embassy Ankara
Hong Kong Ports and Maritime Command (Hong Kong)
Modern Terminal (Hong Kong)
U.S. Consulate Hong Kong
Aerospace Industrial Development Corporation (Taichung, Taiwan)
Armaments Bureau, (205th Arsenal) MND (Kaohsiung, Taiwan)
China Shipbuilding Corporation (Kaohsiung, Taiwan)
National Defense University (Tayoun, Taiwan)
Naval Shipbuilding Development Center (Kaohsiung, Taiwan)

INTRODUCTION

Two key factors can be expected to shape the near future for the United States (U.S.) weapons industry and the Defense Industrial Base (DIB) which supports it. First, the strategic "rebalance" toward East Asia and the Pacific announced by the President early this year in his strategic guidance for the Department of Defense (DoD)[1]. Second, the Budget Control Act (BCA) of 2011. The growing strategic importance of Asia and the relative decline in security threats emanating from Europe makes a shift in focus toward the East appropriate. Following the great recession of 2008-2009 and a long-simmering debt crisis, a new era of budget austerity for the U.S. Government that will impact the DoD deeply should come as no surprise. Capabilities to contend with potential threats in East Asia and the Pacific will emphasize air and sea power, and specifically the ability to counter anti-access/area denial forces. Other sectors of the weapons/capabilities mix may not fare so well in coming procurement fights. And while the DoD already absorbed a spending cut of nearly $500 billion over the next decade, another $500 billion in cuts looms under sequestration rules if the Congress fails to come to a budget agreement. With or without sequestration, virtually no corner of the DoD budget will be unaffected.

The U.S. weapons industry is not monolithic, but varied, and some sectors will be more affected than others are by these coming challenges. Those sectors which are less reliant on military and government customers, such as small arms and optical/thermographic sensors, will have more flexibility in adapting to the changed landscape. Others, such as energetics and missiles, are less adaptable, and in fact are already in a long, continuous slide resulting in real questions about future sustainability of the base. Research, Development, Technology and Engineering cuts over the next five years will bring funding down nearly twenty-five percent from their 2009 peak.[2] Procurement spending has been declining steadily since 2008, including a nearly 10 percent cut from 2011 to 2012.[3] While certain sectors, such as aerospace and intelligence, reconnaissance, and surveillance (ISR) may see some growth, other sectors, such as ordnance, are declining and likely to continue to do so.[4]

Since the height of the Cold War, the U.S. has grown accustomed to enjoying an unchallenged edge in military technology. While the collapse of the weapons DIB is not imminent, its future health is a serious concern. Significant defense budget cuts in the early 1990s dramatically shrank the number of U.S. defense companies. A new era of reductions threatens more consolidation, with the risk that some companies will exit the defense market entirely. Growth in overseas sales, facilitated by the Administration's Export Control Reform Initiative (ECRI), could help boost industry health but will not affect all sectors evenly and is unlikely to fully make-up for reductions in DoD spending. In addition to budget cuts and strategic rebalance, other challenges for the industry include the impact of the emerging field of cyber weapons, managing the effects of globalization, and keeping and developing a skilled workforce. The overview and analysis that follow seek to provide an insight into the nature of the coming challenges for the weapons industry and some recommendations on how to prevail in an admittedly tough environment. This analysis makes use of Michael Porter's "Five Forces" framework (threat of entry, power of suppliers, power of buyers, threat of substitutes, and rivalry among competitors) to help understand the competitive forces shaping the industry and assess its vitality now, and in coming years, as part of the overall defense industrial base.[5]

KEY ASSUMPTIONS

This report based its results on several assumptions. First, the Fiscal Year (FY) 2013 budget will be approved in accordance with the constraints of the BCA of 2011, and in accordance with the DoD January 2012 budget priorities. Sequestration or some additional lesser budget reductions will occur after FY13, with the government fiscal crisis continuing to pressure further DoD reductions. Operation ENDURING FREEDOM will be completed as scheduled in 2014, resulting in reduced demand for many, if not all, weapons systems. U.S. forces are expected to conduct limited engagements against asymmetric threats rather than major combat operations.

THE INDUSTRY DEFINED

By its very nature, the weapons industry DIB is broad, complex and difficult to accurately define. It encompasses high technology weapons such as directed energy weapons, to relatively low technology weapons such as firearms. It includes projectiles ranging from Intercontinental Ballistic Missiles (ICBMs) to small caliber ammunition (and the chemical propellant inside them). It also includes non lethal weapons, such as the TASER and electromagnetic radiation. Additionally, it includes the sensors (electro-optical, infrared, hyper spectral, etc.) required to locate, identify and track targets which are commonly integrated into the weapon itself. Finally, the weapons industry can include non kinetic weapons such as the emerging field of cyber weapons. In order to bound this broad array of products, the seminar focused on the following representative sectors:

- *Small Arms*. The Small Arms sector focuses on man-portable or crew-served weapons such as revolvers, semi-automatic pistols, rifles, machine guns, and shotguns for government and civilian customers. The Small Arms industry is based on a relatively low level of technology with multiple companies in the market.
- *Sensors.* The Sensors sector includes the optical devices required to target other weapons. It includes electro-optical, infrared and hyper spectral sensors and the components required to build them. These sensors can be hand held or integrated into the weapon system. Some sensors can fuse multiple image types together or rapidly switch between image types. This study focused on thermal imaging sensors.
- *Energetics and Nuclear*. The Energetics and Nuclear sector is comprised of two elements. Energetics includes chemical propellants for firearm ammunition and rockets, and chemical decoys such as flares. It also includes electromagnetic propulsion systems such as rail guns. Energetics has both military and commercial applications, though its customer base is predominately military. The Nuclear element is comprised of the infrastructure, facilities, and expertise required to design, built, and maintain the nation's nuclear weapons arsenal. This arsenal is deployed using a strategic "Triad" of intercontinental and submarine-launched ballistic missiles and bombs. This is only a government market.

Small Arms

Small arms are the simplest and most elemental tools of war. They cost little to manufacture and the technologies to produce them have proliferated around the world. The United States relies on a commercial defense industrial base to produce small arms for its military and law enforcement requirements. Based on categories used in the United Nations Program of Action, the accepted definition for small arms is as follows:

> "Small arms" are, broadly speaking, weapons designed for individual use. They include, inter alia, revolvers and self-loading pistols, rifles and carbines, sub-machine guns, assault rifles and light machine guns.[6]

Current Condition of the Market:

The market for small arms is divided into two segments: commercial (recreational/sport shooting) and government (military and law enforcement).

Barriers to competitive entry are relatively low for producers of handguns and sporting rifles (there are nearly 6,000 licensed manufacturers registered by the Bureau of Alcohol, Tobacco, Firearms and Explosives[7]). The manufacturing of military infantry weapons, however, carries substantial initial capital requirements, and this segment of the market is dominated by a small number of companies with high brand recognition and a historical legacy of supplying U.S. (and in some cases, foreign) armed forces. For example, Colt Defense produces the M4 carbine, which is a standard infantry rifle for the U.S. Army and Marine Corps. Beretta, similarly dominates the U.S. military handgun market, providing U.S. armed forces with its M9 sidearm, while Glock enjoys widespread use among federal, state, and municipal law enforcement agencies. Federal government acquisition policies and legislation have created winners among those few recipients of long-term contracts while leaving other companies to focus on state and municipal law enforcement contracts as well as the lucrative commercial gun market. Smith and Wesson, for example, recently made the decision not to pursue the forthcoming DoD carbine contract due to the high costs of competition and dubious gains vis a vis the lucrative commercial gun market.

Materials necessary to build weapons are readily available. What separates manufacturers is the quality of materials used and workmanship. For example, Heckler and Koch compete at the high-end of the handgun and carbine market using higher quality steel and manufacturing processes to differentiate their product from their competitors. Comparatively, some other manufacturers in the commercial market produce handguns and rifles using lower quality materials and manufacturing processes that allow them to sell at a lower price point and make profits on volume.

The power of buyers is substantial because the U.S. commercial market is the largest market for handguns and rifles in the world. Export sales for most companies are a small fraction of overall business, accounting for less than ten percent of sales.[8] Most of the small arms industry caters to the U.S. market in its design, sales and operational planning.

The threat of substitutes, such as non-lethal weapons, appears to be impacting the handgun market. Taser products are used widely by federal and local law enforcement, and are making inroads in the commercial personal protection market with their relatively safe electroshock weapon.

Rivalry amongst the competitors exists, with leading firms trading on their brand name and reputation. For example, Colt and Smith and Wesson are iconic brands with a rich history and excellent brand recognition. These companies rely on that legacy as a means to sell their product in this competitive market. Perhaps as a consequence of this history, small arms are a conservative industry, focusing on minor stylistic modifications rather than pushing the development of truly new and innovative products.

Market Outlook:

The current outlook for the commercial market segment is positive, based on extensive back orders and several consecutive years of high sales reported by major producers such as Sturm-Ruger, Smith and Wesson, and Colt.

The Weapons Industry Seminar visited several leading small arms manufacturers and gained insights into industry practices and challenges. For example, Beretta USA's strategy is to maximize different options for its customers and trades on the strength of the Beretta name and a diverse product line including both military and sporting weapons. As a consequence, Beretta is able to diversify their market and compete worldwide. Beretta's United States operations are running at full capacity -- three shifts daily. Beretta's U.S. commercial market share is approximately 6% to 10%.

The U.S. small arms industry is an oligopoly dominated by a few firms, and products differentiated on the margins. The industry vies for a robust but finite U.S. commercial and government markets.[9]

Challenges Facing the Market:

The small arms industry lags in the development of new markets. Strict laws governing civilian firearm ownership are the norm worldwide, limiting growth in overseas markets.[10] This places the industry at a competitive disadvantage with other industries where the prevailing strategy is to penetrate global markets with their product base. The small arms market seems to have resigned itself to a one-dimensional approach of capturing ever-smaller portions of the dwindling U.S. market.

A 1994 Army Science Board recommended consolidation in the small arms industry and identified three "essential" contractors necessary for the preservation of the small arms industrial base.[11] Recent legislative attempts to increase competition and support the small arms DIB such as the Small Arms Competition and Innovation Act of 2010 (HR 5181) met resistance by lobbyists and died in the Congress[12], although the three member "cartel" written into law in the aftermath of the 1994 study ended in 2010 with provisions in the National Defense Authorization Act which allowed for adding or removing firms from the original list.[13]

The U.S. Army is currently seeking replacements for the Colt M-4 carbine and the Beretta M9 handgun. The potential for replacement of both weapons offers the winners of the competition huge opportunities to solidify their position within the small arms arena for decades to come. In addition to providing the weapons, there will be long-term profits from maintenance and repair contracts, as well as the increases in worldwide commercial contracts that typically follow purveyors of key U.S. armaments.

The M4 and its predecessors have been dogged by performance issues, particularly jamming incidents, if the weapon is not maintained to standard (always an issue in combat conditions). This led for calls to find a replacement for the M4 through open competition. As of August 2011, the known M4 replacement competitors are Colt, Beretta, FN Herstal USA, Heckler and Koch USA, and Remington. While this competition continues, with no outcome in sight, the Army has granted Colt a contract to modify and upgrade existing M4 carbines[14]

Similarly, the M9 sidearm has often been criticized due to its heavy weight, lack of stopping power and service life of only 5000 rounds per barrel.[15] New polymers offer manufacturers opportunities to lighten the weapon and still offer larger calibers to provide the military a weapon that has the stopping power needed on modern battlefields. While a replacement for the M9 is not yet official, the vetting process is underway and according to a recent Army Times article, "all participants are "working diligently" to create a budget-friendly fielding and funding plan."[16]

Policy Recommendations:

As a customer, the U.S. Government should seek increased competition in the small arms industry while ensuring, via its acquisition and contracting policies, that it has the capacity to meet future needs. This will serve as a hedge against the possible shrinking of the small arms DIB if companies vacate the market due to cultural or legal shifts that constrict the market within the U.S.

Sensors

Current Condition of the Market:

As the U.S. enters a period of declining defense budgets, the military services will increasingly seek technologies that offer significant force-multiplier effects. Thermal imaging systems represent one of these technologies. Thermal imaging systems detect radiation in the infrared range and display it as an image based on the relative differences in wavelength or temperature with or without the presence of visible light. The capability to see the environment regardless of the ambient conditions has made thermal imaging systems ubiquitous in military, security, and law enforcement applications such as navigation and targeting, surveillance, and chemical, radiological and explosives detection.

Given the historical high demand for this technology, the U.S. defense market for thermal imaging systems is extremely competitive and characterized by the rapid introduction of new technologies and requirements, as well as a fairly small number of companies that comprise the large majority of the market.[17] The Weapons Industry Seminar visited several major manufacturers of defense thermal imaging systems, including FLIR Systems, BAE Systems, Raytheon, and Lockheed Martin. Collectively, these companies together with L-3 Communications and DRS Technologies (a Finmeccanica North America company), define the core domestic thermal imaging market with over 70 percent of all defense-related sales.[18]

While there is a huge range in the size and diversification of the individual companies--from Lockheed Martin with 140,000 employees and $45.8 billion in revenue to FLIR Systems with 3,100 employees and $1.23 billion in revenue -- no single company dominates this $5.8 billion market.[19] Raytheon and Lockheed Martin are the largest individual players with an 18% share, DRS and FLIR each have an 11% share, and BAE and L-3 have a 7% and 6% share, respectively. Worldwide, there are about 15 other companies with very small market shares that compete in the U.S. Government thermal imaging market. Essentially, all the competitors are price takers, especially since many of the companies share the same small, single-source suppliers for key electronic components, and therefore these companies compete on technical innovation, customer relationships, system quality and reliability, price, and ability to deliver.[20] The division of the market among the leading companies appears to be stable.

Market Outlook:

Given the realities of the fiscal challenges facing the services, the market outlook for thermal imaging systems is mixed. While it is difficult to separate out the performance of the

thermal imaging portfolios of the large companies, especially since those systems are often components of larger acquisition programs, generally, demand slumped in 2011 as evidenced by a five percent drop in FLIR U.S. Government sales.[21] This was prior to (although possibly in anticipation of) the implementation of the (BCA) that slashed $487 billion from the defense budget over the next ten years. Moreover, if sequestration is executed, the reduction may more than double, with the lion's share of those cuts occurring within the next five years. Either way, the indicators are that the procurement of thermal imaging systems will be negatively affected.

First, the rebalancing of the force, including the elimination of over 100,000 ground troops and their support assets (such as helicopters and armored vehicles) and the gradual withdrawal of coalition forces from Afghanistan, will obviate the need for systems that would have otherwise been purchased to equip them. Furthermore, whereas in the past the military services had the money to capitalize on incremental increases in performance, the funding shortage over the next decade will drive DoD customers to forgo systems that offer only marginal increases in performance or to extend the life of systems that would have been replaced under less constrained circumstances. Under these conditions, the overall inventory should shrink. Conversely, these factors are potentially mitigated by planned increases in special operations forces and unmanned aerial vehicles, and an emphasis on ISR subsystems. Additionally, military-quality systems are in high demand by non-defense agencies to offset the manpower cuts along the U.S. borders, prosecute the war on drugs at sea, and modernize law enforcement , among other reasons.[22] Taken together, these conflicting changes in requirements suggest that the U.S. Government market for thermal imaging systems will contract, but not as dramatically as many other areas. These dynamics also suggest that since large acquisition programs will be disproportionately affected by the upcoming cuts, the smaller competitors, like FLIR Systems, could face increased pressure from the large defense contractors as they begin to focus more on stand-alone subsystems, like thermal imaging.

From a technology perspective, it is unlikely that there will be fundamental changes in these systems within the next five years. Manufacturers are currently increasing the value of their thermographic devices by fusing compatible technologies to create “all-in-one” solutions. BAE Systems, for example, has integrated thermal imaging with image intensification, GPS, a laser designator and wireless communication into a binoculars-shaped device. The synergy of these technologies will significantly increase the systems’ usability and warfighter effectiveness. Manufacturers will also focus on streamlining the integration of large, turret systems into both rotary- and fixed-wing aircraft. In general, this period will see evolutionary improvements in resolution, reliability, ruggedization and cost driven by industry competition. Top-of-the-line handheld systems that now cost $80,000, or helicopter- or aircraft-mounted turrets that now cost $700,000, could drop in price considerably.

Thermal imaging cameras fall into two categories: cooled and uncooled. Generally, cooled systems have much greater resolution and range than uncooled systems (e.g., 35 km versus 5 km), while uncooled systems are much less expensive and have much longer service lives than cooled systems since they have fewer moving parts and eliminate the need for a costly cryocooler.[23] Within the next 15 years, this industry should make significant progress towards improving the performance of uncooled systems and the expense and sustainability of cooled ones. In the long run, uncooled variants or a new technology will emerge to address military requirements. In fact, the cost of these systems is very sensitive to changes in technology introduced even by the smaller players, giving them the potential to generate market power. For example, recent advances in the design of infrared detection cores slashed the price of portable

uncooled imaging cameras from $25,000 just two years ago to $3,000 today.[24]

Challenges Facing the Market:

The concern for the future of the defense industrial base was palpable during the Weapons Industry Study group visits. The entire defense industry has high hopes that the Obama Administration's Export Control Reform Initiative (ECRI) will help expand their markets overseas to replace some of the income lost from reduced U.S. defense budgets. Thus far, from the U.S. thermal imaging industry perspective, the ECRI has not yet achieved much as the Defense Technology Security Administration continues to restrict exports without regard to wide-spread foreign availability of comparable technologies and increasing commercial market demand.[25] For some of these companies, the potential losses will be mitigated by non-defense and commercial sales, and many already make significant internal investments in thermal imaging research and development. FLIR, for example, spends eight percent of their revenue on internal R&D, a considerably higher sum than the industry average, which is leveraged across multiple markets.[26] The Weapons Industry Study group experienced the genesis of this foreign competition first hand during a visit to the Middle East Technical University's Micro-Electro-Mechanical Systems Research and Application Center (METU-MEMS) in Ankara, Turkey. With a modest capital investment, the Center was having some success in the development of extremely small and inexpensive uncooled infra-red detectors for smart-phone applications that have the potential to revolutionize the commercial and military thermographic markets.

Policy Recommendations:

From the government point of view, the health of this industry is about the monopsonistic demand that will (or will not) be there. At this time, government intervention is not warranted, since the intrinsic dual-use nature of the technology should be adequate to meet military requirements. That notwithstanding, as the manufacturers get caught up on existing backorders, the future prospects for the military-specific thermal imaging industry are unclear given the conflicting demand possibilities.

It is unlikely that the thermographic industry will be immune to the consolidation that is taking place in the broader defense industry as prime contractors acquire their lower-tier competitors. Such future acquisitions would further limit market competition, which in turn would likely stifle innovation and lower capacity while raising costs to the DoD.

Energetics and Nuclear

Energetic materials have been broadly defined as a class of material with high amounts of stored chemical energy available for release.[27] These materials are classified as explosives and propellants. Explosives support a range of weapons systems such as munitions, rockets, the Joint Direct Attack Munition and the Massive Ordnance Air-Delivered Bomb. Energetic propellants are found in all propelled weapons and have been grouped into four accepted categories (solid, liquid, air-breathing, or electric). Of these categories, solid propellants represent over 80 percent of all current propelled weapon types within the U.S. inventory.[28] The other categories of propellants represent only a small percentage of the weapons industry and consequently, will not be covered in this report. Energetic materials are related to nuclear materials in that they provide the compressive forces on special nuclear materials that produce the tens to thousands of kilotons of explosive power generated by a nuclear weapon detonation. Energetic materials also include the solid and liquid propellants used in the nuclear delivery vehicles of ICBM and submarine launched ballistic missiles as well as cruise missiles.

Current Condition of the Market:

The conventional explosives industrial base is currently comprised of eight Government Owned/Government Operated (GO/GO) facilities, six Government Owned/Contractor Operated (GO/CO) facilities, and over 150 that are contractor-owned-contractor-operated. [29] This base supports the production or acquisition of energetic materials (conventional and nuclear explosives, and propellants), the loading, assembling, and packaging of these materials, and delivery to the warfighter. Funding is distributed roughly 75% to commercial contractors, 20% GO/COs, and 5% GO/GOs. The conventional explosives market is an oligopoly, with high barriers to entry due to high facility costs from environmental, manufacturing, and construction requirements. This industrial base primarily supports the U.S. government through long-term contracts, but also supports foreign military sales as well. The DoD has implemented initiatives to improve the conventional explosives industrial base as a part of its 2009 strategic plan.[30] These initiatives included balancing reductions in physical infrastructure and physical capacity with funding preservation of critical equipment and facilities as reserve capacity for future requirements. Also, several GO/CO facilities were modernized and aggressive lean six sigma practices were implemented

Hundreds of U.S. suppliers, three Department of Energy (DoE) national laboratories, one former DoE weapon-testing site, and four DoE GO/CO industrial facilities comprise the nuclear weapons industrial base. This industry base ensures the safety, security, and reliability of the nuclear warhead stockpile, with the national laboratories conducting computer modeling and laboratory experimentation, and the industrial facilities conducting "lifetime extension program (LEP)" activities to extend a weapon's operational lifetime without underground nuclear testing.[31] The market for this nuclear sector of the industry is an oligopoly, with only a few firms competing for contracts to work on nuclear weapons and their components. High barriers to entry exist due to requirements for manufacture of close-tolerance and high-quality components as well as requirements for specialized skill sets, personnel security clearances, and stringent export and environmental control standards. These GO/CO facilities support U.S. customers only, with the exception of the Pantex industrial facility, which also supports the United Kingdom. Nuclear facilities are characterized by high operating and maintenance costs with an aging infrastructure built during the Cold War that is slowly being modernized. The DoE, and by extension, the DoD is the primary customer for the nuclear sector, so this sector is characterized as a monopsony.

Seven prime contractor companies design, integrate, assemble, and test completed missiles for the DoD: Boeing, Raytheon, Alliant Techsystems (ATK), Lockheed Martin, Northrop Grumman, General Dynamics, and Textron Systems. Four of the seven primes only operate in one segment (Boeing – Smart Munitions, General Dynamics – Tactical Missiles, ATK – Tactical Missiles, and Northrop Grumman – Strategic Missiles) and Lockheed Martin and Raytheon account for 85 percent of DoD's procurement business.[32] This sector appears to be a monopsony with multiple sources servicing one customer, the U.S. Government. The market is a duopoly, with each of the seven primary contractors relying exclusively on the only two sub-prime companies, ATK and Aerojet (GenCorp), currently capable of providing solid rocket motors for their assembly lines. Delving further into this business arrangement, an oligopoly for basic raw materials also exists as both ATK and Aerojet rely exclusively on the Radford Army Ammunition Plant (AAP) for the production of nitrocellulose (NC) or the Shanghai Fuda Fine

Chemicals (SFFC) company in China for production of Butanetriol (BT) as an energetic propellant.

Market Outlook:

In an era of DoD budget cuts within the next five years, expect conventional explosives funding to cycle downward for modernization, but critical sustainment requirements to be met. Modernization efforts will reduce inefficiencies associated with aging facilities, deteriorating equipment, and obsolete or unavailable parts. This sector will continue to invest in low rate and highly flexible production lines as part of this modernization and to maintain critical capabilities to hedge against future surge requirements. The sector [is] "further focusing on entering new commercial markets to find products for operations due to volumes below minimum sustaining rates required to sustain profit margins."[33] Also, a lack of insights/clarity into out year requirements for the next five years will hamper commercial firms' ability to plan investments. This lack of requirements knowledge also creates challenges for commercial firms' ability to retain jobs, skills and expertise to support the warfighter. The fifteen-year outlook consists of completion of facility modernization efforts and workforce expertise reduced by natural attrition of an aging workforce. Assuming no major combat operations occur that require surge capabilities, the GO/GO and GO/CO facilities will further consolidate into fewer firms as budgets are reduced.

The five- and fifteen-term outlook of the nuclear industry hinges on Congress funding the FY13 DoE request to modernize their infrastructure, and to sustain LEP activities. In the next five years, expect the firms supporting nuclear facilities to diversify their capabilities away from support to life extension activities. They will seek to increase their market share in growing fields of alternative energy, nuclear nonproliferation, and security in the absence of any policy changes to allow new weapon designs. Thomas D'Agostino, the DoE undersecretary for nuclear security, stated in April 2012 "the number of nuclear scientists with weapons testing experience is somewhere in the mid to low teens" "Five years from now, they will no longer be active employees of our laboratories."[34]

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Many companies within the sector are attempting to reorganize, restructure and refocus within the next five to fifteen years in response to the 2011 BCA and the 2012Defense Strategic Guidance.ATK, for example, is streamlining its organization by condensing its armament and missile groups, which will allow it to focus on emerging sports groups and international sales.[35] Meanwhile, Aerojet feels that it is well positioned to benefit from DoD's investment in high-priority transformational systems within the strategic areas of focus outlined in the Defense Strategic Guidance.[36] Industry players will attempt to maximize and extend revenues throughout the budget downturn and streamline and reduce costs by leveraging Foreign Military Sales (FMS), using long-term contracts and production backlogs as revenue extensions, and by reorganizing in response to recent budgetary pressures. Together, these variables, along with the redeployment of current weapons back into our stockpiles, will cause a reduction in the demand signal and associated levels of procurement contracts.

With the exception of BT production by the SFFC company in China and the NAMMO company in Norway that is a co-source for solid rocket motors for the Raytheon Evolved Sea Sparrow Missile; all solid propellant energetic material used in missile development is currently sourced domestically. Recent DoD studies have shown that the solid rocket motor (SRM) market has been in a decline in recent years and that trend is expected to continue. This decline has created significant overcapacity within the SRM industrial base compounded by the presence

of single source suppliers (Radford AAP and SFFC), and an aging workforce. Many companies are also experiencing a sharp reduction in Science, Technology, Engineering, and Math (STEM) related workforce expertise

The recent decision by NASA to discontinue the space shuttle program has substantially reduced the demand for Solid Rocket Motor (SRM) productions by more than seventy-five percent. Because of their responsive and safe operational characteristics, along with their long shelf-life storage capability, SRM production is critical to DoD maintaining its strategic missile program. Currently, small tactical SRM production capability does not transfer to large SRM production capability and cannot sustain the larger SRM industrial base needed to support large SRMs, specifically our ballistic missile (SLBM/ICBM) capabilities. The SRM industrial base has segregated these two subsectors apart, to include segregating large and small facilities as well. This decision has then exacerbated a declining market, significant overcapacity throughout the industry, large consolidations leading to single/sole source suppliers, and an aging workforce. All of these factors have contributed to the limited competitive opportunities available in the industry today. With the projection of declining budgets in the foreseeable future, SRM producers may consider strategic changes away from SRM production which may significantly reduce U.S. future domestic SRM capabilities.

Challenges Facing the Market:

1. Nuclear modernization requires replacement of aging facilities such as the Y-12 plant in Tennessee to improve energy efficiency, reduce operating costs, and improve capabilities.[37] The drawback of these modernization efforts is the high costs incurred by requirements to remediation of the original site due to extensive environmental contamination.
2. Ensure nuclear stockpile reliability without testing. The nuclear base is not optimized for production but relies on refurbishment and reuse of existing nuclear warheads in the stockpile. Now, out of 5113 warheads in the U.S. stockpile, a couple thousand non-deployed ("inactive") warheads are maintained as potential spares to hedge against problems with deployable ("active") warheads.[38]
3. Nuclear Workforce expertise: "Sustaining a high quality workforce remains one of the most important aspects of maintaining a safe, effective nuclear deterrent, according to a recent National Academy of Sciences report." [39]
4. Conventional warheads and propellant production: Many parts are obsolete and unattainable numerous pieces of equipment that are deteriorated or obsolete, and we have extreme difficulty finding spare parts for repairs.
5. Effects that globalization and foreign sourcing of energetic materials (e.g.: SFFC in China) will have on domestic industrial market and on National Security.
6. Limited sourcing options for solid energetic materials (ATK and Aerojet as missile sub-primes, and Radford AAP and SFFC as material producers) has significantly reduced market competition and introduces increased risk of single source vulnerability.
7. Over the past decade, industry players used mergers and acquisitions to help vertically integrate and streamline costs. This option is no longer a viable option in this sector causing a challenge to many companies to seek other methods to reorganize and streamline processes.

Policy Recommendations: Consistent levels of procurement should be implemented to sustain the energetics industrial base. Government activities should incorporate new and innovative technologies to maintain environmental compliance, reduce environmental impact, and reduce energy consumption. DoD should consider sourcing some energetic material from multiple global sources that do not infringe on national security concerns. For the nuclear industrial base,

the Secretary of Defense should lobby once again for Congress and the President to authorize development of new weapon designs to modernize the nuclear weapon stockpile. This design should replace the different designs used by the U.S. Air Force and U.S. Navy, to streamline maintenance and replacements requirements. New designs could include advanced safety and security features, less sensitivity to manufacturing tolerances or to aging of materials, and certification without the need to conduct nuclear testing. This change would increase innovation, competition, and ultimately reduce costs.

Government intervention into SRM production is warranted in order to ensure that SRM production capability is maintained. This intervention should seek to ensure the production line maintains at least a "warm status" with a surge capability to support large SRM production. This will also support the future capacity expansion needed by NASA when follow-on space programs continue. In order to maintain a constant demand during this "warm status," excess SRM propellant can be stored similarly to our current ammunition storage levels based on surge requirements and some SRM and/or propellant can be sold to commercial users within the commercial spaceflight market.

INDUSTRY TRENDS AND MAJOR ISSUES

After analyzing the domestic and international weapons industry markets, the Weapons Industry Seminar identified four cross cutting topics which impact the financial health, stability and long-term health of the weapons industrial base. These topics are: the impact of the 2012 U.S. Strategic Guidance, how cyber capabilities fit into the weapons portfolio, the impact of globalization on domestic and international suppliers of weapons, and the problems facing the industry due to declining numbers of STEM graduates pursuing career in defense-related industries. Each of these topics is addressed in more detail in the essays below.

Impact of the 2012 U.S. Defense Strategic Guidance on the Weapons DIB

The 2012 Strategic Guidance on rebalancing U.S. military priorities poses the question as to whether the U.S. is truly prepared to meet this new vision in light of looming fiscal constraints and an increasingly complex operational environment. With challenges and commitments around the globe, the U.S. will need to maintain its advantage in superior weapons technology innovation in order to continue to perform as a global power and international partner of choice. Recently, President Obama, with the full endorsement of the DoD, highlighted a list of primary missions that the DoD and Joint Force 2020 will "need to recalibrate its capabilities and make selective additional investments" to protect U.S. national interests.[40] The challenge remains prioritizing DoD efforts and resources in the coming years of extreme fiscal tightening.

. Categorization of capabilities as "rising stars," "cash cows," or "dogs" enables cost saving trade-offs for efficient resource allocation in the management of the DIB. In portfolio management terms, ageing technologies that have been superseded by cutting-edge technologies, constitute "cash traps," or "dogs". Portfolio management will help in prioritization (keep the stars and phase out the dogs) efforts while highlighting capabilities that are ripe for foreign sales (sell the cash cows). The American aptitude for disruptive innovation, which develops paradigm-changing technologies (rising stars), should be exploited to preserve its dominance of the global security market. The classic example of disruptive innovation is the U.S. development of the atomic bomb during World War II, which provided the U.S, an asymmetrical advantage and forever changed the global security paradigm. When such disruptive innovation is wielded

through a portfolio management approach, the element of time can also be leveraged to enhance asymmetric advantage in that market.

In portfolio management terms, the incubator for "rising star" innovations that can disrupt the security market sustains those disruptive innovations for increasingly shorter periods of time. Accelerated acquisition options can extract a longer duration of advantage from such innovation, and choreograph their introduction for maximum market disruption. The DoD must accelerate the acquisition of means to match the pace of technology. As such, slowing industry down to the DoD pace makes them less competitive, increases cost, and diminishes utility of the means produced.

The portfolio management concept helps nurture potential stars whose injection into the market can shape the future of warfare.[41] But this model for procurement and acquisition challenges existing U.S. institutions as well as foreign competitors and potential adversaries. Cyber, for example, now recognized as a new warfare domain, has forced change upon the DoD. As the developer of new technologies, the U.S. has an advantage in its effort to absorb the disruptive innovation into armed forces service cultures more quickly than rivals, though the information weapon's diminished shelf life demands more rapid acquisition cycle times. Accordingly, service culture must adjust or risk irrelevance. Yet the existence of separate uniformed services (portfolio businesses) increases the odds America can produce the next disruptive innovation, and generates healthy competition to integrate the means as they battle each other for market share within the DoD. Portfolio management demands products (capabilities) be categorized commensurate with achieved and projected cash flow (risk mitigation potential). This exercise to separate the cash traps from the cash cows allows one to compete different means against each other to achieve cost saving trade-offs. When the dog (cash trap) is divested, so too is the DIB sector that has been placed on government life support for its sustainment.

Some categorically protest global sourcing of defense production as a dilution of security, yet it has been argued that global industry restructuring should be welcomed if nations can coordinate their defense industrial and arms export policies to manage the global reach of transnational defense firms.[42] Risk mitigation and improved partnering are already being explored through diplomatic means, such as the United Kingdom and Australia Defense Trade Treaties, which allow freer exports of defense articles and technologies among key allies. New technologically advanced disruptive innovations such as cyber weapons are resource starved by expensive procurement programs and the sustainment of complex legacy hardware. These dogs threaten the rising star by consuming resources that could be used to develop more effective strategic capabilities. Portfolio management can clarify this tradeoff. Risk can be more effectively tethered to the value of a capability. Hence, rather than update yesterday's capabilities and simultaneously produce new ones, a portfolio management strategy enables divestiture of legacy technology in favor of new capabilities that better prepare us for an evolving strategic environment.

<u>Policy Options to mitigate the challenge:</u>

1) Adopt Portfolio Management: The portfolio management approach likens the DoD to the diversified company with a portfolio of businesses able to direct capital investment into the most productive areas.[43] Capital investments can be moved between and within businesses (the Services) to incubate and grow the next "star" innovation. In order to most effectively manage the portfolio to ensure the proper means are available in a timely manner to U.S. policy-makers, one must consider the challenges and environment in which this approach will be used.

2) "Sifting" to determine the right capabilities: Portfolio management enables policymakers to prioritize technologies, but a strategy is required to select the innovations that best suit the transformed force. The ten missions presented in the 2012 Strategic Guidance identify the type of tasks for which the DoD must be capable. . With no strategy, resources will not be economized, and the net result will be an inferior force. What's more, it will further degrade the weapons DIB, precluding its ability to innovate and shape the future security environment will be lost. As a mature process, "sifting" can be used to inform the FY2014 budget submission.
3) Initiate new strategic partnership talks: In response to the expect fiscal tightening in the next five years and the new 2012 Strategic Guidance rebalancing on Asia Pacific; the U.S. should seriously consider leading diplomatic efforts with key allies to offer joint venture and co-production opportunities for a portion of the DIB. At the same tie the U.S. should continue to find ways to safely relax export controls on the "cash cows" to bolster the DIB's revenue stream. The key is to actively manage risk by making value choices (tradeoffs) associated with security return on investment as portrayed by one strategy – in this case, the Asia / Pacific rebalancing.

Cyber As a Weapon System

Is "Cyber" a weapon or not? As a prefix that modifies a virtually endless supply of root words, the application of cyber as a descriptor is now endemic within the weapons industry. Several of the largest defense contractors have begun to define the amorphous concept of cyber to describe specific capabilities, threats or environments.

Raytheon, for instance, categorizes cyber in two of its six markets (Cybersecurity and the Effects Markets). Raytheon's 2011 10-K states:

> Effects – Effects achieve specific military actions or outcomes, from small-unit force protection to theater/national missile defense. The mission may be achieved by kinetic means, directed energy or information operations. Our Effects capabilities include advanced airframes, guidance and navigation systems, multiple sensor seekers, targeting, net-enabled systems, multi-dimensional effects, directed energy and cyber systems…"[44]

Northrop Grumman has chosen, for now, to bound cyber terminology within their Intelligence Systems division. Dynamic Cyber Defense, Cyber-Signals Intelligence Mission Management and Cyber Exploitation are three specific and distinct categories in Northrop Grumman's portfolio.[45]

While all organizations visited by the Weapons Industry Study group shared concern over the protection of their information systems, the majority also expressed cyber in terms of a weapon or countermeasure that could potentially have the same effect as a more traditional kinetic alternative. From a system perspective, cyber elements can be seen as pivot points, influencing other systems while also being considered its own unique system with its unique domain of operations. Secretary of Defense Leon Panetta stated that DoD needs to ensure the ability to effectively operate "in cyberspace, space and across all domains."[46] Cyber capabilities are highlighted in the recently released 2012 DoD Strategic Guidance.

<u>A Growth Segment Within The Weapons Industry</u>

The cyber weapon and countermeasure business is not clearly delineated in financial reporting. The employment rate, recruitment efforts and salaries for cyber talent can be seen as a corollary to the health of this sub-sector of the weapons industry. The current shortfall of qualified workers can indicate significant sustained growth in the sector. The federal government has fallen short on its ability to hire cybersecurity experts. In 2009, the Department

of Homeland Security planed on hiring 1,000 people, but by 2012 changed its goal to 400 after only gaining 260 new hires. [47] The candidate pool was too shallow to even come close to their original goal.

Who Is The Cyber Enemy And What Can They Do?

Cyber is increasingly accepted as an instrument of national power worldwide. Because of the low barriers to entry for cyber combatants, a lone hacker or "hacktivist" with a home personal computer and readily available software can access information for which they are not authorized (Information Access). They also can alter stored data rendering it unreliable (Information Assurance). There are multiple examples documented of lone hackers compromising supposedly secure networks.[48] For purposes of this paper, only nation-states and their sponsored militias are considered.

Maintaining an innovative competitive advantage and agility are key attributes for an industry that is rapidly evolving. We have witnessed cyber skirmishes between Russia and its neighbors Georgia and Estonia. In an operation known as "Moonlight Maze", Russian hackers attacked numerous U.S. government sites, including the Pentagon.[49] China is purportedly the most prolific culprit, hacking not just into U.S. public and private networks, including defense contractors (Operation Aurora), but ministries of foreign affairs and embassies in more than one hundred countries (GhostNet).[50] Perhaps most disturbing, according to then Deputy Secretary of Defense William Lynn, China even hacked the classified DoD network.[51] The consequences of this loss of information are incalculable but fortunately, these cyber events did not cause significant physical damage.

> Recently, the cyber attack on the Iranian centrifuges, known as Stuxnet, has shown cyber attacks can produce physical results comparable to a kinetic attack.[52] The Wall Street Journal reported in 2009 that Russia and China had inserted potentially destructive malware into the U.S. electrical grid and other critical infrastructure. Secretary Lynn went further, also including the financial system and stating it "… could cause massive physical damage and economic disruption."[53]

It is theoretically possible for an adversary to get "inside" Precision Guided Munitions (PGMs), i.e. cyber can usurp kinetic.[54] Imagine the consequences of a cyber combatant being able to render a PGM inert or even reassign target coordinates. This is among the most disconcerting scenarios to DoD and the DIB.

What Needs To Be Done?

China, North Korea, and Russia all pose significant cyber risks and garner a great deal of attention, but other countries, organizations and even individuals are in a unique position to punch well above their weight class because of the technology involved. Even more problematic, the difficulty in attributing offensive cyber actions creates doubt for decision makers when considering appropriate responses. The question of who did it is just as difficult as the decision on how to retaliate.

Defining what constitutes a cyber weapon, or cyber act of war is required to allocate resources to build a strategy to account for the unique capabilities cyber provides. The inability to clearly define anything with a cyber prefix, or have technology quickly render definitions obsolete, is similar to Moore's law regarding computer processing capability and sets a pace that exceeds our current procurement and workforce development capabilities.

The U.S. needs to invest to secure our cyber infrastructure and workforce. More importantly, the framework in which cyber is evolving requires policy makers and leaders that are capable of exercising the greatest degree of intellectual flexibility for the challenges ahead

including developing a professional cyber workforce and an acquisition system that can respond to the speed of cyber development. Where cyber capabilities are concerned, special considerations should be made to consistently field leading technology, to continue to be one step ahead of our competition. The new strategic guidance recognizes development of cyber capabilities and the integration of those capabilities across an ever increasing number of our weapons systems. As with any new technology, high turnover in fielded systems due to obsolescence is required in order to be at the forefront. Our procurement system needs to recognize the special requirements of cyber requirements, and the development of new capabilities.

Globalization and the Defense Industrial Base

For over a century, the U.S. has benefited from free trade, open markets, and the rule of law. Technological advancements contribute to globalization by increasing the mobility of goods and services. As a result, the industrial base supporting the DoD and weapons industry is becoming increasingly international.[55]

Global economic integration poses risks such as diminished economic strength and technological leadership, a potential decline in innovation, reliance on a foreign supply chain, and threats to critical infrastructure.[56] Some observers have suggested that the ability of the U.S. to project power may be diminished due to our reliance on a highly integrated global economy and industrial base.[57] Technological flattening and interdependence gives the enemy an opportunity to seek an irregular or asymmetric advantage. Through a desire to avoid direct engagement with military forces, civil and economic infrastructures become soft targets that are vulnerable to asymmetric attack. Insurgent groups have the means to exploit commercial technologies and services to gain an advantage. Foreign production of hardware and software provides opportunity to disrupt critical infrastructure.

A key question is establishing where effective government intervention can be implemented in order to maintain technological leadership and mitigate risks posed by globalization. The U.S. should continue to explore how critical manufacturing with trusted foreign partners can provide for the production of sensitive components overseas. In the meantime, industrialized nations maintain their technological advantage and state-of-the-art industries through direct spending on military equipment and weaponry.

The weapons industry is not exempt from this globalization process. A significant U.S. foreign policy shift took place in 1969 with the introduction of the so-called Nixon Doctrine.[58] Whereas previously the U.S. directly intervened militarily in defense of allies, the Nixon Doctrine established the concept of U.S. economic and military assistance to support the self-defense of allies. A direct consequence of the doctrine has been overseas co-production of weapons systems such as those that continue today under the FMS and related security assistance programs, and the growth of indigenous (initially supported by the U.S.) defense industries among many countries in the developing world.

Decreased government spending on weapons has forced continued consolidation of U.S. suppliers. U.S. defense industries are subject to an expanded global supply chain, an increase in overseas suppliers of critical components, and an increase in the number of foreign firms trying to gain access to the U.S. market. As Pentagon budgets decline over the next ten years, many in the defense industry are looking toward foreign sales, which allow production lines to remain active thereby increasing corporate revenues.[59] Defense exports have grown during the past decade and have topped over $100 billion in recent years. The Obama Administration's ECRI

hopes to assist export related growth by reducing outmoded restrictions on certain widely available parts and components and clarifying overly complex regulations governing arms exports. There are limits, however, to this as most weapons-related exports will still be subject to International Traffic in Arms (ITAR) controls, which will restrict their sale and prohibit it entirely to certain destinations.

Major prime weapons manufacturing firms continue to search the globe for component suppliers and expand their supply base. This strategy permits them to find the best suppliers as well as establish a base in foreign markets. Not all globalization flow is external from the U.S., however. Major international defense firms, such as BAE Systems and Finmecanica, have increased their stake in the U.S. market by acquiring smaller U.S. firms. This has positive benefits as foreign firms hire workers in the United States, helping to sustain the U.S. industrial base and overall economic posture.

Overcapacity caused by the end of the Cold War and the defense build up of the Reagan era led to a period of deep reduction and consolidation in the U.S. defense industrial base.[60] Major weapons producing countries, including the U.S., reduced production capacity as the industry restructured during the 1990s.[61] The subsequent globalization of the weapons industry entailed moving away from the traditional forms of arms manufacturing toward a global approach to the development and production of weapons.[62] It is at this moment that the weapons industry DIB, as well as many other high technology manufacturing firms recognized that the development of integrated global relationships and operations were critical to the survival of the industry.[63] What were formerly thought to be domestic defense firms were suddenly assuming global identities and operating like multinational corporations. Decreased defense budgets, increased cost of modern weapons systems and the extensive globalization of the world economy, will increasingly compel the weapons firms to hasten globalization efforts.[64] Export control restrictions notwithstanding, U.S. should be well positioned for success in the global market: a still cutting-edge technological base due to U.S. defense procurement and legacy investment in research and development; U.S. marketing of support for weapons exports (via FMS, for example); and, a weapons industry eager to provide enticements to create sales.[65]

The most recent sale of Patriot-3 missile defense systems to the United Arab Emirates (UAE) is a good example. Raytheon, the manufacturer of the Patriot-3 missile system, is partnering with local businesses in Abu Dhabi to provide light manufacturing facilities, as well as maintenance and training for its Patriot missile defense system. The current deal is worth more than $5 billion over the service life of the contract which includes spare parts, training and services as the UAE joins its Gulf Cooperation Council (GCC) neighbors in order to try and build a credible air and missile defense program.[66] In addition, the UAE is funding upgrades to the system which can be applied to the existing U.S. fleet of Patriot missiles. This gives the U.S. a way to upgrade its systems without paying for the upgrade development itself. The UAE benefits by being a partner in the supply chain, and it gets an opportunity to develop a home-grown highly technical manufacturing industry. Through the maturation of the funded program and through the use of the testing facilities and capital in-flows the U.S. has the potential to subsidize our own domestic system innovation.

In spite of robust export controls, the U.S. government supports responsible arms transfers to U.S. allies and commercial exports to trusted foreign buyers. In addition to export restrictions of certain sensitive items to certain destinations, firms also must contend with guarantees to foreign buyers. These arrangements, called offsets, include local product assembly, subcontracting, joint weapons development and sometimes transfer of technology.[67]

In today's markets, offsets can exceed 100% of the weapons value and increased access to U.S. technology. Such cases send jobs and production overseas and challenge the argument that arms sales benefit the U.S. economy.[68]

Amid the current ECRI effort, and despite the Administration's strong commitment to boosting exports and supporting U.S. manufacturing, the U.S. government can be expected to continue to observe strong foreign policy considerations in determining arms export decisions and policies. Economic benefits of weapons exports cannot be more important than the risk that those weapons could contribute to adversary capabilities or destabilizing arms races.

Weapons industry globalization is having a positive impact by increasing weapons collaboration projects and sharing research and development and production capacity with allies. The work of coalition forces in Afghanistan and Iraq demonstrate that some levels of interoperability does exist among NATO nations but this capability needs to continue to be developed in order to maintain operational effectiveness. In the end, national security is inherently linked to economics in defense spending, but globalization of the arms industry will also have an impact on national security strategy by changing our acquisition practices and our concept of the DIB.

Science, Technology, Engineering and Math Workforce

The creation and the retention of human capital has become a critical issue for the DIB impacting all sectors of the base from small arms to cyber warfare. While there are many problems facing the weapons industry DIB workforce, the two most pressing issues are the simultaneous aging of the current workforce and the growing scarcity of new employees with the STEM skills required to design and build high technology weapons systems. The DIB's workforce is atrophying with U.S. employment rates dropping from 1.1 million in 1990 to 584,000 in 2003.[69] This loss of experience and knowledge, coupled with the challenge of developing and retaining new talent, partially driven by DoD budget reductions and industry consolidation, impacts the DIB to its core. The U.S. technological advantage, based on historic strong research and development support for innovation, is central to the ability of U.S. armed forces to effectively operate across the spectrum of conflict.[70]

Thirty eight percent of the DIB workforce is 50 years old or older and 9% are over 60.[71] By 2008, approximately 27 percent of employed engineers were eligible for retirement, and during the next decade, the number of employees with science and engineering degrees reaching traditional retirement age will triple.[72] This demographic shift in the defense industrial workforce, coupled with decreasing DoD budgets and lack of interest in STEM, has created a lack of skilled and experienced scientists and engineers, especially in middle management According to market analysts Patricia Maloney and Michael Leon,

> "the aerospace and defense industry has made a concerted effort to attract new employees, there is a large gap in the 30–40-year-old range, where it is estimated that supply is actually 29–46 percent below demand. These are the people with theoretical as well as practical knowledge—the individuals who will be the program managers, both in industry and on the government side in the next 6–10 years, the concern is that there may not be enough of them to fill vital positions."[73]

In order to fill the gap created by retirees and a younger generation less enthusiastic about entering the weapons industry workforce the DIB must recognize exceptional talent early and "incentivize" that talent in order to create and build a sustainable force. This could include signing bonuses for new talent and for retaining high performance individuals, sabbaticals and or

access to post-graduate study outside the industry to keep workers' perspectives fresh and reward creative freedom to apply new scientific theories to weapons development. The DIB's retiring workforce still possesses the knowledge, technical ability and the passion to still be valuable assets to the defense industry. So providing incentives to this segment of the workforce to allow them to contribute, consult, and mentor young engineers and scientists are critical.

The origins of flight, space travel, and the patriotic desire to contribute to national defense drove many of the technological innovations that we as a nation now enjoy. U.S. Government investment in space travel, in particular, as well as Cold War era defense research and development, was critical; it is imperative that the U.S. Government continues to invest in the future. Even with current budgetary constraints, U.S. leadership in science, engineering, and technology is too important to forgo. The links between the government, universities, and industrial base needs to become seamless with a greater efficiency and trust. A senior defense industry leader noted, "This will help put our talent shortage in perspective. More than four million students will begin kindergarten this year. Of those, only sixty thousand will become engineers--of any type. We will need more than four times that many aerospace engineers alone."[74]

Exacerbating the problem, today's science and engineering graduates rank aerospace and defense low, and for some it is ranked dead last as an employer of choice. Bain & Company conducted a study at fifteen of the top engineering schools and found that just 7 percent of students expected to pursue a career in aerospace and defense, and a survey of five hundred U.S. aerospace workers found that 80 percent would not recommend that their children pursue aerospace careers because of workplace instability.[75] These are staggering facts, especially when coupled with a decrease in federal funding for basic research, and the age of the current workforce. In this context, the future of the aerospace industry looks rather bleak. The private sector also has to deal with the scarcity of engineers. Steve Jobs reportedly told President Obama that, "Apple employs 700,000 factory workers in China because it can't find the 30,000 engineers in the U.S. that it needs on site at its plants."[76]

Financial security, technically challenging work, and intellectual satisfaction are central themes to creating and retaining STEM professionals, specifically when there are competing disciplines that require less rigorous preparation and provide opportunity for much more lucrative compensation. This situation is compounded by declining support for basic research and development. Declining support not only impacts our defense industrial base, but commercial innovation as well, as military technological breakthroughs, like the Internet, have historically found widespread commercial application as well. Thus the entire technological base will be affected.

The emergence of cyber as a critical area of interest for the DoD has also had a significant impact in the way we view the defense workforce by forcing industry to look in non-traditional venues for talent. For example, Raytheon has recently begun hiring cybersecurity experts with nontraditional backgrounds. One recent hire had only a General Educational Development Diploma and was working in a pharmaceutical plant while participating in recreational online hacker competitions. Another recent hire single-handedly defeated the other teams in a hacker competition while still a teenager.[77]

Academic programs alone won't attract the most promising talents to the field, Robert Giesler, SAIC senior vice president for cyber programs cautioned. In the past 30 years, the most innovative cyber-operators he has seen have been military kids with no more than a high school education. Giesler also said, "The country needs to understand that this is more than just hiring

people. It needs to be infused all the way through the school system as a viable career choice, as something that everybody has to be familiar with, and we haven't had that call to action yet."[78] Cyber, the domain of the present and shaper of the future battle space, requires skills that transcend traditional education and will require the U.S. Government and DIB to become more inventive and resourceful in their search for cyber talent.

In addition to STEM and age concerns within the DIB workforce, there also appears to be a growing trend between manufacturing expertise and the engineering expertise needed to keep the DIB vibrant, a white and blue collar spectrum if you will. This became apparent in the small arms industry, specifically in the New England area where the seminar observed operations at Smith and Wesson and Colt. Design engineers and other occupations that required a STEM background for the production of small arms were plentiful; however; there was a shortage of experience manufacturing personnel. One manager stated that he had to seek trained employees out of state in order to meet production timelines. However, this wasn't universally noted.

During the seminar's trip to Lockheed Martin in Camden, Arkansas, managers noted that they had sufficient manufacturing personnel, but a shortage of experienced engineers. After a few years, junior engineers left the area for better locations in the country. Camden was viewed as such an unattractive place to live that several employees commuted hours to work.

The options available to resolve defense workforce issues can be divided into those internal to the DIB, those best leveraged through government sponsorship, and the options executed collaboratively between the DIB and the government. The choices for the DIB range from signing bonuses, student loan repayment to retiree mentorship of new scientists and engineers. Governmental options range from sustaining or increasing funding for research, outreach programs to students that demonstrate exceptional potential in the STEM field, targeted scholarships, and passing focused immigration legislation to allow foreign STEM graduates to remain in the U.S. to work in the private sector freeing up STEM graduates who are U.S. citizens. Overall, the benefits of a comprehensive DIB human capital plan are not only relevant for defense, but have positive ramifications across the economy. However, any recommendation must fall in line with the current federal fiscal environment. The following recommendations, if implemented, could ensure a vibrant and competitive DIB in the future:

1. The government and industry should sponsor an active cross-training program to train workers in declining areas including partnering with local education institutions.
2. Retiring engineers and scientists should have the option to return to mentor and pass corporate memory and best practices to new employees.
3. The government can encourage retiring engineers and scientists to promote STEM programs.
4. The government should offer federal tax credits to employers promoting continuing education to help train employees in new skills.
5. Industry could make STEM jobs more attractive by offering signing bonuses, flexible work hours and options to repay student loans after a suitable period of service.[79]
6. Modify service academy and Reserve Officer Training Corps graduate obligations to provide an alternative path into the DIB.
7. Incentivize industry research and development through tax credits.
8. Aggressively pursue 'non-traditional' paths to employment for talent, specifically in cyber.
9. To bridge possible near-term STEM gap, pass pending immigration H-1 visa legislation either to fill DIB STEM positions or to backfill private sector STEM positions.
10. Continue to maximize outreach programs that sponsor STEM education, scholarships, and competitions in high schools, community colleges and public universities.

CONCLUSION AND RECOMMENDATIONS:

The U.S. weapons industry is a critical enabler of the military instrument of power and is integral to our national security. The Weapons Industry Seminar's analysis discovered challenges that could threaten the health of the DIB, particularly in certain sectors. This analysis also found trends in various sectors of the weapons industry that can be reversed with appropriate government intervention. However, government intervention is not always warranted, as is the case with the thermal imaging industry and small arms, both of which enjoyed robust health due to the commercial sides of their business.

The seminar indentified several major issues that threaten the capability of the industry to implement the US defense strategy. The potential detrimental impact of these issues can be mitigated by the following policy recommendations:

2012 Defense Strategy Implementation. The central challenge is to prioritize acquisition of both legacy and innovative weapons systems given severe fiscal constraints. Recommend the government utilize a portfolio management approach and more rapid acquisition options to select innovations most applicable to the rebalanced force and offset their cost with export sales of "cash cows."

Globalization. Globalization does have the potential to increase research and development collaboration as well as production capacity. However, the central challenge is for the U.S. to sustain its technological leadership and mitigate vulnerabilities to the U.S. supply chain. Recommend pursuing joint venture and co-production opportunities with allies to share costs, and to support continued reform of export controls, while ensuring protection of critical technologies, to bolster the DIB's revenue stream.

Workforce Expertise/STEM. The central challenges are to reverse the simultaneous increasing scarcity of new workforce with the required STEM skills and the increasing loss of qualified workforce to retirement. Recommend leveraging "greybeards" expertise to transfer their expertise to young recruits and increase cross training programs to build depth and resilience of workforce within firms.

Since the weapons industry is so diverse, these general policies cannot counter all the broad spectrum of forces facing the DIB. The Weapons Industry Seminar also recommends the following actions specific to each sector of the weapons industry.

Small Arms. This sector is healthy, with a robust U.S. commercial firearms market. The trend is a decreased military demand due to the drawdown in the Iraq and Afghanistan campaigns. Therefore, the U.S. Government should focus on policies which foster competition for contracts and ensure that industry has the capacity to meet future small arms needs. This will serve as a hedge against a shrinking of the small arms DIB if companies vacate the market due to cultural or legal shifts that constrict the market within the U.S.

Sensors. This sector is also healthy, with rapid introduction of new technologies and an increasing demand for innovative products in the government and commercial markets. The trend is continued expansion of commercial markets to offset an expected decrease in military procurement. Government intervention does not seem warranted or prudent as the intrinsic dual-

use nature of the technology should be adequate to sustain the industry to meet military requirements.

Energetics/Nuclear. This sector is characterized by government infrastructure decay, challenges to maintain workforce expertise, and challenges to maintain technological innovation. The trend is decreasing demand from draw downs at NASA and military campaigns, with limited opportunities to offset losses using commercial applications. Recommendations:
1. Maintain a "warm" status for production lines to hedge against future surge requirements and sustain innovation.
2. Development of new nuclear weapon and delivery vehicle designs to spur innovation and modernize the nuclear weapon stockpile.
3. Modernize government infrastructure despite decreases in procurement that may accompany future budget cuts.

The defense industrial base is critical to U.S. national security and it is an indispensible segment of the U.S. economic infrastructure. Acting on the above recommendations will help to put the weapons DIB onto a more sustainable path.

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