

**Spring 2013
Industry Study**

**Final Report
*Weapons Industry***



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WEAPONS 2013

ABSTRACT: The Dwight D. Eisenhower School for National Security and Resource Strategy Weapons Industry Seminar analyzed the domestic, and to a limited extent, international industries that support the development and sustainment of current and future weapons systems. This analysis assessed the current conditions, critical challenges, and outlook for the following eight sectors: small arms, medium and large caliber weapons, bombs and missiles, energetic, ammunition, sensors, nuclear weapons, and non-lethal weapons. In addition, the seminar examined four cross-cutting industry issues common to the eight sectors: workforce, exportability, trade controls, and research and development (R&D) funding. The seminar concluded that certain sectors of the industry may be challenged by the effects of sequestration as well as ongoing decline due to years of insufficient sustainment and R&D funding. In addition, without trade control reform the US will continue to find it more difficult to compete in an increasingly global defense industry.

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PLACES VISITED:**Domestic:**

ATK Allegheny Ballistics Laboratory, Rocket Center, WV
Beretta Defense Technologies, Accokeek, MD
FLIR Systems Inc., North Billerica, MA
BAE Defense Systems, Nashua, NH
Colt Defense LLC, Springfield, MA
Smith & Wesson, Springfield, MA
FN Manufacturing, LLC, Columbia, SC
Savannah River Nuclear Reservation, Savannah, GA
Raytheon Missile Systems, Camden, AR
National Testing Services, Camden, AR
Spectra Technologies LLC, Camden, AR
Aerojet General Corporation, Camden, AR
Esterline Defense Technologies, Camden, AR
Lockheed Martin Missile Systems, Camden, AR
Sandia National Laboratory, Albuquerque, NM
Defense Nuclear Weapons School, Kirtland AFB, NM
Kirtland Underground Munitions Maintenance Storage Complex, Kirtland AFB, NM
Los Alamos National Laboratory, Los Alamos, NM
Federal Bureau of Investigation Hostage Rescue Training Center and Range, Quantico, VA
Raytheon Missile Systems, Tucson, AZ
Aerospace Maintenance and Regeneration Center, Davis-Monthan AFB, Tucson, AZ

International:

None

Introduction

The past year has been one of fiscal turbulence for the federal government and specifically for the Department of Defense (DoD). With sequestration cutting \$48 billion out of the Fiscal Year 2013 (FY13) budget and Congress reducing the top-line DoD budget to pre-9/11 levels, there is great debate about how much defense and national security the United States (US) needs, how much it can afford, and how to maintain a robust and technologically advanced industrial base to support it. The Obama Administration's most current national security strategy includes four enduring national interests: 1) Security - the security of the US, its citizens, and allies and partners, 2) Prosperity - strong, innovative, and expanding US economy in an open international economic system that promotes opportunity and prosperity, 3) Values - respect for universal values at home and abroad, and 4) International Order – “advanced by US leadership that promotes peace, security, and opportunity through stronger cooperation to meet global challenges.”¹ With rising personnel costs (health care, benefits, and retirement) and increasingly expensive advanced weapons systems eroding DoD's purchasing power, the days of doing “more with less” are quickly turning to doing “less with less,” foreshadowing changes in the national security strategy.

The weapons industry has been particularly susceptible to the cyclical nature of the defense budget. Within these cycles there have been numerous changes in the number and type of companies competing in the market. At the end of the Cold War in 1992, there were over 40 top tier defense companies; today there are five (Appendix A). In many cases, DoD is now down to a single supplier and may even be threatened with losing the ability to procure a capability altogether. As an example, 71 of 302 critical components needed to manufacture ammunition come from single source suppliers.² Consolidation of companies will likely continue, but it is expected that this consolidation will occur at the sub-prime level with second and third tier contractors. Furthermore, the barriers to entry into the market as a whole are significantly higher due to increased technologies, increased government oversight and environmental regulation, and inconsistent government budgets.

Meanwhile, globalization has become the predominant factor of success for companies serving customers worldwide, and the integration of people, information, and material allows for and demands the free flow of ideas rapidly across the globe. Like many other countries' defense establishments, the DoD relies on the global defense marketplace to access supplies and services, expecting to obtain the best value, capability, technology, and ideas to meet US national security goals and objectives. Within the US, the DoD is often a monopsony buyer, but within the global marketplace, there are many commercial and/or state suppliers/providers. The US weapons industry is varied, with some sectors (like small arms and sensors) less reliant on military and government customers, which will have more flexibility in adapting to the decrease in the DoD budget. Many of these products and capabilities may have both military and commercial uses. Others, such as energetics and missiles, are less adaptable, and are already experiencing concerns about the future sustainability of their supply base.³

In conducting this study, the seminar held the following assumptions: 1) Near- to mid-term defense budgets will remain flat or decline; 2) Significant shifts in national security resources will continue to occur (e.g., emphasis on cyber, unmanned vehicles, special operations); 3) Rapid advances in technology will continue; 4) Supply chains will continue to be more global, commercial, and financially complex; 5) Department of Defense (DoD) will use tools and

authorities necessary to protect critical materials/industries if normal market forces cannot; and 6) New export control reform will fully comply with existing treaties and obligations.

Just like the Defense Industrial Base (DIB),⁴ the weapons industry is diverse and difficult to define. To better understand this industry, the seminar focused on the following eight representative sectors: **small arms, medium and large caliber weapons, bombs and missiles, energetics, ammunition, sensors, nuclear weapons, and non-lethal weapons**. In addition, the seminar also focused on four cross-cutting weapons industry issues: **workforce, exportability, trade controls, and research and development (R&D) funding**. The overview and analysis uses 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 present and future vitality,⁵ provide insight into the nature of the upcoming challenges to the weapons industry, and offer recommendations on how to prevail in a fiscally austere and uncertain strategic environment.⁶

Small Arms

Sector Defined: This sector includes any weapon typically used and carried exclusively by an individual,⁷ to include handguns, rifles, and shotguns.

Current Condition: While government purchases account for 40% of total revenues (military 25% and law enforcement [LE] 15%), the majority (60%) of sales are to private consumers. As a result, the industry is healthy and characterized by oligopolistic competition with a relatively low level of technology present in the market. Small arms manufacturers compete on price across relatively consistent designs, with some differentiation competition for highly engineered variants. The industry produced \$11.7 billion in sales in 2012.⁸

Challenges: An externality that applies specifically to the small arms sector of the DIB is the influence of gun control legislation on supply, capacity and demand for small arms and ammunition. A series of mass shootings in civilian communities around the country with military-style firearms has highlighted these types of weapons and the high rate of fire they provide. This attention has prompted federal, state, and local governments to reexamine ownership requirements and ammunition magazine capacity, and it has generated citizen and interest group concern over restricted availability of these popular firearms.

Outlook: While these companies are benefiting from the current and perceived upcoming gun control regulations, they are also very aware that this current increase in market demand is temporary and speculative and are very concerned about over-investment and over-production. Over the next few years, the market will continue to be unpredictable.

Small Arms Industry Policy Recommendations:

1. Refrain from government intervention in these commercial operations.

Medium and Large Caliber Weapons

Sector Defined: This sector applies to weapons that are generally considered crew-served weapons, to include 12.7mm (0.50 caliber Browning machine gun and sniper rifles), 20/23/25/30mm cannons (to include Gatling guns), 40mm automatic grenade launchers, 60/81mm mortars, 90mm turret mounted weapons, and 105/155mm artillery. Air artillery systems, as well as other projectile weapons that use missile or rocket technologies, are excluded from this category regardless of diameter.

Current Condition: The sector primarily supplies weapons to military and law enforcement agencies, and is best described as an oligopoly, depending on the availability of foreign markets. The market is currently sluggish with minimal purchase orders and manufacturing based on demand. However, the industrial base for these weapons appears stable and sustainable over the next few years, provided these firms adjust to decreased demand signals. As a result of reduced demand, several sub-tier supply chain issues have resulted in some risk to readiness in the event a surge in capacity is again required.

Challenges: Cyclical government spending in both law enforcement and the military will require most firms in this sector to adjust to reduced demand. The primary vendors in the medium and large caliber projectile sector have done well over the last decade; however, the 2008-2009 Great Recession and subsequent government spending curtailments cast doubt on many firms' ability to adjust to reduced worldwide defense budgets. The sector displayed a significant ability to surge to wartime demands over the last ten years. Most industry leaders indicate 12-18 months will be required to re-constitute a surge capability, given the time required to establish the capacity throughout the multi-tier supply chains associated with these systems.

Outlook: This small cross section of weapons designs average 41.4 years in age since original design (excluding the much-older 0.50 caliber machine gun). It should be noted that several of U.S. medium and large caliber designs originated in Italy and Germany such as the Mk 75 munition and the 120mm cannon found on the M1A2 Abrams tank.⁹ Possibly the technology of medium and large caliber projectile weapons has reached full maturation, but the fact remains that the original designs here predate most engineers working in industry today.

Bombs and Missiles

Sector Defined: This sector consists of tactical missiles (including smart munitions), strategic missiles, and missile defense systems. Missile type weapons are generally considered an unmanned explosive-carrying vehicle that moves above the earth's surface in a flight path controlled by an external or internal source.¹⁰ Bombs differ from missiles in that they generally do not employ any propulsion of their own to place themselves on target, but advances in bomb technology now allow these munitions to employ advanced guidance technology to have them guided or guide themselves as missiles do.

Current Condition: The market for missile systems predominantly supports US government acquisitions with a small percentage of sales going to foreign markets. The market is comprised of five primary sellers with approximately 30 first tier suppliers, all of which are extremely specialized.¹¹ Consequently, the market structure is oligopolistic in nature for new product lines while the market tends to be a bi-lateral monopoly for existing programs. Since there is only one

responsible vendor and no other supplies or services to satisfy agency requirements, procurements are frequently sole source.

A few large, long-term programs, intermittent new program starts, and rapidly changing technologies characterize the market. As a result, there are relatively few new competitive contract awards. In such cases, there are a handful of companies with longstanding legacy positions,¹² with two companies capturing the bulk of the market.¹³ Many of the same sub-tier companies supply all of the competing prime contractors, and in some programs the prime contractors serve as subcontractors on other programs. There are few suppliers, few buyers, and limited substitutes resulting in relatively inelastic supply and demand.

Externalities exist, such as environmental/safety concerns, political concerns, treaties and public acceptance of some weapons. There are also deadweight losses (i.e. keeping a manufacturing capability warm). The market is described as a feast or famine and the industry is usually associated with defense unique products.¹⁴ Participants compete based on best value for price (or cost), schedule, and performance. The government reserves the right to examine cost and pricing information and audit because conditions may not dictate a “real” market price. Generally, the government is obliged to buy from the few US suppliers due to “Buy American” restrictions or other policies. In addition, sellers are often obliged to sell only to the US Government because of laws or policies such as export controls or arms regulations (e.g. ITAR) that restrict suppliers’ ability to compete in the global defense market.

This sector has significant barriers for competitors to enter the market. The technologies to design and build these systems are extremely specialized, requiring a highly skilled workforce and an infrastructure to handle potentially hazardous and technically sensitive material. One industry executive noted that there are only a couple places in the US that teach some aspect of building bombs or missiles.¹⁵ Extensive capital outlays and long research and development periods also inhibit newcomers. Other barriers include the heavy regulations applied to the sector. For example, some contractors are grandfathered from existing environmental laws that allow them to produce their product while a competitor would have to adhere to the new laws.

Like other weapons used exclusively by the military, the bomb sub-sector produces highly capable weapons today that include upgrades from original production designs. Two specific examples explored here are the variants of the Joint Direct Attack Munition (JDAM) and the Small Diameter Bomb (SDB). The JDAM requirement is a product of Operation DESERT STORM in 1991, which exposed the need for precision-guided weapons with greater capability than the laser guided bomb (LGB) series and the tactical air-to-ground (AGM) Maverick missiles. Such a capability would enhance lethality, survivability, and efficiency.¹⁶ Production contracts were awarded in 1995 and JDAM has continued to see product development and increases in capabilities through upgrades in designs. The SDB is a newer weapon with development beginning in the late 1990s and entered service in 2006.¹⁷ The SDB Increment II contract was awarded in 2009 and is expected to enter service in 2013.¹⁸

Challenges: Budget reductions may cause companies to consolidate (especially at sub-tier levels), to lose an innovative edge, or exit the market entirely.¹⁹ The missile industry is only one deep in

many aspects of the supply chain. The volume of product simply does not give a business strong justification for competitors to enter this market as a supplier. Once a prime contractor has qualified a sub-tier supplier, they tend to have long-term agreements with that supplier. If a supplier is changed, the materials must enter a cumbersome requalification process, costing all parties time and money. Some materials are sourced from just a single supplier – in one case the sole supplier is a foreign source requiring a waiver to import the material that is on the US Munitions List.

Outlook: The air-to-air and air-to-surface missile sub-categories present many design challenges increasing risk in the mid and long-term outlook. Although these systems have received resources for continued improvements and upgrades, the industry has challenges in attracting designers, the lack of clear requirements, or funding streams for new missiles. This places the long term design capability of new missiles in the U.S. at risk. The cancellation in early 2012 of the AIM-120 and AGM-88 replacement (the Next Generation Missile) is an example of the wavering requirements signal sent to the industry.²⁰ From 2001 until 2011 missile sales in the industry doubled to over \$20 billion,²¹ brought about mostly by the increased use of missiles in Iraq and Afghanistan, as well as improved technologies, and presidential commitment to develop the National Missile Defense system, employing a much larger inventory of missiles for use in shooting down other missiles.²² However, production cuts seen in just the last two years have resulted in a slowdown in production. Sequestration cuts have taken an additional 5% from missile procurement. In addition, NASA's completion of the Space Shuttle Program has significantly reduced government spending on certain components such as solid rocket propellants needed by the various aspects of the weapons industry. NASA's commitment to a follow-on program, the Heavy Lift Launch Vehicle, has stabilized the propulsion portion of the market.

Government Goals and Role: The U.S. government is intimately involved in this sector. The DoD's Office of Manufacturing and Industrial Base Policy (MIBP) is a governmental organization charged with monitoring the industry's readiness, ability to innovate, competition, and financial stability. MIBP has been studying the missile sector to assess its health. Additionally, the industry is heavily regulated with restrictions dealing with ITAR, environmental protection concerns, the Buy American Act, and the US Munitions List. Finally, the government takes part in keeping a portion of the industry warm by maintaining a production capability in critical areas such as propellants and other precursors for solid rocket motors.

Bombs and Missiles Industry Policy Recommendations:

1. Augment staffing at the Manufacturing and Industrial Base Policy offices to ensure MIBP's sector-by-sector, tier-by-tier (S2T2) analysis of the DIB is thorough, allowing essential information on the health of the industry to be passed to DoD decision makers.
2. Subsidize sectors of the DIB for key areas where the missile sector is only one deep in the S2T2 analysis, consistent with Section 806 of the National Defense Authorization Act (NDAA). Explore public-private partnerships to retain both public and private capabilities.
3. Review export regulations to allow US vendors access to some friendly foreign markets as the US missile industry accounts for greater than 50% of world-wide market share, and many missiles are already in foreign partnerships.

Energetics

Sector Defined: This sector consists of powders, propellants, primers and fuels needed to deliver munitions, as well as stand-alone explosives for military and commercial use.

Current Condition: The current inventory of propellants and traditional energetics was designed in the 1950s and 1960s.²³ The DoD is merely replenishing its existing stock to execute its operational requirements. While energetics products have been incrementally updated throughout the years, there has not been a significant advance in materials in the propellant industry in the last 40 years.²⁴ The propellant industrial market is one of a monopoly, while the traditional energetics side (explosives) is structured as an monopolistic competition, and companies generally set the prices for products produced.

Challenges: The stigma associated with developing explosive materials and fuels is a barrier to entry to any firm that would like to enter the industry due to negative publicity and opinion of having a developer of explosives in the community. In addition, the numerous environmental regulations and high insurance premiums make it difficult to operate a viable business. This puts the continued accessibility of this sector at risk. There are also facilities constraints associated with the manufacture of energetics. Built in a laboratory, the risk is mitigated by using extremely small samples in controlled environments. However, when a company attempts to mass produce energetic materials, the risk grows exponentially. Larger and more stable companies have the resources to absorb this risk, while smaller companies do not, making them more risk adverse in experimenting with new materials.

Outlook: A whole new generation of improved materials is available and materials are continuing to be invented for use in rocket propulsion and munition applications. These are fundamentally new ingredients for use in propellants and explosives. Four areas for energetics enhancement include discovery of new compounds, enhancements to safety of existing compounds, performance upgrades of existing compounds, and innovation to explore chemistry and physics enhancements for alternative uses of energetics. The next 20 years will see significant improvements in conventional weaponry and a fundamental new understanding of energy storage. The challenge is to refine the process to ensure that these new materials will satisfy a wide range of DoD mission needs. Very high potential opportunities in rocket propulsion include implementing significant improvements for solid motors by incorporating advances in oxidizers and binders, developing new hybrid systems with new oxidizers, binders, and next generation fuels such as aluminum hydride, and using cryogenic high energy density materials such as metallic hydrogen to significantly increase access and duration in space.

Energetics Policy Recommendations:

1. Fund and develop research into next generation propellant technologies. New weapons based on advanced energetic materials would give the military larger standoff distances, shorter times to target, and higher destructive capabilities. Improvements such as advancements in energy density of liquid fuels could augment the use of smaller launch vehicles for similar size payloads. This would have dramatic cost savings (estimated at greater than \$30M/launch for a change from Atlas 2 to Delta 2 and greater than \$130M for a change from Titan 4 to Atlas 2).²⁵

2. Provide environmental waivers for small companies wanting to enter the energetic sector. The high cost of environmental regulation compliance deters new companies from entering the market and stifles innovation.

Small Arms Ammunition

Sector Defined: This sector covers the manufacturing processes dedicated to the assembly of munitions designed to be used by projectile weapons.

Current Condition: The sector is a declining industry for which 25 percent of the critical components are produced by oligopoly suppliers, 56 percent of the end items have no peacetime demand, and capital assets have been allowed to deteriorate accumulating a \$1.5 billion modernization backlog. Seventy percent of the firms originally working in this sector have exited, leaving over 300 critical single points of failure.²⁶ The contractors operating these facilities, which have decreased from 28 to 6 during the last 30 years, focus solely on profit margins, with only token attention applied to maintaining government owned capital.²⁷ While similar to commercial off the shelf products, specific military ammunition requirements make it imperative that the government monitor and sustain this sector.

The DoD uses short term contracts with multiple options, attempting to create a long term relationship with ammunition manufacturers that would incentivize them via these long term vehicles to invest in modernization efforts at these facilities.²⁸ This type of acquisition strategy and resulting contracting strategy is characterized by very short periods of time, usually one year. The option-year extensions do not provide sufficient incentive for the contractors to invest in modernization. Corporate investment provided poor returns over such short periods of time, and carried significant risk for the company should the contract be lost or reduced in the out-years. The lack of corporate-owner investment has further exasperated the deteriorating conditions of these ammunition plants.

Challenges: There has been an ongoing battle for decades over how to sustain this sector. Peacetime demand for armed forces use is but a fraction of wartime requirements. Most of these facilities have been carried along under the arsenal system of government owned, commercially operated (GOCO) activities operating under long-term contracts. The contractors responding to industry study inquiries do not consider seven to ten-year contracts as long term, with periods of ten years or more seen as essential for infrastructure and workforce sustainment investments.²⁹ An offsetting positive incentive for GOCO plants allows the contractor to manufacture and sell commercial items after they have met the government's requirements.

Outlook: The opportunity for this sector in the years ahead is to improve the ammunition manufacturing process to satisfy a wide range of DoD mission needs, while allowing contractors to operate the facilities safely and efficiently with sufficient profit to keep them engaged in the improvement and production of ammunition for the DoD.

Government Goals and Role: The DoD should continue to own the small arms ammunition production facilities, but should migrate from long term contracts to long term leases. This will ensure the facilities are maintained and upgraded, the workforce will remain trained and available,

and the production capacity will be managed more efficiently and be ready for surges. These long term arrangements further incentivize product and process R&D as well.

Ammunition Industry Policy Recommendations:

1. Continue to own small arms ammunition production facilities, but migrate from long term contracts to long term leases.

Sensors

Sector Defined: This sector is large and diverse, with sensors in nearly everything from lights, cell phones, and medical equipment, as well as the most advanced military and space systems. These systems are primarily focused on equipment that is used for targeting systems/pods and threat warning, counter improvised explosive devices, as well as for force protection, missile tracking, guidance, and seeker/countermeasure.³⁰ Additionally, thermal imaging systems and devices appeal to dual-use categories, meaning military and civil applications, are instrumental in applications for firefighting, medical imaging and research, thermography/maintenance, gas detection/imaging and utility inspection.³¹ Thermal imaging sensors work within a portion of the infrared (IR) light spectrum, and are either cooled or uncooled. Generally, cooled systems have much greater resolution and range, while uncooled systems are much less expensive and have much longer service lives.

Current Condition: Overall the demand is high, especially during times of armed conflict, which has contributed to the global competitive environment and the need for continued technological improvements as military requirements grow. This sector is characterized as monopolistic competition, with companies competing on price and differentiation of performance. Given the wide range in defense product lines from firearms scopes and night vision goggles all the way to Forward Looking Infrared (FLIR) aircraft sensors and infrared telescopes on satellites, there is a wide variety in the size and type of providers. Six companies make up the overwhelming majority of the domestic thermal imaging market with over 70 percent of all defense-related sales, while 27 companies represent the remaining 30 percent.³² Given the wide range and size of companies and the diversity in product lines, there is no one company that dominates the entire \$5 billion US market.³³ Currently the US is the largest exporter of thermal imaging devices; however, US global market share has been on a steady decline since 2002.³⁴

Challenges: This sector is greatly affected by the International Trafficking and Arms Regulation (ITAR), which controls the US Munitions List (USML) and Export Administration Regulations (EAR), which controls the Commerce Control Lists (CCL). These regulations have made it more difficult for US firms to remain competitive in the global market,³⁵ because foreign companies are free to offer competitive products while US firms are restricted. Worldwide there are over 100 non-US competitors in 23 countries that compete with US firms.³⁶ The majority of the global competition is in the dual-use and lower resolution product lines. In several of the simpler product lines, like night vision goggles and firearms scopes, the competitors are often price takers, since the products are similar and suppliers for key components are often shared. In the more complex product lines, like high-resolution aircraft sensors and satellite focal plane arrays, the government can be the price taker. Competition is more often based upon technical performance, innovation, system quality, and reliability.³⁷

Outlook: There is volatility in the market due in large part to the Great Recession, increased competition, export controls, and unsteady/unpredictable military sales.³⁸ With the continued fiscal challenges facing the DoD, all indicators point to a reduction in funding for R&D and procurement, which will have an adverse effect on thermal imaging systems and components. While the number of product lines has increased during the last five years, especially for uncooled devices, the overall military sales have decreased since 2008.³⁹ Since thermal imaging products are often components of large acquisition programs, it is difficult to distinguish between the performance of the component and the overall system, so long-term impacts are unknown.

Technologically it is unlikely that there will be any radical changes in the performance of thermal imaging systems into the next decade. The current trend is to fuse or combine multiple technologies into one system, with one leading firm integrating thermal imaging binoculars with a high sensitivity thermal imaging camera, global positioning system locator, a long range laser range finder and target geo-location algorithm. Within the next 10-15 years, the industry is poised for making progress towards improving the overall performance of uncooled systems and reducing the expense and sustainability of cooled ones.

A current challenge facing the thermal imaging market is the lack of key suppliers for strategic materials. Mercury Cadmium Telluride (HgCdTe) is the essential material for the substrates used in the construction of IR focal planes, and the principal US supplier is Japanese.⁴⁰ Having only one non-US supplier is problematic, especially when the recent earthquake and tsunami shut down operations for several months.⁴¹ The DoD is developing applications with more common elements to develop higher performing substrates that will eventually replace HgCdTe.⁴² Additionally, the DoD is working with industry to adopt a foundry model, much like that implemented in the current semiconductor industry, which will result in investing in one source for substrate materials with maximum capacity instead of supporting that capability for numerous suppliers.⁴³ Over the long run, new developments and technological advances for cooled and uncooled devices will increase performance in support of military requirements, while reducing overall costs to the DoD and taxpayer.

Government Goals and Role: At the present time, thermal imaging devices and systems are adversely affected by several export controls. US firms are hopeful that changes from the Export Control Reform Initiative (ECRI), will help increase their market share overseas, which could replace some of the lost income due to reduced US sales. So far there does not appear to be any significant changes in this area, all while US firms are steadily losing export business, down to 8% market share in 2010 from more than an 18% share in 2002.⁴⁴ Export Controls are explored more fully as a cross-cutting issue later in this study.

Sensors Industry Policy Recommendations:

1. Fund key IR related activities to prevent any further reduction in the number of firms, applying basic and applied research (6.1 and 6.2 funds), especially in the development of periodic table class III-V materials and the substrate foundry process. Stabilizing programs that use IR technology will also assist with sustaining the industrial base. Continued and sustained development of IR technology will help the US military maintain superiority.

2. Support ECRI and other initiatives to simplify the export rules and increase US competitiveness. Many lower resolution thermal imaging technologies are common across the globe, and these compete with US firms. Export controls should be reduced or even eliminated for those technologies that are prevalent across the global market, allowing US firms to compete openly in the market and increase overall sales, which will assist in reducing overall unit costs across all product lines.

Nuclear Weapons

Sector Defined: This sector includes nuclear bombs and nuclear warheads, as well as all processes needed to design, test, produce, transport, maintain, support, and protect nuclear weapons. The Nuclear Weapons Industry (NWI) is an oligopoly/monopsony consisting of the requirements and acquisition management functions carried out by the Air Force and Navy in partnership with the Department of Energy (DoE); process oversight conducted by DoE's National Nuclear Security Administration (NNSA); and industry partners operating GOCO sites providing weapons research and testing (WRD&T), nuclear materials production (NMP) and weapons production (WP) functions. The end result of the NWI are nuclear bombs (B61 and B83 variants), and nuclear warheads for installation on ballistic missiles (W76, W78, W80, W87, and W88 variants).⁴⁵

Current Condition: The NWI has built over 70,000 nuclear weapons of more than 95 different designs over the past 70 years, but currently only maintains around 5,000 nuclear weapons consisting of seven different designs with twelve variants.⁴⁶ The US has not produced a new nuclear weapon since 1991 or tested a nuclear weapon since 1992.⁴⁷ As a result, the NWI is focused on maintaining and extending the life of the existing inventory of bombs and warheads. The NNSA will spend approximately \$6.8 billion over the next five years on various nuclear weapons maintenance or Life Extension Programs (LEP). See Appendix B for details.

Challenges: The US NWI must comply with a significantly more complex web of guidance derived from multiple laws, treaties, conventions, policies, strategies, plans, directives, and instructions.⁴⁸ President Obama made clear at the beginning of his first term that he has committed the US to "take concrete steps towards a world without nuclear weapons."⁴⁹ The Nuclear Posture Review Report (NPRR) details President Obama's plan to sustain a safe, secure, and effective nuclear deterrent, while pursuing a goal of reducing nuclear dangers and creating a world without nuclear weapons.⁵⁰ The NPRR lays out five key objectives for US NWI policy and posture: 1) Preventing nuclear proliferation and terrorism, 2) Reducing the role of US nuclear weapons in national security strategy, 3) Maintaining strategic deterrence and stability at reduced nuclear force levels, 4) Strengthening regional deterrence and reassuring US allies and partners, and 5) Sustaining a safe, secure, and effective nuclear arsenal.

Two other aspects of the NPRR include the statement that the US will not conduct any critical nuclear detonation testing, and will not develop any new warheads. The NPRR has thus created a policy dichotomy and a predicament for the nuclear enterprise – reducing and eliminating nuclear weapons assets while maintaining, strengthening, and sustaining them. Adding to this predicament is the New Strategic Arms Reduction Treaty (START) between the US and Russia, signed on 8 April 2009. The treaty limits strategic nuclear warheads to 1550, deployed strategic delivery vehicles to 700, and combined deployed and non-deployed strategic delivery vehicles to

800 by 2018.⁵¹ A significant gap or weakness in the treaty is the absence of limits on tactical nuclear weapons.

The Stockpile Stewardship and Management Plan (SSMP) is an overarching 20-year plan the NNSA developed to maintain a safe, secure, and effective nuclear weapons stockpile. The SSMP assesses the current nuclear weapon stockpile and provides modernization plans which do not require any critical nuclear detonation testing or newly developed nuclear warheads. It also provides general polices on physical infrastructure improvements, workforce and critical skills sustainment, and management processes and procedures. The Stockpile Stewardship Program (SSP) is the implementation of the SSMP. The current SSP, managed by NNSA, is intended to maintain the nation's nuclear arsenal in the absence of nuclear testing by using improved scientific and engineering tools, and assigns Lawrence Livermore (LLNL) and Los Alamos (LANL) national laboratories responsibility for upkeep of the nuclear packages. LLNL and LANL are supported by Sandia National Laboratory (SNL) for the specialized nonnuclear components, as well as other nuclear production plants and sites, notably the Kansas City, Pantex, Savannah River, and Y-12 plants, and the Nevada Test Site (NTS). In FY14, NNSA will spend about \$1.2 billion to operate these GOCO sites and \$440 million to sustain facilities.⁵²

While the SSP has discovered and resolved significant stockpile issues, there are notable concerns about maintaining the physical and human infrastructure required to execute a robust program. The US NWI is very robust and purposely redundant, but is aging and very inefficient for today's nuclear weapons mission. Over the last decade, substantial infrastructure has been added to assist in the technical accuracy and capabilities of the SSP, but there is still a significant requirements backlog needed to properly maintain and modernize the NWI. Computational capabilities have been added to address both design and stockpile maintenance problems, revealing and delivering design solutions for SSP assets. The SSP has also completed and operated major research facilities such as the Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT) and the Microsystems and Engineering Sciences Application Facility (MESA), adding much needed analytical capability to the SSMP.

Outlook: While the US NWI strives to be safe, secure, and effective, the current resource strategy and policies in force are defective. Complex organizational structures, untested nuclear weapons, old delivery platforms, dilapidated and inefficient infrastructure, and an aging workforce, while facing a declining defense budget during a fiscal crisis, is not a recipe for success. These issues become even more complex based on the NPRR requirements to not build any new weapons and not conduct any nuclear detonation tests. The US is trying to address many of these issues with some fairly significant investments, but to date this effort has been ineffective. Weapon systems that are 20 to 40 years old remain untested weapons, along with their integration with aircraft that are 25 - 60 years old, missiles over 25 years old, and submarines well beyond 15 years of constant service will all age another decade before any asset is replaced. Also, the US NWI is failing to reduce its infrastructure to make it more efficient and easier to sustain. The US nuclear arsenal requires a serious overhaul to streamline and modernize weapons and delivery systems, shrink organizations, cut wasteful spending, and eliminate inefficient infrastructure. In addition to the overhaul, the US NWI also needs a change in policy to allow it to build new weapons and properly test them so they are truly safe, secure, and effective.

Government Goals and Role: US senior leaders are taking serious risks with the current resource strategy and policies, especially when you consider what Russia, China, India, Pakistan, North Korea and Iran are doing with their NWI. On its current path, the US NWI will need to maintain its 20 to 60 year delivery systems for another decade before it sees a modern replacement.

The Senate and House Appropriations, Armed Services, and Energy committees must provide rigorous oversight (monitoring, reporting, notifications, audits, investigations, hearings, and legislation) over the entire US NWI to prevent further degradation. More specifically, the Senate should not ratify the CTBT. The current arrangement has worked for more than 17 years and provides political flexibility to conduct a short notice, full-yield test, if required. This construct eliminates the external notification requirements of the CTBT and would mitigate potential internal political debate. Congress should fund the design of the next generation warhead to ensure the nuclear enterprise is prepared if a replacement warhead is needed due to aging. A new design could result in a single modular warhead for all weapons reducing life cycle costs. Congress needs to invest in the proper test infrastructure at the NTS to be capable of conducting an underground nuclear test within 6 months of notification. Testing may be required on short notice to rapidly resolve issues found in the SSP, and the 180-day timeline would align with the 200-day notification to Russia required by treaty.

Nuclear Weapons Industry Policy Recommendations:

1. Maintain the status quo with the CTBT – Presidential signature without Senate ratification and a ban on full-yield nuclear testing.
2. Maintain appropriate funding of the Stockpile Stewardship Program to ensure robust surveillance and management of the stockpile.
3. Develop an active design program to develop the next generation nuclear warhead.
4. Fund the Nevada Test Site upgrades in order to ensure the site can execute a robust full-yield underground nuclear test within 6 months of notification.
5. Ensure NTS site is viable for underground testing, and the human capital is properly trained to execute full-yield tests if needed.
6. Secure funds for planned infrastructure upgrades at NWI facilities to maintain the capability to produce needed weapons components as the stockpile ages.
7. Consider base closure and realignment type process to consolidate the labs. It is critical to maintain 2 out of 3 labs to ensure proper technical review and crosscheck.
8. Expand internship and recruiting programs at all of the national labs to offset the growing percentage of DoE laboratories' essential workers who are over 50 years old.⁵³

Non-Lethal Weapons

Sector Defined: These weapons are explicitly designed and primarily employed so as to incapacitate personnel while minimizing fatalities, permanent injury, and undesired damage to property. NLWs are designed to be less than lethal, but this does not mean there is zero probability of producing fatalities or permanent injuries. This category of weapons can be further sub-categorized based on their principal effects against the human body, other human senses, or the physical surroundings.⁵⁴ NLW types include projectile weapons that use kinetic energy to disable, electronic weapons which disrupt the nervous system, light-based weapons that cause dizziness and temporary blindness, noise-based weapons that inflict nausea and temporary deafness, and chemical weapons that can irritate or anesthetize human targets.⁵⁵

Current Condition: This sector is characterized as an oligopsony market. Recent decisions by the US Department of Justice allowed for legal production and sale of NLWs in all 50 states.⁵⁶ Commercial sales of lasers and personal defense chemical sprays are unrestricted,⁵⁷ lowering barriers to entry for suppliers. For kinetic (body effect) and optic (eye effect) NLWs, there are a substantial number of vendors modifying existing products for use as NLWs,⁵⁸ such as rubber bullets, foam batons and shotgun-launched bean-bags. The most commercially successful NLW to date is the Taser,⁵⁹ a brand name electronic control device, used by more than 130,000 police officers in 7,000 police departments nationwide.⁶⁰ Chemical NLWs are heavily regulated by national and international convention, but a fair number of competing vendors offer pepper spray, mace and tear gas⁶¹ sprays and derivatives. The Chemical Weapons Convention of 1993⁶² failed to apply “warfare” standards to law enforcement activities, therefore police forces are prominent customers for manufacturers of these products.⁶³ Acoustic (ear effect) and electromagnetic (nerve effect) NLWs are relatively immature technologies with only a few laboratories and research companies exploring viable product sales. Military deployment of the Long Range Acoustic Device (LRAD)⁶⁴ and the Area Denial System (ADS)⁶⁵ have yielded questionable operational success, but politically sensitive issues for their use counter any producer’s inclination to invest heavily in their further development.

Challenges: The most significant barrier to entry for companies in this market is the limited budgets customer activities have to procure NLWs in addition to supporting/sustaining their lethal weapons capabilities. Manufacturers (both current and hopeful emerging ones) tend to cater their product offerings to the military because the services have generally had greater financial resources and more institutional patience for products in development.⁶⁶ This element will likely prove a greater disappointment and barrier to entry in the coming years of fiscal restraint and sequestration.

Outlook: The NLW market offers customers the full range of the force continuum to inflict the desired effect on the aggressor without automatically defaulting to a lethal result.⁶⁷ “The customer’s ultimate goal is to fight military operations on urban terrain using weapons with rheostatic capability that, like *Star Trek* phasers, will allow military commanders to fine-tune the amount and type of force used in a given situation.”⁶⁸ The US Global Strategy Council argues that NLWs offer “revolutionary advantages” in minimizing political fallout as a result of unintended fatalities.⁶⁹

Government Goals and Role: Former Secretary of Defense Robert Gates warned that “over the long term, the US cannot kill or capture its way to victory.”⁷⁰ Gates, and his predecessor Donald Rumsfeld, were proponents for the capabilities introduced with NLWs.⁷¹ There is presently a lack

of clarity in NLW employment. Warfighters do not entirely embrace their use, either from skepticism, legal concerns, or lack of trust in their proper function.⁷²

Non-Lethal Weapons Industry Policy Recommendations:

1. Institute continuum of force guidance for use of NLW assets for all DoD forces by OSD.

Cross-Cutting Industry Issues

The following areas represent challenges for the weapons industry across all sectors, namely concerns for a shrinking skilled workforce, preparing and producing products with improved exportability as a factor, reducing the impact of trade controls for the weapons industry, and reduced R&D funding applied to weapons. These issues are pervasive in several, if not all, of the weapons industry sector studied this year.

Weapons Workforce

The industry is characterized by a relatively small design engineer workforce with a fair amount of cross flow of personnel between companies. The leadership of the various weapons industry sectors visited indicated it takes between two and three years of on the job training to take a newly trained college engineer and make them a productive member of new weapons design teams.⁷³ Several trends emerged with regard to the designer workforce in the industrial base. The first is the age of designers and engineers (Appendix C). Most firms indicate their workforce is typically shaped by a bi-modal distribution with some of the designers in their mid-thirties and the others in their mid-to-late fifties.⁷⁴ Most of the design team workforce attrition is through retirements and not from designers seeking employment in other fields or endeavors. Training for new designers seems to take from between five to ten years to become leading edge designers and managers (although new designers become contributing members in 6-12 months).⁷⁵

Moderate risk exists in recruitment from a Science, Technology, Engineering, and Mathematics, as well as Manufacturing skills (STEM+M) perspective due to the lack of qualified personnel available to fill openings.⁷⁶ Many companies are partnering with universities on projects and intern programs as a method to create interest and develop more STEM+M graduates. It is critical to take steps to retain this experience, in order to retain the technological advantage that the DoD has enjoyed. There is an aging workforce of skilled designers, scientists, and production engineers.⁷⁷ As an example, in the nuclear weapons sector there are only five current employees at LANL that were involved in the test of a nuclear weapon. Without a change in US policy, soon there will be no workforce members with real live experience in nuclear testing.

Recruiting new STEM+M graduates into the DIB is also a challenge. Eighty percent of current DIB workers would not recommend the DIB as a career choice.⁷⁸ Although the US has actually seen a slight increase in the number of STEM+M Master's degrees, foreign students receiving degrees in the US have significantly outpaced the US citizens. "For example in 1985 roughly 5,000 foreign students received their doctorate as compared to 14,000 US citizens. In 2005, nearly 12,000 foreign students received their PhD versus 15,000 US citizens."⁷⁹ The overall workforce employment has been on a downward trend as DoD budgets continue to decrease. With the reduction of the workforce, challenges in retention, and difficulty in recruiting new STEM+M

skilled workers, knowledge transfer and sustained design and production capabilities presents moderate risk to the DIB.

The DIB employs workers with unique skill sets not routinely sought and employed in other industries. Machinists working with both traditional machine tools as well as multiple-axis automated Computer Numerically Controlled (CNC) machines oversee high-volume production of components with extreme tolerances for handling explosive pressures. Engineers apply traditional techniques for metallurgy, computer-aided design, and explosives chemistry in the creation and fabrication of combined system-of-systems products used worldwide by often unskilled end-users. Artisans practice centuries old craft skills in wood and metal, shaping and lacquering elegant gunstocks and working in gold and gemstones to create singular works of art on fully-functional firearms. The population of the artisan workforce has been aging, thereby systematically reducing the number of workers in the trades and skilled practitioners. Recent public concern for the manufacture and sale of firearms has revealed academic skepticism and individual reluctance of new workers to enter the weapons industry. The DIB faces a shortage of trained and skilled human capital which could adversely affect the nation's ability to both sustain weapons manufacturing, as well as provide innovative designs for the next generation of weapons.

Exportability

Intellectual Property: There are four different types of intellectual property (IP): patents, trademarks, copyrights and trade secrets. Intellectual property rights (IPR) are legal rights granted by a government to bolster innovation. IPR is granted by governments, however they can be traded or licensed to others usually for money or royalties based on the IP. The World Trade Organization (WTO) provides some standards of IPR protection under the Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement; however, most governments can only enforce those rights granted in their respective country. Intellectual property right infringement is a violation of IPR or a misuse of the IPR. Piracy of IP can be against either copyrights or trademarks. Copyright piracy involves either unauthorized duplication of copyrighted material, or dissemination of that material or commercial transactions that involve copyrighted material without proper consent of the copyright owner. Counterfeiting, or the production of a product that is a "fake" but marketed as an original, is the biggest challenge for items that carry a trademark.

The US ranks number one in the world for the number of patents held. The number of patents received under the Patent Cooperation Treaty (PCT), an international patent filing system administered by the World Intellectual Property Organization, has seen an increase recently as a result of increased spending on R&D. Although the US remains at the top of the list, the average number of patent applications, when compared to previous years, is actually a negative percentage, indicating a downward trend in patent applications by US firms and individuals. This is in stark comparison to China, ranking fourth in the PCT, which saw a 56% growth rate in recent years.⁸⁰

Anti-Tamper provisions: The intentional design of weapon system components to prevent their intrusion and duplication⁸¹ by another manufacturer was a frequent concern among businesses visited by the seminar. Several small arm companies discussed how numerous employees have moved between their companies. This opens the door for IPR infringement, or at a minimum a small amount of information transfer. These companies did not seem overly concerned as they often stated that there have been few significant differences in weapons manufacturing over the

years. Although these companies did have slight differences in their respective weapons, they again were more concerned with anti-tamper (AT) measures to prevent counterfeiting or copyright infringement.

Trade Controls

Export Controls: In the globalized economy, US firms face export restrictions not applicable to foreign firms selling competing weapons. Addressing these restrictions has stymied both policy makers and industry officials for decades.⁸² While some contend that US export controls overly restrict exports and make firms less competitive, others argue that US defense and foreign policy considerations should trump commercial concerns. The centerpiece of the government's actions is the Export Control Reform Initiative (ECRI), detailed in Appendix D.

Throughout most of the Cold War, researchers focused primarily on developing military technologies, and occasionally commercial uses for those technologies were “spun off” – thus creating the need to create controls for such dual-use items. Today, the model has been flipped – with the rapid advances in technology and globalization, more technologies are emerging from the commercial sector and being “spun on” to military applications. Unfortunately, the Cold War–era export control regime still in place can now actually inhibit military access to technology because many commercial firms are unwilling to meet defense needs that are just a fraction of the overall global market and require controls that cut in to their bottom line.⁸³ The situation is described perfectly below:

The current system is based on two different control lists administered by two different departments, three different primary licensing agencies (none of whom sees the others licenses), a multitude of enforcement agencies with overlapping and duplicative authorities, and a number of separate information technology systems (none of which are accessible to or easily compatible with the other), or agencies with no IT system at all that issues licenses. The fragmented system, combined with the extensive list of controlled items which resulted in almost 130,000 licenses last year, dilutes our ability to adequately control and protect those key items and technologies that must be protected for our national security.⁸⁴

Recommendations:

1. Continue to support the ECRI, even if not complete at the end of the Obama Administration. These initiatives will enable many positive outcomes for DoD to include: access to state-of-the-art technologies and capabilities, a way to provide consistency and fairness to US allies that should encourage weapons systems interoperability and mutually beneficial industrial arrangements, exposure of US industry to international competition, and reduced overhead cost to administer and enforce the resulting fewer restrictions.⁸⁵

2. Develop a national trade control strategy that includes: 1) clear criteria to determine the need for military or dual-use item control and 2) a sunset provision to keep the export control list up-to-date and relevant. Without such guidance, government authorities will continue to make ad hoc decisions and have difficulty making judgments about the relative importance of trade in different military and dual-use item groups.⁸⁶

Defense Trade Agreements: One of the biggest challenges with international trade arms is the numerous bureaucratic barriers that exist, even with trusted allies. In 2008, the United States began a series of treaty discussions with the UK and Australia to bring them under some of the same security controls that the US has shared with Canada. The goal is to create an ever-expanding security circle of trusted allies with a simplified process in place to import and export defense related items.⁸⁷ Due to the impacts of a competitive defense market space, the US and DIB should strongly consider leveraging our Defense Trade Agreements and Reciprocal Defense Procurement Agreements. In addition to providing contracting opportunities for other nations, it will be easier for US firms to gain subcontract opportunities abroad. With this shared cooperation between member nations, it will allow the US to purchase foreign made weapon systems and munitions that meet US safety and durability requirements.

Buy American Act: Congress has broad authority to place conditions on the purchases made by the federal government and has done so many times in the past for specific purposes. One of the most familiar is the Buy American Act (BAA), which is a domestic preference statute that applies to direct purchases of more than \$3,000 that are consistent with the public interest, reasonable in cost, and used in the US.⁸⁸ While the BAA applies government-wide, there are also DoD-only restrictions. Perhaps the most well-known are the Berry Amendment and the Specialty Metals Clause. The Berry Amendment bars DoD from acquiring food, clothing, fabrics, and hand or measuring tools, which are not grown or produced in the US.⁸⁹ The Specialty Metals Clause prohibits DoD from acquiring certain components containing specialty metals (e.g., aircraft, space, and missile systems) unless they have been melted or produced in the US.⁹⁰ Both restrictions include a myriad of exemptions and waivers developed throughout the years that make enforcement and administration both costly and time-consuming.

The Defense Production Act (DPA) of 1950 gives the President authority to force private industry to give priority to defense and homeland security contracts and to allocate the resources needed.⁹¹ Specifically, Title III promotes industrial production to meet essential government requirements and establish commercial viability for key industries.⁹² While “Buy American” legislation was created to “protect” US industries and ensure that the US has secure sources for critical national security needs, it has often isolated companies from the need to innovate and compete in a global market. Now, faced with an uncertain fiscal future, the number of companies has declined dramatically.⁹³ That was certainly the case with the Merchant Marine Act of 1920 (Jones Act), which was meant to save the merchant marine industry by requiring ships that operated in American waters be built in the US and manned by American crews. Since the passage of the Jones Act, more than 60 US shipyards have gone out of business, eliminating 200,000 jobs.⁹⁴

Buy American advocates argue that policies like the Berry Amendment and the Specialty Metals Clause decrease dependency on foreign sources of supply which will prevent a potential adversary from cutting off access to militarily critical items in times of crisis or conflict. Others argue that they often benefit small, minority-owned, veteran-owned, or women-owned, businesses that depend solely on DoD for their survival.⁹⁵ Still others believe that they are critical to the maintenance of a warm US defense industrial base when there is a requirements surge.⁹⁶ The difficulty lies in how to take advantage of foreign technology and equipment without being vulnerable, losing jobs, or weakening the US defense industry.⁹⁷

Recommendation: Repeal all DoD “Buy American” requirements and instead develop criteria (Appendix E) to determine whether an industrial sector warrants special protection. If it does, the President should use his authorities in the Defense Production Act (DPA) of 1950 to do so. There are several positive outcomes from this course of action for DoD: 1) access to state-of-the-art technologies and capabilities; 2) a way to provide consistency and fairness to U.S. allies that should encourage weapons systems interoperability and mutually beneficial industrial arrangements; 3) U.S. industry is exposed to international competition, helping to ensure they remain innovative and efficient; and 4) reduced overhead cost to administer and enforce the resulting fewer restrictions.⁹⁸

Research & Development Funding

With the reduction in defense spending and the anticipated decrease of new start Major Defense Acquisition Programs, many firms within the weapons industry stated that they were concerned with DoD R&D investment strategy, and many of them have decreased their internal R&D funding as a result of globalization the US no longer has a monopoly on scientific and technological innovation.⁹⁹ Other countries are making new and significant investments in basic research, and a larger number of them are participating at the leading edge of scientific discovery. In order for military applications to remain on a competitive edge and to avoid technological surprise, the DoD must invest in R&D, and the Quadrennial Defense Review acknowledges that it must work in partnership with other agencies and sectors such as academia and industry to maximize its ability to innovate and compete.¹⁰⁰ Additionally, the MIBP should implement policy that directs basic applied research through the various DoD and civilian labs to provide a hedge against emerging threats and future technologies in the weapons arena. Current examples of this investment are found in the 2012 National Defense Authorization Act which sets aside \$30 million for the Industrial Base Innovation Fund for manufacturing techniques for titanium.¹⁰¹ Similar programs should be implemented with respect to weapons design research.

Concerns from several government agencies and industry were gathered via a poll by the Government Accountability Office (GAO). The poll included agencies and private sector companies that were responsible for 88% or \$191 billion of government procurement for FY 2001.¹⁰² The government’s concerns included limited awareness of the program’s flexibility and expertise, poorly defined data requirements to track investment uses, lack of oversight of projects involving multiple parties, and lastly limited participation in contracts with inventions that might warrant patents by the inventor.¹⁰³ Deputy Secretary of Defense Ashton Carter has identified investment in R&D as a priority, especially in for research for “preserving our seed corn.”¹⁰⁴

Conclusion

From the industry’s perspective, there are fewer compelling reasons to remain so closely aligned to a shifting budget. Following the Great Recession many companies have moved on to more profitable industries, or have simply evaporated. In many cases where there used to be more than one supplier in a particular defense sector, now there is only one and the armed forces face the very real threat of losing entire capability altogether.¹⁰⁵

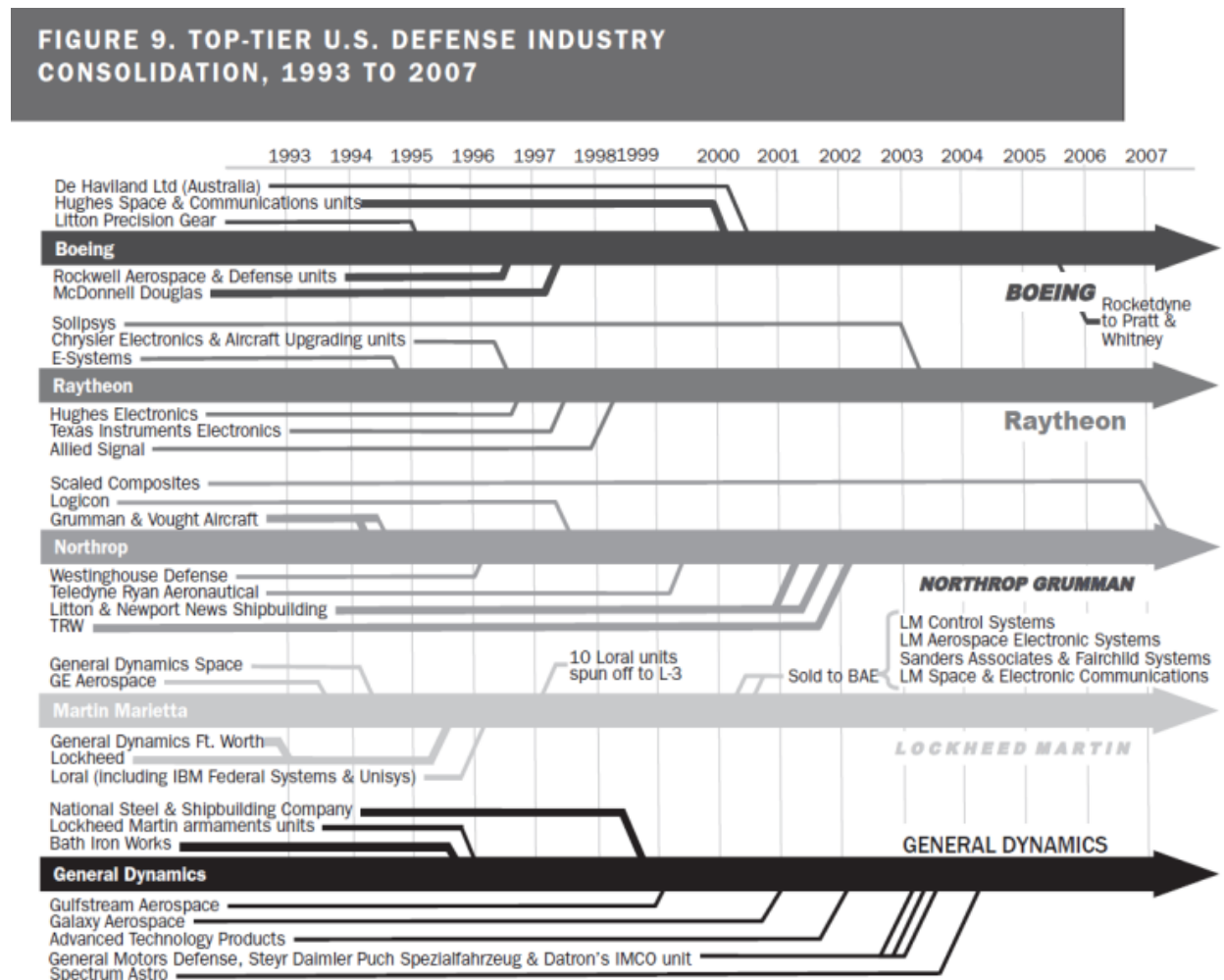
With the current and expected future turbulence of the federal budget due to sequestration, the days of DoD being able to do “more with less” is quickly turning to do “less with less.” Where the US government was historically in a place where the contract award “picked a winner” from the group of eager suppliers, it is now a case where the government must “win” itself the industrial support it needs to accomplish the nation’s business. Where US DoD technologies were once “spun-off” to successful commercial applications, the trend of late is taking innovative commercial technologies and “spinning them on” to DoD uses. The question for the nation’s leaders remains the same: how much defense and national security can the US afford? What is the proper balance between procurement and repair of DoD assets? How can the US maintain a robust and technologically advanced defense industrial base to support US national security strategy?

To help understand these issues within the weapons industry, the seminar focused on the following eight representative sectors: small arms, medium and large caliber weapons, bombs and missiles, energetics, ammunition, sensors, nuclear weapons, and non-lethal weapons. In addition, the seminar also focused on four cross-cutting weapons industry issues: workforce, exportability, trade controls, industrial base policy, and research and development (R&D) funding. From the seminar’s perspective, there are opportunities and risks in each of the eight sectors. Certain sectors may be challenged by the effects of sequestration as well as ongoing decline due to years of insufficient sustainment and R&D funding. Almost all are affected in some way by trade controls that degrade US firms’ ability to innovate and compete in the global market. Some negative trends identified 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 have a vibrant commercial aspect to their sector.

While President Eisenhower is famous for his remarks about the perils of a strong industrial base, he also said, “I have one yardstick by which I test every major problem - and that yardstick is: Is it good for America?”¹⁰⁶ Maintaining the health of the weapons industrial base, in balance with military requirements, and Congressional oversight, is good for America and will be instrumental in securing the nation’s security for many years to come.

Appendix

Appendix A: Consolidation of the Defense Industrial Base to Top-Tier Companies



Barry D. Watts and Todd Harrison, "Sustaining Critical Sectors of the US Defense Industrial Base." Center for Strategic and Budgetary Assessments. (2011). 75.

Appendix B: Nuclear Weapons Industry Table of Supported Systems

The NWI currently maintains around 5,000 nuclear weapons consisting of seven different designs with twelve variants.¹⁰⁷ The primary function of the NWI centers on maintaining and extending the life of bombs and warheads inventory. Figure 1 and the following paragraphs provide additional details on the current US nuclear weapon inventory.

Weapon	Type	Delivery Platform	Maintenance Cost over 5 years (FY14 \$M)	LEP Cost over 5 years (FY14 \$M)	User	Designer
B61-3/4/10	Bomb	Fighter	339	2,900	USAF	LANL/SNL
B61-7/11	Bomb	Bomber			USAF	LANL/SNL
B83-1	Bomb	Bomber	253	N/A	USAF	LLNL/SNL
W76-0/1	Warhead	Submarine	239	1,200	USN	LANL/SNL
W80-1	Warhead	Bomber	397	N/A	USAF	LLNL/SNL
W87	Warhead	Missile	383	N/A	USAF	LLNL/SNL
W78	Warhead	Missile	273	466	USAF	LANL/SNL
W88-1	Warhead	Submarine	319		USN	LANL/SNL

Figure 1 – Current US nuclear weapon inventory

The US NWI maintains two bomb designs. The 0.3 to 300 kiloton B61 has six variants each costing about \$4.9 million per bomb in FY98 dollars,¹⁰⁸ and was originally built for deployment from tactical fighter aircraft and strategic bombers. NNSA will spend approximately \$339 million to maintain the B61 over the next five years. The B61 is also currently undergoing a life extension program (LEP) with NNSA expecting to spend about \$2.9 billion over the next five years and completing this effort by 2019.¹⁰⁹ The B83-1 was originally built around 1983 with a yield of 1.2 megatons for deployment from strategic bombers.¹¹⁰ NNSA will spend approximately \$253 million to maintain the B83 over the next five years. There is no current LEP plan for the B83.¹¹¹

The US NWI maintains five warhead designs (W76, W80, W87, W78, and W88) with six variants, for deployment from USN Trident submarines¹¹² and USAF ICBMs, delivering yields from 5 to 425 kilotons.¹¹³ NNSA will spend more than \$1.5 billion to maintain these warheads over the next five years.¹¹⁴ Several of these warheads are also undergoing an LEP with NNSA expecting to spend about \$1.2 billion over the next 5 years and completing this effort by 2021.¹¹⁵ The W78 and W88-1 are undergoing a LEP feasibility study with NNSA expecting to spend about \$466 million over the next five years and field the first rebuilt warhead by 2025.¹¹⁶

Appendix C: Weapons Design Teams Population Analysis

The average age of our current weapons designs is approximately 25 years. Assuming a designer starts at age 25, they could work on the same weapon for the majority of their career. Reference Table 1 for a graphic depiction of the weapons presented in this monograph and the average age the weapons.

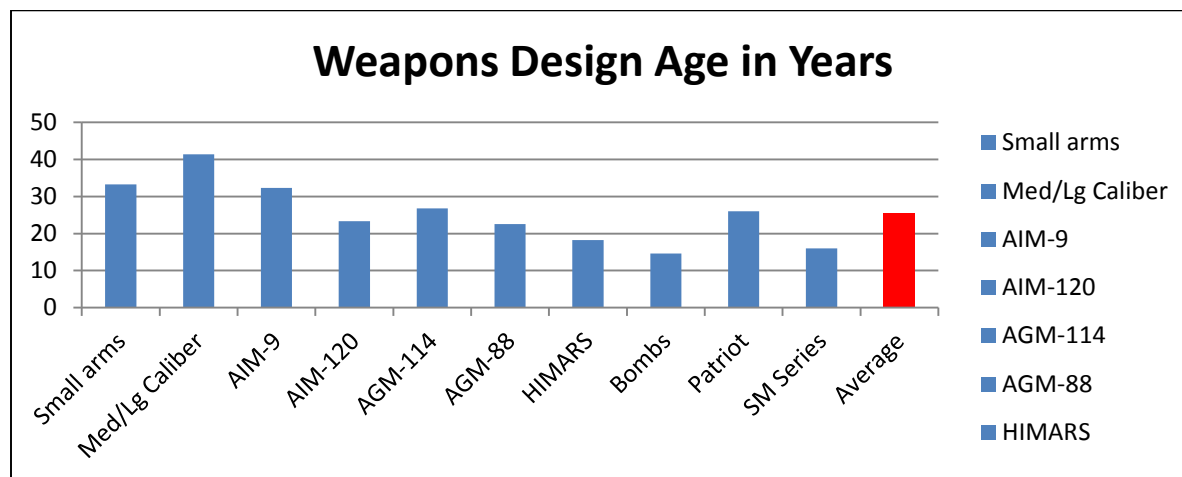


Table 1. Weapons Design Age

Training a new weapons designer takes on from 2-10 years depending on the complexity of the weapon. The weapons industry is well positioned in regards to designer recruitment and retention in small arms; however, due to the lack of new requirements and weapons procurement, there is moderate risk for medium / large caliber projectile weapons, and rockets, missiles, and bombs. Incremental upgrades appear to keep the industrial base warm from a designer perspective.

Appendix D: Administration of the Export Control Reform Initiative

The two main departments involved in export control are the Department of State (DoS) and the Department of Commerce (DoC). Interestingly, the US today is the only country in the world that has more than one licensing agency for both munitions and dual-use items for export.¹¹⁷ The Directorate of Defense Trade Controls (DDTC) within DoS is the lead agency for regulating US arms. The DDTC administers the export licensing system and provides export licenses through the International Traffic in Arms Regulations (ITAR) via the Arms Export Control Act of 1976. The ITAR includes the US Munitions List (USML) which is a listing of those categories of equipment and technologies that are subject to export control. In addition, the ITAR contains a list of those countries prohibited from receiving US defense related technology.¹¹⁸

Commercial US technology and equipment that are categorized as dual-use items (commercial and military uses) fall under a different set of laws, regulations, and policies that are implemented by DoC.¹¹⁹ The Bureau of Industry and Security (BIS) within the DoC is the lead agency for regulating the export and re-export of commercial and dual-use items via the Export Administration Regulations (EARs). The EARs contain the Commerce Control List (CCL) which controls several thousand items as a matter of US policy in support of anti-terrorism, crime control, and firearms conventions, as well as regional stability efforts, and United Nations sanctions.¹²⁰

President Obama's Export Control Reform Initiative (ECRI) was developed in 2009 to address the current system's shortcomings on the following four "singularities" that would establish the following:

- a single export control licensing agency for both dual-use and munitions exports;
- a unified control list;
- a single enforcement coordination agency; and
- a single integrated information technology (IT) system, which would include a single database of sanctioned and denied parties.¹²¹

While the singularities were to be implemented incrementally starting almost immediately, it was not until March 2013 that President Obama signed an executive order to update delegated presidential authorities over the administration of certain export controls and notified Congress of the first in a series of changes to the USML. Specifically, the executive order consolidates all brokering responsibilities with DoS, eliminates possible "double licensing" requirements between the USML and Commerce Control List, and updates the USML with respect to aircraft and gas turbine engines.

Appendix E: Buy American Act Sample Criteria to Determine Domestic Preference

These criteria should focus on capability preservation and address the following questions with regard to an item or system:¹²²

1. Does it perform a unique military function essential to national defense?
2. Does it contain classified or sensitive technology that an adversary could exploit?
3. Does it enable a unique strategic national security or military advantage?
4. Does it require long lead times to produce without DPA Title III assistance?¹²³

If the answer is “yes” to any of the above questions, then the item or system is most likely of strategic importance and consideration should be given to safeguard it by ensuring access and stimulating academic interest in similar technology. If the answer to all questions is “no,” then no special preference should be given.¹²⁴

Endnotes

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- ¹ Barack Obama, *National Security Strategy*, May 2010. 7.
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- ² Lawrence P. Farrell, “US Must Resolve Industrial Base Issues,” *National Defense Magazine*, June 2003.
- ³ Weapons Industry Study AY 2012, Industrial College of the Armed Forces, Ft. McNair, VA.
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