Annual Industrial Capabilities

Report to Congress for

2015

September 2016

Office of the Under Secretary of Defense
for Acquisition, Technology, and Logistics

Office of the Deputy Assistant Secretary of Defense
for Manufacturing and Industrial Base Policy

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1. Requirement

This report is being provided to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives. This report simultaneously satisfies the requirements pursuant to title 10, U.S.C., section 2504, which requires the Department of Defense (DoD) to submit an annual report summarizing DoD industrial capabilities-related guidance, assessments, and actions and Senate Report 112-26, which accompanied the National Defense Authorization Act (NDAA) for FY 2012, and requires a report containing a prioritized list of investments to be funded in the future under the authorities of Title III of the Defense Production Act (DPA) of 1950. This report summarizes DoD industrial capabilities-related guidance, assessments, and actions initiated during 2015 and as they existed at the close of that year. It is important to note that the status of some of the programs described herein has changed in the intervening time.

2. Defense Industry Outlook

The defense industrial base (DIB) is comprised of a diverse and dynamic set of companies and DoD organic facilities that provide both products and services, directly and indirectly, to the Department of Defense and national security agencies to support national security objectives. It includes companies of all kinds, from some of the world's largest public companies to small businesses. The Department relies on an industrial base that is now far more global, commercial, and financially-complex than ever before.

Overall, our defense industry remains viable and competitive. As the industrial base continues to diversify, DoD contractors must constantly examine and realign their business activities while competing for capital in competitive markets. The good news is larger defense companies remain profitable; they are carefully managing shareholder value through equity buybacks, debt reduction, reduced capital expenditures, and reductions in the labor force. Reduced costs, more transparency, and accountability in spending can lead to greater efficiency. However, concerns about future budget levels, in part, impact companies' investment in their defense portfolios and sometimes deters new firms from working with the Department.

2.1 Trends in Defense Sectors

The United States produces the best systems in the world; however, in many cases we both require and produce fewer of them than in prior decades. As a result, the DIB has seen erosion in multiple sectors, including missiles, electronics, ground combat vehicles, and materials, with associated decreases in design engineering and manufacturing capability. Typically, our large defense firms are more diverse and able to manage fluctuations in defense spending. Budget impacts are more dramatic and challenging in the lower sub-tiers of the DIB as smaller firms, with more limited access to capital, must adapt to these same conditions.

Mergers and acquisitions (M&A) can further complicate this challenge. While competition remains robust in most defense markets, consolidation in the defense industry over the past several decades has been substantial. As Mr. Frank Kendall, Under Secretary of Defense (Acquisition, Technology and Logistics) (USD(AT&L)), noted in September, "there has been a dramatic reduction in the number of weapon system prime contractors producing major defense programs" since the 1980s.[1] Fewer companies can reduce competition, weaken the pool of prospective suppliers, and maximize prime contractor leverage over suppliers.

Despite pressure in some areas, several new entrants have emerged in recent years. In the shipbuilding and space sectors, for example, some unexpected companies have become major players in the DIB. While these new entrants are promising, perceptions about issues such as contracting practices and intellectual property protection have deterred some commercial technology and other companies (inelegantly labeled "non-traditional defense contractors")[2] from working with the Department. To address this situation, DoD leaders worked aggressively throughout 2015 to improve the way the Department does business with both traditional and non-traditional firms (see Section 3.3 below).

2.2 Technological Superiority

As Mr. Kendall has noted on many occasions, research and development (R&D) drives modernization. It still takes lead-time to get a new capability designed, tested, and then produced and acquired, and budget swings can retard and disrupt this multi-phase process. Accordingly, DoD is concerned about protecting the adequacy of R&D investments in capabilities and systems that will allow DoD to dominate on future battlefields and keep engineering design teams who develop advanced defense systems fully engaged. The risk for defense-unique industrial sectors at the sub-tier supplier level is especially pronounced. Such suppliers may not have the diversity of programs or products from other markets to support their design and production skills. One approach to continued innovation is to incentivize industry to increase its investment in internal R&D funds focused on next-generation capabilities. Another is to increase the use of prototyping to reduce design risks and sustain system integration and design engineering skills.

Over the past several years, defense companies have generally taken an income-focused strategy toward capital deployment, emphasizing bottom line cash flow over top line growth-focused approaches. Corporate internal R&D has generally been flat or down as a result of this approach. A report by the Information Technology and Innovation Foundation, for example,

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[1] Frank Kendall, "Statement on Consolidation in the Defense Industry," September 30, 2015.

[2] The term "non-traditional defense contractor" was revised in the 2016 NDAA (10 USC 2302) to include "an entity that is not currently performing and has not performed, for at least the one-year period preceding the solicitation of sources by the Department of Defense for the procurement or transaction, any contract or subcontract for the Department of Defense that is subject to full coverage under the cost accounting standards prescribed pursuant to section 1502 of title 41 and the regulations implementing such section."

found that R&D spending, as a share of sales by defense contractors, declined by nearly one-third between 1999 and 2014.[3] The December 2015 two-year budget agreement, however, could potentially incentivize industry to change the trajectory of their internal R&D spend.

"R&D is not a variable cost. In the past there has been a tendency to reduce R&D more or less proportionately to other budget reductions. This can be dangerous, if done in excess. R&D costs are not related to the size of our force or the size of the inventory we support. The cost of developing a new weapons system is the same no matter how many of that system we intend to produce."

■ ***Under Secretary of Defense for Acquisition, Technology, and Logistics (AT&L), Frank Kendall, "Protecting the Future"***[4]

2.3 Globalization

The defense industry is becoming more integrated with global commercial markets, changing both the source and tempo of innovation. As a result, the United States no longer has the luxury of assuming that it will remain the sole origin of new technology breakthroughs. Indeed, international collaboration and cooperation have reduced the time from technology breakthrough to product development. This change requires that DoD acquisition processes be able to take advantage of emerging capabilities, regardless of where they originate.

Effective global supply chain integration and management are even more critical to DoD program success than in previous years. Globalization brings many benefits to both defense firms and the Department, but this cross-border collaboration has also increased the potential threat of global supply chain disruption, counterfeit parts, sabotage, and theft of critical American defense technology. This shifting landscape of defense production may require new tools and authorities to address prospective security threats and to safeguard the value and integrity of American technology.

2.4 Looking to the Future: DoD and the Defense Industrial Base

Government and industry stakeholders are keenly aware of the significant ongoing pressures on the DIB. While the two-year budget agreement has provided welcome relief to industry and DoD planners, budgetary and other challenges loom in the coming years. The good news is that defense markets are cyclical and there will be an upturn eventually — but DoD and

[3] Federal News Radio – "DoD's Kendall wants more research spending from industry", November 9, 2015.
[4] Defense AT&L Magazine: May-June 2014 http://www.dau.mil/publications/DefenseATL/DATLFiles/May-Jun2014/May-Jun2014DATL.pdf.

the DIB must be ready for it. Firms that succeed in the future will need to make strategic investments in new technology now. Going forward, it is imperative that DoD and industry strengthen their strategic collaboration to help position the industrial base for success in the coming years.

A key part of the solution is greater DoD awareness of ongoing trends in commercial industry that affect defense and to increase collaboration with industry to ensure that firms remain viable producers even if their operations are not defense-unique. Gone are the days when the Department relied on dedicated contractors that received most of their investment capital from DoD and produced primarily in the defense market. Firms need to remain profitable to produce for the defense sector and the Department must take into account the way defense trends affect the willingness and ability of commercial firms to sustain defense-related production.

3. DoD Industrial Base Priorities and Initiatives

3.1 Overall Vision

The DIB is an integral part of the Department's force structure and a pillar of the national security strategy. DoD must promote a competitive, innovative, and financially healthy industry that will provide the most affordable, highest performing capabilities to the Warfighter. The Long-Range Research and Development Planning Program (LRRDPP) and other efforts aimed at advancing our technical dominance and power projection capabilities will only be successful if the DIB remains modern and cutting-edge. It is therefore imperative that the Department develop a more proactive and predictive approach for identifying industrial base vulnerabilities and a more comprehensive and cost-effective strategy for mitigating them. As described below, the Department moved aggressively in 2015 to implement this vision.

3.2 Maintaining Technology Superiority

In 2015, the Department developed broad new guidance to shape its modernization strategy. One of the major thrusts of this new effort was the LRRDPP. The purpose of the LRRDPP was to identify high-payoff enabling technology investments that could help shape future U.S. production and the trajectory of future competition for technical superiority. The plan focused on technology that could be moved into development programs within the next five years. On January 28, 2015, the Department published a request for information seeking to identify current and emerging technologies or projections of technology-enabled concepts that "could provide significant military advantage to the United States and its partners and allies in the 2030 timeframe." [5]

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[5] Long Range Research and Development Plan, Solicitation Number: HQ0034-15-RFI-1. https://www.fbo.gov/index?s=opportunity&mode=form&id=ed0bfb18c8857a602abafdd8b3fbbb28&tab=core&_cview=1.

The LRRDPP focused on technologies that could be applied in novel ways for a new kind of system capability; emerging technologies that could quickly be turned to new military capabilities; or technologies for nondefense applications that could offer new military capabilities. Five LRRDPP technology priority areas identified were space, undersea technology, air dominance and strike, air and missile defense, and other technology-driven concepts. Funding these LRRDPP priority areas was a major focus during the development of the FY 2017 budget submission.

3.3 Encouraging Innovative Entrants

The DIB is strengthened when there is a competitive market and an influx of new firms. However, perceptions about DoD contracting practices and intellectual property protection have sometimes deterred non-traditional companies from working with the Department. Fortunately, major efforts are underway to incentivize new entrants into the defense sector. The Defense Innovation Unit Experimental (DIUx), for example, was established in the heart of the U.S. innovation ecosystem—Silicon Valley, California—in August 2015. Located near Moffett Field and around the corner from the NASA Ames research center in Mountain View, California, the DIUx facility is inspired by design-thinking culture. This is DoD's Silicon Valley outpost to serve as a bridge between those in the U.S. military executing some of the Nation's toughest security challenges and companies operating at the cutting edge of technology. Similar DIUx units are planned for other U.S. centers of innovation.

"The DoD has a long history of technological breakthroughs and innovations originating from within the Department. In order to sustain technology superiority, the Department must take advantage of the rapid evolution of emerging commercial technologies that, when integrated with military systems and novel concepts of operations, will be a source of battlefield advantage. While the Department is beginning to focus on innovation in the commercial technology sector, a more concerted effort is needed."

- ***Statement by the Honorable Robert O. Work, Deputy Secretary of Defense, July 2, 2015***[6]

The goal of DIUx is to increase the speed and efficiency of DoD by tapping into the rapid evolution of commercial technology development and to help facilitate the integration of those ideas within military systems and concepts of operation. Ultimately, DIUx will create innovative

[6] July 2, 2015 Memo: https://www.whitehouse.gov/sites/default/files/omb/legislative/sap/114/saphr4909r_20160516.pdf.

partnerships to benefit the U.S. national security community and industry. DIUx has a particular interest in engaging industry in dual-use technology areas, such as big data, analytics, autonomy, robotics, and cybersecurity.[7]

More broadly, the Department has continued to focus on increasing roles and opportunities for small businesses. Small businesses, as both prime contractors to the Department and sub-contractors within the supply chain, are effective sources of innovation and reduced cost. The Virginia Class submarine acquisition strategy, for example, specifically identified subcontracting plans to include opportunities for small businesses. As a result, the program involved 4,000 small and mid-sized suppliers in its construction and the program office continually challenged the primes to increase small business participation as part of their strategy. This is a model for renewed efforts to ensure that DoD contracts comply with statutory requirements to fully integrate small and disadvantaged businesses with cost and technical advantages.

"The Department doesn't encourage the use of small business just because we like small businesses. We do it for very practical reasons. One of the greatest engines for innovation in this country is small businesses. Some people have great ideas and want to take them out and make them into businesses."

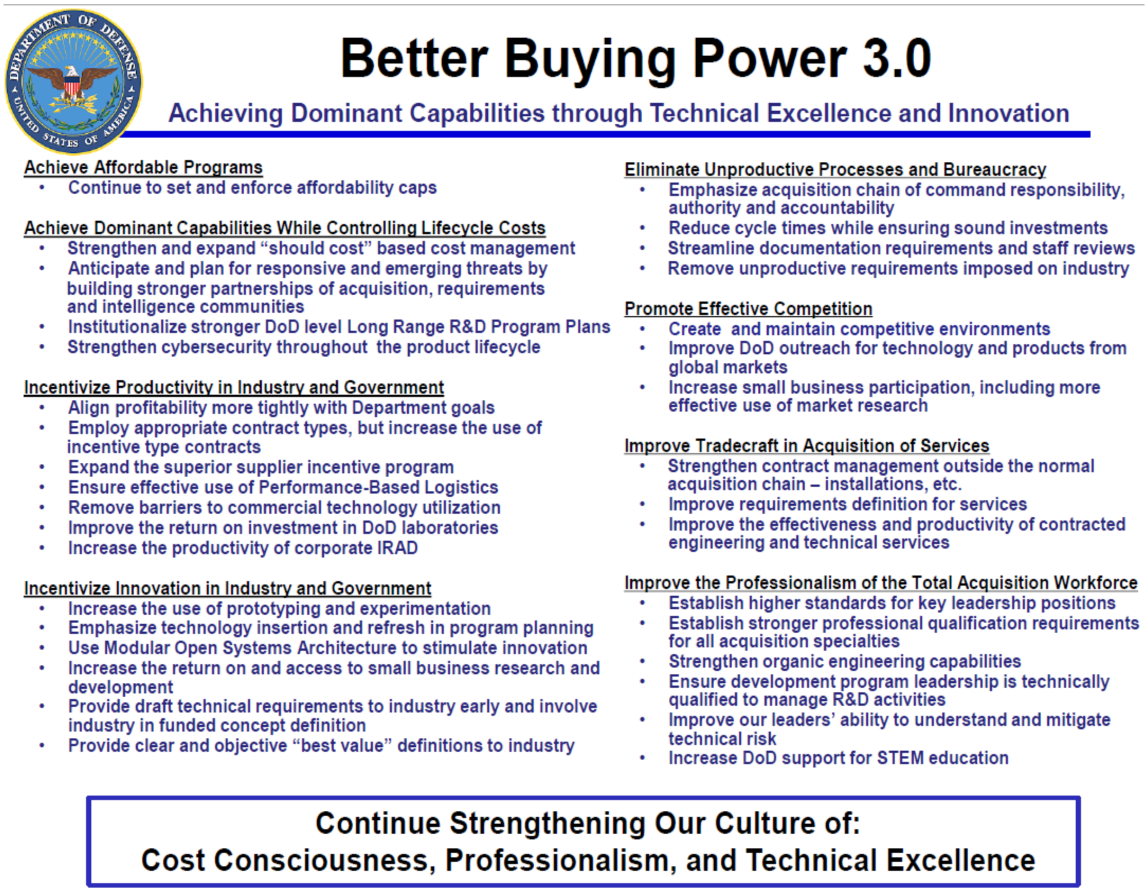
■ ***Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), Frank Kendall, Federal News Radio -- June 29, 2015***

3.4 Continuation of the Better Buying Power Initiative

The Better Buying Power (BBP) series of initiatives are based on the principle of continuous improvement to the performance of the defense acquisition enterprise. Then Under Secretary of Defense (AT&L) Ash Carter introduced BBP in 2010 to help DoD deliver necessary warfighting capabilities in the face of a declining defense budget. The focus of BBP 1.0 was on helping acquisition professionals think critically and make better decisions as they confront the myriad, complex situations encountered in defense acquisition. In 2013, USD(AT&L) Kendall introduced BBP 2.0, which utilized lessons learned from BBP 1.0 implementation and feedback from industry to focus on professionalism and providing better tools to help DoD acquisition officials make sound decisions. In September 2014, Kendall introduced BBP 3.0, which emphasized technical superiority and innovation while continuing to promote earlier efforts and continuous improvement. In April 2015, USD(AT&L) issued implementation guidance for BBP 3.0. The major thrusts of BBP 3.0 are outlined in Figure 1:[8]

[7] Additional information on DIUx is available at www.diux.mil (Accessed July 25, 2016).
[8] Better Buying Power, http://bbp.dau.mil/.

Figure 1: BBP 3.0 Initiatives

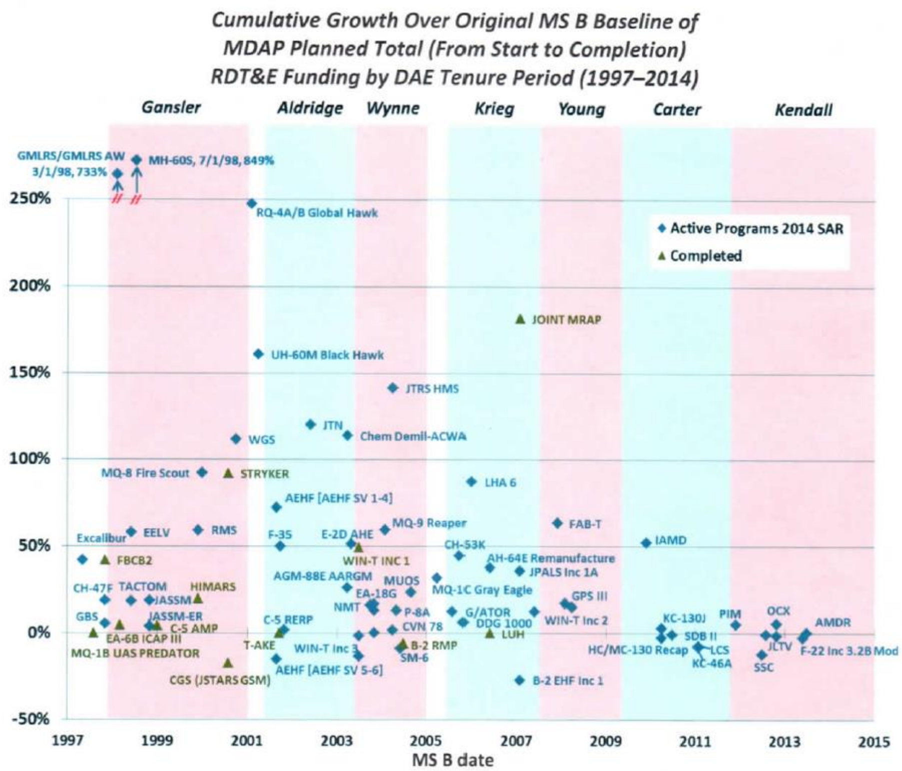


Taken together, the BBP initiatives continued DoD efforts to strengthen a culture of cost consciousness, professionalism, and technical excellence in defense acquisition.

Evidence of the impact of BBP on DoD acquisition enterprise is emerging, as documented in the third annual report on the "Performance of the Defense Acquisition System."[9] The performance report continues the effort to provide data and analysis so the Department can see how it is doing, measure the effectiveness of ongoing efforts to improve acquisition, and learn from past experience. Among the results that may be evidence of success of the BBP initiative, illustrated in Figure 2, is the fact that contractors on Major Defense Acquisition Program contracts are doing a better job of meeting cost targets, potentially spurred by the BBP "should cost" initiative, which requires DoD managers to actively seek ways to save money and to set targets for doing so. Another BBP initiative supported by the data is the increasing use of incentive-type contracts (both cost-plus-incentive-fee and fixed-price-incentive) that tie contractor financial results explicitly to cost performance and indirectly to schedule performance.

[9] The 2015 Performance of the Defense Acquisition System report is available at http://www.defense.gov/Portals/1/Documents/pubs/Performance-of-Defense-Acquisition-System-2015.pdf (Accessed April, 2016).

Figure 2: MDAP (RDT&E) Cost Growth, 1997-2014[10]



3.5 MIBP Authorities and Activities

The Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy (ODASD(MIBP)) within OUSD(AT&L) is the focal point for industrial base matters in the Department and led many DoD industrial base initiatives in 2015.

3.5.1 MIBP Authorities

Section 896 of the Ike Skelton NDAA for FY 2011 (P.L. 111-383) established the ODASD(MIBP). MIBP supports the Office of the Secretary of Defense and the Service Acquisition Executives (SAE) by: (1) providing detailed analyses and in-depth understanding of the increasingly global, commercial, and financially-complex industrial supply chain essential to our national defense; and (2) recommending or taking appropriate actions to maintain the health, integrity, and technical superiority of that supply chain. In addition to MIBP's core mission to broadly assess and address the health and resiliency of the DIB (title 10, U.S.C., sections 2501, 2503, 2505, and 2506), it oversees important program and policy functions, including:

- Title 50, U.S.C., DPA Title I, Defense Priorities and Allocations System (DPAS);

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[10] Ibid, p. 7.

- Title 50, U.S.C., DPA Title III program, Expanding Production Capability and Supply;
- Title 10, U.S.C., section 2521 Manufacturing Technology (ManTech) program;
- Title 50, U.S.C., DPA Title VII, Section 721, Committee on Foreign Investment in the United States (CFIUS);
- Title 15, U.S.C., section 18a, Hart–Scott–Rodino Antitrust Improvements Act of 1976; and
- Title 10, U.S.C., section 2372, Independent Research and Development (IR&D).

This extensive and diverse portfolio enables MIBP's holistic focus on defense manufacturing, domestic and foreign business transactions, and industrial base issues.

3.5.2 Expanded Efforts to Incorporate Industrial Base Impacts in DoD Budget Deliberations

The Department continues to seek new ways to ensure that funding to mitigate risks to the industrial base is available on a priority basis. Important 2015 initiatives and programs focused on the industrial base included:

- Industrial Base Deputy's Management Action Group (DMAG) meeting. DoD held an industrial base-focused session of the DMAG, the Department's highest decision-making body, in December 2015 to educate senior leadership on key industry trends and important strategic priorities. This was the third consecutive year that DoD held an industrial base DMAG. DoD leaders, for instance, discussed the potential development of tools to mitigate the risk of consolidation in the DIB. The Under Secretary of Defense (AT&L) stressed the importance of planned additional funding in two sector-specific issues: (1) funding for sub-tier capabilities in the space industrial base (SIB), provided through a Memorandum of Agreement among space sector stakeholders, and (2) funding to maintain uninterrupted trusted access to products in the microelectronics sector.

- The Industrial Base Analysis and Sustainment (IBAS) program. IBAS addresses critical capabilities shortfalls in the base, specifically capabilities that are at-risk of being lost and crossing Service/DoD agency boundaries. The goal of IBAS is not to sustain all capabilities indefinitely, but to avoid reconstitution costs when capabilities are likely to be needed in the foreseeable future. IBAS makes investments only when sustainment is more cost-effective than reconstitution and results in overall cost savings to the Department.

- DPA Title III. Title III aids manufacturers that specialize in materials used for defense applications. Production capabilities that would otherwise be inadequate are transformed to support the material requirements of defense programs in a timely and affordable manner. Title III focuses on materials and components that can be used in a broad spectrum of defense systems as opposed to individual weapons platforms. By statute, requests for Title

III funding are approved by the President, with the concurrence of key congressional committees.

- ManTech. The ManTech program serves as an important mechanism for technology transition, bringing affordable technologies to acquisition program managers through new manufacturing and production processes and systems. While ManTech is not structured to address the entirety of industrial base challenges, its operational perspective and deep understanding and insights into technology-based supply chain risks make it vital to sector, tier, and sub-tier vulnerability assessments. In general, ManTech, which includes separate Service offices, is a highly versatile R&D investment program that helps bring attention and technological resources to bear on the Department's most pressing requirements for affordable modernization and sustainment.

The Department continues to secure steady funding through these programs, which are discussed in greater detail in Section 7 of this report.

3.5.3 Presidential Commitment to Advanced Manufacturing

Throughout 2015, both the Administration and the Department's leadership gave high priority to advancing U.S. manufacturing capabilities. One example of this is MIBP's leadership in the establishment of Manufacturing Innovation Institutes (MIIs). Technological innovation and leadership in manufacturing are essential to enable our military to maintain technological advantage, but some fragmented and frail ecosystems are at risk due to infrastructure and workforce complexities. To advance the Department's goals, advanced manufacturing ecosystems must be built to meet common commercial and defense manufacturing challenges for shared risks and shared benefits. The MIIs serve as regional hubs to accelerate technological innovation into both defense and commercial applications and concurrently develop the educational competencies and production processes via a shared public-private partnership.

DoD launched two MIIs in 2015. In July, the Vice President announced the establishment of the American Institute for Manufacturing Integrated Photonics, AIM Photonics, headquartered in Rochester, New York, and funded with $110 million of DoD investment and over $500 million in cost share. In August, the Secretary of Defense announced the formation of the newest public private partnership, Nextflex, America's Flexible Hybrid Electronics Manufacturing Institute, headquartered in northern California, with total funding of $176 million. For 2016, DoD plans to award a cooperative agreement for Revolutionary Fibers and Textiles and is working to establish two additional Institutes within the next two years. Each of these institutes are part of the National Network for Manufacturing Innovation (NNMI), focused on successful scale-up of emerging, world-leading, advanced manufacturing capabilities, enabling

U.S. industry to maintain its edge in a hypercompetitive global environment and to meet vital economic and national security needs.[11]

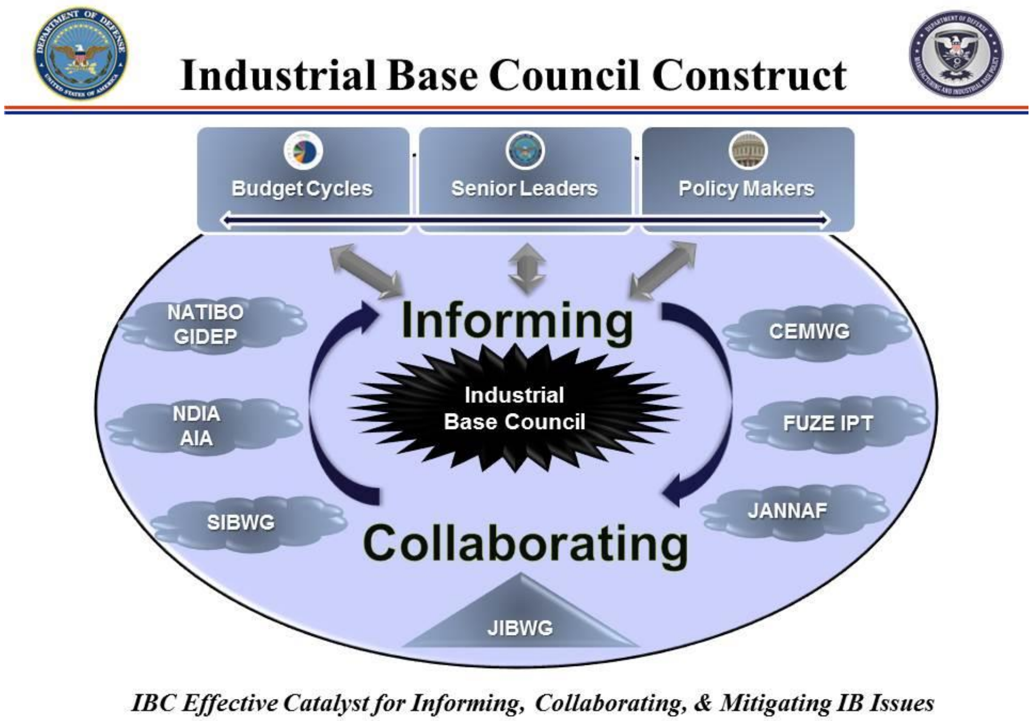
3.5.4 Developing a Proactive and Predictive Approach to the Industrial Base

MIBP is transforming DoD's approach to DIB challenges. MIBP is focusing efforts on improving our understanding of and interaction with the increasingly global, commercial, and financially complex industrial base essential to our national defense. Central to this initiative is the development of a business intelligence and analytics (BI&A) capability for the DIB. MIBP's intent with this effort is to deliver business intelligence and analytics products to decision makers to support robust, innovative, affordable, and technologically superior defense industrial capabilities today and in the future. Taking advantage of the use of "big data" principles, MIBP is leading efforts to provide more effective and timely analytics on global and domestic DIB trends and health. MIBP is making investments in this area and the objective is to develop and field an initial BI&A capability during 2016.

In addition to developing this BI&A capability, MIBP worked during 2015 to raise the visibility on DIB issues within DoD. While annual industrial base DMAG sessions have been held for three consecutive years, there has generally been limited regular visibility on industrial base issues at senior DoD levels. As a result, MIBP established the Industrial Base Council (IBC) with the objective of providing an executive level forum for senior DoD leaders to review and discuss key DIB trends and issues to: (1) inform and facilitate enterprise-wide program investment decisions; (2) develop policies, programs, and business incentives to mitigate industrial base vulnerabilities and attract innovative technology suppliers; and (3) seek ways to diversify investments to attract new and innovative technology suppliers. The IBC consists of three-star level representatives from the Military Departments, relevant agencies, and the Office of the Secretary of Defense (OSD) organizations focused on industrial base matters. The IBC met initially in December 2015 and is expected to meet periodically in 2016 and beyond. The IBC will discuss global market trends, foreign direct investments, industrial base vulnerabilities, and other issues of interest. The IBC fits within the eco-system of DoD industrial base collaboration as illustrated in Figure 3:

[11] Additional information on the NNMI is available at http://www.manufacturing.gov/nnmi/ (Accessed March 22, 2016).

Figure 3: The DoD Industrial Base Eco-System[12]



To improve outreach, MIBP is also playing a leading role in DoD efforts to increase effective communication between the Department and industry. USD(AT&L), for example, brought his senior AT&L leaders to meet with the CEOs of the Executive Committee (ExCom) of the Aerospace Industries Association (AIA) twice during 2015. These AIA-ExCom engagements were extremely well-received by industry and led to productive dialogue on important policy and regulatory issues. DoD also regularly met with the CEO and leadership teams of the major prime defense companies during the year to improve communication and increase transparency. The standup of DIUx, described in Section 3.3, and numerous other efforts during 2015 focused on building the Department's relationship with non-traditional companies to help grow the DIB.

3.5.5 Monitoring Industry Consolidations

Companies constantly adjust to market conditions and they function efficiently when allowed to operate in this manner. However, free markets can also allow for industry consolidations that can unduly restrict competition and cause market distortions that can weaken the health of the industrial base. The Department must intervene in the marketplace only when

[12] Working Groups part of the DoD industrial base eco-system include: the North American Technology and Industrial Base Organization (NATIBO); the Government-Industry Data Exchange Program (GIDEP); Trade associations such as the National Defense Industrial Association (NDIA) and the AIA; the Space Industrial Base Working Group (SIBWG); the Joint Industrial Base Working Group (JIBWG); the Joint Army Navy NASA Air Force (JANNAF); the Fuze Integrated Product Team (FUZE IPT); and the Critical Energetic Materials Working Group (CEMWG).

necessary to maintain access to critical capabilities that might otherwise disappear or when concentration provides disproportionate pricing power to the determent of taxpayers. On occasion, for example, this may require DoD to sustain supplier capacity to ensure continuity in design and development even if no new procurements in that sector are anticipated in the short term.

The last significant defense downturn resulted in more than 300 primes, platform providers, and sub-tier companies merging to form the five "mega-primes" of today—Boeing, Lockheed Martin, Northrop Grumman, Raytheon, and General Dynamics. Recent M&A involving mega-primes have highlighted the Department's limitations in addressing transactions that can lead to problematic industrial base issues such as:

- Disincentives for investment to ensure global technological leadership in areas affecting national security;
- Barriers that deter entry, or even continued participation, in critical industrial base sectors – limiting the variety, breadth, and diversity of innovation;
- Subjugation of an independent lower-tier supply base; and
- Leverage over the Department in contract negotiations and over competitors in adjacent-market dependent relationships.

To address these concerns, the Department worked during 2015 to propose a new framework to review industry consolidations that can threaten the DIB. The emphasis of all such efforts must be to preserve the open market while zeroing in on those consolidations that have real national security implications.

"The trend toward fewer and larger prime contractors has the potential to affect innovation, limit the supply base, pose entry barriers to small, medium and large businesses, and ultimately reduce competition — resulting in higher prices to be paid by the American taxpayer in order to support our war fighters."

■ ***Under Secretary of Defense for Acquisition,
Technology, and Logistics (AT&L), Frank Kendall,
September 30, 2015***

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4. DoD Approach to Industrial Base Assessments

4.1 Fragility and Criticality Assessment Methodology

MIBP continued the work it began in 2013 to refine a more technically rigorous methodology for identifying and mitigating weaknesses in the DIB. The methodology involves subject matter experts in a sustained process of identifying and assessing the most vulnerable sectors, with breakdowns by sector tier and sub-tier. The methodology, known as the Fragility and Criticality (FaC) assessment, is intended to serve as a model for other agencies.

"Fragility" and "criticality" are roughly analogous to the traditional risk factors of probability and consequence. Fragility characteristics are those that make a specific product or service likely to be disrupted. Criticality characteristics are those that make a product or service difficult to replace. MIBP's assessment model is based on four fragility factors and six criticality factors. Table 1 lists the 10 factors used in the current assessment model. The four fragility factors are the total number of firms engaged in manufacturing a product or service, their current DoD sales level and broad financial outlook, and their degree of foreign dependency. The six criticality factors are the skilled labor, design, and facility/equipment requirements needed to produce a military product or service, its "defense-uniqueness," the availability of alternative sources, and the time and cost required to replace it.

Table 1:

FaC Assessment Metrics

"FRAGILITY"	
• Financial Outlook (current provider)	• Firms in Sector (existing market)
• DoD Sales (current provider)	• Foreign Dependency (existing market)
"CRITICALITY"	
• Facility/Equipment Requirements	• Defense-Uniqueness
• Skilled Labor Requirements	• Reconstitution Time
• Defense Design Requirements	• Availability of Alternatives

4.2 Data Driven Assessments

MIBP has focused its resources on ensuring that when indications of potential industrial concerns arise they are identified, analyzed, and effectively integrated into key DoD budget, acquisition, and logistics processes. DoD-wide industrial assessments evaluate and address changes and issues in key system, subsystem, component, and/or material providers that supply many programs and affect competition, innovation, and product availability.

DoD Components conduct their own assessments when there is an indication that industrial or technological capabilities associated with an industrial sector, subsector, or commodity important to a single DoD Component could be lost or to provide industrial capabilities information to help make specific programmatic decisions. These assessments generally are conducted, reviewed, and acted upon internally within the DoD Components.

Industrial base issues highlight the need for the Department to continue to improve its requirements generation process, particularly for contingency operations, in order to provide better and timelier guidance to its industry partners. The Department must carefully balance the costs associated with maintaining excess production capacity for operationally-critical items in order to respond to a sudden accelerated production requirement, the unavoidable lead time necessary to fund and establish increased production capacities for those items, and the risk associated with having only a marginal peacetime production capacity on which to draw should sudden accelerated production become necessary. Whenever DoD identifies conditions where our requirements could potentially exceed the capabilities or capacities of our suppliers, studies are conducted to assess the ability of our suppliers to meet those requirements and identify appropriate actions that may be needed to ensure continued availability of the full range of supplies and services we need. Some examples of specific conditions which may result in the need to conduct industrial base studies include:

- Contingency requirements or operational lessons learned;
- Incremental changes or dislocations in the DIB;
- DoD’s annual budget development cycle;
- Studies required by Defense Authorization or Appropriation Acts and congressional letters citing specific industrial concerns; and
- Changes to DIB to support transformation of Warfighter capabilities.

5. Industrial Sector Assessments

The following sub-sections review the results of the main MIBP assessments conducted during 2015. Subsequent sections of this report review the results of additional assessments, including those conducted by MIBP in conjunction with other agencies.

5.1 Aircraft Sector Industrial Summary

Industry Overview

The aircraft sector is comprised of commercial and defense products. The defense aircraft industrial base is divided into three sub-sectors:

- ***Fixed Wing*** includes fighters, bombers, cargo, transportation, and any manned aircraft that uses a set of stationary wings to generate lift and fly. Large airframes and subsystems rely heavily on commercial technologies, processes, and products, and will be sustained by ongoing and planned military and commercial aerospace programs. However, defense-unique design and manufacturing skills are needed to meet the requirements of military weapon systems, produce next-generation aircraft, and maintain technological advantage.

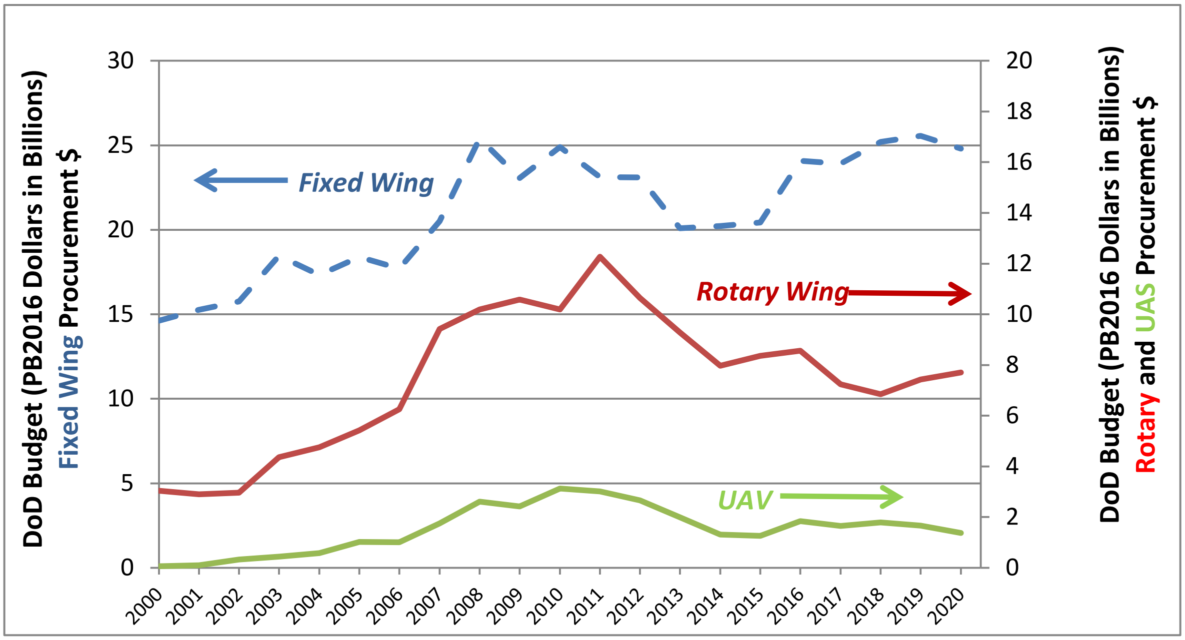
- ***Rotary Wing*** includes the helicopters used for a variety of military missions that fall into three main areas: combat, combat support, and services. Unlike commercial helicopters, DoD helicopters operate in harsh battlefield environments, which require robust, advanced capabilities and systems such as fire control, armor, weaponry, night vision, advanced avionics, stealth, speed, and power. As a result, unique design and engineering capabilities are needed to design, produce, and test DoD helicopter systems. These capabilities are not required for the commercial market.

- ***Unmanned Aircraft Systems/Vehicles (UAS/UAV)*** include the necessary components, equipment, network, and personnel to control an unmanned aircraft; in some cases, UAS also include a launching element. UAVs typically fall into one of six functional categories (although multi-role airframe platforms are becoming more prevalent): target and decoy, reconnaissance, combat, logistics, R&D, and civil/commercial. The growing demand for increasingly sophisticated and versatile unmanned systems reflects the Warfighter's need for intelligence, surveillance, and reconnaissance (ISR) support that can reduce the risk to combat forces and associated deployment costs.

Budget considerations

In 2015, the procurement funding for fixed wing aircraft continued to remain steady at $20 billion, down from its peak of $25 billion in 2008. Under current budget planning, funding is projected to return to $25 billion by 2018 and remain at that level until 2020. Funding for UAS reached $3 billion in 2010, but it declined sharply to $1.2 billion by 2015. The procurement investments in the UAS sub-sector will stay stable, with an average of $1.7 billion per year from 2016 to 2020. Funding for rotary wing aircraft peaked in 2011 at $12.3 billion and declined to $8.4 billion in 2015. While funding for rotary wing is scheduled to increase in 2016, a sharp decline is expected by 2018. However, rotary wing projections for 2019 and 2020 indicate a slight increase in procurement funding.

Figure 5.1.1: Aircraft Procurement Funding Profile



Source: Defense Research Data Warehouse

Near-term DoD procurements forecasted for the FY 2016 DoD budget are listed in Figure 5.1.2. The Air Force is developing a trainer under the (T-X) program, which will replace its aging fleet of T-38 training aircraft with an advanced jet to train pilots flying-fifth generation fighter aircraft. The Navy is introducing a new UAS system, known as the Carrier-Based Air Refueling System (CBARS). The Navy is continuing to work on the requirements for this system.

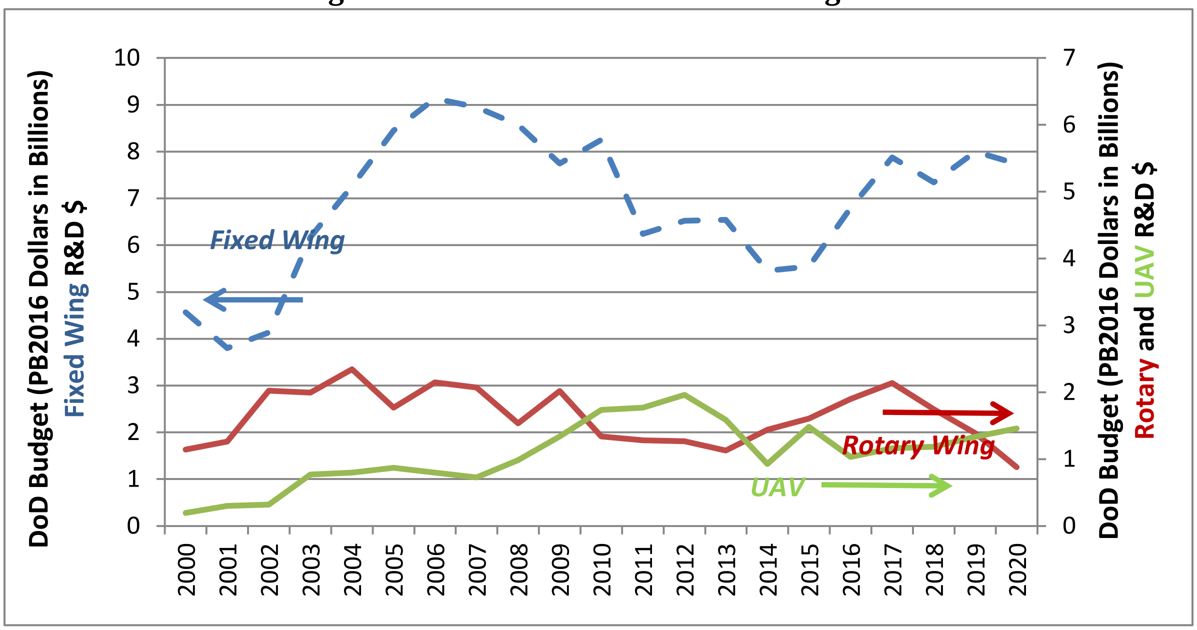
The Army is developing a new Future Vertical Lift (FVL) rotary wing capability. The concept incorporates new technology, materials, and designs that are quicker, have further range, provide better payload, are more reliable and easier to maintain and operate, have lower operating costs, and can reduce logistical footprints. The objective is to develop four different sizes of aircraft that will share common hardware such as sensors, avionics, engines, and countermeasures. FVL is meant to develop replacements for the Army's UH-60 Black Hawk, AH-64 Apache, CH-47 Chinook, and OH-58 Kiowa helicopters. The precursor for FVL is the Joint Multi-Role (JMR) demonstrator, which will provide technology demonstrations planned for 2017.

Table 5.1.2: Future Aircraft programs (FY 2015)

Program	***Type***	***Lead Service***	***Award Year***
Trainer (T-X)	Fixed Wing	Air Force	2017
CBARS	UAS	Navy	2018
FVL	Rotary Wing	Army	2022

In 2015, there was a 10 percent increase in Research, Development, Test and Evaluation (RDT&E) funding for the aircraft sector compared to the previous year, as depicted in Figure 5.1.3. Projections indicate that investment in fixed wing and UAS sub-sectors will remain stable for the next five years while investment in RDT&E for rotary wing will decrease by 2019.

Figure 5.1.3: Aircraft RDT&E Funding Profile



Source: Defense Research Data Warehouse

Industry Suppliers

Six companies provide the majority of aircraft platforms and possess the full range of capabilities to bring a new weapon system from the research, design, and development phases into full production. The six firms are among the largest U.S. defense contractors, including Boeing, Lockheed Martin (including Sikorsky), Northrop Grumman, Bell Helicopter, Airbus Helicopter, and General Atomics. On November 6, 2015, Lockheed Martin Corporation acquired Sikorsky Aircraft, a world leader in military and commercial rotary-wing aircraft. Aligned under the Lockheed Martin Mission Systems and Training business segment, Sikorsky Aircraft is now known as Sikorsky, a Lockheed Martin company. The acquisition expanded Lockheed Martin's core business into the growing areas of helicopter production and sustainment. The systems produced by each company are listed in Table 5.1.4.

Table 5.1.4: Prime Contractors for Major Aircraft Acquisition Programs (includes previous major programs that are not currently in production)

Aircraft Sector Prime Contractors	Fixed Wing	Rotary Wing	UAS
Boeing	A-10, B-52, B-1, F-15, EA-18G Growler, F/A 18-E-F Super Hornet, C-40A, F/A-18-A-D Hornet, KC-46A, KC-135, P-8A Poseidon	CH-47F Chinook, V-22 Osprey Fuselage, AH-64D Apache New & Remanufacture	Blackjack
Lockheed Martin	F-35, F-22, F-16	MH-60 assembly Sikorsky's lines of products: UH-60 Blackhawk, MH-60S, VH-92A Presidential, CH-53K	Dark Star/Sentinel UAS
Northrop Grumman	EA-6 Prowler, T-38, B-2, B-21[13]	N/A	RQ-4 Global Hawk, MQ-4C Triton, MQ-8B, Fire Scout
Bell Helicopter	N/A	AH-1 W/Z Viper, UH-1Y Venom, Huey, V-22 Osprey	N/A
Airbus Helicopter	N/A	Light Utility Helicopter	N/A
General Atomics	N/A	N/A	MQ-1C Gray Eagle, MQ-1 Predator, and MQ-9 Reaper
Beechcraft	T-6 Texan II	N/A	N/A
Eurocopter	N/A	UH-72A	N/A

[13] Northrop Grumman won the contract award for the B-21 in October 2015. This program is one of the top priorities for the Air Force and the largest military aircraft contract since the Joint Strike Fighter program was awarded.

Risk Assessment

The Department is focusing on defense-unique aerospace capabilities that could be at risk and that are not sustained by the commercial market. Our main concern is the industry's ability to sustain the design and manufacturing skills and capabilities needed for future aircraft design and manufacture.

Long-Term Challenges

- There has been a steady decline in the number of defense development programs for fixed-wing and rotary wing aircraft. Modernization programs will help sustain important capabilities but will not provide opportunities for major design, development and integration work. With the approaching end of development programs and an absence of new requirements in the next five to seven years, critical design capabilities are facing shortages.

- Design shortfalls are also projected because much of the defense aerospace workforce is close to retirement and the pool of young engineers available to replace them is dwindling. Opportunities for hands-on, real-time transfer of knowledge have been very limited. Therefore, future technical challenges are likely to be tackled by engineers with significantly less experience than the generation before. The consequences may include longer and more expensive development and initial production costs.

Recent Mitigation Efforts

- The Aerospace Innovation Initiative will provide the opportunity to build aircraft prototypes to cover the design gap between the F-35 program and the next generation of fighters. Prototyping design and manufacturing will also provide the hands-on experience that new engineers in the aerospace field need.

- R&D investments in technology programs to satisfy future requirements will also allow the DoD to sustain design teams, maintain competition in critical areas, and promote industry innovation. For example, the Adaptive Engine Transition Program is allowing Pratt & Whitney and General Electric to work on the development of a new engine that will increase fuel efficiency and power. The Air Force is expected to award a contract in FY 2016 to both companies to build and test their engines models.

- DoD is also working on platform requirements for the next-generation rotary wing systems through the FVL program and JMR technology demonstrators. It is expected that these efforts will help maintain the rotary wing critical engineering design and manufacturing skill sets productive and operational.

5.2 Electronics Sector Industrial Summary

Industry Overview

The modern electronics industry can be traced to the development of the transistor by scientists at AT&T's Bell Labs in 1947. This was followed in 1958 with the invention of the integrated circuit (IC) by scientists at Texas Instruments. Much of the early development of the electronics industry was funded by the Department. Today, the electronics industry is a two-trillion dollar-plus industry that manufactures products for a wide variety of end user markets, including consumer electronics, computers, automotive, industrial equipment, medical equipment, telecommunications, and aerospace/defense. Although electronic systems and components are ubiquitous throughout all DoD weapons systems, global military production represents only 8.5 percent of a market that is dominated today by commercial devices.[14]

Suppliers in the electronics supply chain can be broadly categorized as follows:

- Original Equipment Manufacturers (OEMs).
- Contract Manufacturers - Electronic Manufacturing Services (EMS) and Original Design Manufacturers (ODM).
- Printed Circuit Board (PCB) manufacturers.
- Semiconductor (IC) Manufacturers.

OEMs: OEMs constitute the highest level of the industry. These are the companies that develop final commercial products, such as mobile phones and computers, and then market and sell them to consumers. In the 1980s, U.S. OEMs began moving assembly of their products to countries with cheaper labor rates, primarily to Asia. In the 1990s, this trend continued with outsourcing of manufacturing to multinational contract manufacturers. Today, this has left most OEMs with responsibility for overall product creation, design, and marketing. It should be noted that outsourcing applies primarily to commercial products; defense contractors have more restrictions on where systems may be manufactured.

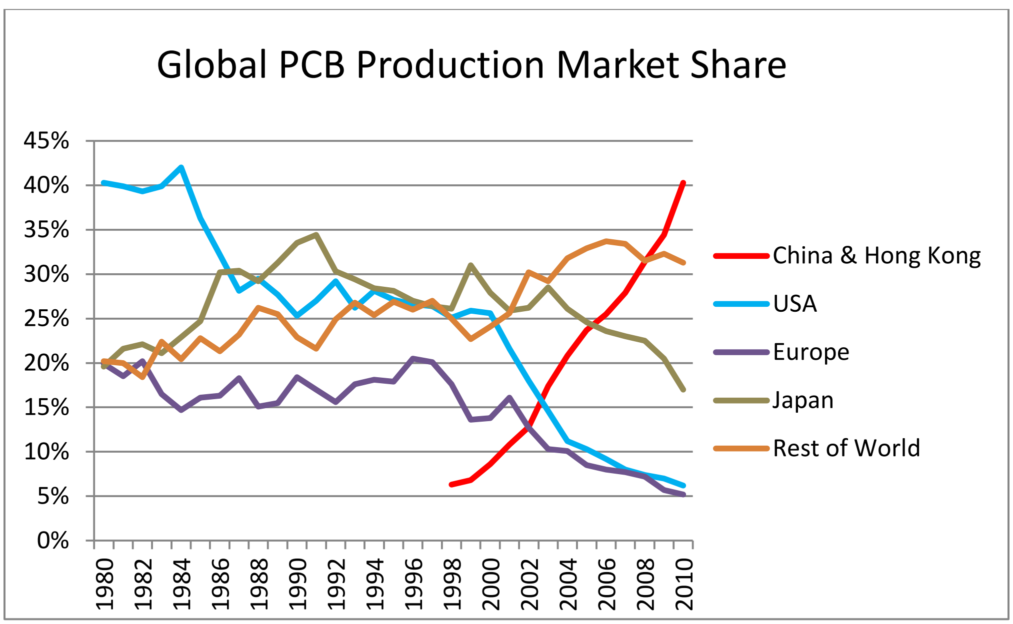
Contract Manufacturers: Contract Manufacturers test, manufacture, distribute, and/or assemble products on contract typically for a number of different OEMs that brand the products and sell them to end customers. Contract Manufacturers that perform design work are called ODMs. Those without design capabilities are referred to as EMS companies. Today, many U.S. OEMs buy their products from ODMs and brand them as their own.

[14] World Electronic Equipment Production by Type @ 2014 Exchange Rates, Electronic Outlook, September 2015.

Combined revenues for EMS and ODM companies total over $400 billion, of which over 70 percent goes to Asian companies.[15] By revenue, Taiwanese companies dominate with seven of the top ten EMS/ODM companies, for a combined market share of 66 percent.[16] Hon Hai Precision Industries (Foxconn) alone has a 34 percent market share, with major U.S. customers including Apple Inc., Dell, and HP.[17] Foxconn is headquartered in Taiwan but operates heavily in mainland China. The sole U.S. company in the top 10 is Jabil Circuit Inc., a multinational corporation headquartered in the United States. Other smaller U.S. companies in the EMS/ODM space include Sanmina-SCI Corp, Benchmark, and Plexus Corp.

PCB Manufacturers: PCBs provide the substrate and interconnects for the various ICs and components that make up an electronic system. Like the overall electronics market, the global PCB market has experienced explosive growth—from $30 billion in FY 2000 to $60 billion in 2013.[18] Growth occurred primarily in Asia while the North American industrial base declined and outsourced to contract manufacturers located primarily in Asia, especially China. During this same period, U.S. production decreased 70 percent from $10 billion to $3 billion.[19] The dramatic rise in China's market share can be seen in Figure 5.2.1.

Figure 5.2.1.: Trends in Global PCB Production Market Share



IPC World PCB Production Report, 2010

[15] Data retrieved from Bloomberg, International Data Corporation.
[16] Ibid.
[17] China Daily, "US labor group offers helping hand to Foxconn workers", July 22, 2010.
[18] World Electronic Circuits Council (WECC), "WECC Global PCB Production Report for 2014", WECC, October 2015.
[19] Ibid.

Today, 90 percent of worldwide PCB production is in Asia, with only 5 percent in the United States. The number of domestic PCB manufacturers has shrunk from more than 2,000 in the 1980s to 265 in 2015.[20] This consolidation trend continued in 2015 with the loss of 15 more manufacturers, including the finalization of the merger of the two largest domestic PCB manufacturers, TTM Technologies and Viasystems Group Inc. As a result, DoD is becoming increasingly dependent on foreign-sourced PCB products to meet critical military requirements, and with the loss of market share, U.S. suppliers have become increasingly reliant on the U.S. military to survive. The Aerospace/Defense segment represents 27 percent of the domestic PCB market.[21]

Semiconductor Manufacturers: ICs are the lowest level of the modern electronics supply chain. However, they are also the most critical and technologically advanced, as they are the "brains" of any electronic system.

Despite the growth of the electronics industry in Asia, the United States maintains its leadership in semiconductors.[22] In 2015, sales of U.S. semiconductor companies represented 50 percent of the global market. Worldwide semiconductor sales have experienced steady growth over the past two decades, rising over 200 percent from $101.9 billion in 1994 to $335.2 billion in 2015. During the same period, U.S. sales increased almost 300 percent from $44.2 billion to $166 billion, despite a 4 percent drop from 2014. In 2015, semiconductors were the U.S.'s third largest export by value (>$40 billion) after aircraft and automobiles. It is estimated that the U.S. semiconductor industry accounts for 250,000 direct U.S. jobs and indirectly supports over 1 million.

Because much of electronics production is now in Asia, Asia is by far the largest customer of U.S semiconductor companies, accounting for 62 percent of all U.S. sales. Sales to China alone account for half of these. U.S. companies continue to dominate the Chinese market with 56 percent market share. Japan has traditionally been a weak area for U.S. companies (36 percent market share) while the United States holds 42 percent and 50 percent market share in the Americas and the remainder of Asia, respectively. Since 2001, most growth in the global semiconductor market has been driven by sales to the Asia Pacific market outside of Japan, which has quintupled in size from $39.8B to over $200B in 2015, including a $98.6B market in China alone (~8 percent increase over 2014).

Global semiconductor sales are driven by consumer products such as cell phones, computers, and automobiles. Staying competitive requires a significant investment in R&D and new plants and equipment. The U.S. semiconductor industry spends roughly 30 percent of its

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[20] H. Miller, "FabFile Online," [Online]. Available: http://www.fabfileonline.com.
[21] World Electronic Circuits Council (WECC), "WECC Global PCB Production Report for 2014", WECC, October 2015.
[22] Semiconductor market data is from the Semiconductor Industry Association (SIA), "2016 Industry Factbook."

sales on R&D and capital expenditures annually. Its annual R&D expense as a percent of sales is more than any other U.S. industry.

The semiconductor industrial base can be segmented into several different types of suppliers: 1) Semiconductor Manufacturing Equipment (SME) vendors that provide equipment to foundries, 2) Electronic Design Automation (EDA) vendors that provide the software tools for design, 3) "Foundries" that fabricate the ICs, and 4) IC vendors who sell the final chip. Some IC vendors such as Intel are vertically integrated and also design and manufacture the chip while others are "fabless" and outsource manufacturing to a foundry.

- SME vendors: The U.S. position for SMEs is strong, with three of the top six vendors (Applied Materials, Lam Research, and KLA Tencor) based in the United States. It should be noted, however, that the world leader in lithography is ASML, which is based in the Netherlands. Lithography defines the device functionality and is a critical step for ICs.[23]

- EDA: Modern IC design is performed using EDA software tools. EDA touches every part of an IC and requires protection from threats of sabotage and malicious functionality. Therefore, it is critical that the United States maintains a strong domestic EDA industrial base. Currently, the United States dominates in EDA, with the three leading vendors (Mentor Graphics, Cadence Design Systems, and Synopsys) holding over 70 percent of the market.[24]

- Foundries (contract manufacturers): Leading-edge foundries are now either based outside the United States (primarily in Asia) or are foreign owned. Global leaders in this area are TSMC and UMC based in Taiwan, Samsung based in Korea, and Global Foundries, which is headquartered in Abu Dhabi but has manufacturing facilities in the United States, Europe, and Asia. TSMC (54 percent) and UMC (10 percent) combined had 64 percent of world foundry market share in 2014, with Global Foundries (nine percent) and Samsung (five percent) a distant third and fourth, respectively.[25]

- IC vendors: IC vendors supply a wide variety of final chips, including memories, processors, sensors, and programmable devices such as Field Programmable Gate Arrays. The United States and its allies dominate the world IC market. Eleven of the top 20 companies are U.S. owned. The remaining nine are from South Korea, Japan, Taiwan, Japan, or Europe. Intel Corporation is the worldwide leader with 14 percent market share with Samsung (Korea) close behind at 11 percent market share. Qualcomm and Micron Technology are a distant third and fourth, with six percent and five percent market shares, respectively.[26]

[23] Review of major semiconductor equipment vendors, MarketResearchReports.biz, 2016.
[24] 2011 Complete Market Trends: Executive Summary: EDA Grows Again, Gary Smith, garysmitheda.com, 2011.
[25] Major 2013 IC Foundries, IC insights, 2014.
[26] IHS Supply Semiconductor preliminary rankings for 2014.

DIB Considerations

Weapons systems do not represent a significant share of the electronics market; therefore, changes in defense budgets do not have a large impact on the industry as a whole. However, specific segments of the supply chain and specific suppliers, such as domestic PCB suppliers in particular will be impacted as military and aerospace applications make up over a quarter of the market for domestic PCBs. Since 2008, PCB demand in the defense segment has declined and can no longer support as many domestic manufacturers. This has resulted in industry consolidation and a reduction in the number of PCB suppliers.[27]

Although military electronics are not a large segment of the electronics market, the Department does spend significant amounts of money on R&D in this area. DoD R&D funding has been increasing approximately eight percent per year since 2000, as our systems have become more and more reliant on electronics. However, in 2015 DoD R&D funding for microelectronics dropped by 50 percent. Such a large reduction in spending may have an adverse impact on DoD's ability to influence this research-driven industry.

In July 2015, Global Foundries (GF) finalized its acquisition of IBM's semiconductor manufacturing business unit. GF is a multinational semiconductor foundry whose majority shareholder is an Abu Dhabi government-controlled investment fund. IBM was the single source provider of leading edge "trusted" ASIC (Application Specific Integrated Circuits) foundry services to U.S. government suppliers. DoD will continue to have access to these services because GF retains trusted supplier status at its Burlington, VT and East Fishkill, NY locations. In addition, DoD has developed a long-term strategy to expand access to trusted microelectronics.

Long-Term Challenges

The Department currently faces three long-term challenges in the electronics industry: (1) globalization, (2) the rise of China, and (3) commercialization. Although different, all three of these challenges are interrelated and could impact the Department's ability to domestically produce weapons systems: denial of access to technology, loss of market influence, increased costs, and untrustworthy supply chains. These challenges have been building for quite some time and will continue to grow for the foreseeable future.

Globalization: As noted earlier, much of the electronics industry manufacturing has been outsourced to Asia. This outsourcing has progressed steadily from assembly to manufacturing and design. Today, we have ODMs that produce the entire product while U.S. companies' only value added is marketing. A 2014 McKinsey & Company report estimated that

[27] World Electronic Circuits Council (WECC), "WECC Global PCB Production Report for 2014", WECC, October 2015.

"more than 50 percent of personal computers and between 30 and 40 percent of embedded systems contain content designed in China."[28]

As the overall electronics industry has moved to Asia, so too has the PCB industry. In 2014, Asia had a 90 percent market share in this area, half of which is in China, while the United States only represents five percent of the market. The small U.S. market share has resulted in the inability of domestic manufacturers to invest in R&D at the levels required to stay competitive with Asia. This is especially true in areas related to miniaturization and operating speed/frequency, such as microvias[29] and optoelectronic interconnections, respectively. At the same time, the Government's PCB production capacities continue to shrink, limiting the Department's ability to sustain systems and acquisition engineering expertise.

China: In 2015, China became the largest consumer of semiconductors in the world. It is also the United States' largest semiconductor customer, accounting for a third of all U.S. sales.[30] China has long recognized its dependence on imported semiconductors and has tried unsuccessfully several times in the past to develop an indigenous semiconductor manufacturing capability. In June 2014, China released a new policy to increase semiconductor production by at least 20 percent per year and by 2030 be a global leader in all parts of the semiconductor supply chain, with several companies in the ranks of globally leading semiconductor companies. The new policy takes a market-based approach by establishing a national industry investment fund to increase industrial capacity and to consolidate the market with the aim of creating a viable domestic industry. The details of their plan became clearer in 2015: the fund was started with an initial investment of $20 billion and plans to invest $100 billion over the coming decade.[31] If China is to meet its very aggressive growth targets, it will most likely have to do this through foreign acquisitions rather than internal domestic development.

In line with its announced plan, 2015 saw a significant expansion of China's global merger and acquisition efforts in the semiconductor industry.[32] In 2015, China completed the acquisition of four U.S. semiconductor firms worth $2.6 billion while publicly pursuing several additional U.S. acquisitions. Most notably, the state-directed Tsinghua Uni-group reportedly tendered a $23 billion bid to acquire leading memory-chip maker Micron Technology.[33] The companies were unable to come to terms, and the deal appears to be dormant. Following this, Tsinghua offered $3.78 billion for 15 percent of disk-drive maker Western Digital while announcing the creation of a Chinese based joint venture to sell Western Digital products inside

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[28] "Semiconductors in China: Brave new world or same old story?", McKinsey on Semiconductors, Number 4, Autumn 2014.

[29] Microvias are minute holes drilled by a laser to generate the electrical connection between the layers in a multilayer circuit board.

[30] SIA 2016 Factbook.

[31] "SEMI, Industry Luminaries Outline China's Semiconductor Growth Prospects", 7 April 2015. http://prod.semi.org/en/node/55536.

[32] "China Push Is Part Of Merger 'Mania' Reshaping Global Semiconductor Industry" Aug 2, 2015 Forbes.com.

[33] "State-Owned Chinese Chip Maker Tsinghua Unigroup Makes $23 Billion Bid for Micron", Eva Dou, Wall Street Journal, July 14, 2015.

China.[34] These completed and proposed acquisitions include a broad cross-section of U.S. industry, including fabless chip and memory designers, packaging and testing, and semiconductor equipment manufacturers.

Concurrently, Chinese firms spent $2 billion acquiring South Korean, Swedish, and Dutch semiconductor businesses. Chinese offers are often highly attractive; in the past five years, Bloomberg identified an average premium of 60 percent to enterprise value for Chinese semiconductor takeovers, compared with an average of 18 percent for other acquirers globally.[35] These deals offer China a rapid route to acquire technology, know-how, and personnel to strengthen China's domestic semiconductor design and manufacturing capabilities. For 2016, the Department believes that the number and size of these acquisitions, mergers, and joint ventures, both in the United States and globally, will continue to grow. Chinese firms will have ready access to capital to support such acquisitions while U.S. firms are under increasing pressure due to the industry's conditions, which are marked by severe cyclical demand, rising costs in R&D and capital investments, and robust competition from new overseas entrants. These tough industry conditions are clearly evident in the fact that IBM had to pay Global Foundries $1.5 billion to acquire IBM's foundry after many years of losing money.[36]

It should be noted that because China is the world's largest consumer of semiconductors, it does not need to acquire a large amount of market share to succeed in building a domestic semiconductor industry. It only needs to create a company with the capacity and capability to service the Chinese market and position it as the national semiconductor champion. It can then divert Chinese semiconductor consumption to this company, thereby substantially reducing sales to its foreign competitors. In 2015, the Chinese announced this as their goal. In "China Manufacturing 2025," the Chinese State Council called for 40 percent of Chinese semiconductor consumption to be produced domestically by 2020 and 70 percent by 2025.[37] If this were to happen, it would be a major blow to U.S. industry. China has employed these tactics in many other industries with great success, most notably in solar panels, Light Emitting Diode (LED) displays, and telecommunications.

Commercialization: The semiconductor industry is driven by the commercial sector, in particular consumers. The Department represents less than one percent of global demand for semiconductors. Therefore, the Department has very little influence on the semiconductor industry and, as a consequence, there is often a large gap between military requirements and industrial capabilities. This is a major cost driver in acquiring and maintaining military electronics. The two most notable gaps are in volume and life cycle time. Commercial volumes

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[34] China's Tsinghua Buys Western Digital Stake for $3.8 Billion", Tim Culpan, Bloomberg, Sept. 30, 2015.
[35] Bloomberg, China's Memory Hole, 6 January 2016, http://www.bloomberg.com/gadfly/articles/2016-01-06/fairchild-would-still-leave-china-with-a-memory-hole.
[36] IBM to Pay Globalfoundries $1.5 Billion to Take Chip Unit", Alex Barinka and Ian King, Bloomberg Technology, October 19, 2014.
[37] "China Manufacturing 2025", China State Council, United States Information Technology Office Unofficial Translation, May 2015.

are typically several orders of magnitude larger than military volumes. Similarly, commercial technology life cycles are typically measured in months while military technology life cycles are typically measured in years, if not decades. Today, electronic components are often obsolete in the development stage of a program. This becomes a big cost driver in programs in addition to posing a major threat from counterfeit electronic parts.

Mitigation Efforts

The Department has a comprehensive policy for managing risks to DoD warfighting capability from foreign intelligence collection; hardware, software, and cyber vulnerability; and supply chain exploitation. The Department requires its acquisition programs to produce and maintain robust program protection planning throughout the acquisition life cycle. The Program Protection Plan is the primary means by which the Department integrates assured microelectronics policy into program management, engineering, and the configuration, parts, and contract management disciplines. In 2014, the Department established a joint federated assurance center, federating expertise, tools, and methods to support acquisition program hardware and software assurance needs.

Program protection planning gives special attention to ASICs. For ASICs that are custom designed, manufactured, or tailored for specific DoD military use, DoD requires they be procured from a trusted supplier accredited by the Defense Microelectronics Activity (DMEA). DMEA manages the DoD Trusted Foundry Program. This program provides the Department, as well as the National Security Agency (NSA) and other agencies, with access to the trusted state-of-the-art microelectronics design and manufacturing capabilities necessary to meet the confidentiality, integrity, availability, performance, and delivery needs of U.S. Government customers. DMEA accredits suppliers as "trusted" in the areas of IC design, aggregation, brokerage, mask manufacturing, foundry, post processing, packaging/assembly, and test services. These services cover a broad range of technologies and are intended to support both new and legacy applications, both classified and unclassified. DMEA is also working with DoD's PCB Executive Agent (EA) to develop trust accreditation methodologies for PCB manufacturer, board design, and electronic assembly as a part of the trust accreditation portfolio. There are currently 72 DMEA-accredited suppliers covering 153 services, including 22 suppliers that can provide full-service trusted foundry capabilities.[38]

The Department actively monitors transactions in the electronics sector, particularly foreign acquisition of U.S. electronics suppliers. The Department conducts in-depth and comprehensive reviews of these foreign transactions through the Treasury-chaired CFIUS. When appropriate, DoD works with the Committee to mitigate any concerns.

[38] DMEA Trusted Foundry Program, http://www.dmea.osd.mil/trustedic.html.

DoD has designated the Secretary of the Navy as the EA for PCBs and Interconnect Technology (PCB EA). The PCB EA provides solutions to ensure DoD has access to a trusted PCB industrial base by investing at Naval Surface Warfare Center (NSWC) Crane Division and other DoD activities to sustain DoD organic knowledge and capability of PCBs and related issues. Several efforts currently underway include an industrial base assessment with a technology roadmap and supply chain risk awareness, development of a PCB manufacturer accreditation methodology for inclusion within the DMEA Trusted Supplier portfolio, and the initiation of a study to quantify the impacts of counterfeit electronic component parts on fielded DoD systems. These efforts will help to provide DoD access to a viable PCB industrial base, ensuring superiority and readiness.

5.2.1 Command, Control, Communications, and Computers (C4) Sector Summary

<u>Industry Overview</u>

A diverse set of vendors are qualified to design and build defense products within the C4 industrial sector, as shown in table 5.2.1.1 below. A robust global commercial electronics industrial base supports these vendors. Second-tier suppliers of assembled components tend to serve both commercial and defense customers. Third-tier suppliers of individual components, such as integrated circuits, frequently supply identical products for both commercial and defense use. At the fourth-tier, such as design tools and reused intellectual property, there is frequently minimal awareness of the final end use in defense products. In essence, the C4 industrial base upon which the Department relies is largely global below the prime contractor tier.

DoD's C4 capabilities are frequently incorporated as subcontracts under a platform prime contractor, though at times C4 capabilities are acquired directly by the Department as stand-alone projects.

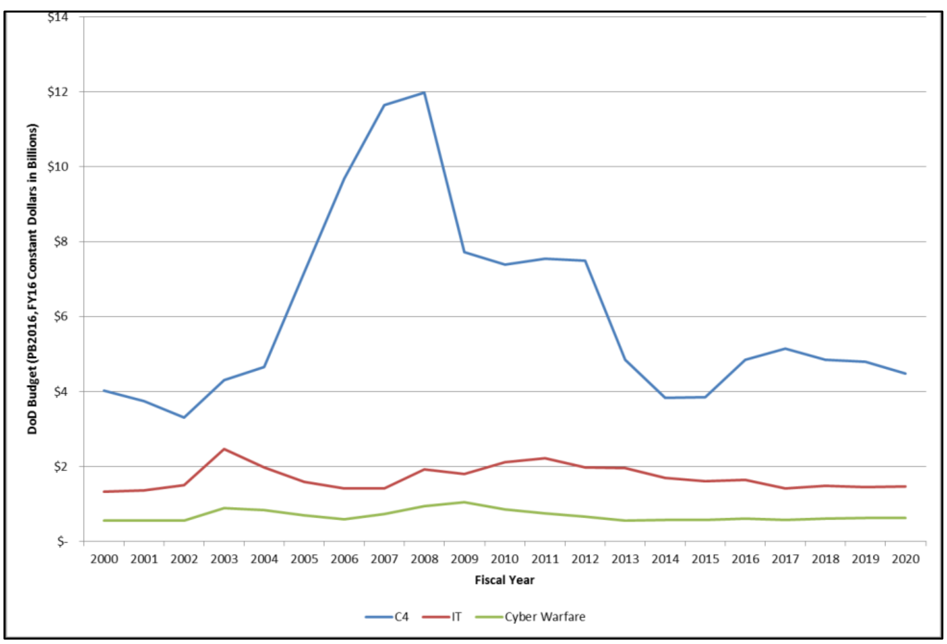
Table 5.2.1.1 Prime Contractors for Major C4 programs

C4 Stand-Alone Programs	C4 Prime Contractors
Airborne & Maritime/Fixed Station (AMF)	Harris/Viasat
Cooperative Engagement Capability (CEC)	Raytheon
Integrated Air & Missile Defense (IAMD)	Northrop-Grumman
Joint Precision Approach and Landing System (JPALS)	Raytheon
AMF Handheld, Manpack, and Small Form Fit (HMS) Radios	Thales/General Dynamics
Multi-Functional Information Distribution System (MIDS)	Rockwell Collins / BAE
Navy Multiband Terminal	Raytheon
Warfighter Information Network – Tactical (WIN-T) Increment 2	General Dynamics
WIN-T Increment 3	General Dynamics

Budget Considerations

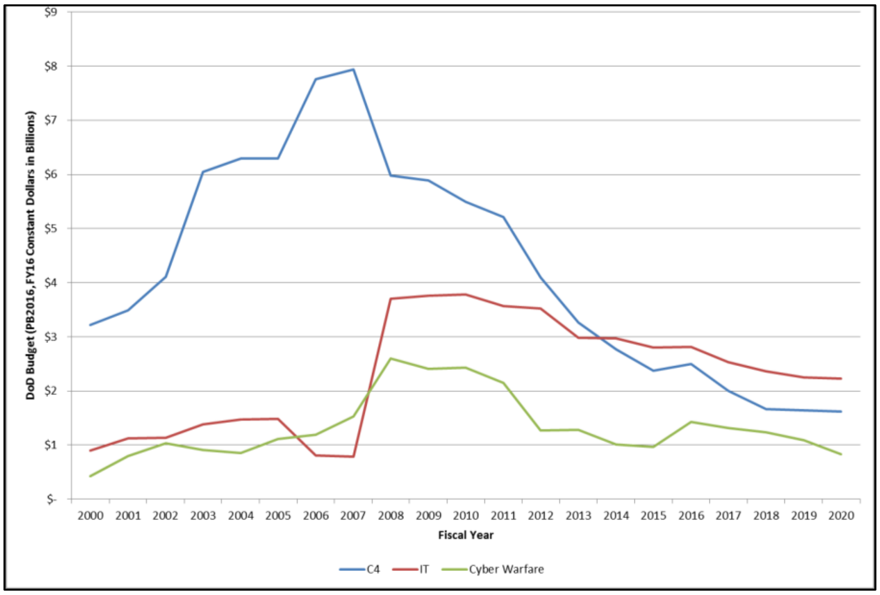
As shown in Figure 5.2.1.2 below, the procurement budget for the C4 sector is scheduled to remain relatively flat. This is due to ongoing support for the above-mentioned Major C4 programs. Figure 5.2.1.3 shows a long term decline in the C4 sector's RDT&E funding. Because of the depth and breadth of the industry as well as the support of the commercial C4 industry, DoD does not have major concerns for the sector related to the downturn.

Figure 5.2.1.2: C4 Procurement Funding Profile



Source: Defense Research Data Warehouse

Figure 5.2.1.3: C4 RDT&E Funding Profile



Source: Defense Research Data Warehouse

<u>Mitigation</u>

The DoD Title III program had two C4-related projects in 2015:

1. Low Cost Military Global Positioning System (GPS) Receivers Project. Military GPS receivers are vital equipment on the battlefield as they enable Warfighters to perform strategic and tactical maneuvers with a high degree of confidence and success. The project will be completed in early 2016.

2. Three Dimensional (3D) Microelectronics for Information Protection Project. Many of the DoD's most sophisticated weapon systems and communications systems, by their very nature, are operated in close proximity to enemy combatants. This project solicited proposals late in 2015 and anticipates an early 2016 start date.

5.2.2 Radar and Electronic Warfare Sector Industrial Summary

<u>Industry overview</u>

Military radar and electronic warfare (EW) systems continue to be upgraded or replaced with Active Electronically Scanned Arrays (AESAs). Industry has been expanding capacity in areas where processes and facilities are specific to AESA. Two types of facilities have been identified as essential to AESA manufacturing: Semiconductor/Captive Monolithic Microwave Integrated Circuit (MMIC) Foundries that manufacture MMICs; and Micro-Electronic Manufacturing/Assembly Facilities capable of producing AESA solid-state devices such as

Transmit/Receive (T/R) Modules, Subassemblies, and Beam formers in Multiple Frequency Bands.

Companies reported that engineering skills specific to AESA development are well staffed and do not anticipate a shortage of any skilled engineering professionals now or in the future.[39] Engineering staffs required for the design/development of AESA products were brought in early in the process and remain today. Most of the skills required in design, manufacture, and testing of AESAs are not unique to the AESA industry. Capacity issues are continually assessed by all manufacturers to assure current and planned requirements can be satisfied. However, rapid swings in requirements (either upturn or downturn) can impose stress on available technically qualified engineering and manufacturing personnel. For this reason, industry employs many strategies to train and maintain its workforce. Some of these strategies include on-site training, coordination with universities via co-ops and degree programs, certifications for technicians and operators, partnerships with their other manufacturing sites, and working relationships with local contracting firms to provide talent on an as-needed basis.

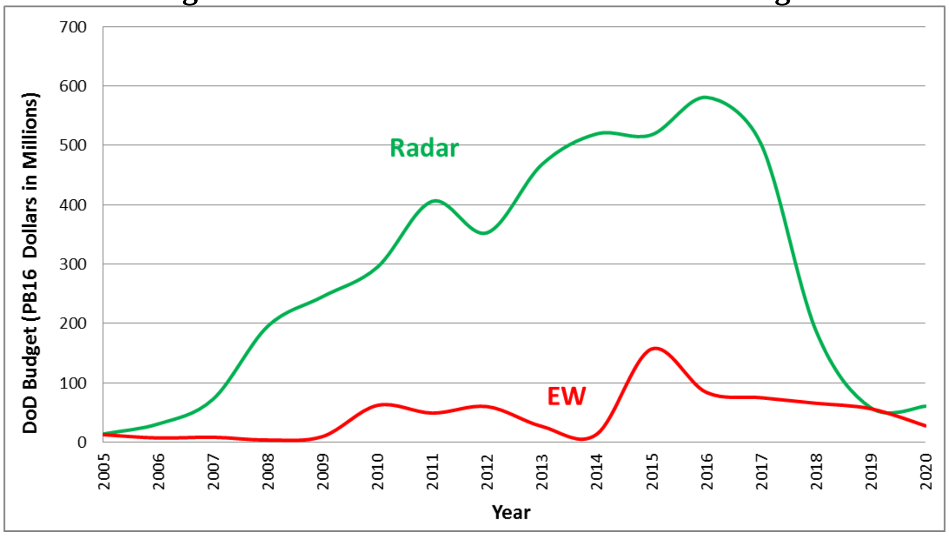
Use of common manufacturing processes and specialized work cells leverages the experience and expertise of highly trained personnel and minimizes redundancy in specialized equipment dedicated to particular programs. Resources are easily shared or shifted among various programs to satisfy customer demands. Commonality in hardware also provides leverage and allows for simultaneous scheduling of multiple programs. Trends toward commonality in hardware have also increased the use of specialty shops or centers of excellence such as machining, electronics, and fabrication. Most prime system integrators use a Captive Manufacturing Process drawing on the expertise of sister facilities located throughout the country, and/or the world, to provide additional support and address capacity issues.

Budget considerations

Radars make up only a small part of the electronics market and AESA makes up only a small part of the radar market, so a downturn in funding for AESA systems will not affect the overall market. The RDT&E funding for radar and EW is shown in Figure 5.2.1. The Procurement funding for radar and EW is shown in Figure 5.2.2.

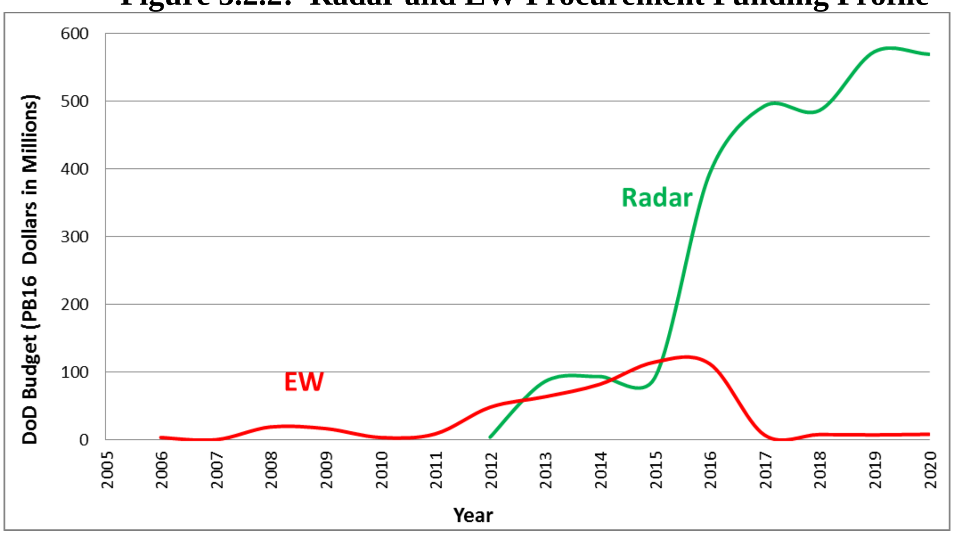
[39] "Surface AESA Radar Industrial Base Assessment" (October, 2013) jointly produced by the Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy and the Defense Contract Management Agency/Industrial Analysis Center.

Figure 5.2.1: Radar and EW RDT&E Funding Profile



Source: Selected Acquisition Reports (March, 2015)

Figure 5.2.2: Radar and EW Procurement Funding Profile



Source: Selected Acquisition Reports (March, 2015)

Industry Suppliers

In 2015 three domestic prime manufacturers dominated the radar sector– Raytheon, Lockheed Martin, and Northrop Grumman, and four domestic prime manufacturers dominate EW – Raytheon, Northrop Grumman, ITT, and BAE Systems. With several full rate production (FRP) programs previously developed for AESA upgrades to air, sea, and land systems, as well as foreign sales, the industrial base appears to be viable and stable. In 2015 there were four programs in the Engineering and Manufacturing Development (EMD) phase and two in low rate initial production (LRIP): Raytheon is developing the Air and Missile Defense Radar (AMDR) for the Navy and the Three-Dimensional Expeditionary Long-Range Radar (3DELRR) (awarded in October, 2014) for the Air Force; Lockheed Martin is developing the Space Fence for the Air

Force; Northrop Grumman is developing the Common Infrared Countermeasures (CIRCM) program (awarded in August, 2015) for the Army and has entered production of the Ground/Air Task Oriented Radar (G/ATOR) for the Marine Corps; and production of Block IV of the Integrated Defensive Electronic Countermeasures (IDECM) is being performed for the Navy by ITT (producing the jammer) and BAE Systems (producing the external decoy).

At-risk areas

Key components for AESAs are ceramics packaging and MMICs. Prior to 2000, the manufacturing infrastructure for ceramic packaging was quite robust. High Temperature Co-fired Ceramics (HTCC) and Low Temperature Co-fired Ceramics (LTCC) are critical technologies for AESA systems. The HTCC and LTCC domestic supply base was served by several manufacturers when many of the AESA electronic packages were in development. However, there has been a downsizing in the HTCC supply base through mergers and acquisitions in recent years. Kyocera in San Diego, CA, which is a subsidiary of Kyocera, Japan, currently supplies the bulk of the HTCC electronic packages for AESA systems. The materials development and package design takes place in Japan. The LTCC package manufacturing infrastructure has undergone similar downsizing. Today, the domestic market is served by three suppliers, Kyocera, Natel Engineering, and Anaren Microwave. Natel Engineering and Anaren are U.S. based companies with Natel Engineering supplying the bulk of the LTCC packages to AESA systems. Most of the manufacturing infrastructure and materials development in LTCC is taking place in Asia to serve the commercial industry. The outlook for the competitive supply of domestically produced ceramic packages is not favorable.

The main suppliers for MMICs are TriQuint in Richardson, TX and Cree in Durham, NC. However, almost all of their output is for the commercial market. Japanese and Korean companies have introduced competitive gallium arsenide (GaAs) and gallium nitride (GaN) technologies that have the potential to transform the MMIC supply base similar to what has occurred in the packaging supply base.

Tactical airborne AESA radar systems for fighter aircraft are a critical capability for the Department and an at-risk area. Raytheon and Northrup Grumman are the only two sources for these radars currently in production or sustainment for the F-35, F-22, F/A-18E/F, F-15, and F-16. However, tactical airborne radar system production for all but the F-35 will wind down within the Future Years Defense Program (FYDP), increasing the risk of reduced competition and innovation in this area.

Long-Term Challenges

The primary challenges AESA technology encounters in today's marketplace are affordability, increased foreign competition, and limited access to foreign markets by U.S. firms. Companies report that, until recently, the U.S. had maintained a lead in defense technology development and capability. Over the past decade the gap in these two areas has decreased.

This is highlighted by the fact that, as recently as 10 years ago, the U.S. provided the majority of defense systems sought by our foreign allies and partners. This position is changing. In 2010, European and Israeli defense companies accounted for greater than 50% of the sales in the non-US defense electronics market. These increased sales by foreign companies highlight foreign technical capabilities. As a byproduct, the expansion of sales will provide investment funds for further development. Since 2000, defense companies have proliferated globally, maturing and creating new and advanced products. This is due to allied/partner ambition to build organic capacity and boost defense export. Beyond enhancing competition, expanding sales to countries with burgeoning defense electronics industries will require co-development and an increased amount of technology transfer. Many European defense firms are now multi-domestic and may become multi-national in the future.

Mitigating the reduced competition and innovation risks for tactical airborne radar systems will require stable research and development investment for next generation AESA technologies to preserve a competitive industrial base.

Mitigation Efforts

There are currently two ongoing Title III projects relevant to the technologies utilized in AESAs. These are the following:

- **GaN Radar and Electronic Warfare MMIC**
  This $35.4 million project seeks to increase the yield, affordability, and availability of GaN, S-Band, and Wideband MMICs produced on 100 mm Silicon Carbide substrates to ensure domestic availability of these devices for next generation defense systems.
- **GaN Advanced Electronic Warfare MMIC**
  This $8.6 million project seeks to establish a domestic, economically viable, open-foundry merchant supplier production capability for Ka-band GaN MMICs.

5.3 Ground Vehicle Sector Industrial Summary

Industry Overview

The Ground Vehicle sector is generally categorized in two broad vehicle classes: tactical wheeled vehicles (TWV) and combat vehicles. TWV are usually trucks modified from commercial variants and specifically designed to accommodate use in demanding military environments/missions. This class has a higher potential to benefit from dual-use or commercial business. Combat vehicles are typically heavily armored and integrated with complex weapons systems, fire control, and sensors. This class of military ground vehicle tends to be defense-unique with little commercial application.

The wartime investment in ground vehicles resulted in an enhanced state of equipment readiness for established ground vehicle fleets in terms of fleet age and material condition. Post-combat overhaul, recapitalization, and the reset of military vehicles is positively contributing to the sustainment of the unique manufacturing capabilities and supporting supply chains, resulting in the enhanced equipment readiness posture.

<u>Budget Considerations</u>

DoD budgets have declined for ground vehicles in the procurement and RDT&E funding profiles as overseas ground combat operations have decreased. This reduced level of funding has not been seen since the mid-1990s. Because of the reduced budgets, new ground vehicle programs have been delayed or cancelled. Instead, the focus has been on recapitalization and reset of the current legacy vehicle fleets. Recapitalization is a process to modernize a legacy platform by updating its systems and technologies. There were two combat vehicle recapitalization programs in 2015[40]:

- Paladin Integrated Management (PIM) replaces the M109A6 Paladin. PIM shares common components with the Bradley Fighting Vehicle, such as the engine, transmission, and tracks. This creates commonality with other systems and maximizes costs-savings in production, parts inventory, and maintenance personnel. PIM's on-board power systems harness technologies originally developed for the Non-Line-of-Sight Cannon. PIM is in LRIP, under contract with BAE Systems Land and Armaments.[41]

- Armored Multi-Purpose Vehicle (AMPV) replaces the M113 family of vehicles. AMPV has a Bradley-based chassis, which allows for commonality between 75 percent of an armored brigade’s combat vehicles, eased maintenance and logistics, and ensured comparable mobility. AMPV is in the EMD phase, under contract with BAE Systems Land and Armaments.[42]

Reset performs necessary maintenance and repairs to bring a vehicle back to its configuration before it is deployed. The U.S. Army and the United States Marine Corps (USMC) are in the process of resetting thousands of ground vehicles, from Heavy Expanded Mobility Tactical Trucks (HEMTT) to Mine Resistant Ambush Protected (MRAP) vehicles to a variety of trailers. Of the original fleet of 27,000 MRAPs, 8,927 MRAP All-Terrain Vehicles (M-ATVs) and MaxxPro variants are slated for reset and 4,332 systems will be modified to serve as route-clearance vehicles.[43] Most of the reset and modification work for both the MRAPs and tactical vehicles is taking place in the Red River Army Depot in Texarkana, Texas. Some reset work is being performed by the original equipment manufacturers to augment the organic base,

[40] Defense Research Data Warehouse.
[41] Army Acquisition Data Master List accessed from http://www.peogcs.army.mil/.
[42] Accessed from http://www.peogcs.army.mil/.
[43] USMC Program Executive Office Land Systems and Army Program Executive Office Combat Support and Combat Service Support Project Manager MRAP.

such as the contract for 800 M-ATV awarded to Oshkosh Defense and the Navistar Defense reset of 473 MaxxPro MRAPs.[44]

The only new ground vehicle program is the Joint Light Tactical Vehicle (JLTV), designed to supplement the High Mobility Multi-Purpose Wheeled Vehicle (HMMWV) for missions requiring higher levels of mobility, reliability, and force protection than supplied by the HMMWV. The M-ATV (the only viable Commercial off the Shelf (COTS) alternative) did not meet JLTV's mobility, transportability, and reliability requirements. Oshkosh's Light Combat Tactical All-Terrain Vehicle (L-ATV) was awarded the JLTV LRIP contract.[45]

Industry Suppliers

Three companies provide the majority of ground vehicle platforms and possess the full range of capabilities to bring a new system from the research, design, and development phases into full production. BAE Systems and General Dynamics dominate the Combat market, while Oshkosh Defense dominates the Tactical market. The systems produced by each company are listed in Table 5.3.1. Note that this table includes previous major programs that are not currently in production.[46]

[44] PB 2015 budget exhibits from Procurement Army and Procurement Marine Corps.
[45] Data Accessed from http://www.peocscss.army.mil/.
[46] Accessed from https://ebiz.acq.osd.mil/DAMIR/PortalMain/DamirPortal.aspx.

Figure 5.3.1: Prime Contractors for Major Ground Vehicle Programs

Current Contractor	Vehicle	Type	Service	Fielded
BAE	AAV-P7/A1	Tracked	USMC	Yes
	AMPV (M113 Replacement)	Tracked	Army	No
	Bradley Fighting Vehicle (BFV)	Tracked	Army	Yes
	M88 Hercules	Tracked	Army	Yes
	RG31 (MMPV)	Wheeled	Army	Yes
	RG33 (MMPV)	Wheeled	Army	Yes
	M109 PIM	Tracked	Army	Yes
General Dynamics Land Systems (GDLS)	Abrams Tank	Tracked	Army/USMC	Yes
	Stryker	Wheeled	Army	Yes
	M1161 &M1163 Growler Internally Transportable Vehicles	Wheeled	USMC	Yes
	Flyer 72	Wheeled	SOCOM	Yes
	Buffalo (MPCV)	Wheeled	Army	Yes
British Aerospace Systems / Science Applications International Corporation (BAE/SAIC)	ACV 1.1 (Two competitors)	Wheeled	USMC	No Milestone B
NAVISTAR	MaxxPro Dash (MRAP)	Wheeled	USA/USMC/ USAF	Yes
Oshkosh Defense	FMTV	Wheeled	Army	Yes
	FHTV	Wheeled	Army	Yes
	JLTV	Wheeled	Army/USMC	LRIP
	MTVR	Wheeled	USMC	Yes
	LVSR	Wheeled	USMC	Yes
	M-ATV (MRAP)	Wheeled	Army/USMC	Yes
	PLS	Wheeled	Army	Yes
	HEMTT	Wheeled	Army	Yes

At-Risk Areas

Two specific component areas were identified as critical and fragile: vehicle Forward Looking Infra-Red (FLIR) sensors and transmissions. The dominant contractors for FLIR are Raytheon and DRS. In addition, cadmium zinc telluride (CZT) substrates used for FLIR focal plane arrays have a sole foreign supplier.[47]

The combat vehicle transmission industrial base currently consists of three key DoD suppliers: Allison Transmission, L-3 Combat Propulsion Systems, and Twin Disc. These companies are sole source transmission suppliers with a unique product line for specific vehicles. In light of projected budgets, current declining transmission demand will likely remain unchanged. Since facilities have been sized based on higher production rates, this presents potential risk to our suppliers as projected demand falls below their minimum sustainment rate (MSR) requirements. These suppliers are now challenged with allocating fixed costs across a smaller product base. This projects affordability challenges for DoD customers. The ultimate DoD industrial base risk, in this situation, is that a current, sole-source supplier decides to leave the market. Current on-hand assets and rebuild capability buffer some of this risk. However, costs to engineer/reverse engineer replacements and the time necessary to requalify new suppliers may be more costly or a greater risk than direct investment in incumbent suppliers.[48]

Long-Term Challenges

The combat vehicle industrial sector faces a number of industrial base challenges, including retaining critical design and integration engineering talent and sustaining critical suppliers in the sub-tier industrial base. There are no new systems development programs in the combat vehicle sector. The AMPV and PIM leverage already demonstrated technology. The upgrade of legacy fleets with component level improvements only partially sustains core skills. This scenario could potentially lead to attrition of capability. However, the highest risks are in the component supplier base and not within the prime contractors. Furthermore, the design engineering capabilities needed for these systems may not be readily available should the skills atrophy in the absence of demand. Declining program requirements and budget issues put Organic Industrial Base (OIB) critical skill sets at risk of being lost. The commercial sector needs to be engaged in Public-Private-Partnerships relationships to enhance workload and maintain critical skill sets needed.

The focus on readiness for the legacy ground vehicle fleets will likely result in a continued trend of reduced investments in design and new development programs. Within the Defense-unique suppliers, the reduced investments translate to reduced production volumes that may be below minimum sustaining rates, forcing industry to make decisions on whether to stay in the defense market. Declining combat vehicle platform production, sustainment requirements,

[47] Conversations with Army PM Night Vison.
[48] 2015 DMC and AUSA Panel Discussions.

schedule slips, and parts obsolescence have a direct impact on the sub-tier supply chain. Companies reliant on DoD business and whose portfolios have no commercial applicability or lack an ability to diversify, potentially manifest more risk based on their defense-unique characteristics and will likely have to continue to consolidate facilities and reduce their workforces. Critical sub-tier suppliers that have not developed a well-diversified product mix with both military and commercial products are at risk. Suppliers will need to expand their non-military production operations, resulting in much less Government-unique manufacturing hardware and floor space utilized for combat systems support. Indications exist for sub-tier suppliers that commercial work may be adequate to carry operations through the military downtime, but future support could be lost since corporate offices, stockholders, and equity holders do not want to extend the costs associated with retaining idle manufacturing operations. These suppliers may not re-enter the defense sector in the future. Sub-tier supplier risks include increased unit costs associated with adjustments for economies of scale procurement. If production zeroes for over a year, requalification costs and excessive lead times will be required for production restart. Lead times will be directly related to the start-up of unique sub-tier supply chain as well as the need to recruit and train new employees. Supplier loss, increased costs, and excessive lead times extend the impacts through the supply chain to negatively affect overhaul/rebuild operations within the OIB and potentially affecting military readiness rates.

Mitigation Efforts

Currently, CZT substrates used for FLIR focal plane arrays have a sole foreign supplier. To mitigate this risk, there is a ManTech program in place to develop a new foundry within the United States to create CZT substrates.

Mitigating strategies for vehicle transmissions include: (1) Direct investment to maintain a minimum capacity at the key suppliers, (2) Working with suppliers to develop a more favorable business model, (3) Continuing science and technology on new transmissions concepts, (4) Developing second sources for key components and systems using both the commercial and organic industrial assets, and (5) Developing alternative transmissions that can replace current products.

5.4 Materials Sector Industrial Summary

Access to the basic materials required for producing finished and intermediate products and components is integral to the U.S. manufacturing base and the Nation’s overall economic and national security. Typically, materials supply chains rely on considerable international trade, including basic raw material inputs through intermediate and fabricated materials products. In general, globalization results in lower costs, more efficient supply chains, and access to more resources. However, it may also create a dependency on foreign resources, which could lead to a range of actions that distort supply chains and price structures such as export controls and differing approaches to the regimes governing mining (e.g., production controls, permitting) and investment activities. For certain materials such as rare earths, difficulties obtaining the necessary permits and accessing sufficient capital remain impediments to the establishment of robust domestic supply chains. In materials such as beryllium and titanium, on the other hand, there are industries with established domestic supply chains that are generating substantial revenues and profits.

Generally, the requirements of the DIB represent a small percentage of overall U.S. demand for materials such that U.S. consumption and supply chains are focused on serving the needs of the commercial sector. Therefore, maintaining a vibrant commercial manufacturing base is essential to the health of the DIB. However, the Department closely monitors the materials required by the DIB and their supply chains—especially those materials where there may not be a strong demand impetus from the commercial sector. Given these dynamics, the Department's concern regarding materials has increasingly shifted away from the mined raw material and has moved toward chemicals, compounds, and semi-finished manufactured goods.

Among the many materials serving as inputs to the DIB, the availability of rare earth materials continues to garner considerable attention. Since the Department's initial rare earths report to Congress in 2011,[49] however, there has been a significant change in the global marketplace concerning rare earths. Increased market supply from a more diversified producer base coupled with decreased demand has led to global surpluses for several rare earth materials. However, gaps remain in the domestic supply chain. For instance, facilities in China, Japan, and other Asian Countries (and to a lesser extent Europe), maintain roles in the complex supply chain that provides intermediate and finished rare earth products to the U.S. and other markets globally. The U.S. rare earth industry is caught in a classic "chicken and egg" dilemma, consisting of whether the development of an upstream sector (e.g., mining and oxide production) will spark the growth of a downstream sector (e.g., metals, alloys, magnets), or whether a downstream sector needs to develop first in order to generate sufficient demand for raw materials to justify the development of the upstream sector. In either case, and especially for the upstream sector, access to capital is a key issue.

The U.S.-based mining and international specialty materials processing company, Molycorp, Inc., demonstrated limited production capacity of its re-opened Mountain Pass rare earths mining and processing plant in California (the mine had been shut-down in 2002). Molycorp reportedly invested $1.7 billion to re-open the mine and construct a new state-of-the-art rare earths processing facility. However, technical difficulties in operating the processing facility resulted in halting production in 2015 while depressed rare earth markets put the company in further financial distress. Molycorp subsequently filed Chapter 11 to reorganize and, just before the end of 2015, the company placed the Mountain Pass mining and processing facilities in a care-and-maintenance status.

[49] Interim Report, Assessment and Plan for Critical Rare Earth Materials in Defense Applications, from USD (AT&L) to the Congress, August 2011.

Nevertheless, the Department notes that the supply of rare earth materials for U.S. defense acquisition programs is not presently disrupted. Based on findings of the "Strategic and Critical Materials 2015 Report on Stockpile Requirements" submitted to Congress, the Department estimates a gross defense shortfall (i.e., before any market mitigating factors) only for high purity yttrium oxide from among the rare earths, and the Department already has sought and received authority from Congress to acquire this material for the National Defense Stockpile (NDS). The report also estimated defense shortfalls for a number of other materials due to primarily single-source foreign production or domestic single points of failure, as required by the amended Stock Piling Act. When market responses are insufficient to eliminate a shortfall, the Department may act to address the shortfall through a number of available authorities including the Defense Priorities and Allocation System, DPA Title III, the Department's ManTech Program, and NDS.

MIBP coordinates with organizations within the Department (e.g., Defense Logistics Agency (DLA) – Strategic Materials) as well as the interagency (e.g., U.S. Geological Survey, Department of Commerce, U.S. Trade Representative, and the White House Office of Science and Technology Policy) to address the issue of materials availability. This whole-of-Government approach effort seeks to identify materials of concern to national security, assess the ability of the supply chains for these materials to meet U.S. industrial base requirements, and develop strategies to ensure their availability. For example, the Department of Energy's (DoE) Critical Materials Institute focuses on technologies that make better use of materials and eliminate the need for materials that are subject to supply disruptions. The Institute focuses on materials essential for American competitiveness in clean energy. However, efforts that enhance the supply chain overall will benefit the DIB as well. The Institute is currently concentrating their research on the rare earths dysprosium, terbium, europium, neodymium, and yttrium, as well as lithium and tellurium.

The DoD is also supporting new efforts to test and qualify commercially available domestic materials as substitutes and second sources of materials that are currently considered unique and proprietary to single foreign producers. Related efforts help to reduce the risks of single foreign sources of supply through diversification while also stimulating competition, lower material prices and additional access to innovative materials. These efforts are aimed at high priority defense systems, including National Security Space, and other important DoD programs.

5.5 Munitions and Missiles Sector Industrial Summary

Industry Overview

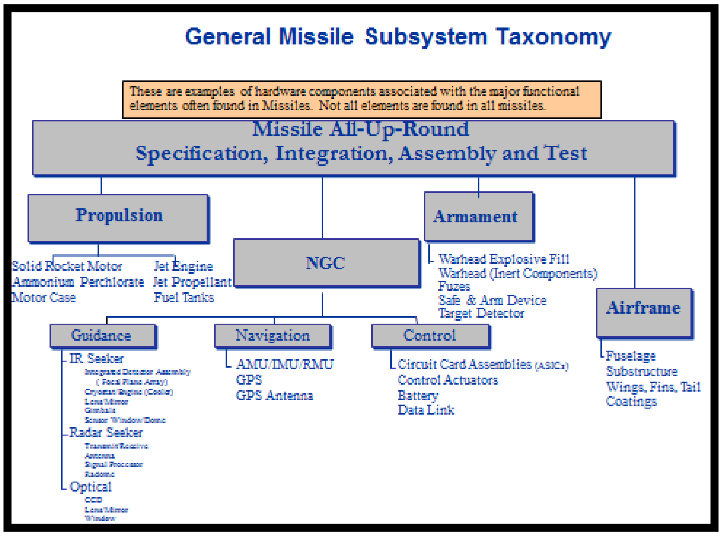
The munitions and missile industrial sector is comprised of DoD's smart bombs, tactical (cruise, air-to-air, air-to-ground, surface-to-air) missiles, missile defense, and strategic missiles, as well as dumb bombs, ammunition, mortars, and tank rounds. The munitions and missiles industrial sector is primarily a defense-unique industrial sector. Since most/all of the major issues lie within the missile industrial base, dumb bombs, ammunition, mortars, and tank rounds are not included in this report.

The Department provides the necessary resources to the industrial sector to ramp up production for munitions and missile systems to support Warfighter needs when the country is engaged in conflict, and it reduces these resources when the conflict ends. This cycle of ramp-ups followed by declines of demand and production adds significant management challenges to munitions, missile companies, and their critical sub-tier suppliers. While all industrial sectors are challenged by rapid changes in DoD demand, this ramping up and down based on global conflicts increases risk for defense-unique industrial sectors at the sub-tier supplier level because many do not have the diversity of programs or products from other non-defense markets to support their design and production skills, and the sub-tier suppliers do not have the backlog of business.

Over the past decade, there have been no new development programs in the munitions and missile sector. All 'new' missile programs have been designed as, or have become, merely upgrades to existing systems. This sector is also undergoing a decline in procurement; as a result, the design and production skills for critical components within the missile sector industrial base are at risk. The loss of this design and production capability could result in costly delays, unanticipated expense, and a significant impact to many current and future missile programs.

The general missile taxonomy shown in Figure 5.5.1 breaks the missile into four functional areas: propulsion; armament; airframe; and navigation, guidance, and control (NGC). In the propulsion area, most missiles use a solid rocket motor (SRM). The size of these motors can range from 2.75 inches in diameter to as large as 83 inches for some strategic and ballistic missile defense systems. Some tactical missiles, like the Tactical Tomahawk, use a jet turbine fan engine. The major distinction for the warhead is either nuclear or conventional. Airframes consist of the fuselage, wings, fins, tail, and substructures. Airframe materials for these components range from aluminum to complex composites. The NGC area, in many cases, comprises of the most expensive components of the system (mostly missile seekers).

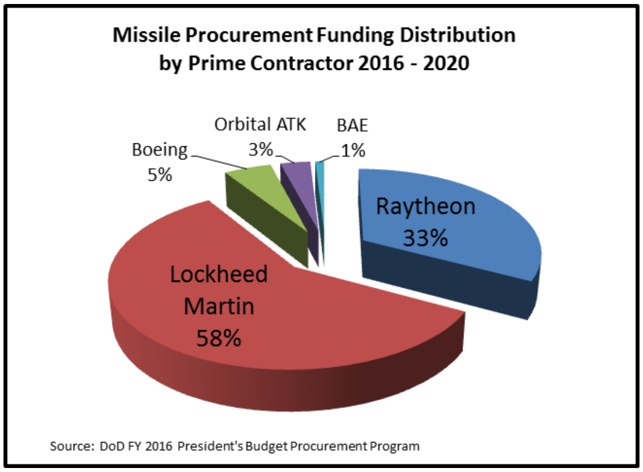
Figure 5.5.1 General Missile Subsystem Taxonomy



Industry Suppliers

Within the munitions and missile sector, two prime contractors, Raytheon Missile Systems (a division of Raytheon Company) and Lockheed Martin Corporation, account for roughly 90 percent of the Department's munitions and missile procurement funding, as indicated in Figure 5.5.2. These prime contractors provide a full complement of missile types across the munitions and missiles sector and, for the most part, are able to meet defense-unique technical performance requirements. DoD's prime contractors and their associated sub-tier supplier base must align company production capacities with expected DoD budget realities while sustaining the industrial capabilities needed for next-generation weapon systems.

Figure 5.5.2 – Missile Procurement Funding Distribution



Budget Considerations

As seen in Figure 5.5.3, RDT&E budgets for tactical missile programs dramatically declined from 2010 to 2014. Although the President's Budget 2016 data is showing an increase from 2015 to 2017 (with another decline in 2018 to 2020), history indicates some uncertainty in this sector. Most recent "new start" missile programs, such as the Joint Air-to-Ground Missile (JAGM), have been converted to or designed as slight modifications of existing systems (new seeker for Hellfire in the case of JAGM) versus actual new missile designs. This does not allow the design, development, and integration skills within the tactical missile industrial base, and specifically the SRM industrial base, to be exercised, and limits competitive opportunities. The skill set necessary to design, develop, prototype and test a new missile is very different from the skill set for producing an existing missile. Most DoD tactical missiles have been produced for many years or even decades and have reached steady state, limiting opportunities for industry to hone its design capabilities. Increases in the strategic missile RDT&E budgets are due mostly to the Ground Based Strategic Deterrent (GBSD) program, the LGM-30G Minuteman III replacement program.

Figure 5.5.3: Missiles RDT&E Funding Profile

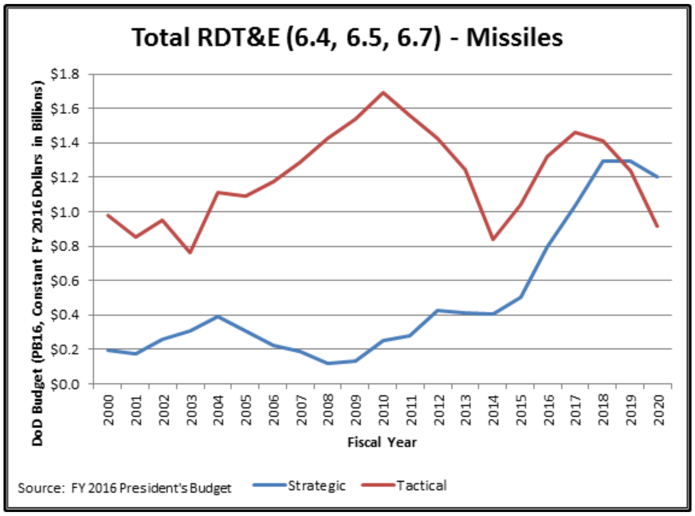
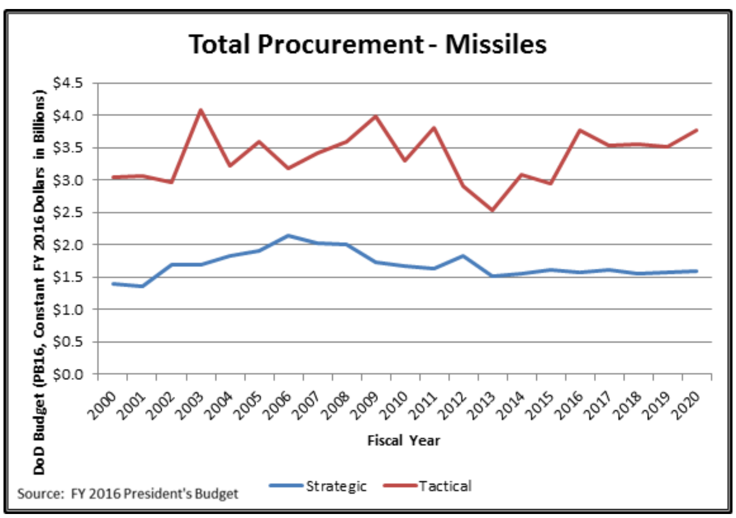


Figure 5.5.4 indicates that procurement budgets for strategic missiles appear fairly steady. However, funding for tactical missile programs can increase and decrease dramatically as inventory and usage demands change. This creates stress on the tactical missile industrial base. Especially on the smaller sub-tier suppliers, who must remain viable in low production environments while remaining ready to ramp up production when needed.

Figure 5.5.4: Missiles Procurement Funding Profile



Risk Assessment

The munitions and missile industrial sector is routinely impacted by significant shifts in DoD demand as a result of various factors, but it is primarily due to the initiation or drawdown of conflicts. As the Department draws down its operations overseas, it is monitoring the impact of reduced demand on the sub-tier supplier base through continuing FaC assessments of the DIB in close cooperation with the Military Departments and the Missile Defense Agency (MDA).

The Department expects to identify a growing number of industrial capability risk areas as sub-tier suppliers realign and adjust their industrial capacities to new DoD budget realities.

In 2013, for example, MIBP performed a FaC assessment of the missile industrial sector. MIBP collaborated with the Fuze IPT and the Critical Energetics Material Working Group for valuable industry and product information in their respective industrial sectors. The health of sub-tier suppliers in defense-unique fields is a serious and valid concern. Important defense unique sub-tier components in the munitions and missile industrial segment that continually face excess capacity challenges include thermal batteries, solid rocket motors, fuzes, jet engines, inertial measurement units (IMUs), GPS receivers, seekers, and warheads. The suppliers that provide these components are used on multiple programs, and some of these components require 12 months or more to manufacture. Some of these sub-tier supplier products have broader utility and commercial applications that provide a more reliable and stable market base to sustain industrial design and production capabilities—such as the IMUs, GPS receivers, and seeker product sectors—while others are more unique to the munitions and missile industrial sector. MIBP continues to monitor the health of the sub-tier suppliers identified in the FaC assessment, which confirmed previously known industrial base challenges. These challenges fall into two broad categories; (1) sustaining our design and engineering teams and (2) sustaining the sub-tier supplier base.

The following missile industrial base issues continue to be identified as the areas with the highest risk:

- *Solid Rocket Motors*: SRMs are predominantly defense-unique items. SRM providers and their sub-tier suppliers face demand uncertainty because munitions and missiles are often used as bill-payers in fiscally constrained environments. The challenge is the high cost for reconstitution should the SRM industry encounter a significant production gap, particularly in the large (over 40-inch diameter) segment of the market. NASA's retirement of the Space Shuttle and the transition of the Constellation program to the Space Launch System have resulted in significant under-utilization of existing capacity.

- *Thermal Batteries*: All DoD missiles and Precision Guided Munitions use thermal batteries. Thermal batteries are predominantly defense-unique items, and the domestic thermal battery industry has historically been dominated by one company with little participation by other firms. The other domestic companies that produce thermal batteries constitute less than 20 percent of the DoD thermal battery market. The dependency on a dominant supplier of thermal batteries makes this industry at risk.

- *Fuzes:* Fuzes are defense-unique items—they are used on all munitions and missile programs. Continued improvements in guided systems significantly reduced the quantity of fuzes required for our current and future systems. This has contributed to an excess capacity in the fuzes sector. Excess capacity limits manufacturers from being cost competitive and sustaining a viable design engineering cadre. The U.S. currently has three full-capability fuze design manufacturing suppliers. The fuze prime contractors are aggressively managing several defense-unique sub-tier component areas, such as electronic energy devices (e.g., bellows actuators), liquid reserve batteries, and certain obsolete electronic components to ensure their ability to design and produce fuzes in the future.

Long-Term Challenges

Sustaining Design and Engineering Industrial Capabilities:

Most current missile development activity consists of modifications to existing missile systems, such as the AIM-9X Block II, PAC 3 Missile System Enhancement (MSE), Advanced Anti-Radiation Guided Missile (AARGM), and Standard Missile-6 (SM-6). Most of the R&D funding in the munitions and missile sector is associated with legacy program upgrades or modifications, which limit competitive opportunities. The limited number of new missile development programs inhibits the Department's ability to fully exercise the industrial capabilities necessary—from design concept, system development, and production—to meet current and future national security needs. The Long-Range Anti-Ship Missile (LRASM) and the JAGM are the only "new" missile development programs in competition. However, these too follow the same model. After being restructured as a technology development program, the JAGM program now reflects a front-end modernization for the Hellfire missile. While LRASM leverages a Defense Advanced Research Projects Agency (DARPA) demonstration project to integrate significant modification to legacy Joint Air-to-Surface Standoff Missile – Extended Range (JASSM-ER), it does not rise to the level of a major new program starting from basic technology development. Neither program has significant design work and SRM design requirements.

The Department of the Navy (DoN) is implementing a Cruise Missile Strategy, as follows: 1. support of Tomahawk Land Attack Block III and Tactical Tomahawk (TACTOM) Block IV through anticipated service lives and integration of modernization and obsolescence upgrades to TACTOM during a mid-life recertification program (which adds 15-years of additional missile service life); 2. fielding of the LRASM as the Offensive Anti-Surface Warfare (OASuW)/Increment 1 material solution to meet near to mid-term threats; and 3. development of follow on Next Generation Strike Capability (NGSC) weapons to address future threats in time to replace or update legacy weapons while bringing next generation technologies into the Navy's standoff conventional strike capabilities. NGSC will address both the OASuW/Increment 2 capabilities to counter long-term anti-surface warfare threats, and the Next Generation Land Attack Weapon (NGLAW) to initially complement, and then replace, current land attack cruise missile weapon systems. Under the NGSC construct, the DoN plans to complete acquisition planning for the OASuW/Increment II program and initiate an Analysis of Alternatives for the NGLAW during calendar year 2016.

Additionally, ship defense missiles are migrating to active seeker capability, leveraging common-guidance section architecture from the Advanced Medium-Range Air-to-Air Missile (AMRAAM) C-7 to SM-6 Block 1 and Evolved SeaSparrow Missile (ESSM) Block 2. This family of missiles approach helps to mitigate the lower production quantities and leverages previous developments to reduce cost and efficiently utilize the missile design engineering capabilities.

The Air Force is beginning early RDT&E efforts for the AGM-86B Air-Launch Cruise Missile (ALCM) replacement, the Long Range Standoff Weapon, along with their next-generation B-21 bomber program.

MDA conducted market research to determine industry capability for providing technical support for all stages of Government Furnished Property (GFP) rocket motors, including Trident I (C4), CASTOR IVA/IVB, Orion, and Orbus 1/1A. The performer would be responsible for providing technical support for motor refurbishment, flight certification, safe handling, transportation, propulsion, propellant/motor/component testing, propellant sensitivity studies, aging assessment, storage, demilitarization, and other technical support as needed. MDA is currently conducting final market research to support its acquisition strategy development.

MDA also conducted market research to determine industry capability to provide Medium Range Ballistic Missile (MRBM) T3c2 All Up Round targets in support of Ballistic Missile Defense System (BMDS) flight tests activities. The MRBM T3c2 target requirement includes the design and development of the complete target system, including production equipment, logistics, associated support equipment, system engineering and analysis, and mission operations. MDA determined that sufficient capability existed in industry, issued a Request for Proposals (RFP), and is currently assessing three responses.

The Department remains concerned that the design engineering capabilities needed for tactical and nuclear weapon systems may not be readily available in the absence of a long-term demand signal. An indication of the concern for strategic missile design engineering capabilities can be seen as the newest DoD strategic missile in the U.S. inventory, the Trident D5 missile, began its development in 1978. This has the potential to affect the GBSD development program, which is already on a short time-line. Table 5.5.5 provides a sampling of U.S. missile programs, their dates of development, and their current program variants.

Table 5.5.5 History of DoD's Missile Development Programs

DoD Missile Program Updates			
Missile Program	Development Started	Production or Delivery Started	Current Variant
AIM-9 Sidewinder	1946	1953	AIM-9X
AMRAAM	1979	1988	AIM-120D
Hellfire	1974	1982	AGM-114R
TOW	1963	1968	TOW-2B
Patriot	1969	1981	PAC-3 MSE
Standard Missile	1963	1967	SM-6
Trident II D5	1978	1987	D5
Minuteman III (LGM-30G)	1964	1968	MM III
Tomahawk	1970's	1983	Block IV
JASSM	1995	2001	JASSM-ER

A contraction in the munitions and missile development and procurement market has created a thinning of expertise in defense-unique technologies in both the contractor and Federal Government workforces. Declining munitions and missiles R&D funding coupled with limited competitive opportunities projected in the near-term for new munitions and missile systems may make it difficult for the missile sector industry to attract and retain a workforce with the industrial capabilities to design, develop, and produce future missile systems that will meet national security requirements.

Critical Issues

MIBP collaborated with the OSD-chartered Critical Energetics Materials Working Group (CEMWG) to assess missile energetic materials. Many of these materials have single or sole source suppliers, many of which are foreign. Examples of domestic and foreign source supplier issues are highlighted below, and various mitigation efforts are discussed in the next section:

- *Hydroxly-terminated Polybutadiene (HTPB):* HTPB is a polymer that is a key component in a majority of DoD missile systems. The current domestic sole source supplier of HTPB for propulsion applications is Total, a French company. There have been a number of deficiencies in the material quality and repeatability identified by users, including variability and inconsistency from lot-to-lot, which has resulted in the material being unusable in certain missile systems. Therefore, in addition to the risk from a sole source, foreign-owned supplier, there is risk of unavailability of this material for key DoD weapons systems.

- *Ammonium Perchlorate (AP)*: The DoD must find a long-term solution to mitigate the high cost and schedule risk to our missile programs, resulting from the fragility of our sole domestic supplier for AP. Numerous studies and reports to Congress have identified the

Department's this supplier, American Pacific (AMPAC), as a critical sub-tier supplier. AMPAC produced AP is used in virtually all of the DoD's missile programs. However, due to decreasing demand, AMPAC is currently operating at 10–15 percent of facility capacity, resulting in large overhead expenses distributed among a small volume of customers. To date, there has been an order of magnitude increase to the price per pound of AP, and projections are for this to continue to increase as demand decreases.

- *Butanetriol (BT)*: The Department has been dependent on a foreign source for BT since 2008. BT, identified on the U.S. Munitions List (USML), is a chemical precursor needed for production of Butanetriol trinitrate, a nitrate ester/plasticizer (part of the binder) used in the production of SRMs for the Army's Hellfire, TOW-2, Griffin, and Javelin missile systems.

- *Triaminotrinitrobenzene (TATB)*: TATB is one of the least sensitive explosive materials known. This material is predominantly used in PBXN-7 and PBXW-14 for fuze applications. TATB had not been produced since 2006. The Department awarded facilitation contracts to establish a new domestic source of TATB in 2011. The TATB plant design was completed in 2013 and leverages existing infrastructure. Process prove-out, completion of consecutive specification compliant production runs, and formulated production scale batches of PBXN-7/PBXW-14 have been completed. TATB and PBXN-7 have been qualified. The data package for the qualification PBXW-14 has been submitted to the Naval Surface Warfare Center, Indian Head Explosive Ordnance Disposal Technology Division for approval. DLA has begun to stockpile TATB, PBXN-7 and PBXW-14.

- *Antimony Sulfide*: Antimony sulfide is a component of energetic compositions used in percussion primers and several fuze/detonator ignition trains that support over 200 DoD munitions. It is also an industrial commodity material used commercially to manufacture flame retardant plastics and textiles. Antimony sulfide is refined from stibnite ore that is mined underground. Large deposits of stibnite ore are rare in the earth's crust, and there are no known mines producing acceptable grade ore under United States or NATO partner control. China is the largest producer of antimony sulfide and controls its availability on the world market.

- *Dimeryl-di-isocyante (DDI):* DDI is a critical propellant ingredient, used as a curing agent in many DoD missile systems (e.g., AMRAAM, AIM-9X, GMLRS, Patriot, and Trident D5). BASF, the sole U.S. source supplier of this material, informed the missile and rocket motor industry that it would no longer provide DDI, leaving the DoD with no qualified source.

Mitigation Efforts

During 2015, MIBP led activities to develop, plan, and execute seven IBAS projects intended to mitigate missile sector issues.

Lifelines and Safe Harbors – Preserving Unique Capabilities

- *Thermal Batteries:* In 2015, work continued on three IBAS projects for thermal battery technical improvements in battery materials and shelf life that will lower minimum sustaining rates: improved material composition that will provide additional domestic suppliers, characterization of Thermal Battery shelf-life model to enhance production quality and sustainment (reducing costs and industrial base burden), and improved thin film production to broaden and improve the market.

Design Teams – Preserving Critical Skills

- *Fuzes:* Without intervention, loss of industry design and production expertise is expected for GMLRS Electronic Safe and Arm Device (ESAD)-based fuzes. ESADs are most commonly used in missile fuzing, but they have applicability to some of the Department's most critical gun-fired and air-delivered munitions as well. To improve the industrial base capability, IBAS is funding ESAD design projects for cost reduction and commonality across multiple missile and munition end-products. Phase I was initiated by contracting with three different suppliers to exercise their engineering capability, including the use of sub-tier suppliers and component technology to develop lower cost, common architecture ESAD designs. These three suppliers form the critical core of the U.S. Industrial Base for fuzes overall. Phase II is planned for award in FY 2017. In this phase, the work from Phase I will then be applied against a post Milestone C munition, which can benefit the most from an upgraded fuze capability.

Industrial Base Supply, Expansion & Competition – Preserving/Expanding Reliable Resources

- *HTPB.* The Army funded a Phase II Small Business Innovation Research (SBIR) project to establish a second source for this material. IBAS funding will be used to manufacture more production scale batches for reliability and repeatability testing and to test the new HTPB in a rocket propellant formulation. The Army will also be funding part of the propellant testing and qualification.

- *AP*. MIBP initiated a study with support from the Army and Navy to address this critical need. The objective of the study was to explore mitigation alternatives that have the potential to reduce the ammonium perchlorate cost and supply risks for DoD. This was to include identifying approaches to reduce the capacity in the existing facility and analyzing cost and schedule for development of a new right-sized facility. Reducing the re-qualification cost burden for DoD weapons systems that experience an ingredient change was also to be addressed. Results of the study were not as expected. There is not a significant AP supply risk, and AP production capacity is unlikely to leave the U.S. market. DoD is paying a premium for this material, and is actively pursuing approaches to address this situation.

- *Butanetriol.* The U.S. Army qualified a new domestic source for BT in FY 2013. In FY 2014, the Department used IBAS to fund the transition of the process for manufacturing BT from a developmental "Pilot Line" to a production-scale capability with the capacity to meet the Department's program requirements. Qualification of butanetriol trinitrate (BTTN) with the new BT, and then missile systems that will use the new BTTN, will follow. This project will ensure the sustainment of this capability across many DoD programs, including the HELLFIRE, JAGM, TOW, Javelin, Griffin, AIM-9x, AEGIS, and Chaparral weapon systems.

- *Antimony Sulfide.* The Department has identified a potential U.S. source for this material. It is currently undergoing testing to see if it will meet military specification requirements.

- *DDI.* The Department worked with BASF to help them understand the importance of this item to DoD's weapons systems. BASF agreed to additional production campaigns and continued production of BASF material (albeit with a different process).

- *Low Energy Expanding Foil Initiator (key component in DoD fuzes).* This IBAS project established a second reliable source for an at-risk producer of detonators used by 12 key DoD weapons systems.

5.6 Space Sector Industrial Summary

<u>Industry overview</u>

The U.S. space industrial base continues to trend in a positive direction, but growth has slowed from previous years compared to non-U.S. government space spending. The space sector is primarily driven by the commercial (both foreign and domestic) market and includes satellites, launch services, ground systems, satellite components and subsystems, networks, engineering services, payloads, propulsion, and electronics. Reliance on the commercial market provides many benefits to DoD – including sources of new technology – but also imposes sources of vulnerability. For example:

- As the space industry globalizes, companies continue to outsource certain capabilities that are produced more economically abroad;

- Budget declines or program cancellations force companies to reduce R&D spending, eliminate product lines, or go bankrupt;

- Industry shifts its product focus away from defense to commercial products where it can obtain better returns on invested capital;

- Environmental restrictions may prohibit production; and

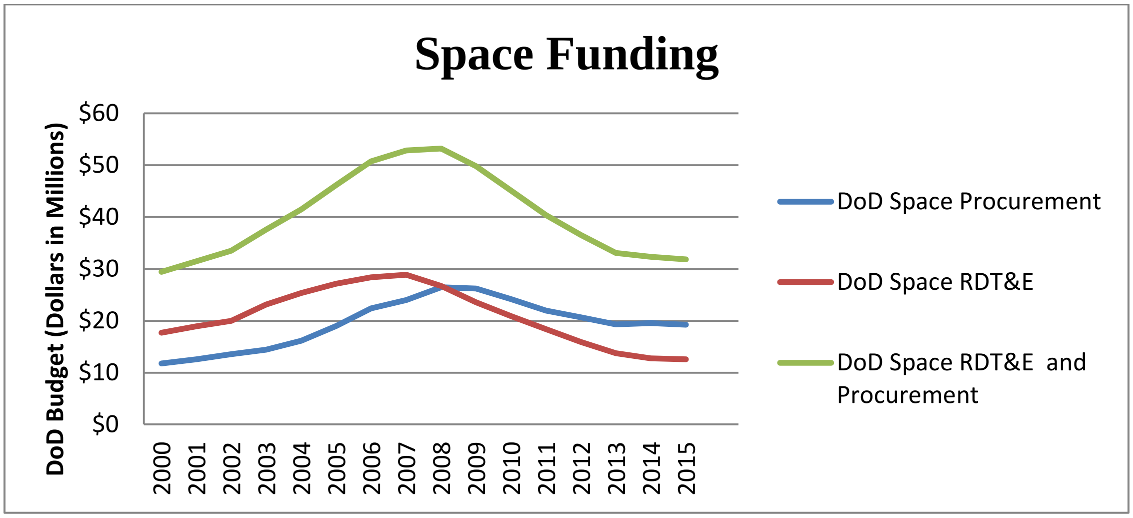
- Commercial viability may be dependent on foreign markets and requires access to competitive financial backing to compete for sales.

Because of these constraints, the Department must remain vigilant to maintain critical capabilities that are specialized for military applications. This is particularly true for DoD space applications, which typically require cutting-edge technology and stringent requirements but often have very low production quantities when compared with commercial products.

Budget considerations.

As shown in Table 5.6.1 below, DoD Space program total funding, including RDT&E and Procurement funds, was lower in 2015 than at any time since FY 2001 (when comparing total budget in BY 2015 constant year dollars). This includes a downward trend since FY 2008, with total funding being reduced 40.2 percent between the PB08 and PB15 budgets, including RDT&E down 53.0 percent and Procurement down 27.3 percent over the same time frame.

Table 5.6.1



Source: Defense Resource Data Warehouse

While this is in contrast to the overall space economy, which has continued to grow over the past several years, it is indicative of the growing reliance on the commercial sector for continued investment in RDT&E for technology innovation and dual use sales vice DoD investment. Declines in DoD space funding could further endanger critical capabilities needed to satisfy current and future program requirements. This finding is consistent with the results of the Department of Commerce (DoC)-led Space Deep Dive (SDD) study, in which over 10 percent of the 3,585 space suppliers surveyed (438 vendors) indicated a potential loss of viability or solvency as a result of sudden decreases in space-related demand.

Risk Assessment

DoD and USG-wide studies and analyses have identified at-risk capabilities, fragile suppliers, and stress in the lower tiers of the SIB. Further, while National Security Space (NSS) will increasingly leverage the growing commercial SIB, there will always be DoD and IC-unique capabilities with no commercial analog or specialized requirements. Continued analysis of the previously conducted DoC SDD study has also highlighted areas of additional consideration for potential risk from foreign only, foreign single/sole, and domestic single/sole source providers, including at-risk suppliers with common components across multiple satellite and launch programs. As such, security of supply and the need for trusted, domestic sources for space-qualified components continues to be a significant challenge. Establishing and maintaining these domestic sources, sustaining manufacturing capability and skills, and improving capacity/efficient production of advanced technology nodes in which DoD is the primary customer are essential for moving forward.

Addressing current vulnerabilities, DoD continues to build upon the 2014 DMAG decision to approve funding of $28 million to sustain critical space technology development and critical elements of the space industrial base as part of the previously established Space Industrial Base Capability Program (SIBCP).[50] The Principal DoD Space Advisor (PDSA) staff, along with MIBP and in coordination with stakeholders, Air Force, MDA, National Reconnaissance Office (NRO), and NASA, has reaffirmed an integrated-Critical Capabilities List, which identifies the 10 highest priority capabilities requiring near-term mitigation. The list also identifies over 100 essential space capabilities considered low to medium risk and requiring active monitoring. Per DMAG direction, the 10 at-risk capabilities were presented to the Defense Space Council, along with associated roadmaps for mitigation execution for FY 2016–2021. As a result of the FY 2015 DMAG, an additional $105 million was approved to address ongoing mitigation challenges.

Key at-risk areas include:

- Radiation hardened advanced technology nodes and components;
- Aerospace structures;
- Infrared detectors;
- Solar cells; and
- Satellite orientation.

[50] The Space Industrial Base Capability Program funds a systematic, sector-wide, interagency approach to identify, assess and mitigate risk in the space industrial base. In addition, this effort will fund targeted investments to: 1) maintain critical space industrial base capabilities, 2) develop manufacturing capability and qualify products and components for future insertion into programs of record, and 3) preserve decision trade space for the department as it satisfies current and future requirements.

The Department continues to synergize implementation of SIB risk mitigation efforts. Consistent with titles 10 and 50 of U.S.C., which require inter-agency collaboration in industrial and supply base risk assessments and mitigations, DoD has acted to renew the existing NSS SIB Risk Management Program. With Defense Space Council (DSC) oversight, the Space Industrial Base Working Group (SIBWG), an inter-agency working group, is addressing these common requirements and challenges by leveraging technical expertise and cooperative funding to mitigate these risks in coordination with industry partners and investment. In addition, there is a coordinated strategy among OSD, AF, NRO, MDA, NASA and other agencies to maximize funding levels and to reduce duplication and other inefficiencies in the planned program executions for the FY2016–2021 period.

Long-Term Challenges

Previously executed "block buys" of systems, such as Evolved Expendable Launch Vehicle (EELV), Space Based Infrared System (SBIRS), Wideband Global SATCOM System (WGS), GPS III, and Advanced Extremely High Frequency (AEHF), continue to provide desired long-term stability across the vast majority of sub-tier providers supporting these programs. However, once sufficient manufacturing and technology readiness levels are established or component bulk buys are completed, some key design teams and skills remain at risk.

Continued investment in advanced technology nodes is critical to prepare for program adoption by next generation spacecraft. Investment by individual programs tends to result in program specific architectures, and cross cutting reviews of anticipated technology requirements must still be conducted to maximize investment across space programs.

In areas where commercial demand is insufficient or DoD-unique components exist, hard-to-reconstitute manufacturing processes must be maintained or improved to sustain efficiency and to avoid schedule and cost impacts associated with re-establishment.

Additionally, DoD must weigh improving cost competitive access to foreign suppliers for critical space components against the vulnerability of relying on non-domestic sources. Protecting the integrity of foreign-produced components requires proactive planning of secure engineering designs and architectures, supply chain risk management practices, software and hardware assurance activities, and anti-tamper techniques.

Mitigation Efforts

The SIBWG previously conducted risk assessments and made investment decisions to sustain sub-tier providers in the following areas: payload, propulsion, power, altitude determination and control, and the parts and materials that impact them. The main goal was to establish a systematic, strategic, and proactive approach to risk assessments and mitigation.

SIBWG analysis identified eleven high-risk capabilities facing erosion. The Department funded investments to support a range of industrial base sustainment activities. These included:

- Power focused projects concentrated on power systems, batteries, photovoltaic solar arrays, solar cells, battery cells, and electrolytes. Completion of a lithium-ion (Li-Ion) batteries project would establish a full domestic production line for Li-Ion cells and their constituent active materials for spacecraft use. Li-Ion rechargeable battery technology provides higher power for longer durations with lower weight and favorable space constraints. The completion date for this contract is expected to be June 2016. The Solar Cells project will expand the domestic ability to produce space-qualified germanium substrates, a key enabler for space solar cells used to power Government satellite systems. Commercial-grade germanium substrates do not possess the quality necessary to produce high-reliability space solar cells.

- Sensor focused projects include travelling wave tube amplifiers (TWTA), imagers (μ/IR/VIS/UV/X/ϒ), readout integrated circuits (ROIC), and CZT substrate. Investment in the TWTA project focused on upgrading manufacturing processes and equipment to produce high quality K-band TWTAs, with improved manufacturing yield and reduced cost for DoD applications. A TWTA is a vacuum electronic device whose function is to amplify a radio-frequency signal. This project concluded on April 30, 2015. Radiation-hardened cryogenic readout integrated circuits are a critical technology employed in the manufacturing of focal plane arrays (FPAs), which are utilized in high altitudes, space-based imaging, and missile systems. Title III resources are being used to establish a domestic foundry for commercial production of Complementary Metal Oxide Semiconductor (CMOS) Radiation-Hardened ROICs. The scope of the ROIC Foundry Improvement and Sustainability Project is to maintain minimal, yet adequate, production capabilities at domestic foundries to ensure a necessary supply of strategic ROICs deemed useful for Government space programs. The primary goal is a sustainment initiative, in which continuous production is coupled with design and process improvements so that more aggressive yields are realized in a timely manner.

- CZT infrared detectors project will enhance the ability of the domestic industrial base to produce large format, space-qualified CZT substrates for use in Government satellite systems. Mercury cadmium telluride (MCT) based infrared detector technology is used for warning threat requirements for missile early warning, missile defense, and other space requirements. A key material for the MCT detector arrays is the lattice-matching substrate CZT, on which the detector array is grown. Potential domestic merchant suppliers were identified and contract was awarded in FY 2015.

- Altitude determination and control focused projects include: telemetry, tracking and command, guidance and navigation, star trackers, and visible light sensors. The Advanced CMOS FPAs for Visible Sensors for Star Trackers Project will expand and enhance the

DIB's ability to produce visible-imagers, which are manufactured using Advanced CMOS technology. Advanced CMOS imagers are designed to enable flexible visible imaging systems, on-board satellite, and other systems for DoD and other U.S. Government needs.

- Propulsion focused projects include propulsion systems (liquid rocket engines (LREs)), heat exchangers and combustion chambers, engine valves, and injectors. In the case of the LREs, projects will be developed to enhance precision fabrication of rocket components used to launch critical assets into Earth's orbit. Advances in the additive manufacturing techniques will provide significant opportunities to reduce costs and mitigate the challenges in continued access to critical components for launch engines. Direct Metal Laser Sintering (DMLS), an additive manufacturing technique, is estimated to provide a 30 percent to 80 percent reduction in critical component cost and schedule for upper stage precision manufactured components. Currently installed DMLS equipment available for domestic production of LRE components has a limited build envelope that does not enable production of the highest risk components, which provide the highest return on investment. Advanced additive manufacturing equipment has been developed that provides the necessary build envelope and capabilities to produce larger critical components for LREs, which would provide a 600 percent volumetric increase in the powder bed over existing additive manufacturing equipment and enable most of the high value components to be produced. As part of a contractual agreement with Aerojet Rocketdyne and the Air Force Research Laboratory, three high-end laser additive manufacturing machines were acquired; this was a major project milestone and essential to meet the project objectives. Aerojet continues to evaluate and down-select components to be produced for engine demand, including consideration of insertion opportunities and the resultant estimation of machine capacity.

Additionally, DoD remains committed to ensuring assured access to space by maintaining at least two sources of highly reliable space launch service providers. The Department was able to reintroduce competition in the EELV program with the May 2015 certification of the SpaceX Falcon 9 launch system. The year also witnessed the ongoing certification of the SpaceX Falcon Heavy launch system, the United Launch Alliance (ULA) submission of the Vulcan launch system for certification, and the continued application of new entrants such as Orbital ATK, which has also begun the certification process. While the opportunity for new entrants remains open, competitive opportunities remain limited to identified launch needs, and providers are highly dependent on the commercial market, both domestic and foreign, for additional sales. As such, the ability to maintain three or more viable domestic providers will continue to be a challenge and will be dictated by the market's ability to sustain multiple providers.

As the Department works to transition away from the Russian RD-180 engine, DoD's approach continues to evolve while keeping the imperative of national security in mind. While sole-source allocation of some launches will be one of the options examined, additional mitigation was put in place in 2015 in the event that two or more viable launch system sources are needed. The Air Force released two Broad Agency Announcement (BAA) RFPs targeting propulsion system development supporting both the industrial base and attainment of at least two domestic launch system providers.

The first, Booster Propulsion Technology Maturation RFP, supports technology maturation and risk reduction for rocket propulsion system development with the ultimate goal to competitively procure launch services in a robust domestic launch market. The Air Force awarded a portfolio of investments through this BAA, totaling approximately $34 million, in the focus areas of Material Manufacturing and Development and Advanced Technologies. These acquisitions will mature booster propulsion technology and reduce risk within the U.S. domestic rocket engine industrial base.

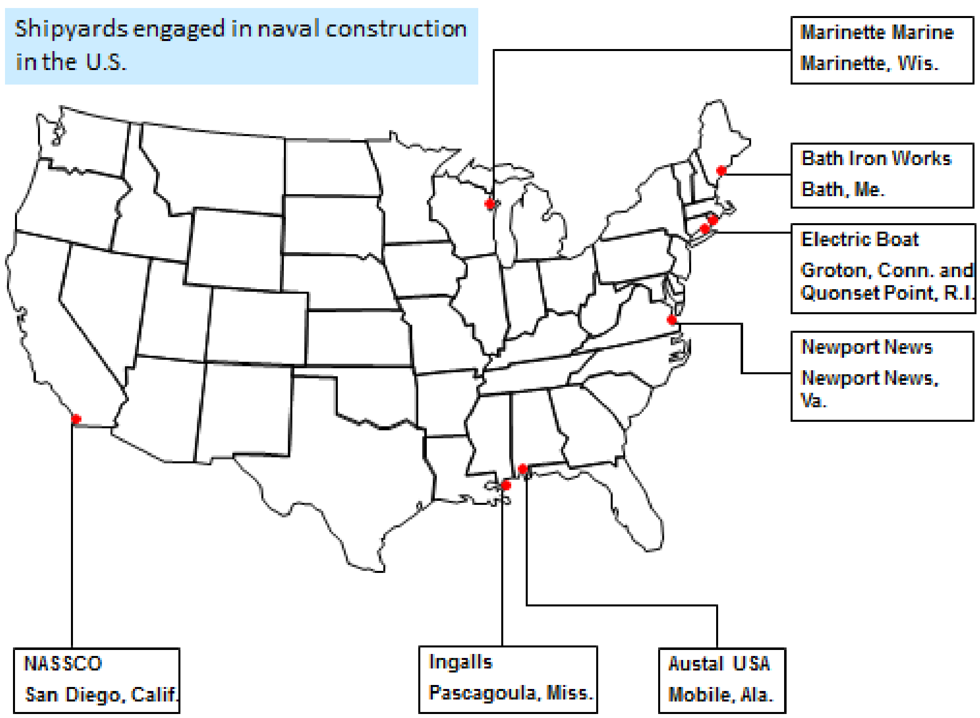
Second, the EELV Rocket Propulsion System (RPS) Prototypes RFP addresses the need to transition from the RD-180 main engine and implements Section 1604 of the FY 2015 NDAA, requiring the Secretary of Defense to develop a next-generation rocket propulsion system that enables the effective, efficient, and expedient transition from the use of non-allied space launch engines to a domestic alternative for national security space launches by 2019. This solicitation was part of the EELV Phase 2 acquisition strategy transitioning away from strategic foreign reliance, and it will support the U.S. launch industry's commercial viability, with the ultimate goal to competitively procure launch services in a domestic launch market. Awards from this solicitation will support a strategy of shared public-private investments to promote the development of a RPS prototype, ranging from full development of a new RPS, modifications to an existing RPS to meet NSS requirements, smaller projects to address high-risk items for an RPS or subcomponents, or activities required to test or qualify a new or existing RPS to meet EELV requirements. Awards from this RFP were made in early FY 2016.

5.7 Shipbuilding Sector Industrial Summary

Industry overview

The shipbuilding DIB consists primarily of seven shipyards owned by four companies and their suppliers. The shipyards and their locations are identified in Figure 5.7.1.

Figure 5.7.1 Primary U.S. Shipyards constructing ships for the Department of Navy



The DIB for shipbuilding is segmented by ship type: aircraft carriers, submarines, surface combatants, amphibious warfare, combat logistics force, and command and support vessels. The shipyards engaged in naval construction in the United States are identified in Table 5.7.2.

Table 5.7.2: Shipyards engaged in naval construction in the United States

Shipyard Engaged in Construction	Owner	Type of Ships	Programs
Bath Iron Works	GD	Surface combatants	Arleigh Burke Class Guided Missile Destroyer (DDG 51 Class)
			Zumwalt Class Destroyer (DDG 1000)
Electric Boat	GD	Submarines	Virginia Class Submarines (SSN)
NASSCO	GD	Command and Support vessels	Expeditionary Transfer Dock (formerly MLP)
			Expeditionary Sea Base (formerly AFSB)
Newport News	HII	Aircraft Carrier	Gerald R. Ford Class Nuclear Aircraft Carrier (CVN)
		Submarines	Virginia Class Submarines (SSN)
Ingalls	HII	Surface Combatant	Arleigh Burke Class Guided Missile Destroyer (DDG 51)
		Amphibious Warfare	America Class Amphibious Assault (LHA)
		Amphibious Warfare	San Antonio Class Amphibious Transport Dock (LPD)
		Cutters	National Security Cutters (WMSL)
Marinette Marine	FIN	Surface Combatant	Littoral Combat Ships (LCS)
Austal	AUS	Surface Combatant	Expeditionary Fast Transport (formerly JHSV) and Littoral Combat Ships (LCS)
GD - General Dynamics Corporation FIN - Fincantieri S.p.A.[51]			HII - Huntington Ingalls Industries, Inc. AUS- Austal Ltd.

In addition to the aforementioned shipyards, two mid-sized yards, Dakota Creek Industries and VT Halter Marine, are building an oceanographic research ship (AGOR 28) and an oceanographic surveying ship (AGS 66).

In FY 2015, the Navy Shipbuilding Industrial Base was engaged in various stages of construction of eleven different ship classes (DDG 1000, CVN 78, SSN 774, DDG 51, LPD, LCS, LHA(R), EPF (formerly JHSV), ESB (formerly MLP), T-AGS, and AGOR) and delivered five ships throughout the year (USNS TRENTON (EPF 5), USS JACKSON (LCS 6), USNS LEWIS B PULLER (ESB 3), USS JOHN WARNER (SSN 785) and NEIL ARMSTRONG (AGOR 27).

[51] Lockheed Martin is the prime contractor for LCS ships; however, the ships are built at the Marinette Marine shipyard.

In the FY 2016 FYDP shipbuilding plan, the Navy has begun the efforts to replace five aging ship classes. Two new amphibious programs [LHA 8 and LX-(R)], the fleet replenishment oiler program, the fleet ocean tug program, and the Ohio Replacement program will provide design and production workload for the winning shipyards. Where practical, and to the extent possible, competition is a key tenet of the acquisition strategy for these ships, as it translates into higher efficiency and cost savings for the Government. Table 5.7.3 depicts the planned shipbuilding contract awards.

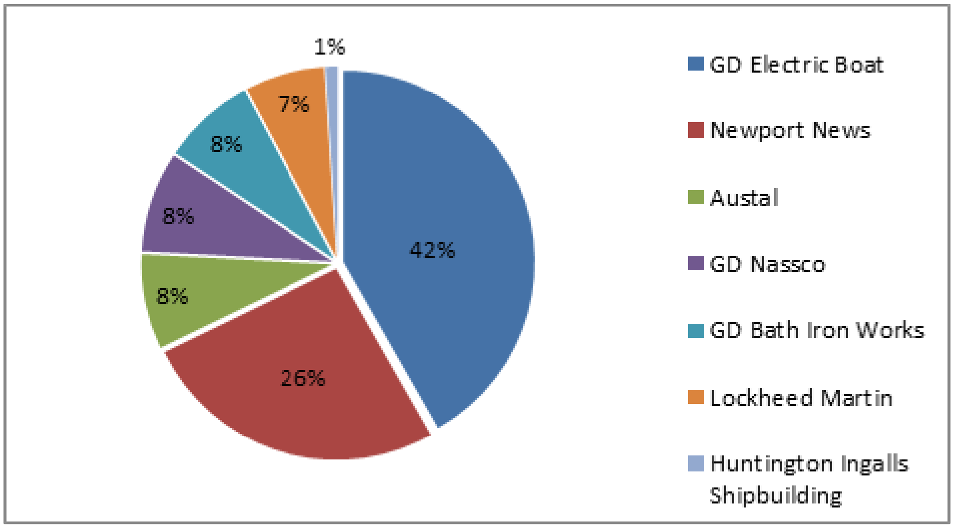
Table 5.7.3: Future Navy Shipbuilding Programs (based on FY 2016 procurement plan)

Program	Type of Ships	Expected Contract Award Year
Fleet Replenishment Oiler (T-AO(X))	Combat Logistics Force	2016
Fleet Ocean Tug (T-ATS, formerly known as T-ATF(X))	Command and Support Vessel	2017
Landing Helicopter Dock (LHA 8)	Amphibious Warfare	2017
Dock Landing Ship (LSD) 41/49 Class Replacement (LX-(R)	Amphibious Warfare	2020
Ohio Replacement Program (OR)	Submarines	2021

Budget Considerations

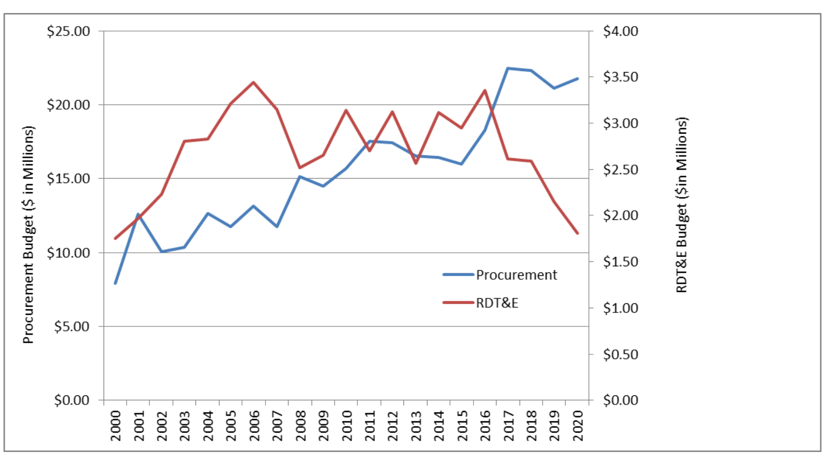
The U.S. shipbuilding industrial base depends on DoD business to sustain critical design and manufacturing skills as well as to maintain their current infrastructure. According to the FPDS, the U.S. Navy awarded around $10 billion in shipbuilding procurement contracts in 2015. Figure 5.7.4 provides the percentage of participation of the primary shipyards in the contracts awarded.

Figure 5.7.4 Percent of Navy's Contracts by Main Shipyards in 2015



In FY 2015, DoD's shipbuilding procurement funds increased by $723 million from FY 2014. Shipbuilding procurement funds are expected to continue increasing until 2020. The U.S. Navy was able to manage the effects of the 2013 sequestration due in part to key budget reprogramming actions made with Congressional support. In order to accomplish this, the Navy also applied mitigating actions to ships in execution and deferred costs to future years in order to avoid breaking programs. With the Bipartisan Budget Act (BBA) of 2013, discretionary funding caps were raised above sequestration level for FY 2014 and FY 2015. The Navy avoided the need to apply funding reductions across all programs in FY 2014 and FY 2015, allowing the Department to avoid discriminate funding reductions across all programs. While the BBA of 2013 provided some relief from sequestration-level funding in those years, significant shortfalls remained compared to the FY 2014 President's Budget. Funds for RDT&E remained stable. Figure 5.7.5 illustrates DoD's budget trends in the shipbuilding sector.

Figure 5.7.5 DoD's Budget Trends in Shipbuilding (Procurement and RDT&E funds based on 2016 Presidential Budget)



Source: Defense Research Data Warehouse

At-risk areas

The combination of new Navy and other Government agencies procurement and maintenance programs combined with commercial ship construction will help support the shipbuilding sector. However, reduced procurements and/or delayed contract awards may negatively impact the workload at the shipyards and, in some cases, disrupt production.

Critical Issues

The potential impact of additional budget cuts to existing contracts and future acquisition programs continues to be a concern. Given the dependence of the shipbuilding sector on defense contracts to maintain a skilled workforce and infrastructure, reductions in quantity and/or fleet composition may threaten the viability of some of the shipyards and their suppliers; therefore, reducing potential benefits achieved from competition in this market.

Long Term Challenges

The long-term challenge for the U.S. Navy is balancing the procurement of the Ohio Replacement program without impacting remaining shipbuilding programs. The Ohio Replacement program is the number one priority for the U.S. Navy and part of the national defense strategy to modernize the sea-based strategic deterrent submarine.

Mitigation Efforts

Through acquisition strategies, the Navy is promoting dual sourcing options to drive innovation and reduce costs. In order to maintain stability in the sector, the Navy is involving the shipyards early in the design process, supporting shipbuilding capabilities preservation agreements, and promoting block buys and multiyear procurement strategies. They are also monitoring the health of major suppliers and the quality trends across industry.

Construction plans have been developed to minimize impacts to the industrial base where possible in order to avoid future increases in cost above inflation or potential permanent losses to this national industrial capability.

6. Defense Mergers and Acquisitions

The Department examines potential transactions on a case-by-case basis. It is the Department's policy to oppose business combinations that:

- overly reduce or eliminate competition;
- limit innovation;
- raise credible threats to national security; and
- are not otherwise in the Department's or the public's ultimate best interest.

The Department reviews several types of business combinations involving defense suppliers:

- Proposed mergers or acquisitions filed under the Hart-Scott-Rodino Antitrust Improvement Act of 1976 (generally, transactions valued at more than $78.2 million in 2016);
- Other transactions and business relationships that are not considered by the antitrust agencies or those of special interest to the Department that do not meet the Hart-Scott-Rodino Act filing threshold; and
- Proposed acquisitions of U.S. defense-related firms by non-U.S. firms for which filings have been made pursuant to the Exon-Florio Amendment to the Omnibus Trade and Competitiveness Act of 1988, as amended by the Foreign Investment and National Security Act of 2007, (P.L. 110-49).

The first two review types are conducted under M&A reviews pursuant to DoD Directive 5000.62, "Impact of Mergers, Acquisitions, Joint Ventures, Investments, and Strategic Alliances of Suppliers on National Security and Public Interests." The third type of review is conducted by the Department under CFIUS.

6.1 Major Defense Supplier M&A Reviews

The Federal Trade Commission (FTC) and the Department of Justice (DoJ) (the "Antitrust Agencies") have the statutory responsibility to determine the likely effects of a defense industry merger on the performance and dynamics of a particular market and whether a proposed merger should be challenged on the grounds that it may violate antitrust laws. As the primary customer affected by defense business combinations, DoD's views have been particularly significant because of its special insight into a proposed merger's impact on innovation, competition, national security, and the DIB. Accordingly, the Department actively works with the Antitrust Agencies but also independently addresses issues where appropriate.

The Department's transaction reviews are structured to identify impacts on competition, national security, and defense industrial capabilities. The reviewers evaluate the potential for loss of competition for current and future DoD programs, contracts and subcontracts, and for future technologies of interest to the Department. In addition, the reviews address any other factors resulting from the proposed combination that may adversely affect the satisfactory completion of current or future DoD programs or operations. The policies and responsibilities for assessing major Defense supplier M&A reviews are identified in DoD Directive 5000.62. While these reviews can include transactions that are also evaluated in the CFIUS review process, the issues considered are distinct.

The Department's current policy is to conduct assessments of proposed business combinations on a case-by-case basis and to support the Antirust Authorities' review process. The Department's reviews have included the consideration of potential impacts on national security, but recent transactions have demonstrated that the current antitrust provisions may be too narrowly constrained. The current law only prohibits M&A that are found to lessen competition or which tend to create a monopoly. Potential national security implications or possible harm to the overall public interest associated with a proposed transaction are not considered. Reviewing transactions to assess the national security implications is critical to stewardship of an industrial base structure needed to meet national security objectives. Defense firms are not just other commercial businesses. They provide a critical service to the nation, providing the equipment and support that our armed forces use to ensure the security of our country.

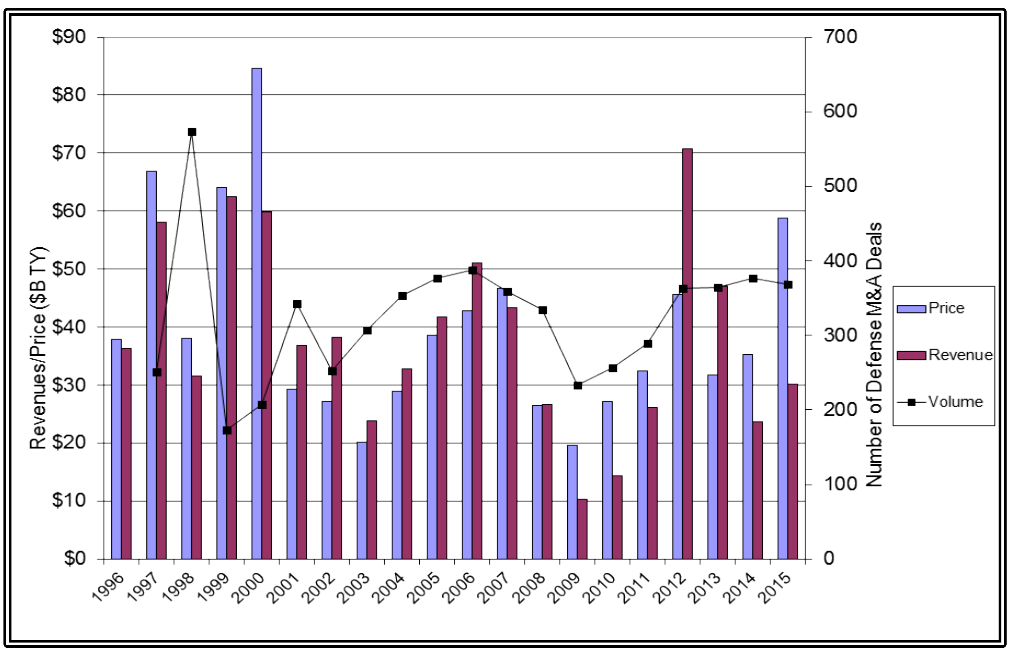
The Department will continue to work closely with the Antitrust Authorities to ensure that transactions do not reduce competition or cause market distortions that are not in the Department's ultimate best interest. DoD relies on robust, credible competition to provide high-quality, affordable, and innovative products. The trend toward fewer and larger prime contractors has the potential to affect innovation, narrow industrial capabilities and technology, limit the supply base, pose entry barriers to small, medium and large businesses, and ultimately reduce competition, or may otherwise not be in the Department or the public's interests. The Department is mindful of the past loss of peer-to-peer competition at the prime level, resulting from significant industry consolidations over the past twenty-plus years. The Department has been concerned about M&A among the top tier of weapons suppliers for some time and does not view consolidation among our top weapon system primes as a favorable development.

The competitive dynamics and the positioning of defense firms are significantly different today than in the 1990s. With the excess capacity overhang resulting from the budget decline at that time, the Department anticipated that consolidation rationalization benefits would offset harm to competition. In retrospect, the proposed benefits may not have been realized to the extent anticipated. Today, there is a lower potential for M&A-derived reductions of excess capacity and overhead to offset the loss of competition, and the Department is increasingly skeptical about proposed benefits. In response to the recent budget restrictions, the major defense contractors largely addressed expenditure declines through internal rationalization through workforce and facility footprint reductions. Therefore, the Department does not currently believe consolidation is systemically necessary to maintain healthy industrial base dynamics.

6.1.1 Major Defense Supplier M&A Activity in 2015

In 2015, the Department completed 12 reviews of significant transactions out of the approximately 370 defense-related M&A over the course of the year. The table below highlights the aggregate number and value of these transactions, as reported by InfoBase. While the total revenue of the transactions has fallen since the 2012 high (influenced by United Technologies' $18.4 billion acquisition of Goodrich), the number of transactions has remained steady. The spike in the aggregate deal valuation is led by Lockheed Martin's $7.1 billion acquisition of Sikorsky, Orbital's $5 billion merger with ATK, and Harris' $4.75 billion acquisition of Exelis.

Figure 6.1.1 Defense-related M&A Transaction



Source: Infobase Defense Merger & Acquisition data on publicly announced deals.
Includes foreign-only deals and failed deals. (Defense Merger and Acquisition Transactions 1996-2015).

The Department reviewed a wide range of transactions in 2015, including the ultimately blocked acquisition of BumbleBee Tuna by Thai Union, the owner of Chicken of the Sea, Orbital's acquisition of ATK, and Harris' acquisition of Exelis. However, 2015 was dominated by Lockheed Martin's acquisition of Sikorsky, the largest defense transaction since the 1990s.

6.2 Committee on Foreign Investment in the United States

Section 721 of the Defense Production Act of 1950 (50 U.S.C. Section 4565) authorizes the President, acting through CFIUS, to review any merger, acquisition, or takeover proposed by any foreign person that could result in foreign control of any person engaged in interstate commerce in the United States (a "covered transaction"). The Committee is chaired by the Secretary of the Treasury and includes the Secretaries of State, Defense, Commerce, Energy, and Homeland Security, the Attorney General of the United States, and the United States Trade Representative.

A CFIUS review is intended to determine the effects of a covered transaction on the national security of the United States. The factors affecting national security, which the Committee may consider as part of this review, are broad, including:

- The capability and capacity of domestic industries to meet national defense requirements;
- The control of domestic industries and commercial activity by foreign citizens as it affects the capability and capacity of the United States to meet the requirements of national security;
- The potential effects on sales of military goods, equipment, or technology to countries involved in terrorism, proliferation, or that pose a potential regional military threat to the interests of the United States;
- Potential effects on United States international technological leadership in areas affecting United States national security;
- Potential effects on United States critical infrastructure, including major energy assets;
- Potential effects on United States critical technologies;
- Whether the transaction could result in the control of any person engaged in interstate commerce in the United States by a foreign government, either directly or indirectly; and
- Such other factors as the President or CFIUS may determine to be appropriate.

MIBP, on behalf of USD(AT&L), has the lead within the Department in representing the Department at CFIUS. MIBP coordinates its work on CFIUS matters with a wide range of internal Department stakeholders and experts. Pursuant to 10 U.S.C. Section 2537(c), the Defense Intelligence Agency provides the Department with an assessment of the risks of unauthorized technology transfer and diversion. Pursuant to the Foreign Investment and National Security Act of 2007 (FINSA) (P.L. 110-49), the Office of the Director of National Intelligence prepares a national security threat assessment for CFIUS that evaluates potential threats posed by the acquiring firm and country.

For each covered transaction, the Secretary of the Treasury designates a lead agency on behalf of the Committee. When the Department as lead agency concludes that a covered transaction poses a threat to the national security of the United States, it may, on behalf of the Committee, negotiate, enter into or impose, and enforce any agreement or condition with any party to the covered transaction in order to mitigate the threat. As part of this mitigation process, the Department develops, in conjunction with the Committee, a risk-based analysis of the threat to national security arising from the transaction. The Department will then monitor the completed transaction to ensure compliance with any mitigation agreements or conditions imposed on the parties to a transaction.

Ultimately, if the President finds that there is credible evidence that a covered transaction might impair the national security of the United States and that neither CFIUS mitigation nor any other provision of law do not, in the judgment of the President, provide adequate and appropriate authority for the President to protect national security, the President may take action to suspend or prohibit any such covered transaction.

Finally, it is important to note the special confidentiality requirements imposed by Congress on CFIUS-related information, both on the Executive Branch and on itself. Any information filed with CFIUS is exempt from disclosure under the Freedom of Information Act (5 U.S.C. Section 552), and no such information may be made public, except as may be relevant to any administrative or judicial action or proceeding. While nothing in statute shall be construed to prevent disclosure of any such information to Congress, members of Congress and their staff are subject to the same limitations on disclosure as the Executive Branch. Furthermore, proprietary information that can be associated with a particular party to a covered transaction can be furnished only to a committee of Congress and only when the Committee provides assurances of confidentiality, unless such party otherwise consents in writing to such disclosure.

7.0 Programs and Actions to Sustain Capabilities

7.1 The Defense Production Act

DPA, as amended (50 U.S.C. App., §2061 et seq.), is the primary source of presidential authorities to expedite supply and expand productive capacity of materials and services needed to promote the national defense. For the purposes of the DPA, "national defense" means programs for military and energy production or construction, military, or critical infrastructure assistance to any foreign nation, homeland security, stockpiling, space, and any other directly related activity. National defense also includes emergency preparedness activities conducted pursuant to Title VI of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) (42 U.S.C. § 5195 et seq.) and critical infrastructure protection and restoration.
Major DPA provisions include:

- The authority to require acceptance and priority performance of contracts and orders to promote the national defense (DPA section 101);

- The authority to allocate materials, services, and facilities in such manner, upon such conditions, and to such extent as deemed necessary or appropriate to promote the national defense (DPA section 101);

- Various forms of financial incentives and assistance for industry to reduce current or projected shortfalls of resources essential for the national defense; or to create, maintain, protect, expand, or restore domestic industrial base capabilities essential for the national defense (DPA Title III);

- Antitrust protection for voluntary agreements and action plans among business competitors to enable cooperation to plan and coordinate measures to increase the supply of materials and services needed for the national defense (DPA section 708);

- The authority to establish a cadre of persons with recognized expertise for employment in executive positions in the Federal Government in the event of an emergency (DPA section 710(e)); and

- The authority to review certain mergers, acquisitions, and takeovers by or with any foreign person that could result in foreign control of any person engaged in interstate commerce in the United States (DPA section 721).

7.1.1 DPA Title III Program Execution

In 2015, the DPA Title III Program had 34 projects (some with multiple industry partners) underway during the course of the year, and five of those projects concluded by the end of the year. At the start of CY 2015, 30 domestic firms were executing agreements or contracts. Pre-award acquisition activities were initiated for an additional 12 projects in 2015, anticipating contract awards in 2016.

DoD budgets for the baseline DPA Title III program. Projects are developed in response to specific Government requirements and associated funding that is provided for these efforts. Detailed descriptions of the CY 2015 projects are provided in Appendix C, Section C.1 "Title III – Defense Production Act Summaries Defense Production Act Title III Program Execution."

7.2 DoD Manufacturing Technology Program

For over 50 years, the DoD ManTech Program has demonstrated its value through process technologies that make new products possible as well as through manufacturing process improvements that focus specifically on defense system affordability challenges. The program provides the crucial links from technology invention to production of defense-critical needs in areas beyond normal investment risks within industry. ManTech ensures technology is affordable and producible, both of which are key to the Department's BBP initiative, and ensures that U.S. military forces are more agile, deployable, sustainable, lethal, and dominant. While ManTech investments generally translate into initial system affordability improvements or cycle time reduction, investments are also made in new capabilities that provide dividends in system performance or life cycle cost that can far outweigh the initial system delivery costs.

The industrial base is significantly enhanced through ManTech Program enabled transition of S&T successes. Specifically, ManTech serves as an important mechanism for technology transition, bringing affordable technologies to acquisition program managers through new manufacturing and production processes and systems, thus bridging the gap between discovery and implementation of new capabilities for the Warfighter. Further, the DoD ManTech Program can contribute important information to MIBP's ongoing industrial base analyses through its operational perspectives of defense manufacturing capabilities as well as its deepening understanding and insights of technology-based supply chain risks. Conversely, ManTech can be used as an appropriate investment lever for targeted industrial base intervention, when necessary, to help the Department close newly identified, defense-critical, manufacturing technology related supply chain gaps.

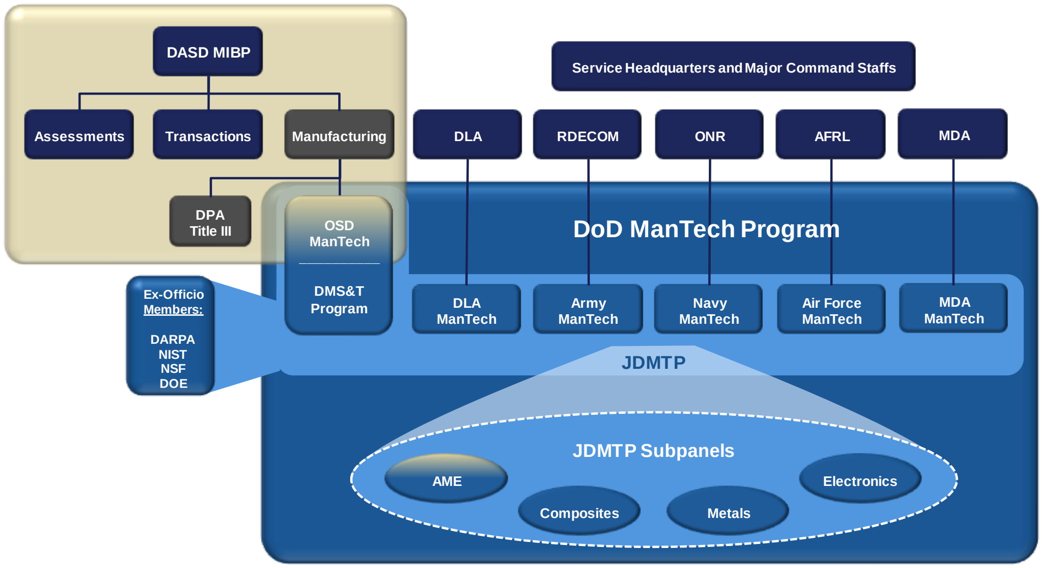
While ManTech is not statutorily structured to address the entirety of DIB challenges, it is a highly versatile R&D investment program that can serve as a key focal point to bring attention and technological resources to bear on the Department's most pressing requirements for affordable modernization and sustainment. The ManTech Program shares an expansive vision with the broader defense manufacturing enterprise; namely, *a responsive, world-class manufacturing capability to affordably and rapidly meet Warfighter needs throughout the defense system life cycle*. This vision captures the overriding imperative to satisfy Warfighter requirements across the spectrum of manufacturing activities while doing so *affordably* and *rapidly*. Congress has long recognized this essential, enabling role, establishing ManTech in Section 2521 of Title 10, United States Code to:

> *…further…national security objectives…through the development and application of advanced manufacturing technologies and processes that will reduce the acquisition and supportability costs of defense weapon systems and reduce manufacturing and repair cycle times across the life cycles of such systems.*

The program's mission is both multi-faceted and vital; namely, DoD ManTech anticipates and closes gaps in manufacturing capabilities for affordable, timely, and low-risk development, production, and sustainment of defense systems. The program looks beyond the normal risk of industry, and directs investments at improving the quality, productivity, technology, and practices of businesses and workers providing goods and services to the DoD. ManTech's role as a crucial link between technology development and industrial application gives the program a unique and vital position within the DIB and broader strategic security environment.

Section 2521 of Title 10, United States Code (10 U.S.C. 2521) requires the USD(AT&L) to administer the DoD ManTech Program on behalf of the Secretary of Defense, and this is further delegated to the DASD(MIBP), which exercises OSD-level oversight of the ManTech Program pursuant to 10 U.S.C. 139c. Component ManTech programs are individually executed by the Departments of the Army, Navy, Air Force, DLA, MDA and OSD.

Figure 7.2.1: DoD ManTech Program Organization



These Component programs collaborate and coordinate their efforts through the Joint Defense Manufacturing Technology Panel (JDMTP), depicted within the blue box in Figure 7.2.1. The Principals of the JDMTP are senior technology managers representing the Army, Navy, Air Force, DLA, MDA and OSD. The OSD Principal possesses the dual role of communication link to OSD through MIBP as well as manager of the DMS&T Program line. Ex-officio members of the JDMTP include DARPA, National Institute of Standards and Technology, NASA, and DoE. The JDMTP categorizes ManTech investment areas by the technology portfolios of subpanels—the current subpanels are Electronics, Metals, Composites and Advanced Manufacturing Enterprise—enabling Component ManTech programs to maximize opportunities for shared investment in initiatives and strategies with joint application and to prevent duplication of effort.

Component ManTech programs are each overseen and managed from within the S&T organizational structures of their associated DoD Component. Additionally, the DASD(MIBP) ManTech Office administers the DMS&T Program and is a member of the S&T Executive Committee composed of those key organizations in DoD that oversee and coordinate the S&T activities of the Department. Although all Component ManTech programs work in concert toward common goals, each has important focus areas to meet individual Component mission needs.

- The Army ManTech Program is structured around enabling manufacturing improvements of components and subsystems for ground, Soldier/squad, air, lethality and command, control, communications, and intelligence systems.

- The Navy ManTech Program's critical goal is to reduce the acquisition cost of current and future platforms, resulting in an affordability investment strategy currently focused on five ship platforms as well as the F-35 and CH-53K aircraft.

- The Air Force ManTech Program is the DoD lead for manufacturing technology in aerospace propulsion, structures, and ISR, and is the only Air Force corporate program working strategic issues and opportunities in manufacturing and industrial readiness. Manufacturing Technology plays a pervasive role in enabling many Air Force S&T Strategy priorities, chiefly through attaining next-generation agile manufacturing.

- The DLA ManTech Program focuses on sustaining the Warfighter and improving materiel readiness; ongoing efforts seek to 1. Improve Industrial Base Manufacturing (additive, casting, forgings, batteries), 2. Maintain Viable sources of Supply (microcircuits, strategic materials), and 3. Improve Technical and Logistics Information (MBE, DLIR, 3-D TDP).

- The OSD-managed DMS&T Program takes a broad, overarching view towards closing critical gaps in cross-cutting, military manufacturing enabling technologies that will have a significant impact on multiple Military Departments or platforms.

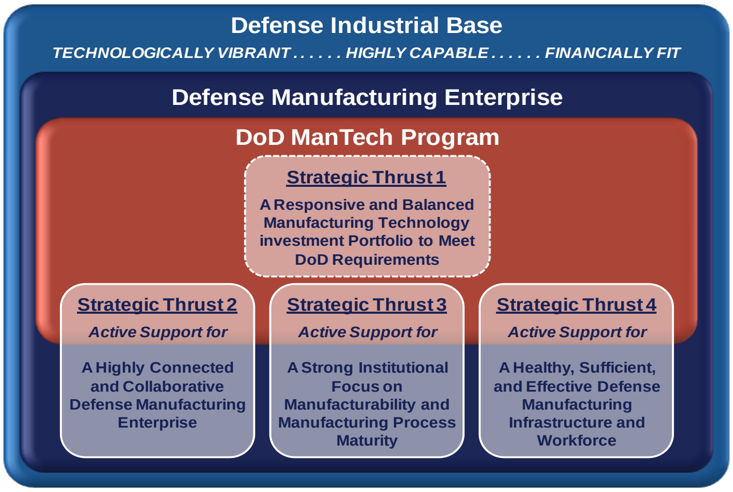
The JDMTP and MIBP jointly developed a 2012 DoD ManTech Program Strategy[52] that recognizes the ManTech Program's central role within the defense manufacturing enterprise and its extended impacts and leverage across the DIB and broader national security environment.

The theme of the strategy is Delivering Advanced, Affordable Manufacturing for the Warfighter, and the following four strategic thrusts (with supporting enabling goals) have been established to unify and guide the joint ManTech enterprise, consistent with the USD(AT&L)'s BBP initiatives and the defense manufacturing vision and ManTech Program mission:

- Thrust 1: A Responsive and Balanced Manufacturing Technology Investment Portfolio to Meet DoD Requirements.
- Thrust 2: Active Support for a Highly Connected and Collaborative Defense Manufacturing Enterprise.
- Thrust 3: Active Support for a Strong Institutional Focus on Manufacturability and Manufacturing Process Maturity.
- Thrust 4: Active Support for a Healthy, Sufficient, and Effective Defense Manufacturing Infrastructure and Workforce.

[52] DoD ManTech Program Strategic Plan. https://www.dodmantech.com/relatedresources/DoD_ManTech_Pgm_2012_Strat_Plan.pdf.

This framework establishes the program's core focus on ensuring responsiveness and balance across the full portfolio of manufacturing technology investments (Thrust 1), and it couples that focus with the objective to actively and collectively support broader defense manufacturing needs (Thrusts 2, 3, and 4). This approach underscores the importance of program support for these broader needs while recognizing it is beyond the program's charter and resources to fully satisfy them. Even so, each of these four thrusts directly supports the Secretary of Defense's current strategic guidance in key ways. In particular, processing and fabrication breakthroughs enable affordable production for effective modernization; material and manufacturing investments made concurrently with S&T R&D projects deliver technological superiority to the Warfighter quickly; and enterprise level initiatives create more connected and collaborative environments, a stronger focus on manufacturability, and improved manufacturing infrastructure. All of these support the maintenance of a healthier and more resilient industrial base.



The JDMTP is moving forward with joint planning and coordination on major weapon systems. In the case of the F-35 Lightning II, four ManTech projects—two Navy and two Air Force—directly impacted F-35 affordability. With a combined investment of $14.5 million, these initiatives are projected to reduce F-35 program costs by $1.1 billion over 30 years of production. More importantly, these technology advances can be leveraged by current and future defense programs to reduce costs and bolster U.S. manufacturing capabilities.

Other successful projects include:

- The Joint DMS&T/Army ManTech program Affordable Substrates for Focal Plane Arrays significantly increases the Warfighter's access to night-vision capabilities. Yields increased from 30–90 percent, size increased more than 25 percent, DoD saved $150, and most importantly, it strengthened the supply chain.

- Chip Scale Atomic Clock program enables precise timekeeping within C4ISR systems in GPS-denied environments, reduces unit cost from $8,700 to ~$400 and raises unit production from 100 per year. to 40,000 per year. Potential savings is approximately $291 million.

- Army ManTech enabled affordable low light sensor for multiple weapon systems (Apache, Soldier Systems, and F-35 JSF): increased life 10X, decreased cost 75 percent, ROI of 85-1 with $907 million cost benefit.

- Virginia Class Submarine initiative-36 of the ManTech affordability projects have been implemented or are in process. Realized cost savings/hull of over $32.4 million has been recognized by the VIRGINIA Class Program Office and General Dynamics Electric Boat, returning the entire annual Navy ManTech Budget through savings of greater than $60 million per year.

- Air Force ManTech delivers Vertical-cavity Surface Emitting Lasers (VCSELS) for UAS, doubling yields and decreasing cost by 10X. VCSEL ManTech enables use in weapon illumination and rangefinders, low cost security, and laser welding.

Further joint planning and coordination are exercised by the JDMTP Subpanels. In response to the 2012 ManTech Strategy, and particularly in support of Thrust 1, the JDMTP began to develop Joint Technical Pursuit Areas (JTPAs) as part of the annual planning cycle. Thrust 1 focuses on the need to balance mission-specific priorities of Service ManTech Programs with broader Joint-Service priorities, which can deliver significant advantages to the DIB. JTPAs represent manufacturing challenges, which cross-cut multiple Services and multiple systems; topics which are beyond the risk for a single Service, but provide dramatic return on investment (ROI) through Joint-Service collaboration.

7.3 Manufacturing Innovation Institutes

The Administration has signaled the growing importance of advanced manufacturing to the economic and national security of the United States. Key examples include:

- The President's Council of Advisors on Science and Technology (PCAST) 2011 report, *Ensuring American Leadership in Advanced Manufacturing*;
- The 2011 establishment of the President's Advanced Manufacturing Partnership (AMP) initiative across Government, industry, and academia;
- The 2012 State of the Union Address emphasis on manufacturing's importance to the nation;
- The 2012 release of the National Science and Technology Council's (NSTC), *National Strategic Plan for Advanced Manufacturing;*
- The formation of the Department of Commerce-hosted Advanced Manufacturing National Program Office (AMNPO) supported by DoD and other Interagency partners;
- The release of *Capturing Domestic Competitive Advantage in Advanced Manufacturing,* the final report from the Advanced Manufacturing Partnership Steering Committee created by the President;
- The 2013 State of the Union Address announcement of the formation of three new Institutes of Manufacturing Innovation, one led by Department of Energy and two led by DoD;
- The 2013 launch of the Advanced Manufacturing Partnership Steering Committee "2.0;"

- The 2014 State of the Union Address announcement of four additional Institutes for Manufacturing Innovation; and
- The October 2014 PCAST report to the President, *Accelerating U.S. Advanced Manufacturing.*

In support of these and the NNMI in particular, DoD provided key funding, technical leadership, and program management support to successfully launch the $110 million "pilot" institute, the National Additive Manufacturing Innovation Institute (NAMII). Now called "America Makes," the Institute officially opened on September 27, 2012, and it will serve as a training and collaboration center to bridge the gap between basic research and technology adoption for additive manufacturing design and technologies. More commonly known as "3D printing," additive manufacturing is an enabling manufacturing technology for our military platforms. Participants include DoD, DoE, NASA, National Science Foundation (NSF), and the DoC's National Institute of Standards and Technology (NIST). The interagency investment of $55 million has been matched by a $55 million cost share from non-Federal sources, and this institute has the goal of becoming self-sufficient within five years.

Building upon that success, DoD then led an effort to launch two new public-private partnerships for Advanced Manufacturing on behalf of the Department: the Digital Manufacturing and Design Innovation Institute (DMDII) and Lightweight Innovations for Tomorrow (LIFT) The $176 million DMDII, headquartered in Chicago, Illinois, focuses on enterprise-wide utilization of the digital thread, enabling highly integrated manufacturing and design of complex products at reduced cost and time. The digital thread captures information generated from concept development and design to analysis, planning, manufacturing, assembly, maintainability, and through to disposal. By demonstrating the potential for integrating information technology, smart factory processes, intelligent machines, and sophisticated analytics, DMDII will be a key competitive differentiator for the U.S. industrial base. The $148 million LIFT institute focuses on the design of lightweight systems, including the design of lightweight materials, the design of manufacturing operations to produce lightweight components, and the integration of these designs into revolutionary new lightweight systems. During the past 15 years, significant U.S. investments in lightweight metals, intended for demanding critical applications, have not transitioned into the marketplace due to cost of necessary scale-up and certification requirements. Defense, transportation, energy, and automotive industrial segments all benefit significantly from lightweight structures and components. By integrating the emerging capabilities in materials and process design, with the design of new lightweight components and products, the speed at which products enter the marketplace can be accelerated, at competitive price points, and drive global competitiveness.

In 2015, the ManTech Program continued its successes by establishing two additional institutes, with technical focus areas of integrated photonics (IP) manufacturing and flexible hybrid electronics manufacturing. AIM Photonics, with $600 million of total funding, will seek to automate the assembly of integrated photonics systems to minimize the touch-labor component, whose high cost has prompted industry to seek offshore production solutions in recent decades. Headquartered in New York, with founding academic partners in California, Massachusetts, and Arizona, AIM Photonics will bring government, industry, and academia together to organize the current fragmented domestic capabilities in integrated photonics and better position the U.S. to compete globally. IP applications include ultra high speed data and communications, high-performance IT systems, medical diagnostics, and multiple sensor integrations.

The second institute, NextFlex, is headquartered in San Jose, California, with total funding of $176 million. NextFlex will focus on innovative processes at the intersection of the electronics industry and the high-precision printing industry, with the power to create electronics or sensors that are lighter in weight, or conform to the curves of a human body, while preserving the full operational integrity of traditional electronic architectures. Integrating ultra-thin silicon components through high-precision handling, printing with conductive and active inks, and printing to integrate on stretchable substrates, flexible hybrid technologies can improve the connectivity of devices through the Internet of Things. Applications of flexible hybrid electronics include medical monitoring, asset tracking, soft robotics, and highly integrated wearables.

During 2016, ManTech will work towards establishing three additional institutes. Revolutionary Fiber and Textiles will focus on manufacturing of technical textiles, consisting of fibers and fabrics with extraordinary properties of strength, flame resistance, and electrical conductivity, among others. These technical textiles are built upon a foundation of synthetic, natural fiber blends, and/or multi-material fibers that have a wide-range of applications in both the defense and commercial sector that go beyond traditional wearable fabrics. Two additional institutes will be developed based upon opportunities and key demand signals from DoD, industry, and academia.

All the existing DoD Institutes, along with the two DoE-led institutes focused on wide bandgap semiconductor power electronics and advanced composites, are members of the NNMI formed to directly support the national agenda to aggressively develop or sustain world-leading, advanced manufacturing capabilities. Congress authorized the establishment of a national network as part of the Revitalize American Manufacturing and Innovation Act of 2014.

7.4 Industrial Base Analysis and Sustainment Program

The IBAS program's main objective is to address critical capability shortfalls in the DIB. Capabilities that are at-risk of being lost and cross Service/DoD-Agency boundaries are specifically targeted. The goal is not to sustain all capabilities indefinitely but to avoid reconstitution costs when capabilities are likely to be needed in the foreseeable future. IBAS makes investments only when sustainment is more cost-effective than reconstitution and results in overall cost savings to the Department.

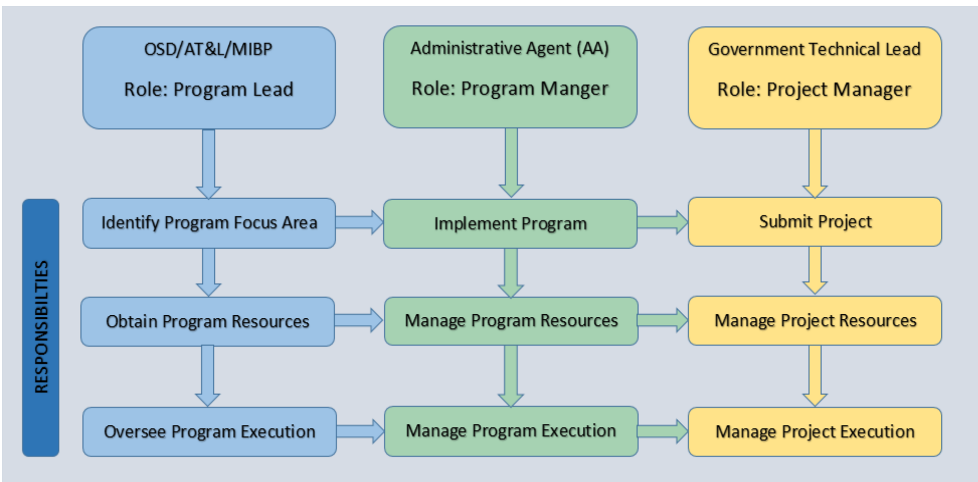
The three areas of IBAS focus are:

- Unique Capabilities – Lifelines and Safe Harbors for critical, unique capabilities with fragile business cases.
- Design Teams – Preserving Critical Skills for technological superiority.
- Industrial Base Supply, Expansion & Competition – Supporting expansion of Reliable Sources.

Proposals for IBAS funding are evaluated in a four step process. First, proposals are scored with established fragility and criticality criteria. Fragility examines characteristics that make a specific capability likely to be disrupted. Criticality examines characteristics that make a specific capability difficult to replace if disrupted. Second, proposals are reviewed for alignment with IBAS objectives. Third, proposals are ranked by a multi-Service/multi-Agency Joint Industrial Base Working Group (JIBWG) review panel. Fourth, DASD(MIBP) evaluates the review panel results and makes the final selections for IBAS funding.

The IBAS Program is executed according to the following framework:

Figure 7.4.1: IBAS Program Framework



The ultimate responsibility for program execution lies with MIBP. The office is responsible for ensuring the areas being addressed are based upon the latest vulnerability information associated with the DIB. Focus areas can change year to year for a variety of reasons including budget shifts, changes in risk, and technology advancements that can render current capabilities obsolete.

While MIBP is responsible for submitting and tracking the annual budget requests and for execution, they depend upon an Administrative Agent for actual day-to-day management of the program. This agent calls for project proposal submissions, tracks project progress, and interacts with the individual Government technical leads who directly liaison with the principle performers of the work. They follow the program strategy as directed by the MIBP program office while pre-screening all proposals submitted for consideration and provide an evaluation and ranking to the JIBWG review panel.

Sources for IBAS project ideas come from a variety of different sources. A general call for proposals can be sent to the DoD SAEs and Agencies. Sector specific working groups, such as the SIBWG or the CEMWG, can engage the IBAS program office directly. Additionally, industrial base FaC assessment results can be used to target specific areas of concern.

Program Details.

Since program inception, the IBAS program has sponsored 14 major efforts during FY 2014 and 2015. These programs have preserved fundamental capabilities across the IB in all three of the IBAS focus areas. A brief synopsis of these efforts is provided below.

Lifelines and Safe Harbors – Preserving Unique Capabilities

- *Counter Bomber* – IBAS has sustained this unique suicide bomber detection capability that was in fiscal jeopardy as declining troop deployments reduced demand. This system will now be enhanced and available to be utilized in military and commercial applications, both domestically and abroad.

- *Cyclotron* – This rare capability to perform radiation testing on space hardened components was preserved by IBAS at the University of California, Berkeley. Using ion "cocktail" beams, parts are pre-qualified to ensure they meet standards required to reduce in-service failures before they are deployed into space.

- *Electromechanical Actuator Planetary Roller Screw* – IBAS sustained the domestic capability to produce non-commercial actuators tailored to unique Navy requirements. Government lifecycle funding anomalies jeopardized timely procurement and sole source provider viability of the elevator actuator system used in the Ford Class aircraft carriers and the Littoral Combat System (LCS) Class ships.

- *Thermal Batteries* – The decline in missile production has made the industrial base for thermal batteries very fragile. Production is falling below minimum sustaining rates. IBAS has initiated three projects for thermal battery technical improvements in battery materials and shelf life that will lower minimum sustaining rates: improved material composition that will provide additional domestic suppliers, characterization of Thermal Battery shelf-life model to enhance production quality and sustainment (reducing costs and industrial base burden), and improved thin film production to broaden and improve the market.

Design Teams – Preserving Critical Skills.

- *FPAs*: Next Generation Development – IBAS preserved an industry design team capable of performing the design research necessary to advance the next generation of FPAs. Maintaining this design team averted an imminent sole source situation. This project will have a positive impact on the ground vehicle and aircraft DoD industrial base sectors for years to come.

- *MCT production for FPAs*: The IBAS program preserved a valuable design team responsible for advancing the production of MCT. Infrared (IR) detectors play a critical role in detecting and monitoring defense and meteorological events on both terrestrial and space electro-optical (EO) systems. There is currently only one affordable solution for these systems, MCT. No other detector material exists today that has demonstrated comparable performance or Technology Readiness Levels/Manufacturing Readiness Levels (TRL/MRL) as MCT. If MCT FPA manufacturing capability was lost, the United States would not have the superior capability to see first, most, and farthest. Volumes for MCT wafer fab production have fallen below the historical annual average for the past seven years. The business case for this situation has resulted in deep staffing cuts of skilled operators. Further reductions will require making radical decisions to down-scale capability.

- *Advanced Solid Rocket Propulsion*: This IBAS project focused on supporting and maintaining a design team with special talents for developing weapon systems applications using solid rocket propulsion. This project resulted in a new Solid Diverter and Attitude Control System (SDACS), which can be used in future missile interceptor missions with advanced kill vehicle thrusters for high precision and long duration missions. This project enhanced the DACS capability in the United States specifically cited as an industrial base concern by Congress. Additional work is planned to exercise design teams with innovations on small, tactical, solid rocket motors.

- *Fuzes*: Because of the decline in missile production, fuzes are experiencing a decline in production, making the industrial base very fragile. Without intervention, loss of industry design and production expertise is expected for ESAD-based fuzes. ESADs are most commonly used in missile fuzing, but they have applicability to some of the Department's most critical gun fired and air delivered munitions as well. To improve the industrial base capability, IBAS is funding EASD design projects for cost reduction and commonality across multiple missile and munition end-products. Phase I was initiated by contracting with three different suppliers to exercise their engineering capability, including the use of sub-tier suppliers and component technology, to develop lower cost, common architecture ESAD designs. These three suppliers form the critical core of the U.S. Industrial Base for fuzes overall. Phase II is planned for award in FY 2017. In this phase, the work from Phase I will then be applied against a post milestone C munition, which can benefit the most from an upgraded fuze capability.

Industrial Base Supply, Expansion & Competition – Expanding Reliable Resources

- *BT*: The IBAS program addressed a sole source situation for this critical energetic ingredient used as a rocket propellant precursor chemical. The sole source was also a prohibited source. Major process engineering and a minor modification to a defense contractor facility enabled the first full-rate domestic production of this material since 2002. This project will ensure the sustainment of this capability across many DoD programs, including the HELLFIRE, JAGM, TOW, Javelin, Griffin, AIM-9x, AEGIS, and Chaparral weapon systems.
- *Hydroxyl Terminated Polymer of Butadiene (HTPB)*: This project will provide a reliable second source for HTPB R45M, a polymer that is a key component in the majority of DoD missile systems. There is risk of unavailability of this material for key DoD weapons systems.
- *Low Energy Expanding Foil Initiator*: This IBAS project established a second reliable source for an at-risk producer of detonators used by 12 key DoD weapons systems.
- *Radiation Hardened Bi-polar Transistors*: IBAS preserved a second source for technology vital to National Security. These particular components are used on most space-based platforms and strategic military systems. The Trident program also heavily relies on these components.
- *Large Steel Cartridge Cases*: This project will develop an alternate process for manufacturing large steel cartridge cases. The only known worldwide manufacturer of deep drawn cartridge steel cases for "Navy 5" guns and the Long Range Land Attack Projectile has divested of the business and the current production facility, which is owned by the U.S. Government, is in a lay-away status at Rock Island Arsenal.
- *Aerospace Structures*: This project seeks innovation on aerospace structures.

IBAS is successfully supporting the National Defense Strategy by maintaining and improving the health of critical and fragile IB capabilities that are at risk of being lost. Projects address cross-service capabilities at risk of "falling through the cracks." The IBAS sustainment of these capabilities has shown great success in keeping critical industrial capabilities alive, enhancing the readiness and effectiveness of our National Defense, and lowering total cost to DoD.

8.0 Conclusion

In 2015, the Department made significant progress in aligning its capabilities to better maintain and expand the DIB. MIBP helped to lead DoD's efforts to address and mitigate the Department's industrial base concerns through the establishment and utilization of various programs and activities. Highlights of 2015 activities included:

- Establishment of DIUx and a concerted effort to improve DoD's collaboration with both traditional defense contractors and the non-traditional commercial high-tech industry;
- Establishment of two new MIIs, AIM Photonics and NextFlex, and commitments to establish three additional institutes by the end of 2017;
- Conduct of industrial base assessments on SRMs, Microelectronics, and other areas, as well as an assessment of the potential impact of the Budget Control Act on all the industrial base sectors;
- Creation of the IBC to provide an executive level forum for senior DoD leaders to review and discuss key DIB trends and issues; and
- Conduct of fourteen IBAS projects to preserve fundamental industrial capabilities, primarily in the missile and space industrial sectors.

The changing nature of warfare and sources of innovation as well as the increasingly complex global market trends significantly impact the health and stability of the defense industrial base. Bold leadership and sophisticated strategies are therefore essesntial to support this critical part of DoD's force structure. The Department's leadership responded proactively to these challenges in 2015 and the initiatives undertaken will help to develop and strengthen the nation's vital industrial base capabilities for the coming years.

Over the coming year, MIBP plans to develop a BI&A tool to enhance its efforts to better anticipate and mitigate weaknesses in the DIB. This technology platform coupled with continuous improvements and closer Government-private sector collaboration will help the Department navigate to a future industrial base that successfully addresses tomorrow's national security challenges.

Appendix A – Annual Report Requirements

Section 2504 of title 10, U.S.C., requires that the Secretary of Defense submit an annual report to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives, by March 1st of each year. The report is to include:

(1) A description of the Departmental guidance prepared pursuant to section 2506 of this title.

(2) A description of the methods and analyses being undertaken by DoD alone or in cooperation with other Federal agencies to identify and address concerns regarding technological and industrial capabilities of the national technology and industrial base.

(3) A description of the assessments prepared pursuant to section 2505 of this title and other analyses used in developing the budget submission of the DoD for the next fiscal year.

(4) Identification of each program designed to sustain specific, essential, technological, and industrial capabilities and processes of the national technology and industrial base.

Section 852 of the National Defense Authorization Act for FY 2012, required that the annual report to Congress on the DIB submitted for FY 2012, pursuant to section 2504 of title 10, U.S.C., includes a description of, and a status report on, the sector-by-sector, tier-by-tier assessment of the industrial base undertaken by DoD. As required, the report included a description of the steps taken and planned to be taken:

(1) To identify current and emerging sectors of the defense industrial base that are critical to the national security of the United States;

(2) In each sector, to identify items that are critical to military readiness, including key components, subcomponents, and materials;

(3) To examine the structure of the industrial base, including the competitive landscape, relationships, risks, and opportunities within that structure;

(4) To map the supply chain for critical items identified under paragraph (2) in a manner that provides the Department of Defense visibility from raw material to final products; and

(5) To perform a risk assessment of the supply chain for such critical items, and conduct an evaluation of the extent to which:

(a) the supply chain for such items is subject to disruption by factors outside the control of DoD; and

(b) such disruption would adversely affect the ability of DoD to fill its national security mission.

(c) Follow-up Review.—The Secretary of Defense shall ensure that the annual report to Congress on the defense industrial base, submitted for each of FYs 2013, 2014, and 2015, includes an update on the steps taken by DoD to act on the findings of the sector-by-sector, tier-by-tier assessments of the industrial base and implement the strategy required by section 2501 of title 10, U.S.C. Such updates shall, at a minimum:

- Be conducted based on current mapping of the supply chain and industrial base structure, including an analysis of the competitive landscape, relationships, risks, and opportunities within that structure; and

- Take into account any changes or updates to the national defense strategy, National Military Strategy, national counterterrorism policy, homeland security policy, and applicable operational or contingency plans.

The Senate Report 112-26 accompanying S. 1253, the National Defense Authorization Act for FY 2012, noted at pages 65-66 that the Senate Armed Services Committee is interested in how the determination of DPA Title III projects will be linked to the outcome of the S2T2 assessments, which would identify sectors of the defense industrial base that may require additional resources. The committee requested the DASD(MIBP) to submit an annual report by April 1st to the congressional defense committees containing a prioritized list of potential investments required to address industrial base shortfalls to be expected to be funded by the Department in future years through the DPA Title III program. This report contains the required information.

This report simultaneously satisfies the requirements pursuant to title 10, U.S.C., section 2504, which requires the DoD to submit an annual report summarizing DoD industrial capabilities-related guidance, assessments, and actions and Senate Report 112-26, which accompanied the National Defense Authorization Act for FY 2012, and requires a report containing a prioritized list of investments to be funded in the future under the authorities of DPA Title III.

Appendix B – Summary of Key Industrial Capabilities Assessments Completed During FY 2015

This appendix summarizes assessments conducted by the Military Departments and Defense Agencies during 2015. It is classified For Official Use Only Business Sensitive. For access, contact the Office of Manufacturing and Industrial Base Policy, 703-697-0051.

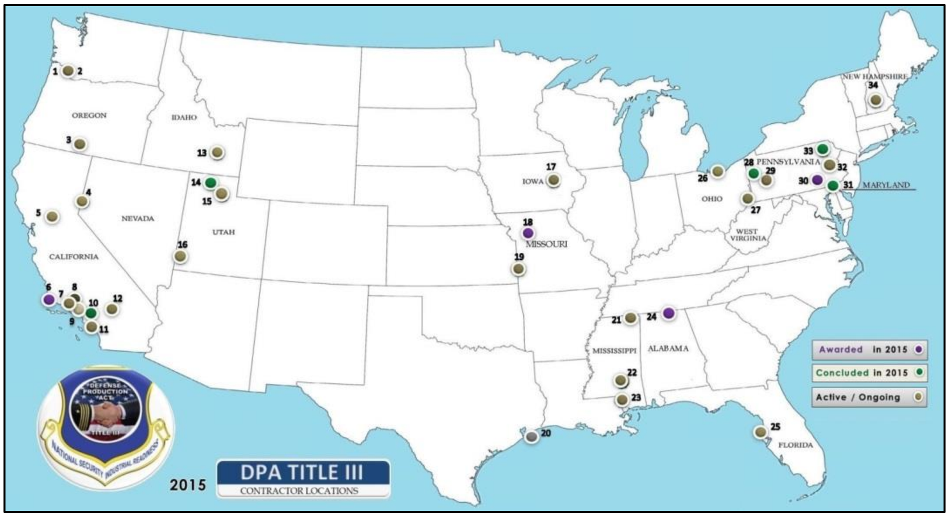
Appendix C – Title III – Defense Production Act Summaries

Defense Production Act Title III Program Execution

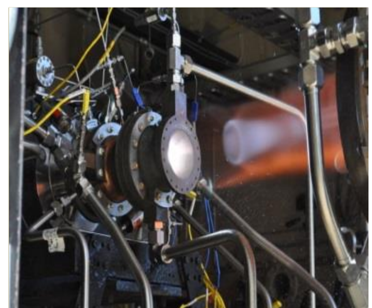
In CY 2015, the Title III Program had 34 projects (some with multiple industry partners) underway during the course of the year, and five of those projects concluded by the end of the year. At the start of CY 2015, 30 domestic firms were executing agreements or contracts. Pre-award acquisition activities were initiated for an additional 12 projects in 2015, anticipating contract awards in CY 2016. Additional funding for individual Title III initiatives may also be provided by the Joint or Military Department Program Offices of Record, Defense Agencies, or other Federal Agencies as funding offsets for specific Title III efforts. Projects are developed in response to specific requirements and associated funding that is provided for these efforts. The image below identifies the locations of the domestic firms participating during 2015 in the DPA Title III Program:

1. **ON Semiconductor** – Gresham, OR – Read Out Integrated Circuits (ROICs)
2. **ON Semiconductor** – Gresham, OR – Advanced Complementary Metal Oxide Semiconductor (CMOS) Focal Plane Arrays
3. **Red Rock Biofuels** – Lakeview, OR – Advanced Drop-In Biofuel Production Project (ADBPP)
4. **Fulcrum Sierra BioFuels** – McCarran, NV – Advanced Drop-In Biofuel Production Project (ADBPP)
5. **Aerojet Rocketdyne** – Rancho Cordova, CA – Solid Rocket Motors (SRM)
6. **Raytheon Vision Systems** – Goleta, CA – SIBWG Cadmium Zinc Telluride (CZT) Substrates
7. **Aerojet Rocketdyne** – Canoga Park, CA – SIBWG Additive Manufacturing for Liquid Rocket Engines
8. **Quallion** – Sylmar, CA – Lithium Ion Battery Production for Space Applications (LISA)
9. **Northrop Grumman** – Redondo Beach, CA – Gallium Nitride Advanced Electronic Warfare Monolithic Microwave Integrated Circuit
10. **L-3 Electron Technologies** – Torrance, CA – SIBC Traveling Wave Tube Amplifiers (TWTAs) for Space
11. **Jazz Semiconductor** – Newport Beach, CA – SIBWG Read Out Integrated Circuit Foundry Improvement and Sustainability
12. **UOP / AltAir Fuels** – Paramount, CA – Bio-Synthetic Paraffinic Kerosene (BSPK)
13. **ON Semiconductor** – Pocatello, ID – Radiation Hardened Cryogenic Read-Out Integrated Circuits (ROICs)
14. **Orbital ATK** – Clearfield, UT – (IACFP) Integrated Advanced Composite Fiber Placement
15. **Conductive Composites** – Heber City, UT – Conductive Composites
16. **5N Plus/ Sylarus** – St. George, UT – SIBWG: Space Qualified Solar Cell Germanium Substrate Supply Chain
17. **Rockwell Collins** – Cedar Rapids, IA – Low cost Military GPS Receivers
18. **EnerSys** – Warrensburg, MO – Submarine Valve Regulated Lead-Acid (SVRLA) Batteries
19. **EaglePicher Technologies** – Joplin, MO – Lithium Ion Batteries for Military Applications (LIMA)
20. **Emerald Biofuels** – Gulf Coast – Advanced Drop-In Biofuel Production Project (ADBPP)
21. **Orbital ATK** – Iuka, MS – Extremely Large Domestic Expendable & Reusable
22. **Hybrid Plastics, Inc.** – Hattiesburg, MS – (POSS) Polyhedral Oligomeric Silsesquioxane Nanomaterials
23. **MAC** – Bay St Louis, MS – Light-weight Ammunition
24. **GE Aviation** – Huntsville, AL – SiC Fiber Production for Ceramic Matrix Composites
25. **The ENSER Corporation** – Pinellas Park, FL – Thermal Battery Production
26. **Rhenium Alloys Inc.** – Elyria, OH – Tungsten Rhenium Wire (W-Re) Production Sustainment
27. **Touchstone Research Lab** – Triadelphia, WV – Coal Based Carbon Foam
28. **FLIR Precision Optics** – Freeport, PA – Military Lens Fabrication and Assembly
29. **Gautier Specialty Metals** – Johnstown, PA – Non-Aerospace Titanium Armor and Structures Transformation (NATASTP)
30. **ArcellorMittal** – Coatesville, PA – Navy Grade Steel Plate
31. **Micropore** – Elkton, MD – (Reactive Plastic) Co2 Absorbent
32. **Lehigh Heavy Forge** – Bethlehem, PA – Heavy Forgings Capacity Improvement
33. **SCHOTT North America** – Duryea, PA – High Homogeneity Optical Glass (HHOG)
34. **Nanocomp Technologies** – Merrimack, NH – Advanced Carbon Nanotube (CNT) Volume Production

DPA Title III Projects – Active in 2015



Additive Manufacturing for Liquid Rocket Engines Project (Map Location #7)



Hot fire testing of an additive manufactured injector assembly at NASA Glenn Research Center.

Awarded in July 2014, this project aims to advance the domestic capability for precision manufacturing of components utilized by NSS agencies to launch critical assets into Earth orbit. Advanced additive manufacturing equipment, now being deployed, provides up to a 600 percent volumetric increase in the powder bed compared to existing additive manufacturing equipment. This essential equipment provides the necessary build envelope and capabilities to produce larger critical components for liquid rocket engines (LRE).

The industrial base for precision manufactured components for LREs is high cost and is facing component obsolescence challenges. DMLS, an additive manufacturing technique, is estimated to provide a 30–80 percent reduction in critical component cost and schedule for upper stage precision manufactured components. Under this effort, the contractor will establish and qualify the production of various RL10 and RS-68 nickel, aluminum, and copper LRE components. Total Government funding for this project is $6.29 million, augmented by $5.46 million of contractor cost sharing. The completion date for the contract is October 2017.

Advanced Carbon Nanotube (CNT) Volume Production Project (Map Location #34)


Continuous roll of carbon nanotube (CNT) sheet material

This Title III project is providing infrastructure for the world's first industrial scale manufacturing facility producing CNT yarn, sheet, tape, and slurry materials. These materials provide the Warfighter with improved protection and survivability while improving mission effectiveness and reducing operating costs. Project emphasis is on increasing output volume by expanding flexible, scalable, and modular production processes; improving product availability, quality, and yield; and reducing manufacturing costs.

Carbon nanotubes exhibit extraordinary strength, unique electrical properties, and are highly efficient thermal conductors. They are the strongest and stiffest materials discovered in terms of tensile strength and elastic modulus, respectively. CNT materials conduct electricity, shield from electro-magnetic interference and electromagnetic pulses, block flames, and enhance ballistics protection while being impervious to corrosion, heat and cold, or sunlight degradation. CNT yarn, sheet, tape and slurry based-products have shown they can successfully operate in broader temperature ranges, radiation levels, or corrosive environments than conventional materials.

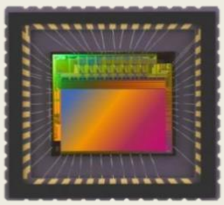
This project initially established an operational pilot facility for the manufacture of CNT material for test and evaluation purposes. Tens of thousands of square feet of sheet material and thousands of kilometers of yarn made in this facility have been delivered to customers. From this contractor, CNT Electro-Static Discharge/Electro-Magnetic Interference shielding has achieved a TRL of 8/9 for spacecraft, while CNT heaters, data cables, and enhanced soft and hard ceramic armor have all achieved TRL 6.

The project most recently funded expansion from Pilot to LRIP level. For the first time, this expanded capability provides tonnage quantities of advanced CNT products sufficient for qualification and initial insertion into programs for aerospace, ballistics protection, and aircraft.

DPA Title III funding is $24.76 million, augmented by $9.21 million of contractor's cost share. The completion date for the contract is February 2016.

CMOS FPAs for Visible Sensors for Star Trackers Project (Map Location #2)

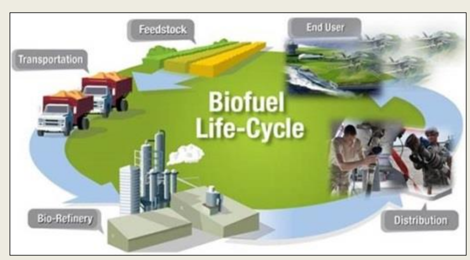
This project will expand and enhance the domestic industrial base's ability to produce visible-imagers manufactured using Advanced CMOS technology. Advanced CMOS imagers are designed to enable flexible visible imaging systems on-board satellite and other systems for DoD and other U.S. Government needs. Current domestic Star Tracker manufacturers are using older, more expensive, and less capable Charged Couple Device sensor technology that has put domestic suppliers at a disadvantage with international competitors. This project will insert critical technology into the defense industrial base and ensure a level playing field for Star Tracker production.


Packaged Focal Plane Array (FPA) chip assembly.

Staring Technology for Enhanced Linear Line-of-site Angular Recognition (STELLAR) chip specification and testing framework acceptance have been achieved. Second Cycle of Learning (COL) Pixel Design Arrays (PDA2s) are in fabrication and will be completed in 2015. PDA1 designs have completed radiation effects analysis and are meeting threshold limits. Total Government funding for this project is $12.54 million, augmented by $4.24 million of contractor cost sharing. This effort was sourced through a competitive solicitation. The completion date for the contract is August 2016.

Advanced Drop-In Biofuel Production Project (Map Locations #3, 4, 20)

The objective of this project is to form one or more Integrated Biofuel Production Enterprises (IBPEs) comprised of partnerships that establish the complete value chain and are capable of producing drop-in replacement biofuels. The project was initiated in support of the Departments of the Navy, Energy, and Agriculture to partner with private industry and accelerate the commercialization of drop-in biofuels for military and commercial use. "Drop-in fuels" utilize existing infrastructure, are delivered to DoD fully blended with conventional petroleum product counterparts JP-5, JP-8 (aviation fuels) and/or F-76 (marine diesel), and are ready for use with no modification to distribution infrastructure or aircraft/ship equipment systems.



Complete value chain capable of producing drop-in replacement biofuels

The three Departments developed a plan to invest across multiple years to spur private industry and financiers to match Title III funds for the construction or retrofit of multiple commercial-scale integrated bio refineries. Each proposed bio-refinery must be based in the United States or Canada, use renewable biomass from acceptable domestic sources, comply with the Energy Independence and Security Act (EISA), and produce a minimum of 10 million gallons of neat fuel annually.

A two-phased approach is being executed. In Phase 1 of the program, the Title III Program awarded four contracts totaling $20.5 million of Government funding for an initial 15-month effort, subsequently extended to 24 months. Phase 1 involved validation of production technology, verification of technical maturity, site selection, plant design, permitting, detailed cost estimation, environmental assessment, and contractor financial closing with commercial financial markets.

All Phase 1 Awardees submitted a Phase 2 follow-on proposal, from which three were selected and awarded a Phase 2 effort in August 2014. Phase 2 activities involve finalizing detailed design and engineering plans, physical plant construction and mechanical completion, start-up and initial operations, plant performance testing, and commencement of routine operations. Government cost share funds will be deployed to purchase commercial manufacturing equipment, engineering and design services, and prime contractor labor charges. Following financial close, 30 to 36 months will be required to complete all Phase 2 activities and achieve full-rated production capacity.

Title III funding for Phase 1 activities of $20.5 million and $23.5 million of contractor cost sharing. Total Title III funding for Phase 2 activities is $210 million ($70 million each), augmented by a total $700 million of contractor cost sharing. The planned completion date for these projects is September 2018.

Bio-Synthetic Paraffinic Kerosene (BSPK) Project (Map Location #12)

Refinery producing BSPK

The objective of this project is to establish a domestic, large-scale, commercial, feedstock flexible, manufacturing capacity of BSPK. BSPK is a biomass derived fuel product with strategic importance for diversifying U.S. energy sources, achieving energy security, and increasing environmental stewardship. Energy security and environmental stewardship for DoD requires unrestricted, uninterrupted access to affordable, clean energy sources to sustain mission objectives. Biomass based fuels are an attractive alternative to petroleum-based fuels since they are produced using renewable resources and can be exploited using more environmentally friendly technologies. The U.S. military's lack of diversified fuel options could negatively impact mission capabilities if crude oil supplies were disrupted.

The anticipated output from this project will be 20 to 28 million gallons per year of renewable distillate (renewable diesel and BSPK). This output will be achieved by retrofitting portions of an existing oil refinery in Paramount, California. The retrofit will consist primarily of revamping and/or installing hydro-processing units and other supporting equipment. The Technology Investment Agreement (TIA) was executed September 21, 2012. Total Title III funding is $3.61 million, augmented by $25.69 million of contractor cost sharing. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest. The planned completion date for the project is April 2016.

Cadmium Zinc Telluride (CZT) boule

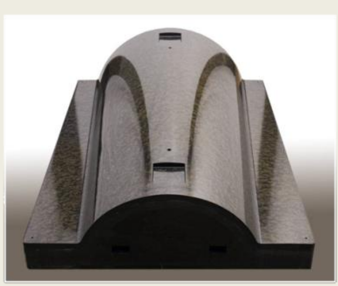
Cadmium Zinc Telluride Substrate Project (Map Location #6)

The objective of this Title III Project is to enhance and expand the domestic industrial base to produce CZT substrates for use in NSS IR FPA applications. A number of NSS agencies rely on MCT detector technology for missile early warning, missile defense, space surveillance, and awareness. A key material for the development of the MCT detector arrays is the lattice matching substrate, CZT, on which the detector array is grown.

CZT is a challenging compound semiconductor to manufacture. Growth of large area single crystal material is difficult, and since the material is both soft and brittle, significant expertise in cutting and polishing is required. The focus of this effort involves developing CZT substrates at sizes and quality needed to meet the requirements of NSS agencies for strategic detectors. In 2015, the contractor completed a demonstration of existing CZT boule growth capability for baseline capability analysis.

Total Government funding for this project is $9.88 million. This was a competitive solicitation, and contract award occurred June 2015. The completion date for the contract is June 2019.

Coal-Based Carbon Foam Project (Map Location #27)



Durable CFOAM tool

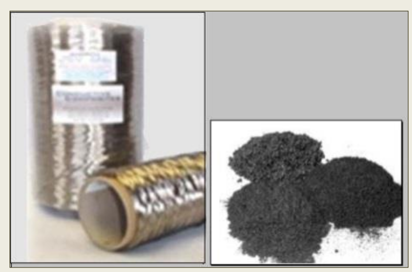
Coal-based carbon foam (CFOAM) is an inexpensive, lightweight, fire-resistant, impact-absorbing material that can be fabricated in a variety of shapes, sizes, and densities. It replaces conventional materials that are heavier, more costly, offer lower structural capability, and present fire hazards. Its electrical conductivity can be varied over nine orders of magnitude, and it has a low coefficient of thermal expansion.

Carbon foam's applications include lightweight tooling, blast mitigation panels, and hot structure applications. It exhibits similar properties as alternative materials, but at a lower cost, and it outperforms other products in noise reduction, fire resistance, impact resistance, energy absorption, and thermal properties. The goal of this Title III project is to expand the domestic production capability for coal-based carbon foam to meet DoD's needs for blast mitigation, hot structure applications, and low-cost composite tooling.

During the project, industry increased CFOAM production capacity by 30 percent; implemented process improvements; yielded an overall material cost reduction of 35 percent; and developed a rapid prototype composite tooling surface, which reduced fabrication time by 75 percent and cut overall prototype tooling costs in half. In 2013, an 8 ft.x25 ft. high-temperature/high-pressure horizontal autoclave was installed, increasing CFOAM capacity three-fold, from 8,500 cubic ft. to more than 36,000 cubic ft. annually. In 2015, two 5-axis machining centers were installed to increase CFOAM fabrication capacity by over 100 percent.

Total Title III funding is $15.0 million, augmented by $1.4 million of contractor cost sharing. This was a sole source solicitation, as only a single domestic source was identified for the specific technology of interest. The completion date for the contract is May 2016.

Conductive Nano-Materials Scale-Up Initiative Project (Map Location #15)

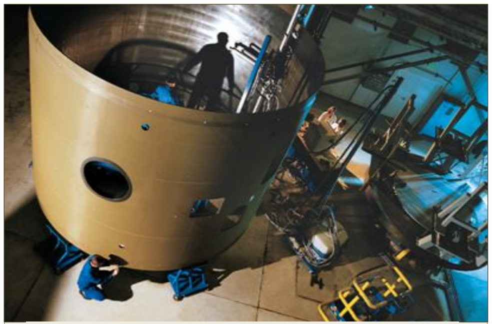


Nickel coated fiber (left) and powder (right) are used in products that shield critical electronic assets.

This project is establishing a domestic source for high-performance chemical vapor deposition (CVD) coated materials to solve current and future Warfighter materials problems. Conductive nickel coated-materials produced using CVD based processes have created lightweight structural composites that deny or survive any electromagnetic threat, either manmade or natural, across the electromagnetic spectrum. The effort is scaling up coatings capabilities, utilizing commercially available materials (nickel, carbon substrates) to construct nickel-coated fibers and Nano-materials that can be subsequently blended into a normally non-conductive substrate (i.e., polymers, paints) to make them conductive. Nickel CVD coated carbon fibers provide light weight shielding capabilities. Project tasks include: development of a comprehensive production expansion plan; evaluation (and implementation) of critical processes for optimization; and improvement of product quality, yields, and production cost reduction. Business and marketing planning activities assist with long-term growth of industry partners. Emphasis is placed on business activities that support sustainable economic viability.

To date, the project has installed a second nickel-CVD (NiCVD) fiber coating machine, increasing capacity fourfold. Additionally, a modified and upgraded NiCVD nonwoven coating machine has increased capacity fivefold. A new organ-metallic gas synthesis unit was installed, doubling capacity. The industry partner moved their manufacturing facility to a new location. New facility construction began February 2015 and was completed with a ribbon cutting in June 2015. Partial production capabilities were available beginning August 2015.

Title III Government funding is $10.27 million, with contractor cost sharing of $2.78 million. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest. The completion date for the contract is June 2018.


Advanced hand layup techniques and fiber placement technology is employed to build large composite structures for the Delta II/IV and Atlas V launch vehicles.

Extremely Large Domestic Expendable & Reusable Structures (ELDERS) Project (Map Location #21)

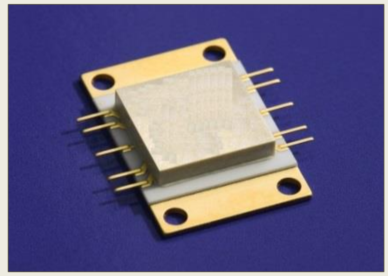
The objective of this Title III project is to ensure a dedicated source for the manufacture of larger-scale diameter composite structures to satisfy defense and non-defense U.S. space industry requirements. The project includes the evaluation and modification of current production facilities; the procurement, installation, startup, qualification, and operation of an advanced machining center; procurement of an automated ultrasonic inspection system; the development and procurement of a combined Automated Tape Laying & Fiber Placement Machine [known as a Dockable Gantry System (DGS)]; as well as procurement of other ancillary support equipment.

Driven by the need for improved fuel efficiency and operability, composite materials are commanding an important role in airframe, engine structures, and space launch vehicles. Automated composite technologies and improved non-destructive inspection techniques are being implemented to deliver affordable, high performance parts and assemblies for DoD and the U.S. aerospace industry. Several DoD and NASA programs will benefit through the efficient and expanded production of larger scale components. Such programs include those applications requiring crew and heavy-lift cargo transport capabilities. These systems will provide mission support for continued crew transfer and logistics supporting the International Space Station, current and future space crew exploration vehicles, and payload/satellite deliveries.

The industry partner made significant progress with building the Dockable Gantry System at the machine fabrication shop and completed the foundational concrete pour for the DGS. Continued development and extensive software testing are in process. DGS shipment and installation started in late-2015.

Total Title III funding is $14.29 million, augmented by $9.85 million of contractor cost sharing. The completion date for the contract is September 2016.

Gallium Nitride Advanced Electronic Warfare Monolithic Microwave Integrated Circuit Producibility Project (Map Location #9)



Packaged Gallium Nitride Monolithic Microwave Integrated Circuit (GaN MMIC)

The objective of this Title III project is to establish a domestic, economically viable, open-foundry merchant supplier production capability for Ka-band GaN MMICs. The overarching goal is to achieve MRL 8, meaning the process is ready for LRIP in a DoD acquisition program. This MRL target will be achieved through the application of process improvement techniques, such as Six Sigma and LEAN manufacturing, to reduce process variation and enable repeatable MMIC performance and reliability. This project leverages prior Government-sponsored work by DARPA, AFRL, and ONR/NRL.

Testing and analysis to determine GaN MMIC yield, cost, capacity, cycle time and the MRL on the four mid-term MRA lots was completed in 2015. Data was positive for most metrics, particularly yield, which surpassed program thresholds. Further, the final MRA utilizing the single wafer Molecular Beam Epitaxy (MBE) system/material commenced in October 2015. Once the four lots of wafers have been fabricated, GaN MMIC yield, cost, cycle time, capacity, and the MRL, which increased from MRL 6 to MRL 7 in 2015, will be assessed again.

Total Government funding is $8.573 million, augmented by $8.573 million of contractor cost sharing. A single contract was awarded in January 2013 in response to a competitive 2012 solicitation. The completion date for the contract is August 2017.

Heavy Forgings Capacity Improvement Project (Map Location #32)

A manipulator rotates parts on the 10,000 ton open die forging press.

The purpose of this Title III project is to upgrade and refurbish heavy forging manufacturing equipment. DoD applications include propulsion shafts for surface and sub-surface naval vessels, periscope tubes, ring forgings for bull gears, and reactor vessels.

Heavy forgings are unique in that they require a 10,000-ton open die forging press to produce parts that begin with ingots up to 11 feet in diameter and weighing up to 600,000 lbs. In addition to the press, other special requirements include ingot manipulators, forge furnaces, treatment furnaces, specialized machine tools, building foundations, and structural capacity to support the processing of such heavy ingots. The focus of this project is to address production constraints and single points of failure that are critical to maintaining the supply of heavy forgings to DoD.

Major accomplishments in Phase I include the upgrade of a vertical boring mill, the installation of a 90' 75/25 ton overhead crane, and the structural overhaul of the contractor's 10,000 ton open die forging press.

In September 2013, a Phase II effort was awarded and included activities to increase capacity, provide new capabilities, and address potential high consequence events. Some of the tasks being executed include, but are not limited to, open die forging press improvements, multi-axis vertical turning/milling center procurement, computer numerical control (CNC) lathes and vertical boring mill retrofits, and electrical infrastructure upgrades.

The total project funding level is $23.9 million, which includes Government funding of $20.5 million and Contractor Cost Share of $3.4 million. The contractor has invested an additional $11.5 million in unrecognized cost share to demonstrate commitment to the heavy forging business in support of DoD. This was a sole source solicitation, as only a single domestic source was identified for the specific technology of interest. The completion date for the contract is December 2017.

Light-Weight Ammunition Project (Map Location #23)

Lightweight, polymer-cased, .50 caliber ammo

The objective of this effort is to establish a domestic production capability for the manufacture of light-weight ammunition based on polymeric material. The initial focus is the development, production, and qualification of light-weight .50 caliber machine gun rounds that can be deployed in conventionally fielded weapon systems at a comparable cost to standard brass ammunition. The light-weight, polymer-cased .50 caliber ammunition weighs approximately 25 percent less than standard brass ammunition.

In 2015, an Air Worthiness Release (AWR) was received by the contractor, which allows its lightweight .50 caliber ammunition to be deployed on Army helicopters. However, each individual unit is required to test the contractor's ammunition on its particular helicopter to make sure that there are no anomalies. The contractor supported several demonstrations in 2015, including demos for its .50 caliber ammunition, .300 Winchester Magnum round, and 7.62mm ammunition. The Marine Corps' qualification testing for the light-weight .50 caliber round was put on hold while the test plan was revised. Qualification testing will resume in the 2016.

Total Government funding on contract is $19.99 million, augmented by $10,000 of contractor cost sharing. This was a sole source solicitation, as only a single domestic source was identified for the specific technology of interest. The contract completion date is August 2017.

Lithium-Ion Battery Production for Military Applications (LIMA) Project (Map Location #19)

Li-Ion large format prototype battery cell developed in Phase I of the project

The purpose of this project is to establish a long-term, viable, world-class domestic manufacturer of high-energy density Li-Ion batteries that is responsive to customer requirements with respect to performance, reliability, quality, delivery, and price.

High energy density Li-Ion batteries are critical for a number of military systems, specifically for enhancing the endurance of UASs and providing portable power to support the mission for the dismounted solder (long endurance autonomous systems, tactical vehicles, unattended sensors, and reconnaissance and surveillance systems). The Li-Ion cells of interest will have an energy density greater than 250 Watt-hours per kilogram (Wh/kg) at 250 Watts per kilogram (W/kg) continuous (i.e., 1C rate) for military applications. The goal is to create a flexible manufacturing line capable of producing multiple battery form factors for both military and commercial applications. Another key goal will be to achieve a MRL 8: capable of supporting LRIP.

The project will effectively reduce the cost of high-energy density Li-Ion batteries by leveraging increased combined assembly line volumes, even at low production run volumes of individual battery form factors. There will be commensurate improvements in power density, discharge rate, temperature range and safety, and delivery of sample cells/batteries to the Government for independent testing.

Three Phase I contracts were awarded in early 2013 and concluded in 2014. Phase I delivered sample cells for independent Government testing along with strategic business and marketing plans. The Phase II option was a competitive down-select to one contractor with the basis for selection comprised of Phase I business plan deliverables, as well as technical and manufacturing accomplishments. The Phase II contract was awarded in September 2014 and is focusing on refining Li-Ion ion cell chemistries for military applications, production facility, and capacity expansion process improvements, and advancing to MRL 8.

The total project funding is $29.8 million, which includes Government funding of $22.3 million and Contractor Cost Share of $7.5 million. This was a competitive solicitation. The completion date for the contract is September 2017.

Lithium Ion Battery Production for Space (LISA) Project (Map Location #8)

Completed cells are tested on a production line

This Title III project supports the development of a domestic source for Li-Ion cells and their constituent active materials for spacecraft use. Li-Ion rechargeable battery technology provides higher power for longer durations with lower weight and favorable space constraints when compared to Nickel Cadmium (NiCd) or Nickel Hydrogen (NiH) rechargeable batteries. The Li-Ion battery offers the highest energy and power package of developed batteries today. Additional advantages include better recharging capability with no memory effect and increased temperature operating ranges. This technology offers designers a weight savings option compared to other battery types for overall weapon systems performance.

In 2013, the project successfully completed an initial technical effort to create production capability for prismatic low earth orbit (LEO) cells and constituent materials. In 2015, the project began developing production capability for 18650-size wound cells for space launch vehicles and micro-satellites. This ongoing effort employs the long life material production capacity and the electrode production capability established in the earlier phase of the project. The industry partner demonstrated proof-of-concept for a cell design that meets customer needs, improved its production facilities, and procured necessary manufacturing equipment.

Total Government funding is $55.2 million, augmented by $15 million of contractor cost sharing. This was a competitive solicitation. The completion date for the contract is June 2016.

Low Cost Military GPS Receivers Project (Map Location #17)

Warfighter in combat equipped with MicroDAGR, the world's smallest, lowest-power handheld GPS receiver providing trusted navigation and targeting solutions

Military GPS receivers are vital equipment on the battlefield as they enable Warfighters to perform strategic and tactical maneuvers with a high degree of confidence and success. Without secure, reliable GPS receivers, soldiers lack the necessary situational awareness and confidence when determining their specific position relative to fellow Warfighters and enemy combatants. Military GPS receivers also contain anti-spoofing and anti-jamming technologies in comparison to commercially available, non-DoD, lower-technology alternatives.

The primary objectives of this Title III project are to create domestic production capabilities for essential subcomponents for the Defense Advanced GPS Receiver (DAGR) and to pursue methods for reducing their weight, size, power-consumption and cost, while improving performance capabilities. A new phase was awarded in

August 2013 to focus on improving size, weight, power consumption, cost, and capability, thereby continuing to evolve the capabilities of dismounted soldiers.

Total Government funding is $11.1 million, augmented by $16.0 million of contractor cost sharing. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest. The current completion date for the contract is February 2016.

Modernization of Navy-Grade Alloy Steel Plate Production Project (Map Location #30)


Applications: U.S. Navy Shipbuilding: Aircraft Carrier USS *Gerald R. Ford*

The goal of this Title III project will be to enhance existing domestic capabilities to produce very wide (at least 150 inches), very thick (up to and including 8 inches), and very heavy (up to 75 tons) Navy-grade alloy steel plate. The demand for specialized steel plate of the required thicknesses, widths, and specifications for Navy applications is cyclical and without a widespread commercial application. Consequently, there is an insufficient ROI for the domestic industry to invest in production enhancements that can reduce variation in thickness and flatness, improve surface finish, and support increased throughput.

Phase I was awarded in August 2015. Potential benefits to the Navy as a result of upgrading outdated steel production facilities, tooling, and processes include reduced overhead costs related with the manufacturer’s maintenance of aging resources and lower costs associated with a reduction in non-value added re-work for shipbuilders.

The total project funding level is $22.6 million, which includes Government funding of $17.6 million and Contractor Cost Share of $5.0 million. This was a competitive solicitation. The completion date for the contract is December 2018.

Non-Aerospace Titanium for Armor and Structures Transformation Project (Map Location #29)

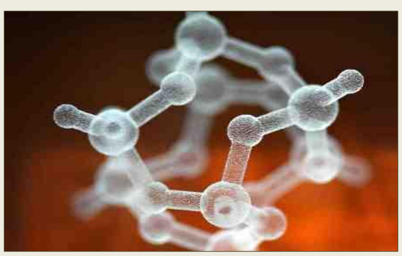
Plate mill motors provide the power required to produce titanium plate for armor tiles, structural material for military and commercial ground vehicles, and naval ship piping.

The excellent strength-to-weight and corrosion-resistance properties of titanium make it useful for many structural applications. It also has excellent ballistics properties that, along with the low weight, make it ideal for armor. Due to large increases in commercial aerospace demand for titanium, lead times for titanium are approximately six months, while costs remain extremely volatile.

By working outside the aerospace titanium supply chain, this Title III project will help reduce cost and shorten delivery lead-times for structural titanium and titanium armor. The initial effort is focusing on implementing the capability to direct-roll titanium and other alloy plate in widths and thicknesses that can be used for armor tiles on military ground vehicles. Military applications include reactive armor tiles, armor, and structural material for military vehicles, tanks, and naval ship piping, which is subject to corrosion.

Finishing equipment, installed in Phase I, processed the following items: armor brackets, JLTV prototype parts, and components for retrofitted racking systems on DoD vehicles. The contractor, in Phase II, procured and installed a plate mill for enhanced in-house production capability.

Total project funding is $15.3 million, which includes Government funding of $12.8 million and Contractor Cost Share of $2.5 million. This was a competitive solicitation. The completion date for the contract is June 2016.



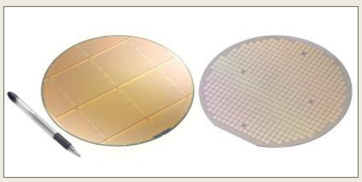
POSS, a versatile Nano-chemical, is used in items such as paint, plastics, hemostats, and personal care products.

Polyhedral Oligomeric Silsesquioxanes (POSS™) Nanotechnology Project (Map Location #22)

This Title III project is scaling up production of Polyhedral Oligomeric Silsesquioxanes (POSS®), which is a Nano-sized material. When used as a chemical additive, POSS can greatly enhance the performance of polymers for a variety of DoD and commercial applications. POSS® has been demonstrated as useful in applications, such as radiation shielding and coatings for space-survivable microelectronics, coatings that prevent growth of tin whiskers on lead-free solder, aerospace air and fuel filters, food packaging, optical lenses, and weapon lubricants and cleaners. POSS® was the enabling catalyst for the world's first synthetic organ transplant in 2011 (a surgical procedure performed in the United Kingdom).

During the course of this project, production capacity of POSS® at the industry partner has grown from 50 tons to more than 500 tons annually. More than 250 POSS® compounds have been created, with 100 plus varieties synthesized and compounded for commercial use. The contractor achieved ISO 9000:2008 certification and a Manufacturing Readiness Level (MRL) of 9: Low Rate Initial Production demonstrated, ready for Full Rate Production. Demand has outpaced capacity for particular formulations, and this project is currently modernizing production controls and installing production equipment to meet consumer requirements.

Total Title III funding was $21.29 million, augmented by $2.22 million of contractor cost sharing. This was a competitive solicitation. The completion date is November 2016.



ROICs convert visible light into digital images for uses ranging from digital cameras to surveillance satellites.

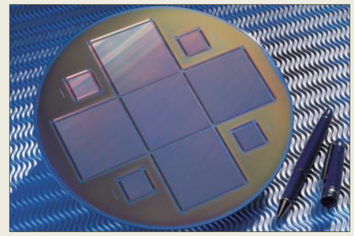
Radiation-Hardened Cryogenic Readout Integrated Circuits (Map Location #13)

Title III resources are being utilized to establish a viable, domestic foundry for commercial production of less than or equal to 0.18 micron deep sub-micron CMOS Radiation-Hardened Cryogenic ROICs. These microelectronics are a critical technology employed in the manufacture of focal plane arrays (FPAs), which are utilized in high altitudes, space-based imaging, and missile systems. The next-generation imaging requirements are dependent on the availability of advanced ROICs that provide high density with analog components, smaller pixels (increased resolution), and increased functionality through on-chip processing. Additionally, ROICs need to be physically larger (enabled through stitching technology) to meet increasing focal plane array size requirements, reducing particle counts that improve production yields, and improving fabrication cycle times. These improvements will collectively increase the mission capability of the systems.

Title III funding is providing industry the capability to produce less than or equal to 0.18um Large Format (LF) ROIC device per vendor design. Funding is also being used to determine radiation immunity standards via vendor surveys to better understand industry needs. Yields have increased 5-fold and continue to gain efficiency. Yield improvement has been attained through better failure analysis resulting in reduced defect densities. In addition, as part of the Title III effort, the contractor has attained Trusted Foundry certification.

Total Government funding is $13.0 million, augmented by $19.7 million of contractor cost sharing. This was a competitive solicitation. The completion date for the contract is January 2016.

Read Out Integrated Circuit Foundry Improvement and Sustainability Project (Map Location #1)



Large formatted ROIC, 5 die on 8 inch wafer, ROICs are essential to military and government surveillance programs.

A number of challenges are present related to the design and fabrication of LF ROICs. As detector arrays grow in size and number of pixels per array (> 1 million), the complexity of the ROIC also increases and adds to the challenges of the foundry that must now utilize advanced CMOS processing techniques at 0.18 micron and below, with competitive wafer sizing (8 inches).

Other factors affect the design, processing, and performance of the ROICs for Government space programs. The ROIC must exhibit very low noise to avoid contributing substantially to the noise of the sensor. Defect density in the ROIC reduces yield during manufacturing and may affect the operability of the sensor once it is hybridized. In addition to the low yields due to defect density, wafer size, and design complexity, long periods of time between orders are common due to the relatively small market for LF ROICs, resulting in production gaps.

As a result, maintaining equipment and staff at peak performance is difficult in this environment. The scope of the ROIC Foundry Improvement and Sustainability Project is to maintain minimal, yet adequate, production capabilities at domestic foundries to ensure a necessary supply of strategic ROICs deemed useful for Government space programs. The primary goal is a sustainment initiative where, in addition to running continuous production, design and process improvements are made so that more aggressive yields can be realized in a timely manner.

The first of two industry partners for this project was placed on contract in April 2010 and has increased yields by five-fold in small wafer lots, demonstrating continued process improvement. Failure analysis has been improved with the capital purchase of an upgraded KLA Inspection Tool. This tool allows for closer inspection of 0.18 micron ROICs to detect smaller (and potentially damaging) defects that were undetectable with older inspection tools. The contractor continues to work closely with a design house to improve testing programs resulting in improved defect densities.

A second industry partner signed in June 2012. Utilizing 0.18 micron LF-ROIC chips, this contractor has produced remarkable power probe yields that have exceeded expectations. This supplier is also working closely with a design house to assist with required testing programs. This cooperation has led to faster yield reporting and identification of potential wafer defects.

Total Government funding for the project is $10.45 million, or $5.225 million per industry partner. Contractors cost sharing/contributions are $5.66 million and $5.47 million, respectively. Competitive solicitations were the basis for execution of this project. The completion date for the first partner is January 2016 and May 2018 for the second partner.

High-temp SiC fiber enables superior aircraft jet engine performance.

Silicon Carbide (SiC) Fiber Production for Ceramic Matrix Composites (CMCs) Project (Map Location #24)

This Title III project is providing infrastructure for the first domestic industrial scale manufacturing facility producing silicon carbide fiber, specifically high temperature fibers used in ceramic matrix composites. SiC fiber is a building block of CMCs, which are used in applications where high temperature resiliency and durability are paramount. SiC-fiber-based CMCs have proven themselves to be a material of choice in designing the military aircraft turbine engines of the future.

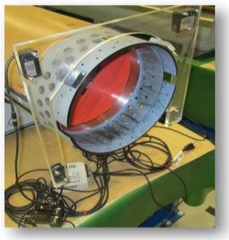
Research and development work has shown that the use of SiC CMCs can improve aircraft jet engine fuel efficiency by as much as 25 percent, extend flying ranges by 25 to 30 percent, and increase thrust 5 to 10 percent when compared with current technology. A sustainable domestic SiC fiber production capability is an essential element in achieving these performance improvements for national security applications in addition to applications in commercial aircraft turbine engines, industrial gas turbines, and nuclear fuel rod cladding.

This project will establish an operational full-rate production facility for the manufacture of SiC fiber capable to meet current and anticipated future demand. Silicon carbide fiber is currently commercially manufactured only in Japan. The contractor for this project is in a joint venture in Japan and will replicate the successful processes and infrastructure currently operating there.

DPA Title III funding is $21.99 million, augmented by $29.54 million of contractor cost share. The completion date for the contract is July 2019.

Solid Rocket Motors Production Project (Map Location #5)

This Title III project will establish the foundation for a digital factory environment through the procurement and installation of state-of-the-art equipment and digital interconnectivity tools that enable development and production processes, thus creating a cohesive, adaptable, and efficient manufacturing capability. The project is specifically designed to benefit the Standard Missile (SM)-3



With a laser inspection system, data is available for immediate process control.

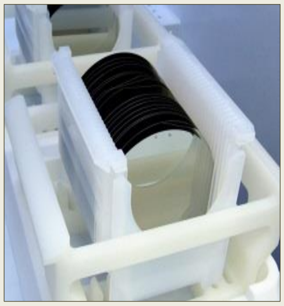
Throttleable Divert and Attitude Control System (TDACS) program as well as other SRM programs currently in production. Throughout the program, metrics will be collected and analyzed to demonstrate and validate the effectiveness of the newly deployed equipment and digital tools.

In 2015, facility site preparations, equipment acquisitions, and equipment installations continued for various quality inspection and manufacturing process equipment and tools. Also, the baseline MRA was completed in 2015.

This Title III project is working in conjunction with the MDA's Digital Propulsion Factory Initiative to ensure that a critical domestic source remains economically viable and competitive after the conclusion of the project.

Total Government funding for this project is $9.998 million, augmented by contractor cost sharing of $10.205 million. This was a competitive solicitation. The completion date for the contract is January 2017.

Space Qualified Solar Cell Germanium Substrate Supply Chain Improvement Project (Map Location #16)



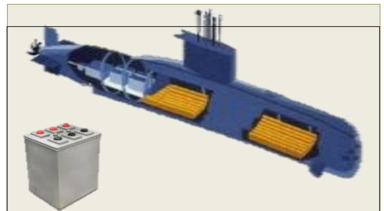
A cassette of in-process polished Germanium solar cell wafers

The purpose of this project is to enhance and expand the ability of the domestic industrial base to produce space-qualified germanium substrates—a key enabler for space solar cells used to power Government satellite systems. Commercial-grade germanium substrates do not possess the quality necessary to produce high-reliability space solar cells. Ge substrates are the basis for the solar cells used on all NSS satellites, and are forecast to continue as such for at least 10–15 years. Current state-of-practice solar cells built on Ge substrates operate at 28–30 percent efficiency. State-of-the-art Ge solar cells operating at 33 percent efficiency will transition to production in the near-term while 35–37 percent Ge solar cells are currently in development.

Major accomplishments in 2015 include introduction of the capability to reduce and melt germanium dioxide powder into 5-Nines pure (5N = 99.999 percent) germanium metal, then to zone-refine that metal to increase it to the 7-Nines pure (7N = 99.99999 percent) germanium metal. The 7N pure metal is used to grow germanium crystal boules, which are sliced into substrates. Other accomplishments include increasing substrate production yields, developing a germanium fines capture and recycle system, and capturing business with a second strategic customer.

Total Government funding for this project is $8.55 million, augmented by $8.8 million of contractor cost sharing. This was a sole source solicitation, as a determination was made that only a single space-qualified domestic source existed. The contract's completion date is December 2017.

Submarine Valve Regulated Lead Acid (VRLA) Battery Project (Map Location #18)



SVRLA battery cell: Advantages include reduced maintenance, lower operational cost, and increased time on station for the U.S. Navy's nuclear submarine fleet.

This Title III project is advancing the domestic production of VRLA batteries used in the entire U.S. Naval nuclear submarines. The effort has two components. The first is to qualify used, or secondary, lead for use in submarine VRLA batteries. The second component will focus on utilization and improvements of industrial manufacturing capabilities and quality management systems for affordable production to meet DoD submarine VRLA battery performance requirements. This includes an increased battery life expectancy with minimal submarine VRLA battery intervention (cell replacements, isolations, and/or charge-profile adjustments). This is critical, given the varied scenarios encountered in U.S. Navy submarine operating environments.

VRLA batteries are critical to U.S. Navy submarines. They are spill-proof, safer, more efficient, and less costly to maintain than other types of batteries. Their distinguishing characteristic is that they are sealed and fitted with a pressure release valve, which is a safety feature in case the rate of flammable hydrogen gas discharge becomes dangerously high, a critically important feature for use on submarines.

The premature failure of the batteries has resulted in increased battery procurements, installation costs, and increased maintenance costs. Additionally, many of these batteries have unexpectedly failed before reaching even 50 percent of their required service life, forcing submarines to suspend operations and return to port to replace the batteries.

DPA Title III funding for the secondary lead qualification effort is $294,000, augmented by $112,000 of contractor cost share. The completion date for this contract is February 2017. DPA Title III funding for production process improvements is $18.7 million with contractor cost sharing of $12.0 million. Negotiations for contract award were close to be finalized at the end of 2015.

Cobalt Disulfide (CoS2) thermal battery

Thermal Battery Production Project

(Map Location #25)

The objective of this Title III initiative is to strengthen and expand what, at the start of the program, was the only domestic source for Cobalt Disulfide thermal batteries. Uniquely designed for military applications, high performance batteries are the only viable power source for many strategic and tactical missile systems. The MDA and multiple DoD acquisition program offices identified high performance Cobalt Disulfide battery technologies as having insufficient domestic capacity and capability to meet growing program requirements. The focus of this Title III program is the scale up production capacity and expansion of capabilities required by military customers. The applicability of these batteries to a wide variety of DoD missile systems offers Army, Navy, and Air Force Program Offices the ability to greatly enhance system performance.

Major accomplishments in 2015 include the qualification of an internally developed cobalt disulfide material and subsequent qualification and production for the Small Diameter Bomb (SDB) and the Long Range Land Attack Projectile (LRLAP) Programs. Several other major programs are in development with delta qualification activities underway.

Total Title III funding is $19.6 million, with no contractor cost sharing. This was a competitive solicitation. The completion date for the contract is July 2016.

Tungsten Rhenium Wire Production Sustainment Project (Map Location #26)

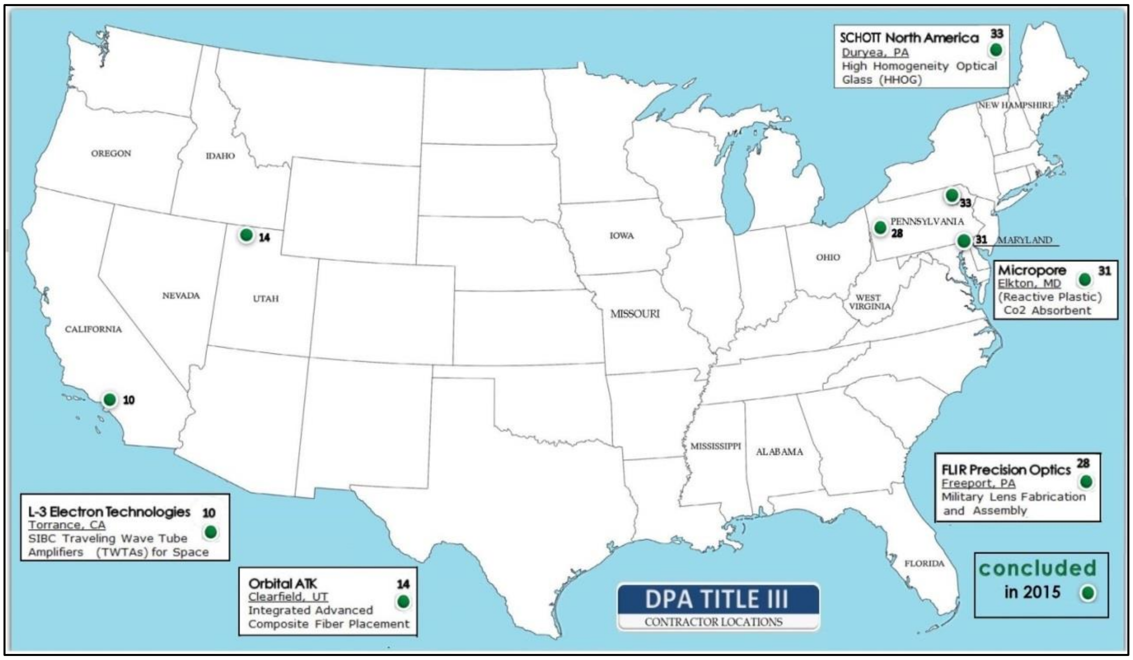
Hot swaging of Tungsten Rhenium (W-Re) rods at 800-950°C

The objective of this Title III effort is to create a viable, domestic source capable of manufacturing a high yielding, reliable and reproducible tungsten-3 percent rhenium (W-3%Re) wire in a cost efficient manner. The quality of the material will be required to meet DoD and commercial microwave tube (MWT) industry standards for use in vacuum tube electronics.

Rhenium powder is mixed with tungsten powder to increase the re-crystallization temperature of the material, which makes the material more ductile, or able to be drawn into wire. Rhenium significantly reduces the brittle characteristics of tungsten at room temperature, and W-3%Re wire has much better ductility, stability, and tensile strength than pure tungsten in high-temperature applications.

DPA Title III funding is $3.00 million augmented by $1.12 million of contractor cost sharing. This was a competitive solicitation. The completion date for the contract is January 2017.

DPA Title III Projects - Concluded in 2015



Rebreather and ExtendAir CO2 Absorbent canisters

CO_2 Absorbent Reactive Plastic Project (Map Location #31)

Status: <u>Project Completed</u>

Calcium hydroxide and lithium hydroxide CO2 absorbent plastics are materials that actively absorb CO2 from the air in environments such as submarines, underwater breathing systems, medical anesthesia, and mines. If left unchecked, increased CO2 levels lead to impaired thinking, unconsciousness, and in extreme cases, even death. CO2 absorbent materials traditionally are found in raw granule form, either packed in canisters or sprinkled loosely on the floor (of a submarine or a mine) in a survival situation. Reactive plastic CO2 absorbent material encapsulates the absorbent chemistry into a plastic matrix or sheet, thereby locking the absorbing material in place and minimizing hazardous dust exposure to the surrounding air. In comparison to existing granular solutions, these reactive plastic CO2 absorbent products improve the rate of CO2 absorption by as much as 300 percent, improve absorbent capacity, reduce the size and weight of absorbers (i.e., 35 percent more absorbent in the same storage footprint of lithium hydroxide granules used on submarines), and eliminate dusting exposures to personnel.

The goal of this Title III project was to expand the domestic production capability to meet DoD needs for calcium hydroxide and lithium hydroxide CO2 absorbent plastics. ExtendAir® material is used today to control the atmospheric CO2 levels in sealed environments, such as military submarines, military and commercial diving rebreathers, personal escape devices, and mine safety shelters. Various "first responder" rescue systems are also beginning to use this new material. The emerging SpiraLith™ product is now used in medical anesthesia machines in both VA and commercial hospitals.

Thanks to the success of this project, industry has increased its extraction capacity six-fold while improving calcium and lithium hydroxide yields by 39 percent and 23 percent, respectively. Technology insertions include: retrofit of all Virginia-class U.S. Navy submarines, completion of three combat diver rebreather platforms (currently undergoing final Warfighter evaluation by the U.S. Navy), newly qualified Emergency Escape Breathing Device (EEBD) systems for U.S. Navy shipboard personnel fire escape and rescue, certification of absorbent for Mine Safety and Health Administration (MSHA) refuge shelters, and the successful introduction of new anesthesia machine absorbents in both VA and commercial hospital emergency rooms. This project successfully focused on cost reduction, material recycling, and market penetration into both the military diving and medical anesthesia markets.

Total project value was $16.34 million. Title III obligated $14.07 million, and the industry partner contributed $2.27 million in additional contractor cost share. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest. The project concluded on March 10, 2015.

High Homogeneity Optical Glass (HHOG) Project

(Map Location #33)

Status: <u>Project Completed</u>

Large format optical glass

This Title III project was structured to increase manufacturing capacity, optimize production yields, and ensure greater availability of affordable HHOG products. HHOG blanks are the basic building blocks in the fabrication of high precision optical lens systems, which are key technology drivers for many defense, commercial, and national security related applications. H4 grade and higher HHOG blanks are characterized as possessing a maximum refractive index variation across the entire optic of $\pm 1.0 \times 10^{-6}$. If the refractive index is non-uniform, or non-homogeneous, then light rays passing through the material at different locations will be bent in random directions and in an amount approximately proportional to the non-homogeneity. This can have several adverse effects depending on the application.

The primary goals of this project included increasing manufacturing capacity, optimizing production yields to greater than 70 percent, and ensuring greater availability of non-active and active HHOG products. The project strove to make improvements to make enhancements to production processes and associated control systems. Of particular concern to DoD was lens products required in optical designs for aerial, satellite, and other space surveillance equipment.

The industry partner built customized power control cabinets, made enhancements to the forming system, retrofitted annealing ovens, acquired optical lens manufacturing equipment, and improved raw material blends. Technicians produced large format non-active and active optical glass for DoD and commercial applications.

A catastrophic fire occurred at the industry partner's facility in March 2015, resulting in the need for significant demolition, construction, and reconstitution of manufacturing capabilities. The Title III team conducted a site visit in September 2015 to observe progress on building reconstruction and to close out the project. Due to the fire, several minor tasks in the Statement of Work were not completed at the concurrence of Title III. Total Title III funding was $5.8 million, augmented by $5.5 million of contractor cost sharing. This was a competitive solicitation. This project concluded on September 30, 2015.

Integrated Advanced Composite Fiber Placement (IACFP) Project (Map Location #14)

Status: Project Completed

Title III partnered with Orbital ATK to increase the U.S. domestic industrial base capability for the production of large aerospace composite products, employing advanced fiber placement technologies. Several contemporary military, space, and commercial aerospace programs depend on large composite structures already incorporated into their design features. Future aircraft architects are using an ever increasing amount of composite material in aerospace designs due to its unique and proven abilities. Next-generation military, space and commercial aircraft, and launch vehicles will have more composite content than ever before.

Advanced composite structures are manufactured using automated fiber placement technology on fiber placement machines.

At the inception of this project, there was insufficient domestic production capacity for large-scale, complex, aerospace composite products capable of meeting and sustaining defense needs for aerospace applications, such as aircraft wing skins, ducts, nacelles, and fuselage skins. Without scale-up to required production levels, DoD risked critical components being unavailable in sufficient enough quantities to meet increasing production schedules. Capacity expansion for the domestic industrial manufacturing base has been achieved through a combination of: (1) modifying existing fiber placement machines, (2) fabricating and installing state-of-the-art fiber placement machines and supporting equipment, and (3) increasing the manufacturing run rates of processed materials by advancing production technologies.

Advanced fiber placement technologies developed and implemented under IACFPP enabled Orbital ATK to produce hundreds of advanced composite aerospace components on time while maintaining a zero part defect rating. The project has expanded the domestic industrial manufacturing base capacity an order of magnitude to meet current and near-term product demands such as those required for F-35 wing skins and other large aerospace parts.

Total Title III funding was $27.1 million, augmented by $15.3 million of contractor cost sharing. This was a sole source solicitation as only a single domestic source was identified for the specific technology of interest. This project concluded on March 31, 2015.

Military Lens System Fabrication and Assembly Project (Map Location # 28)

Status: <u>Project Completed</u>

Robotic high volume lens generation, polishing, and assembly system; optical lens handling tray

This Title III project established a domestic resource for mono-spectral and advanced multi-spectral optical systems and lens components. This effort developed a manufacturing capability for design, fabrication, finishing, coating, assembly, and testing of mono- and multi-spectral night vision optical systems that can be integrated into military and commercial surveillance systems.

Multi-spectral systems are shared aperture systems that allow widely separated wavelength bands to be transmitted through a common aperture and share common elements in the optical train. They offer considerable advantages for the Warfighter, including weight and volume reduction, by allowing the Warfighter to carry fewer pieces of equipment; improving performance, by allowing both bands to utilize the full aperture of the systems; and optimized system design for a larger set of operating conditions/environments.

The industry partner installed advanced optical lens equipment in a new dedicated 30,000 square foot facility and initiated production. Lens production capacity increased from less than 500 lenses to more than 80,000 lenses per year via equipment procurement and manufacturing improvements.

Total Government funding is $8.8 million and is augmented by $2.5 million of contractor cost sharing. This was a competitive solicitation. This project concluded on July 28, 2015.

TWTA for Space Project (Map Location #10)

Status: **<u>Project Complete</u>**

A TWTA is a vacuum electronic device whose function is to amplify a radio-frequency signal. The K frequency band is primarily a communications band. K-band TWTAs provide superior signal strength and larger bandwidth compared to current satellite capabilities and has become the main data frequency band for U.S. military use. The Wideband Global SATCOM satellite system utilizes K-Band TWTAs, and each WGS satellite can route 2.1 to 3.6 Gbps of data, providing more than 10 times the communications capacity of the predecessor DSCS III satellite. DoD satellites using K-band TWTAs will support the growing need for real-time information and controls among deployed assets.

This project focused on upgrading manufacturing processes and equipment to produce high quality K-band TWTAs with improved manufacturing yield and reduce cost for DoD applications. Establishing a globally competitive domestic source for next-gen high power, space qualified, K-band TWTAs is necessary for DoD to obtain high quality components on time and at a fair market price. The outcome of this project ensures reduced schedule, performance, and cost risks to Government satellite programs that are inherent with having only one supplier.

In Phase I, L-3 ETI designed and space-qualified a 130W K-band TWTA, which helped them gain entry into the K-Band market that they didn't have prior to Title III. This new product required new automated test systems, which reduced manpower, increased throughput, and prevented major product damage often leading to scrap. In Phase II, L-3 engineers built upon the Phase I accomplishments by designing, building, and qualifying a state of the art 300W K-band TWTA, which was first to market in a growing segment. To support production of the higher power TWTA, L-3 also designed, developed, and purchased specialized test equipment that created more flexible test stations to support multiple TWTA products types (frequency and power options) in addition to implementing new equipment to support testing the high power K-Band TWTA. This project concluded on April 30, 2015.

DPA Title III Projects - Pre-Award / Active Acquisition in 2015

Projects require signed Presidential Determination for award.

3D Microelectronics for Information Protection Project

Many of DoD's most sophisticated weapon systems and communications systems, by their very nature, are operated in close proximity to enemy combatants. UAS and other weapon systems operating in contested areas unintentionally fall into our adversary's hands. Once these systems are in enemy hands, state-of-the-art reverse engineering equipment and techniques are used to create effective countermeasures to U.S. systems. Adversaries are able to copy and create enhancements over original systems and may attempt to subvert the trusted supply chain for U.S. systems.

Miniaturization and densification of microelectronics are examples of technical strategies that can be deployed in critical defense platforms to increase resiliency and increase technology protection of weapon systems. Recent innovations, enabled by three-dimensional High Density packaging technology, which accepts a wide range of custom and COTS components, will drastically increase security of DoD's most critical platforms. These advancements will increase the opportunity for foreign military sales, thus reducing the costs for the U.S. Government, expanding sales potential, and strengthening the viability of the domestic defense industrial base. Contract award is anticipated in late-2016.

Activated Carbon Capacity Expansion (ACCE) Project

This Title III project will advance the domestic production of activated carbon, specifically military-grade material used as filtering medium against CBRN toxic threats. The effort will focus on eliminating the risk of single point of failure of industrial manufacturing capabilities.

The United States is reliant on a single manufacturing facility for military-grade activated carbon to support CBRN protection requirements for all Federal, state, and local agencies. This facility is operating at 100 percent capacity, and no alternative source exists. This project will expand production capacity with the facilitation of another manufacturing operation at a geographically separate location to ensure adequate capacity is available to meet current and future national defense and homeland security requirements and to mitigate the risk of single point of failure of this critical item. Contract award is anticipated in mid-year 2016.

Harsh Environment Fiber Optic Transceiver (HEFOT) Manufacturing Capability Project

The primary objective of this potential project is to expand existing domestic, economically viable, merchant supplier production capabilities in the manufacture of affordable and robust harsh environment photonic transceivers. The capacity expansion will be achieved through a mix of Government and contractor investments focused up increasing high speed data communications between military aircraft subsystems, enabling advanced sensors, weapons, and other on-board electronics. Key tasks will be focused upon expanding production to better align supply and military demand requirements. These tasks will be achieved through the installation of capital equipment and implementation of innovative process improvements. The desired effect will be to increase harsh environment transceiver part supply, quality, and performance, as well as reduce manufacturing cost.

Harsh environment photonic transceivers for military applications require transceiver components to operate through wide temperature ranges, shock, vibration, condensation, chemicals, and/or radiation environments. Increasing transceiver data bandwidth requirements are key technology drivers as legacy and future systems are becoming more demanding with growing data intensive capabilities such as streaming high definition (HD) videos and other enabling communications between subsystems. Several program offices are displaying a need for more advanced, cost effective harsh environment photonic transceivers. Contract award is anticipated in late-2016.

National Security Space Electron Beam Direct Write Project

The objective of this Title III Project is to address a need for an advanced lithography tool for Government-integrated circuit developments. The project is to complete the development of a piece of lithography equipment that uses multiple electron beams (e-beams) to enable the direct transfer ("writing") of integrated circuit-layer descriptions to a physical wafer being processed. The underlying process is very slow by commercial standards. Thus, an individual multi-beam module tool is an unattractive candidate for high-volume commercial fab production, but one well suited for typical high-value, low volume military/space production. The proposed project will accomplish the first such insertion.

The Electron Beam Direct Write (EBDW) method of manufacture has benefits in vastly reduced mask costs, improved design turn-around times, improved yield and reliability, improved design security (trust), and increased die sizes. Production versions of this Complimentary E-Beam Lithography (CEBL) tool would be inserted in U.S. integrated circuit foundries, fabricating parts for space and defense applications at a relatively low cost (versus commercial advanced lithography solutions in development) per system.

The project is to complete the development of a prototype, followed by production CEBL tools that use multiple electron beams (e-beams) to enable the direct transfer ("writing") of integrated circuit layer descriptions to a physical wafer being processed. Accomplishing this project brings a host of benefits when coupled with 1D (1-dimensional or "unidirectional") layout techniques as part of a complementary e-beam write (CEBW) methodology. Contract award is anticipated in late-2016.

National Security Space Next-Generation Star Trackers System Project

This potential project will establish the development and production of an affordable and reliable modular Next Generation Star Tracker System (NGSTS) that uses advanced domestically-produced CMOS detectors with a capability that meets the specifications of the DPA Title III Advanced CMOS Capability Project. This involves adherence to the STELLAR specification. A NGSTS with CMOS technology is needed to meet military and civil U.S.

Government (including NSS) and commercial market demands for the foreseeable future and will reassert the viability and competitiveness of the domestic industrial base.

The U.S. Government (USG) considers a modular NGSTS to be capable of meeting a range of specifications (i.e., environments, sensitivities, update rates, etc.), for a range of space-borne Medium-Accuracy Star Trackers (MAST: 1-20 arcsec), with the potential to also meet High-Accuracy Star Trackers (HAST: <1 arcsec) specifications for both commercial and USG space applications, all from a single basic system design. A MAST designed to target a majority of the global technical requirements with a common architecture and/or footprint is considered to be the baseline for the modular NGSTS design. Customization of electronics, software, optics, detectors, structures, etc. from baseline design will be required to meet specific program requirements. Contract award is in mid-year 2016.

National Security Space Radiation Hardened 45nm Digital Analog Production & Qualification Project

This potential project will establish a domestic production capability for DoD space qualified ASIC, Application Specific Standard Products (ASSP), and Multi-Core General Purpose Processors (MC-GPP) at less than or equal to 45 nm to support onboard processing and other critical space applications. A number of current and future DoD and intelligence systems have identified the space-qualified 45nm ASIC, ASSP, and MC-GPP devices, previously fabricated at IBM Microelectronics, as a critical enabling technology. IBM Microelectronics was recently acquired by GF, which is wholly owned by the government of Abu Dhabi, a member of the United Arab Emirates. GF is now the sole source provider for these trusted space devices, and uncertainty exists regarding long term availability.

To avoid significant redesign costs and ensure seamless transition of these systems, specifically the 45nm technology, it is proposed to expand the development of a domestic source. The project goal is to achieve a >25 percent improvement in power and performance, as well as supporting lifetime acquisition buys for these critical circuits. This effort will also facilitate future longer term efforts to strengthen the domestic industrial base for trusted space microelectronics. Contract award is anticipated in late-2016.

National Security Space Radiation Hardened Field Programmable Gate Array (FPGA) Project

The DoD and Intelligence Community have identified FPGAs as a critical enabling technology across a wide variety of present and future systems. Advanced, commercially available FPGAs do not meet the DoD requirements for Trusted systems as they are manufactured off-shore and are considered vulnerable to tampering and insertion of malicious software and/or hardware. This program seeks to improve the security posture and reduce the risk associated with FPGA technology by addressing security concerns in the design, development, fabrication, and supply lifecycle of FPGA devices.

The objective of this program is to develop and demonstrate an approach to ensure the availability of advanced "Trusted" and space qualified, reprogrammable FPGA technology to support DoD/IC applications, including satellite and strategic missile systems. Concerning this effort "Trust" is defined as assurance of the integrity and availability of a product wherein that product will reliably operate as intentionally designed and not contain any malicious hardware and/or software that will compromise the intended application, such as exfiltration of sensitive data, etc. Prior to Project Phase I, the Government project team will develop criteria that will be applied during proposal evaluations. These criteria will form the basis for implementing "degrees of assured integrity" for this program. This step is needed to ensure a common standard is applied to the comparative analyses to realistically identify areas that may need greater risk mitigation/controls. Contract award is anticipated in late-2016.

National Security Space Radiation Hardened Transistors & Diodes Project

This potential project will establish a domestic production capability for DoD space qualified, radiation hardened transistors and diodes. Future DoD and intelligence systems have identified Radiation Hardened (Rad Hard) components as a critical technology base, with few remaining suppliers of qualified components such as diodes, Metal Oxide on Silicon Field Effect Transistors (MOSFETs), Insulated-Gate Bipolar Transistors (IGBTs), Optocouplers and other optical devices, and glassless diodes. These components are used almost universally to provide power and conditioned signals to ASIC and FPGA circuits for satellites.

National Security Space Reaction Wheels Project

This potential Title III project will help to ensure the availability of space qualified Next-Generation Reaction Wheels (NGRW). Reaction wheel assembly (RWA) technology is a widely and commonly applied approach that provides spacecraft attitude control torque and angular momentum management functions.

The Government considers scalable NGRW important, as the trend toward smaller dis-aggregated satellite systems will require reaction wheels with low to mid-level moments of inertia. This effort addresses the need for a systematic, comprehensive, low cost/risk investment that maximizes industry partner business case potential, while minimizing recurring USG user community cost.

The Phase 0 goal is to study and assess the business, market, and technology associated with establishing or reviving domestic competition, or expanding an existing vendor's product line, with a focus on smaller wheels using advanced technologies. The results of the Phase 0 study will be reviewed and may be used to develop a Phase 1 production investment solicitation.

Next-Generation Jammer Project

The NGJ mission requires wide bandwidth, efficient, reliable, and affordable phased array antennas. The objectives of this project include increasing wide bandwidth, power amplifier (PA) efficiency to increase manufacturing yields and significantly reduce system cost. Improved PA efficiency will also provide reliability and associated life cycle cost benefits along with size, weight, and power (SWaP) benefits. The other main objective is to significantly reduce wide bandwidth, high power circulator production cost through reductions in material, assembly labor, and test costs. For both objectives, the goal is to achieve a MRL of 8, which means that the manufacturing processes have been approved for release to production and are ready to support LRIP. Contract award is anticipated in mid-year 2016.

Secure Hybrid Composite Containers Project

This Title III project will advance production of secure hybrid composite containers (SHCC). The effort will establish the first domestic manufacturing facility to produce this critical shipping container necessary to protect national assets in transit around the world.

The Department of Homeland Security (DHS) has struggled to find solutions to securing shipping containers. Approximately 16 million twenty-foot equivalent unit shipping containers are used throughout the world. DHS and other Government agencies routinely utilize these commercial containers under contract with shipping companies. At present, container doors are secured only with an inexpensive plastic seal, and container walls have no intrusion or breach detection capability. National assets shipped in these containers are at risk throughout the global supply chain.

DHS has funded the development of a shipping container that mitigates security risks associated with international transit. The DHS composite shipping container has specifications for a conventional steel container perimeter frame and corner castings (50 percent of container weight) and weldable composite panels (90 percent of container surface) with embedded intrusion detection sensors. The SHCC is a next-generation ISO composite shipping container and unit load device with embedded security sensors in all six walls to detect and report tampering or intrusion from the point-of consolidation to the point-of-deconsolidation. The sensors are embedded in the composite material, providing protection from both the harsh marine environment and the jostling of containers when being loaded and unloaded. It is 15 percent lighter but stronger than steel containers, has lower maintenance costs, does not require painting and won’t rust. It costs about 50 percent more than a regular container, but after four years, the shipper will recover those costs and begin to save money. The major cost savings come from the durability aspects of the container. The lighter material will also save money for shipping companies through reduced fuel costs.

Thin Wall Castings (TWC) for Military Applications Project

The primary objective of this potential project is to expand existing domestic, economically viable, merchant supplier production capabilities in the manufacture of complex, large, multi-core magnesium and aluminum sand casting products for rotorcraft platforms. The capacity expansion will be achieved through a mix of Government and contractor investments to recapitalize aging foundries and strengthen a diminishing supply base in order to meet DoD rotorcraft part requirements. Investments will focus on a series of measures designed to increase production efficiencies and/or improve part quality, thus reducing lead times, reworks and costs.

Sand casting is a low-cost manufacturing process generally used for the mass production of large metallic parts. The process involves pouring molten metal into a mold cavity that has been shaped from natural or synthetic sand and allowed to solidify into the same shape as the cavity. More than 70 percent of all metal castings are produced via the sand casting process, which is both faster and more economical than alternative casting methods. Domestic foundries prefer to prioritize high volume, low-risk commercial work over small volume, high-risk defense work. As such, this business strategy has reduced the number of foundries that are qualified to manufacture large defense castings, has limited investment in new technologies, and increased cost and lead-times for defense related casting products. Contract award is anticipated in late-2016.

Appendix D – List of Acronyms

Acronym	Definition
3D	Three Dimensional
3DELRR	Three-Dimensional Expeditionary Long-Range Radar
AAO	Army Acquisition Office
AARGM	Advanced Anti-Radiation Guided Missile
ACAT	Acquisition Category
ACCE	Activated Carbon Capacity Expansion
ACV	Amphibious Combat Vehicle
AEA	Airborne Electronic Attack
AEHF	Advanced Extremely High Frequency
AESA	Active Electronically Scanned Arrays
AFS	Alternate Footwear Solutions
AIA	Aerospace Industries Association
ALCM	Air-Launch Cruise Missile
AM	Additive Manufacturing
AMC	Army Material Command
AMDR	Air and Missile Defense Radar
AME	Advanced Microcircuit Emulation
AMF	Airborne & Maritime/Fixed Station
AMNPO	Advanced Manufacturing National Program Office
AMNPO	Advanced Manufacturing National Program Office
AMP	Advanced Manufacturing Partnership
AMP	Advanced Manufacturing Partnership
AMPAC	American Pacific
AMPV	Armored Multi-Purpose Vehicle
AMPV	Armored Multi-Purpose Vehicle
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AMRDEC	Aviation and Missile Research, Development, and Engineering Center
AoA	Analysis of Alternatives
AP	Ammonium Perchlorate
APKC	AMC Partnership Knowledge Center
APOT	Affordable Protection from Objective Threats
ARI	Aircraft Restructure Initiative
ASA(ALT)	Assistant Secretary of the Army (Acquisition, Logistics, and Technology)
ASH	Armed Scout Helicopter
ASIC	Application Specific Integrated Circuit
ASSP	Application Specific Standard Products
AT&L	Acquisition, Technology, and Logistics

ATIRCM	Advanced Threat Infrared Countermeasures
ATNAA	Antidote Treatment Nerve Agent Autoinjector
AUP	All Up Round
AWR	Air Worthiness Release
BAA	Broad Agency Announcement
BAE	British Aerospace Systems
BATTNETT	Battery Network
BBA	Bipartisan Budget Act
BBP	Better Buying Power
BCA	Budget Control Act
BD	Business Development
BDMS	Ballistic Missile Defense System
BFV	Bradley Fighting Vehicle
BI&A	Business Intelligence and Analytics
BSPK	Bio-Synthetic Paraffinic Kerosene
BT	Butanetriol
BTTN	Butanetriol Trinitrate
C&E	Construction and Equipment
C4	Command, Control, Communication, and Computers
CAB	Combat Aviation Brigade
CBARS	Carrier-Based Air Refueling System
CBRN	Chemical, Biological, Radiological, and Nuclear
CEBL	Complimentary E-Beam Lithography
CEBW	Complementary E-Beam Write
CEC	Cooperative Engagement Capability
CECOM	Communications and Electronics Command
CEMWG	Critical Energetics Materials Working Group
CERDEC	Communications-Electronics Research, Development, and Engineering Center
CFIUS	Committee on Foreign Investment in the United States
CFOAM	Coal-based Carbon Foam
CHRT	Contaminated Human Remains Transfer
CIRCM	Common Infrared Countermeasures
CMC	Ceramic Matrix Composites
CMOS	Complementary Metal Oxide Semiconductor
CNC	Computer Numerical Control
CNT	Carbon Nanotube
COL	Cycle of Learning
CORANET	Combat Rations Network
COTS	Commercial off the Shelf
CPI	Continuous Process Improvement
CVD	Chemical Vapor Deposition
CZT	Cadmium Zinc Telluride

DAB	Defense Acquisition Board
DACS	Divert and Altitude Control System
DAGR	Defense Advanced GPS Receiver
DARPA	Defense Advanced Research Projects Agency
DASD	Deputy Assistant Secretary of Defense
DCMA	Defense Contract Management Agency
DCS	Dry Combat Submersible
DDI	Dimeryl-di-isocyante
DGS	Dockable Gantry System
DHS	Department of Homeland Security
DIB	Defense Industrial Base
DIUx	Defense Innovation Unit Experimental
DLA	Defense Logistics Agency
DLIR	Defense Logistics Information Research
DMAG	Deputy's Management Action Group
DMDII	Digital Manufacturing and Design Innovation Institute
DMEA	Defense Microelectronics Activity
DMLS	Direct Metal Laser Sintering
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DoC	Department of Commerce
DoD	Department of Defense
DoE	Department of Energy
DoJ	Department of Justice
DoN	Department of Navy
DPA	Defense Production Act
DPAS	Defense Priorities and Allocation Systems
DPG	Defense Planning Guidance
DSC	Defense Space Council
EA	Executive Agent
EBDW	Electron Beam Direct Write
ECBC	Edgewood Chemical Biological Center
ECP	Engineering Change Proposals
EDA	Electronic Design Automation
EEBD	Emergency Escape Breathing Device
EELV	Evolved Expendable Launch Vehicle
EISA	Energy Independence and Security Act
ELDERS	Extremely Large Domestic Expendable & Reusable Structures
EMD	Engineering and Manufacturing Development
EMS	Electronic Manufacturing Services
EO	Electro-optical
ESA	Engineering Support Activity
ESAD	Electronic Safe and Arm Device
ESAPI	Enhanced Small Arms Protective Insert

ESSM	Evolved SeaSparrow Missile
EW	Electronic Warfare
ExCom	Executive Committee
FaC	Fragility and Criticality
FAT	First Article Testing
FEMA	Federal Emergency Management Agency
FHE	Flexible Hybrid Electronics
FHTV	Family of Heavy Tactical Vehicles
FINSA	Foreign Investment and National Security Act
FLIR	Forward Looking Infra-Red
FMTV	Family of Medium Tactical Vehicles
FPA	Focal Plane Arrays
FPGA	Field Programmable Gate Array
FRP	Full Rate Production
FTC	Federal Trade Commission
FUE	First Unit Equipped
FVL	Future Vertical Lift
FY	Fiscal Year
FYDP	Future Years Defense Program
G/ATOR	Ground/Air Task Oriented Radar
G2	Government-to-Government
GaAs	Gallium Arsenide
GaN	Gallium Nitride
GAO	Government Accountability Office
GBSD	Ground Based Strategic Deterrent
GDLS	General Dynamics Land Systems
GF	Global Foundries
GFE	Government Furnished Equipment
GFP	Government Furnished Property
GMLRS	Guided Multiple Launch Rocket System
GPS	Global Positioning System
GS	General Schedule
HASC	House Armed Services Committee
HBA	Hard Body Armor
HD	High Definition
HEFOT	Harsh Environment Fiber Optic Transceiver
HEMTT	Heavy Expanded Mobility Tactical Trucks
HHOG	High Homogeneity Optical Glass
HMMWV	High Mobility Multi-Purpose Wheeled Vehicle
HMS	Handheld, Manpack, and Small Form Fit
HR	House Report
HTCC	High Temperature Co-fired Ceramic
HTPB	Hydroxyl-terminated Polybutadiene

HWIL	Hardware-in-the-Loop
I2	Image Intensifier
IAC	Industrial Analysis Center
IACFP	Integrated Advanced Composite Fiber Placement
IAMD	Integrated Air and Missile Defense
IAVA	Information Assurance Vulnerability Alert
IBAS	Industrial Base Analysis and Sustainment
IBBA	Industrial Base Baseline Assessment
IBC	Industrial Base Council
IBex	Industrial Base Extension
IBITT	Industrial Base Information Technology Team
IBMC	Industrial Base Maintenance Contract
IBMFC	Industrial Base Management Fusion Cell
IBPE	Integrated Biofuel Production Enterprise
IBT	Industrial Base Team
IC	Integrated Circuit
IDECM	Integrated Defensive Electronic Countermeasures
IED	Improvised Explosive Devices
IGBT	Insulated-Gate Bipolar Transistor
IMU	Inertial Measurement Units
IO	Innovation Outreach
IP	Integrated Photonics
IQ	Intensive Quenching
IR	Infrared
IR&D	Independent Research & Development
ISA	Industrial Sector Assessment
ISO	Industrial Support Office
ISR	Intelligence, Surveillance, and Reconnaissance
IUID	Item Unique Identification
J4	Joint Chiefs of Staff Logistics
JAGM	Joint Air to Ground Missile
JASSM-ER	Joint Air-to-Surface Standoff Missile – Extended Range
JB2GU	Joint Block II Glove Upgrade
JDMTP	Joint Defense Manufacturing Technology Panel
JIBWG	Joint Industrial Base Working Group
JICAP	Joint Industrial Capability Analysis Process
JICAP	Joint industrial Capability Assessment Process
JLTV	Joint Light Tactical Vehicle
JMR	Joint Multi-Role
JPACE	Joint Protective Air Crew Ensemble
JPALS	Joint Precision Approach and Landing System
JPEO-CBD	Joint Program Executive Office for Chemical and Biological Defense

JPM-P	Joint Project Manager - Protection
JPTS	Thermally Stable Aviation Turbine Fuel, or Jet Propellant Thermally Stable
JSF	Joint Strike Fighter
JSLIST	Joint Lightweight Integrated Suit Technology
JTPA	Joint Technical Pursuit Area
L-ATV	Light Combat Tactical All-Terrain Vehicle
LCMC	Life Cycle Management Command
LCO	Light Cycle Oil
LCS	Littoral Combat System
LED	Light Emitting Diode
LEO	Low Earth Orbit
LF	Large Format
LIFT	Lightweight Innovations for Tomorrow
Li-Ion	Lithium Ion
LIMA	Lithium-Ion Battery Production for Military Applications
LISA	Lithium Ion Battery Production for Space Applications
LLLS	Low Light Level Sensor
LRASM	Long-Range Anti-Ship Missile
LRC	Lesser Regulated Countries
LRE	Liquid Rocket Engine
LRIP	Low Rate Initial Production
LRLAP	Long Range Land Attack Projectile
LRRDPP	Long-Range Research and Development Planning Program
LTCC	Low Temperature Co-fired Ceramics
LVSR	Logistics Vehicle System Replacement
LWACH	Light Weight Army Combat Helmet
M&A	Mergers and Acquisitions
ManTech	Manufacturing Technology
MAP	MDA Assurance Provisions
MASIC	Matching Acquisition Strategies to Industry Capabilities
MATS	Microwave Assisted Thermal Sterilization
M-ATV	MRAP All-Terrain Vehicles
MBE	Model Based Enterprise
MCF	Medical Contingency File
MC-GPP	Multi-Core General Purpose Processors
MCS	Medical Countermeasures Systems
MCT	Mercury Cadmium Telluride
MDA	Missile Defense Agency
MDAP	Major Defense Acquisition Program
MEC-D	Materiel Enterprise Capabilities Database
MIBP	Manufacturing and Industrial Base Policy
MIDS	Multi-Functional Information Distribution System

MII	Manufacturing Innovation Institutes
MIPA	Munitions Industry Production Analysis
MMIC	Monolithic Microwave Integrated Circuit
MMPV	Medium Mine Protected Vehicle
MMT	Meridian Medical Technologies
MOA	Memorandum of Agreement
MOQ	Minimum Order Quantity
MOSFET	Metal Oxide on Silicon Field Effect Transistors
MPCV	Mine Protected Clearance Vehicle
MRA	Manufacturing Readiness Assessment
MRAP	Mine Resistant Ambush Protected
MRBM	Medium Range Ballistic Missile
MRE	Meal Ready-to-Eat
MRL	Manufacturing Readiness Level
MSE	Missile System Enhancement
MSHA	Mine Safety and Health Administration
MSR	Minimum Sustainment Rate
MTVR	Medium Tactical Vehicle Replacement
MUST	Military Unique Sustainment Technology
MWT	Microwave Tube
NAAA	Nerve Agent Antidote Auto-injectors
NAMII	National Additive Manufacturing Innovation Institute
NASA	National Aeronautics and Space Administration
NAVAIR	Navy Air Warfare Center
NDAA	National Defense Authorization Act
NDS	National Defense Stockpile
NGC	Navigation, Guidance, and Control
NGJ	Next Generation Jammer
NGLAW	Next Generation Land Attack Weapon
NGRW	Next Generation Reaction Wheels
NGSC	Next Generation Strike Capability
NGSTS	Next Generation Star Tracker System
NiCd	Nickel Cadmium
NiCVD	Nickel-CVD
NiH	Nickel Hydrogen
NIST	National Institute of Standards and Technology
NNMI	National Network for Manufacturing Innovation
NORTHCOM	Northern Command
NRO	National Reconnaissance Office
NSA	National Security Agency
NSF	National Science Foundation
NSS	National Security Space
NSTC	National Science and Technology Council

NSWC	Naval Surface Warfare Center
OASuW	Offensive Anti-Surface Warfare
ODM	Original Design Manufacturers
OEM	Original Equipment Manufacturers
OIB	Organic Industrial Base
OLED	Organic Light Emitting Diode
OSBP	Office of Small Business Programs
OSD	Office of the Secretary of Defense
PA	Power Amplifier
PCAST	President's Council of Advisors on Science and Technology
PCB	Printed Circuit Board
PCB EA	Executive Agent for Printed Circuit Boards and Interconnect Technology
PDA2s	Pixel Design Arrays
PDSA	Principal DoD Space Advisor
PEO	Program Executive Office
PEO-SS	Program Executive Office Space Systems
PIM	Paladin Integrated Management
PLFA	Primary Level Field Activity
PLS	Palletized Load System
PLT	Production Lead Time
PM	Program Manager
PMAP	Processes Mission Assurance Plan
POSS™	Polyhedral Oligomeric Silsesquioxanes ™
PPSS	Post Production Software Support
R&D	Research and Development
R&E	Research and Engineering
RDT&E	Research Development Test and Evaluation
REE	Rare Earth Elements
RF	Radio Frequency
RFI	Request for Information
RFP	Request for Proposals
RIF	Rapid Innovation Fund
ROI	Return on Investment
ROIC	Readout Integrated Circuits
RPS	Rocket Propulsion System
RWA	Reaction wheel assembly
S&S	Surge and Sustainment
S&T	Science and Technology
S2T2	Sector by Sector, Tier by Tier
SAE	Service Acquisition Executive
SAF/AQ	Secretary of the Air Force for Acquisition
SAIC	Science Application International Corporation

SBIR	Small Business Innovation Research
SBIRS	Space Based Infrared System
SDACS	Solid Diverter and Attitude Control System
SDB	Small Diameter Bomb
SDD	Space Deep Dive
SEC	Software Engineering Center
SHCC	Secure Hybrid Composite Containers
SHM	Structural Health Monitoring
SIA	Semiconductor Industry Association
SIB	Space Industrial Base
SIBCP	Space Industrial Base Capability Program
SIBWG	Space Industrial Base Working Group
SiC	Silicon Carbide
SM	Standard Missile
SMA	Shape Memory Alloy
SME	Semiconductor Manufacturing Equipment
SMP	Shape Memory Polymers
SoS	Security of Supply
SoSA	Security of Supply Arrangements
SPS	Soldier Protection System
SPV	Subsistence Prime Vendor
SRM	Solid Rocket motor
SSL	Soldier Sensors and Lasers
STELLAR	Staring Technology for Enhanced Linear Line-of-site Angular Recognition
STTR	Small Business Technology Transfer
SWaP	Size, Weight, and Power
T/R	Transmit/Receive
TACTOM	Tactical Tomahawk
TATB	Triaminotrinitrobenzene
TDACS	Throttleable Divert and Attitude Control System
TIA	Technology Investment Agreement
TJS	Tactical Jamming System
TRL	Technology Readiness Level
TWC	Thin Wall Castings
TWTA	Travelling Wave Tube Ampliphiers
TWV	Tactical Wheeled Vehicles
TYAD	Tobyhanna Army Depot
UAS	Unmanned Aircraft Systems
UAV	Unmanned Aircraft Vehicles
USMC	United States Marine Corps
UDMH	Unsymmetrical Dimethylhydrazine
UDS	Universal Documentation System

UGR	Unitized Group Ration
UIPE	Uniform Integrated Protection Ensemble
ULA	United Launch Alliance
USD(AT&L)	Under Secretary of Defense, Acquisition Technology, and Logistics
USG	U.S. Government
USML	U.S. Munitions List
USSOCOM	United States Special Operations Command
VCSELS	Vertical-cavity Surface Emitting Lasers
VMI	Vendor Managed Inventory
VRLA	Valve Regulated Lead Acid
W-3%Re	Tungsten-3% Rhenium
WECC	World Electronic Circuits Council
WFaC	Workforce Fragility and Criticality
WG	Wage Grade
WGS	Wideband Global SATCOM System
Wh/kg	Watt-hours per kilogram