REPORT TO CONGRESS

Fiscal Year 2017

Annual Industrial Capabilities

Office of the Under Secretary of Defense
for Acquisition and Sustainment

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

March 2018

Preparation of this report cost the Department of Defense (DoD) a total of approximately $84,000 for Fiscal Year 2018.

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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 United States Code (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; section 852 of the National Defense Authorization Act (NDAA) for fiscal year (FY) 2012 (Public Law 112-81), which requires the annual industrial base report to include a description of and status on the assessments of the industrial base; and Senate Report 112-26, which accompanies section 1253, the 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 FY 2017 and as they existed at the close of that fiscal year. It is important to note that the status of some of the programs described herein has changed in the intervening time.

1. Defense Industry Outlook

The defense industrial base (DIB) is comprised of a diverse and dynamic set of companies, DoD organic facilities, and nonprofit institutions as shown in Table 1. The DIB provides products and services, directly and indirectly, to the Department to support national security objectives. The Department relies on an industrial base that is global, commercial, and financially complex.

Table 1: Industrial Base Composition

ENTITY	DESCRIPTION
Contractors	Private and public companies, ranging from prime system integrators and subsystem suppliers to small businesses.
Government Entities	Government-owned, Government-operated (GOGO) facilities and laboratories, Government-owned, contractor-operated (GOCO) facilities and laboratories
Nonprofit Research Entities	Federally funded research and development centers (FFRDC)
Universities	Private and public universities, laboratories

Partnerships between government, industry, and academia within the defense industrial base allow the Department to:

- Sustain production, maintenance, repair, and logistics for military weapons;
- Maintain advanced research and development activities to provide weapon systems;
- Improve development, production, and integration of information technology;
- Maintain critical design skills to ensure technological superiority;
- Ensure reliable sources of material;
- Reduce the presence of counterfeit parts; and
- Provide critical services

The defense sector continues to financially outperform the broader U.S. equity market as shown in Figure 1. However factors such as obsolescence, foreign dependency, fluctuating demand, industry consolidations, and loss of design teams and manufacturing skills for critical defense products continue to threaten the health of the industrial base, limit innovation, and reduce U.S. competitiveness in the global markets.

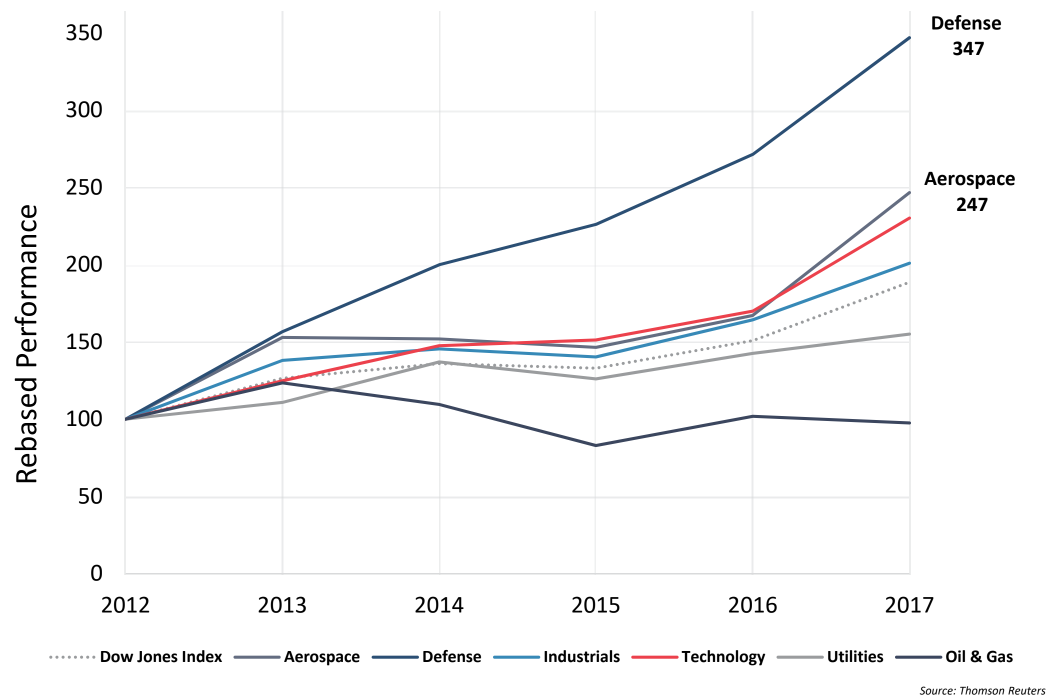


Figure 1: Annual Dow Jones U.S.-Sector Indices Performance, 2012-2017

Major prime system integrators and significant subsystem suppliers are profitable, showing positive Earnings Before Interest, Tax, Depreciation, and Amortization (EBITDA) margins.[1] Figure 2 illustrates EBITDA margin for prime system integrators and Figure 3 shows major sub-system suppliers across the last 6 years.

[1] Earnings Before Interest, Tax, Depreciation, and Amortization is a standard financial measure of a company's structural health; by excluding expenses such as taxes and interest, it focuses on core business expenses and revenues.

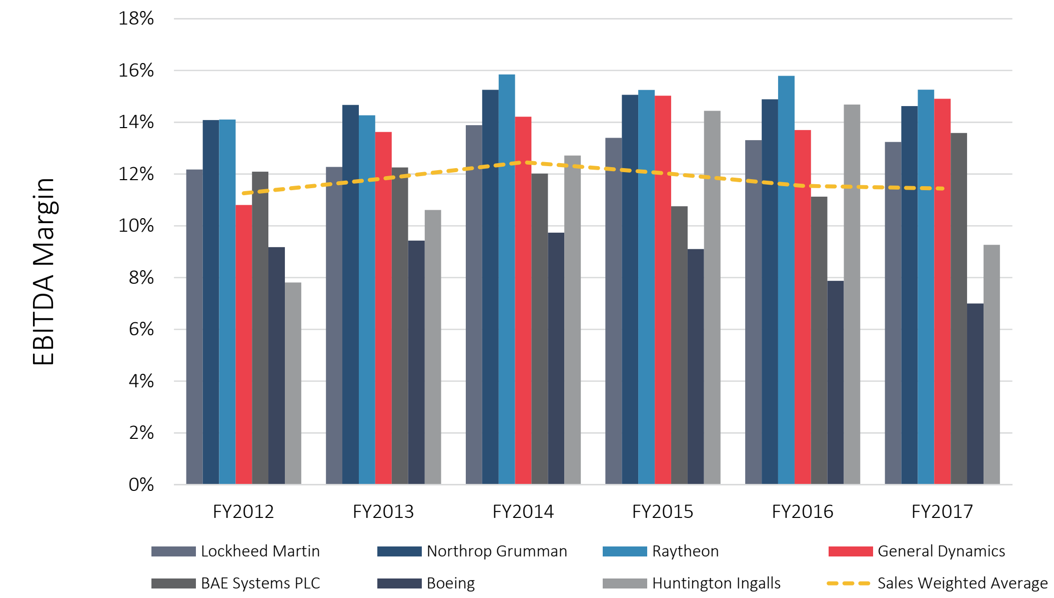


Figure 2: Aerospace and Defense Sector Prime Integrators EBITDA Performance[2]

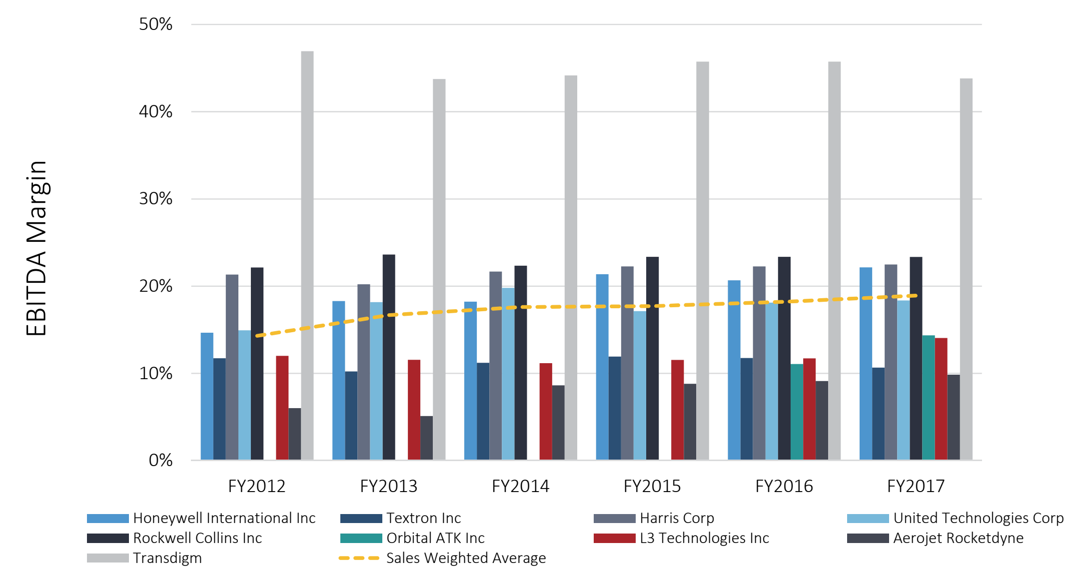


Figure 3: Aerospace and Defense Sector Sub-system and Component Suppliers EBITDA Performance

[2] Weighing average EBITDA margin by sales allows for a more accurate representation of average EBITDA margin across companies of varying sizes.

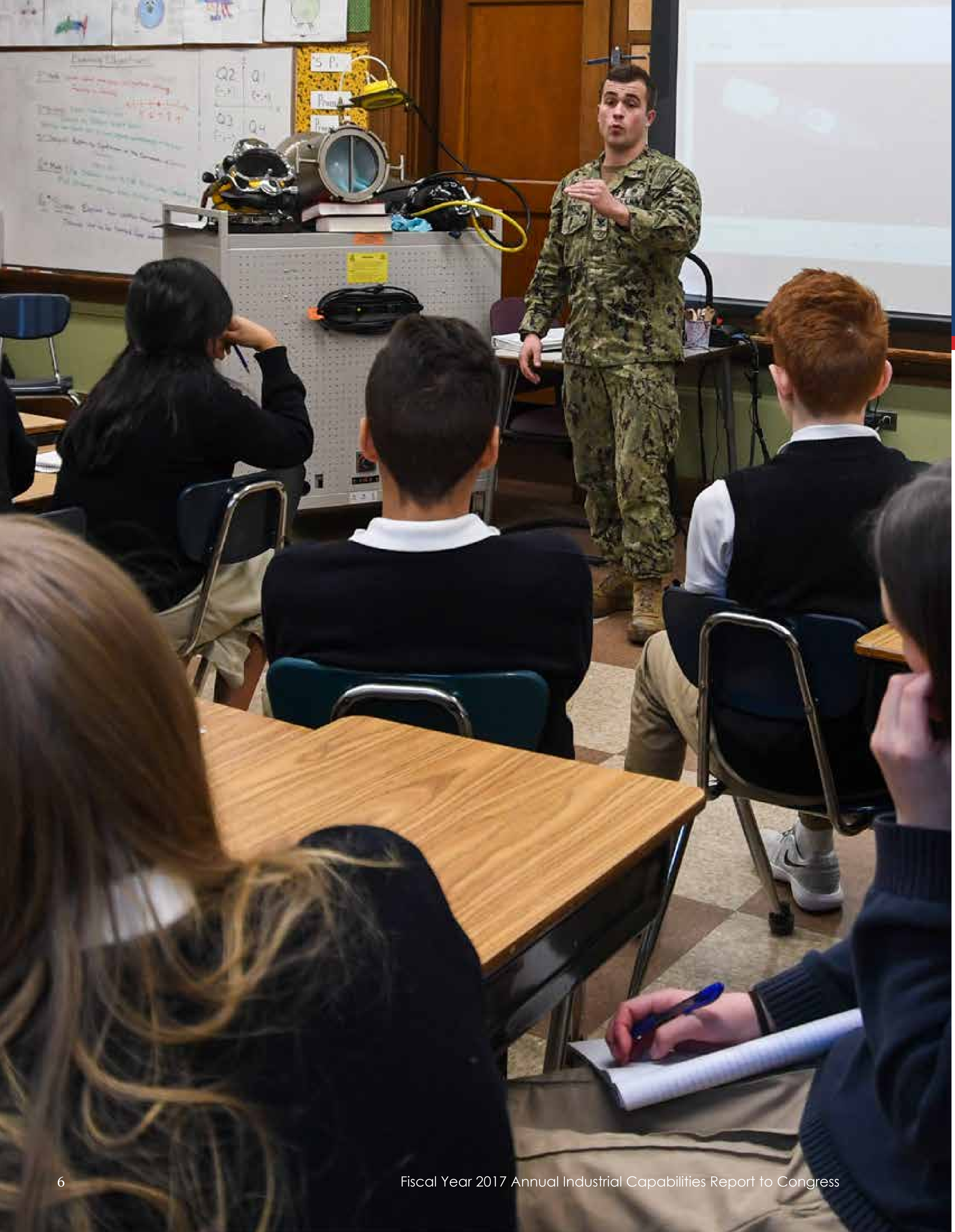
2. Manufacturing Trends Impacting the U.S. Defense Industrial Base

U.S. manufacturing trends dictate the Nation's ability to compete in global markets and support the domestic economy. Globalization, the rapid pace of technology development and integration in manufacturing are challenging the U.S. position as a dominant global manufacturer.

Although recent efforts focused on advanced manufacturing have helped to level off the decline in manufacturing jobs during the past few years, manufacturing's share of employment and gross domestic product (GDP) remain at historic lows.[3] This has led to a growing shortage of well-trained and capable manufacturing workers. Manufacturing industry chief executive officers (CEOs) have underscored this need in a Manufacturing Institute study stating that "the manufacturing industry is projected to fall a startling 2 million workers short of its needs" in the coming years.[4]

It is imperative that the U.S. defense industrial base understand and adapt to these manufacturing trends. The Department continues to expand several programs that speed technology transition into our defense systems and gain access to the innovation centers of the country, such as Defense Unit Experimental (DIUx), the Strategic Capabilities Office (SCO), and the eight DoD Manufacturing USA Institutes.

[3] Bureau of Labor Statistics and Bureau of Economic Analysis.
[4] "The skills gap in U.S. manufacturing 2015 and beyond," Manufacturing Institute, November 2015.



3. Aerospace and Defense Talent Trends

Attracting and retaining a qualified workforce is imperative to sustain a healthy manufacturing and industrial base. The need for talent across the defense industrial base is recognized by industry and government. Highly skilled workers are a key element to manufacturing. Skilled workers allow for better quality products, more efficient processes, and innovation of the manufacturing processes.

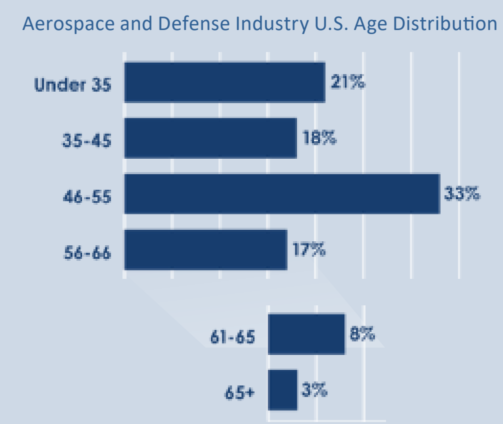
The Department is working to implement solutions to the complex challenges of a skills gap facing aerospace and defense companies. During FY 2017, the Department worked with industry, universities and community colleges to identify workforce gaps and establish programs to train and develop critical skills. The Department has attacked the problem of a sufficient and well-trained workforce through increasing the supply of STEM-oriented students in grades K through 12, focusing college students on manufacturing careers through fellowships and internships and training the current workforce on advanced manufacturing skills.

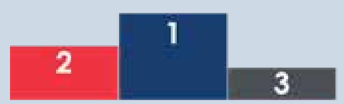
The Department plans to continue collaborative efforts in FY 2018 within the Department as well as outreach efforts with industry and academia to address joint challenges and goals in workforce development in the aerospace and defense ecosystem. These efforts will primarily focus on branding and building the talent pipeline. The following vignette provides information about workforce challenges.

U.S. AEROSPACE AND DEFENSE EDUCATION, TRAINING, RECRUITMENT AND RETENTION

A Complex Challenge[5,6]

THE STATISTICS



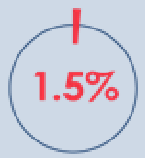


Being a part of a critical technological challenge is the #1 desire of students considering career paths

27,000

Open job requisitions within aerospace and defense companies

percentage of young professionals who believe that aerospace and defense incentives and benefits are comparable to technology giants such as Google, Apple, Facebook, or Amazon



percentage of 25-34 year olds in the U.S. who have a science degree

THE CHALLENGE

These statistics highlight that although interest is high and that plenty of positions are available, there is incredible competition to find qualified candidates with the required skills in engineering, manufacturing, and other STEM proficiencies in the market. A&D companies are being faced with a shortage of qualified workers to meet current demands as well as needing to integrate a younger workforce with the "right skills, aptitude, experience, and interest to step into the jobs vacated by senior-level engineers and skilled technicians" as they exit the workforce.

[5] "2017 U.S. Workforce Study," Aviation Week, 2017.
[6] "The Defining Workforce Challenge in U.S. Aerospace and Defense – STEM EDUCATION, TRAINING, RECRUITMENT & RETENTION," Aerospace Industries Association.

4. Achieving U.S. National Security Priorities

The defense industrial base is a central part of the Department force structure and a key partner in executing the national security priorities articulated by DoD leaders.

4.1 National Security Strategy and National Defense Strategy

In FY 2017, the Trump administration developed its National Security Strategy (NSS). In a parallel and mutually reinforcing effort, DoD planners developed the National Defense Strategy (NDS). Both documents were published in FY2018. Industrial base considerations were central in the development of both the NSS and the NDS.

4.2 Secretary of Defense Top Priorities

Secretary of Defense Mattis has focused his tenure around three lines of effort to provide the military forces needed to protect the security of the country, as he detailed in an October 5, 2017 memorandum.[7] These lines of effort are described in the subsections below.

4.2.1 Restore military readiness to build a more lethal force

"We will execute a multiyear plan to rapidly rebuild the warfighting readiness of the Joint Force, filling holes in capacity and lethality while preparing for sustained future investment."

The Department needs to ensure the military is ready to face the challenges created by global and continuously evolving threats. The demands on U.S. forces are increasing while the capabilities and technologies of our adversaries continues to advance.

[7] "Memorandum for All Department of Defense Personnel – Subject: Guidance From Secretary Jim Mattis," DoD, October 5, 2017.

The Department needs to establish a balance between maintenance, modernization, and new system developments in order to be ready for any conflict. Maintenance and modernization assure that DoD systems are fully mission capable and equipped with the best available capabilities. New system developments are necessary to achieve technological superiority over adversaries.

The industrial base supports readiness by providing the capacity and capabilities necessary to manufacture, maintain, and modernize current systems, as well as to develop the next-generation systems.

4.2.2 Strengthen alliances and attract new partners

"Alliances and multinational partnerships provide avenues for peace, fostering conditions for economic growth with countries sharing the same vision."

There is much to be gained through cooperation with international partners. A globalized technology and industrial base brings new ideas and approaches to address complex problems while delivering new capabilities to the warfighter. Further, the Department regularly engages bilaterally and multilaterally with allies and partners to address any obstacles to market access in all directions and to promote mechanisms for effective industrial cooperation.

The Secretary and other Department leaders met with many international ally and partner counterparts during FY 2017. Allies also factored into industrial base considerations during the year. For example, DoD led a project to implement section 881 of the FY 2017 NDAA, adding the United Kingdom and Australia to the national technology and industrial base (NTIB), which previously included the United States and Canada. The NTIB initiative is discussed in section 5.2 of this report.

4.2.3 Bring business reforms to the Department of Defense

"This line of effort instills budget discipline and effective resource management, develops a culture of rapid and meaningful innovation, streamlines requirements and acquisition processes, and promotes responsible risk-taking and personal initiative."

The industrial base will benefit from organizational changes that simplify and accelerate acquisition processes.

4.3 AT&L Reorganization

The FY 2017 NDAA (Public Law 114-328) contains a provision (section. 901) that amends chapter 4 of title 10, U.S.C., to establish an Under Secretary of Defense (Research and Engineering) (USD(R&E)), an Under Secretary of Defense (Acquisition and Sustainment) (USD(A&S)), and a Chief Management Officer (CMO) within the Department of Defense, effective February 1, 2018. The reorganization is an opportunity to accelerate the introduction of lethal capabilities to the force while improving our business processes.

During FY 2017, the Department worked on a plan to implement the organizational changes necessary to support the overarching objectives of technical superiority and weapon systems affordability through a streamlined acquisition process. Implementation will begin in FY 2018.

5. DoD Industrial Base Initiatives and Priorities

The Department worked in conjunction with the White House Office of Trade and Manufacturing Policy (OTMP),[8] the Departments of Commerce (DOC), Labor (DOL), Energy (DOE), Interior (DOI), Health and Human Services (HHS), Homeland Security (DHS), and other Government agencies in numerous projects and initiatives to strengthen the U.S. manufacturing and industrial base during FY 2017.

5.1 Industrial Base Executive Order

On July 21, 2017, President Trump issued Executive Order (EO) 13806, "Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States." This EO addresses the status of the manufacturing capacity and defense industrial base of the United States. As shown in Figure 4, the overall objective of this effort is to identify, assess, and make actionable recommendations to ensure the United States has a robust, secure, resilient, and innovative manufacturing and defense industrial base to support national security requirements today and tomorrow.

[8] The White House Office of Trade and Manufacturing Policy was established by Executive Order 13797. The mission of the OTMP is to defend and serve American workers and domestic manufacturers while advising the President on policies to increase economic growth, decrease the trade deficit, and strengthen the U.S. manufacturing and defense industrial base.

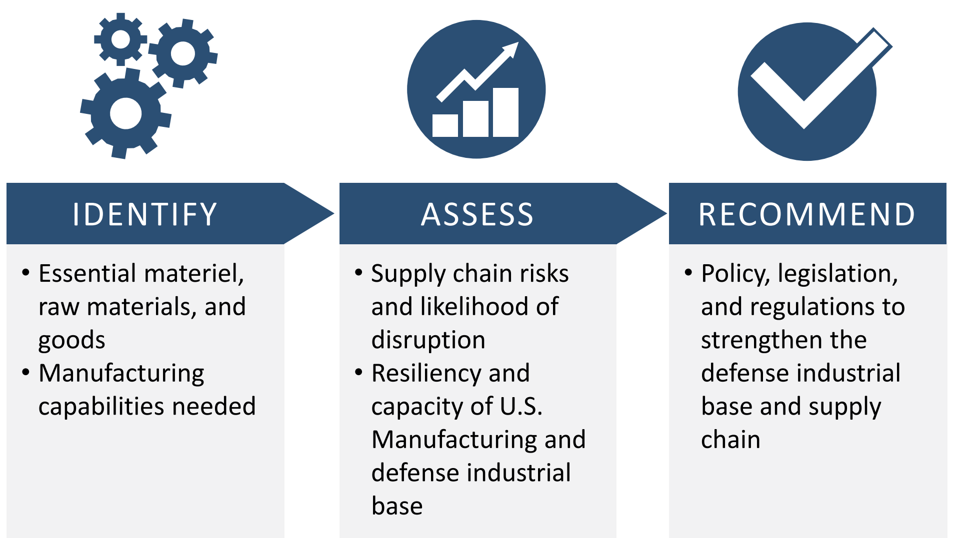


Figure 4: Industrial Base Assessment Approach for EO 13806

In FY 2017, the Department established an interagency task force to conduct this assessment of the industrial base. This involved over a dozen working groups—composed of experts from DoD, DOC, DOL, DOE, and DHS—looking into specific sectors (e.g., shipbuilding) and industrial base-wide enablers (e.g., machine tools).

By April 17, 2018, this interagency task force is expected to deliver a report to the President that assesses the defense industrial base and supply chains, and makes policy, regulatory, and legislative recommendations to mitigate identified risks.

5.2 National Technology and Industrial Base

The FY 2017 NDAA statutorily expanded the U.S. definition of the NTIB to add Australia and the United Kingdom of Great Britain and Northern Ireland; it already included Canada.[9] The expansion of the NTIB definition allows for greater international collaboration in technology, engineering, and manufacturing between the United States and the NTIB partners and may help enhance allied interoperability of forces. The new NTIB definition supports U.S. objectives to strengthen its alliances.

The FY 2017 NDAA, section 881, requires the Department of Defense to "develop a plan to reduce the barriers to the seamless integration between the persons and organizations that comprise the National Technology and Industrial Base" (as defined in section 2500 of title 10, U.S.C.). The Office of the Deputy

[9] FY 2017 NDAA, section 881.

Assistant Secretary of Defense for Manufacturing and Industrial Base Policy (ODASD(MIBP)) is the lead for this effort.

The United States formally invited Australia, Canada, and the United Kingdom, to participate in a 1-day NTIB principals' meeting in August 2017. The goal of that meeting was to identify cross-cutting NTIB pathfinder projects that would outline and test areas for potential NTIB collaboration. Each proposed pathfinder project was designed to represent industrial base transactions between the United States and one or more of the NTIB partners, or transactions where similar priorities are placed on the United States by the other NTIB partner(s).

The principals endorsed four pathfinder projects:

- **NTIB Governance:** A foundational project to formalize governance among the NTIB nations. This pathfinder project includes a nonbinding Statement of Principles among the NTIB countries, appointment of national representatives by the NTIB partner nations, and the creation of an NTIB International Staff Working Group to address any outstanding issues.
- **Investment Security:** Pathfinder on development of a potential consultation mechanism to better share information between NTIB countries regarding foreign direct investment (FDI).
- **NTIB Controlled Technology Transfer:** Pathfinder to review possible models for facilitating controlled technology transfer, including the Canadian controlled goods program.
- **Cybersecurity for Small to Medium Enterprises:** Pathfinder that will explore barriers to and opportunities for improving cybersecurity in small to medium enterprises within the NTIB in a cost-effective manner, such as using cloud-based solutions and compliance with NIST 800-171, Protecting Controlled Unclassified Information in Non-federal Information Systems and Organizations.[10]

In FY 2018, NTIB work will focus on pathfinder projects and completion of the Statement of Principles. NTIB principals will sign the statement and NTIB staff will complete the Terms of Reference (ToR) to support the pathfinder projects during first quarter 2018. This will help govern NTIB activities and manage information from each project.

[10] http://nvlpubs.nist.gov/nistpubs/SpecialPublications/NIST.SP.800-171.pdf.

6. Manufacturing and Industrial Base Policy Authorities and Organizational Structure

The FY 2011 NDAA established the Manufacturing and Industrial Base Policy office. MIBP is the principal advisor to Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics (OUSD(AT&L)) for:

- DoD policies for the maintenance of the U.S. defense industrial base;
- Budget matters related to the industrial base;
- Anticipating and closing gaps in manufacturing capabilities or defense systems;
- Assessing impacts related to mergers, acquisitions, and divestitures;
- Monitoring and assessing impact of foreign investments in the United States; and
- Executing authorities under U.S.C. title 10. See Appendix B for a full list of authorities governing MIBP program and policy functions.

MIBP's mission is to ensure robust, secure, resilient, and innovative industrial capabilities upon which the Department can rely to fulfill the warfighter's requirement. MIBP led many DoD industrial base initiatives in FY 2017 to help the industrial base capabilities meet these characteristics. A depiction of these characteristics is shown in Figure 5.

Figure 5: Ideal Industrial Base Characteristics

MIBP provides detailed analyses and in-depth understanding of the increasingly global, commercial, and financially complex industrial supply chain essential to the U.S. national defense. MIBP's extensive portfolio promotes a holistic focus on defense manufacturing, domestic and foreign business transactions, and industrial base issues. To accomplish the mission, the office is organized in three lines of effort and two cross-functional capabilities, as shown in Figure 6. These organizations conduct the initiatives and programs outlined in section 7.

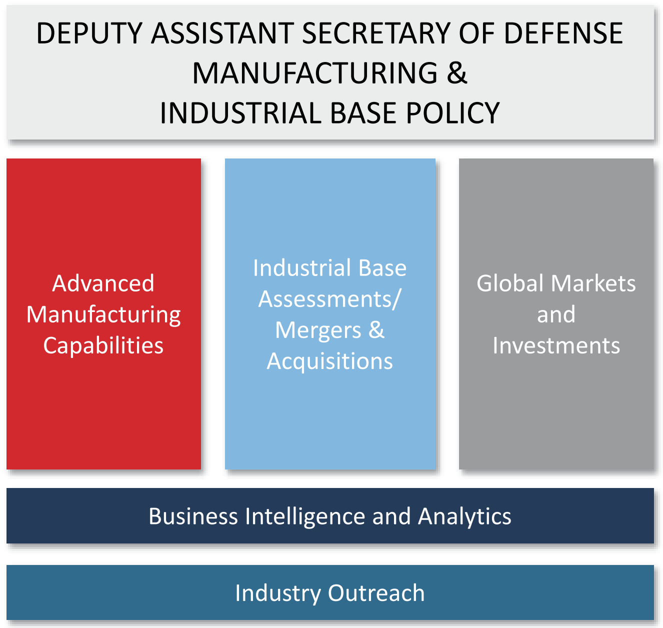


Figure 6: MIBP Organizational Structure

6.1 Advanced Manufacturing Capabilities

The Advanced Manufacturing Capabilities team anticipates and closes gaps in manufacturing capabilities for affordable, timely, and low-risk development, production, and sustainment of defense systems.

- **DPA Title III**: Ensures the timely availability of essential domestic industrial resources to support national defense and homeland security requirements.
- **Industrial Base Analysis and Sustainment (IBAS)**: Strengthens the force posture of the U.S. defense manufacturing and industrial base in support of the warfighter.
- **Manufacturing Technology (ManTech) and Manufacturing USA Institutes**: Provides cutting-edge capabilities through new manufacturing processes and systems and connects people, ideas, and technology.

6.2 Industrial Base Assessments/ Mergers and Acquisitions (M&A)

The Assessment team conducts detailed analyses of the defense industrial base to identify critical capabilities and fragile markets, develops industrial base risk mitigation strategies, and leads DoD in all matters relating to mergers, acquisitions, and divestitures.

6.3 Global Markets and Investments

The Global Markets and Investments team analyzes the national security implications of foreign investments in the United States and proactively assesses the global market trends related to the defense industrial base.

6.4 Business Intelligence and Analytics

The Business Intelligence and Analytics team uses Big Data principles to provide proactive, timely, and relevant information about the defense industrial base to decision makers.

6.5 Industry Outreach

The Industry Outreach team facilitates engagement and collaboration between industry and DoD to support industrial base initiatives like workforce development and policy development.

7. MIBP Initiatives and Programs to Manage Risk

The Office of Manufacturing and Industrial Base Policy focuses its resources and programs on identifying, analyzing, effectively mitigating, and monitoring potential industrial base risks. The MIBP risk management approach, shown in Figure 7, considers DoD risk management guidance principles.[11]

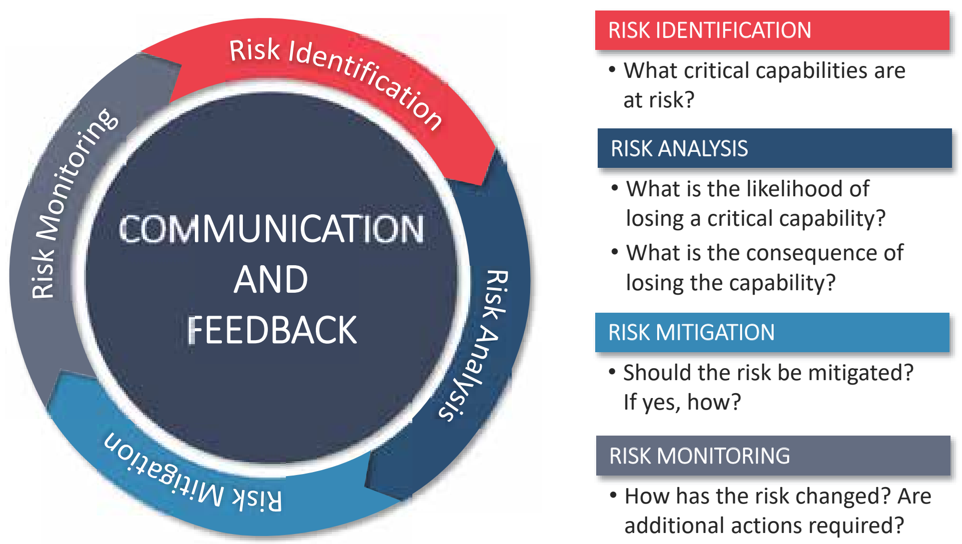


Figure 7: MIBP Risk Management Approach

Each of the steps is explained in detail below.

1. Risk Identification: Use multiple data collection sources including government, academia, and industry partners to ***identify critical capabilities at risk***.
2. Risk Analysis: Perform ***industrial base assessments*** to determine the likelihood and consequence of losing a critical capability. Industrial base risks are grouped based on their consequence to determine the best

[11] "Department of Defense Risk, Issue, and Opportunity Management Guide for Defense Acquisition Programs," Office of the Deputy Assistant Secretary of Defense for Systems Engineering, January 2017.

tool to mitigate the risk. Risk may be mitigated by reducing its likelihood, consequence, or both.

3. Risk Mitigation: Use multiple ***tools to mitigate industrial base risks***. DoD uses programs and authorities to support U.S. manufacturing and sustain a healthy industrial base.
4. Risk Monitoring: Evaluate the ***effectiveness of the risk mitigation tools*** used and ***determine if additional actions are required***.

7.1 Identifying Industrial Base Risks

DoD defines industrial base risks as uncertainties regarding industry's ability to design, manufacture, and sustain present and future critical capabilities. MIBP identifies capabilities at risk through multiple data sources including government, academia, and industry partners.

7.1.1 Joint Industrial Base Working Group

The Joint Industrial Base Working Group (JIBWG) brings together the Services and Government agency industrial base stakeholders to share, coordinate, and collaborate on defense industrial base issues in the interest of managing limited DoD industrial analysis resources, minimizing redundancy, and having an overall view of the industrial base risks impacting multiple programs, Services, and agencies. Core members include AT&L, Military Services, Defense Contract Management Agency (DCMA), Defense Agencies, Joint Staff, and Combatant Commands. The group meets biannually to share industrial base analyses executed during the year and propose new assessments necessary to help senior decision makers achieve DoD strategic objectives.

7.1.2 Defense Planning Guidance Data Call

The Defense Planning Guidance (DPG) includes consideration of fragile and critical components of the industrial base. MIBP coordinates an annual data call to the Services and other agencies to identify DoD industrial base critical capabilities at risk. During FY 2016, MIBP developed a DPG Data Input and Retrieval System to provide a collaborative tool for DoD agencies to collect and share industrial risk information. A pilot program was implemented to collect DPG data in FY 2017. MIBP will continue working on the development of data analytics options to allow for faster and more customized analysis of DPG data.

7.1.3 Industry Outreach

In order to support collaboration and innovation, DoD must ensure ongoing dialogue with industry. MIBP facilitates this dialogue through direct engagement with companies and industry associations.

During each fiscal year, MIBP leads coordination and facilitation of meetings between DoD leadership, industry associations, and their defense-related companies. Meetings include quarterly roundtables between DoD and member companies of the Aerospace Industries Association (AIA), the National Defense Industrial Association (NDIA), and the Professional Services Council (PSC) and one-on-one meetings involving DoD officials and the leadership of large, medium, and small defense companies. Often these engagements provide industry the opportunity to highlight risks in the industrial base, which DoD can actively pursue mitigation strategies to address. During FY 2017, the Department held two roundtable discussions between DoD senior leaders and AIA, NDIA, PSC, and CEOs from their member companies.

Also in FY 2017, MIBP, the Office of the Assistant Secretary of Defense for Research and Engineering and the Office of Human Capital Initiatives began collaborating with AIA on workforce development challenges. From June to December 2017, three roundtable meetings occurred with industry, DoD, and AIA to address joint challenges and goals in workforce development in the aerospace and defense ecosystem. The roundtable participants included leadership from DoD and human resource executives from Boeing, Lockheed Martin, Northrop Grumman, PricewaterhouseCoopers, Rolls Royce, Elbit Systems, and more. The group decided to focus on branding, building the talent pipeline, and diversity and inclusion in FY 2018.

Ongoing engagements between DoD and industry provide a forum to share concerns and discuss how to jointly address challenges each party faces in support of a healthy and robust industrial base. MIBP's industry outreach efforts continue to increase in breadth and depth, ensuring a collaborative relationship between all stakeholders in support of our national security requirements.

7.2 Analyzing Industrial Base Risks

Defense acquisition programs rely on innovative manufacturing capabilities, sustained capacities of domestic sources for critical components and technology items, a highly skilled workforce, and an industrial base that use these capabilities to deliver products that meet the needs of the warfighter.

> "The Pentagon must renew its focus on cooperation and partnership with industry."
>
> Secretary of Defense James Mattis
>
> Air Force Association's annual Air, Space, and Cyber conference, September 2017

MIBP conducts detailed analyses of the defense industrial base to identify critical and fragile capabilities; understand the impact of mergers, acquisitions, and divestures; assess economic trends; and determine the most effective ways to mitigate risks. As data is collected from many sources, multiple groups in MIBP perform assessments to determine the likelihood and consequence of the industrial base risks identified. Collaboration between MIBP and other DoD organizations to provide a comprehensive view of risks is common. The main types of assessments are described in this section.

7.2.1 Committee on Foreign Investment in the United States (CFIUS) Reviews

The Committee on Foreign Investment in the United States plays a vital role in reviewing potential effects related to foreign investment in U.S. companies. CFIUS is a Government body authorized by law to review any merger, acquisition, or takeover that could result in control of a U.S. business by a foreign individual or entity. The review is intended to determine the effects of a covered transaction on the national security of the United States.

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 or proliferation or that pose a potential regional military threat to the interests of the United States;
- Potential effects on U.S. international technological leadership in areas affecting U.S. national security;
- Potential effects on U.S. critical infrastructure, including major energy assets;
- Potential effects on U.S. 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.

The CFIUS 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, the Office of Science and Technology Policy, the National Security Agency, and the United States Trade Representative.

MIBP, on behalf of USD(AT&L), has the lead in representing the Department at CFIUS. MIBP coordinates its work on CFIUS matters with a wide range of internal Department stakeholders and experts.

In FY 2017, Congress introduced legislation called the Foreign Investment Risk Review Modernization Act (FIRRMA) aimed at updating CFIUS. This legislation is meant to ensure that CFIUS has the authority to look at an expanded range of transactions, including joint ventures based outside the United States and smaller, minority-position investments that could give the investing companies access to sensitive information.

7.2.2 Major Defense Supplier Merger and Acquisition (M&A) Reviews

DoD relies on robust, credible competition to provide high-quality, affordable, and innovative products. The Department works closely with the Federal Trade Commission (FTC) and the Department of Justice (DOJ). The antitrust agencies ensure that mergers and acquisitions do not reduce competition or cause market distortions that are not in the Department's ultimate best interest. 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 that may otherwise not be in the Department's or the public's interests. The Department is mindful of past loss of competition at the prime level, resulting from significant industry consolidations over the past 20-plus years.

The antitrust agencies have the statutory responsibility to determine the likely effects of a business combination 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, the Department's views are particularly significant because of its insight into a proposed merger's impact on competition, national security, and defense industrial base capabilities.

The Hart-Scott-Rodino Act (HSR)[12] established the Federal premerger notification program, which provides FTC and DOJ with information about large mergers and acquisitions before they occur. The parties involved must wait a specific period of time while the enforcement agencies review the proposed transaction. Review under the HSR program enables FTC and DOJ to determine which acquisitions are likely to be anticompetitive and to challenge the parties involved at a time when remedial action is most effective. The Department's current policy is to conduct assessments of proposed business combinations on a case-by-case basis and to support the antitrust agencies' review process. Potential national security implications associated with a proposed transaction are a major factor in the Department's position and recommendation.

From all the M&A transactions filed with the antitrust agencies, the Department reviews only the transactions with a potential impact to DoD interest and nondefense suppliers where the Department is a significant customer. In FY 2017, the Department conducted 13 M&A reviews. Examples of the transactions reviewed include cooking oil suppliers with implications for the Department of Defense Commissary Agency, prosthetic limb suppliers impacting Walter Reed and the Defense Health Agency, industrial machinery suppliers, and specialty chemical suppliers.

While the total value of the transactions in 2017 increased from levels earlier in the decade, the number of transactions has remained steady. Three high-profile transactions announced in FY 2017 captured the defense industry headlines: United Technologies' $30 billion pending acquisition of Rockwell Collins, Northrop Grumman's $7.8 billion pending acquisition of Orbital ATK, and Ultra Electronics' pending acquisition of Sparton Corporation for $235 million. As of February 16, 2018, these transactions are still under review by the antitrust agencies. Defense-related transaction volumes and values from 2007 to 2017 are represented in Figure 8.

[12] Hart–Scott–Rodino Antitrust Improvements Act of 1976 (Public Law 94-435).

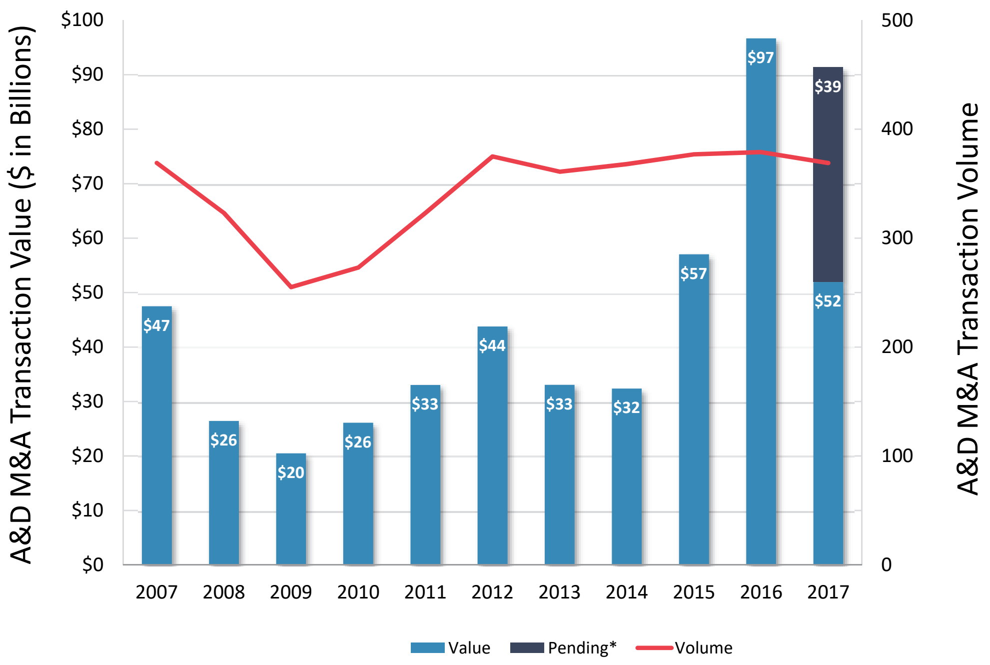


Figure 8: Defense-Related M&A Transactions[13]

Although pre-merger filing is required under HSR for transactions that meet certain thresholds such as deal size, there are instances where below-threshold deals can attract antitrust scrutiny, and such scrutiny can result in post-closing antitrust enforcement. In 2017, the Department was involved in two below-HSR-threshold deals that had previously closed but were investigated by the antitrust agencies, which resulted in litigation and ultimately divestiture by the companies to preserve competition in their respective industries. On December 21, 2017, the DOJ Antitrust Division reached a proposed settlement with TransDigm Group Inc., which requires TransDigm to sell the airline passenger safety restraint businesses it acquired from Takata at the beginning of the year. The second case was related to Otto Bock HealthCare GmbH's closing on its acquisition of FIH Group Holdings on September 22, 2017. The FTC filed an administrative complaint on December 20, 2017, challenging the merger of the two top prosthetics manufacturers.

An HSR filing is not an inoculation from the anti-trust laws. Even when there is an HSR filing, the antitrust agencies have the authority to reopen an investigation. For example, the DOJ required Parker-Hannifin Corporation to divest the Facet aviation fuel filtration business, including the aviation fuel filtration assets that it acquired from CLARCOR, Inc. DoD worked closely with DOJ in reaching a settlement that was in the best interest of the Department.

[13] Infobase data extraction, 2017.

7.2.3 Industrial Base Assessments[14]

The MIBP Assessments team provides detailed analyses of the defense industrial base. DoD-wide industrial base assessments evaluate and address changes and issues in critical system, subsystem, component, and/or material providers that affect competition, innovation, and product availability. These technical assessments include but are not limited to industrial sector summaries, risk-based analysis, and budgetary impacts on the industrial base. These assessments provide strategic views of the industrial base and help inform the Department to implement budgetary, programmatic, and legislative policies to ensure a strong and resilient industrial base.

Data-driven analyses using the Fragility and Criticality (FaC) methodology help DoD continue to improve its requirements generation process, particularly for contingency operations; to provide better and timely guidance to industry partners; and to provide an overall industrial base outlook comprised of multiple sectors.

“Fragility” and “criticality” are roughly analogous to the traditional risk factors of probability and consequence. Fragility factors are those that make a specific product or service likely to be disrupted. Criticality factors are those that make a product or service difficult to replace. MIBP’s FaC assessment model is based on four fragility factors and six criticality factors.

Table 2: Fragility and Criticality Risk Factors

FRAGILITY FACTORS	CRITICALITY FACTORS
DoD Sales	Availability of Alternatives
Financial Outlook	Defense Design Requirements
Firms in Sector	Defense Uniqueness
Foreign Dependency	Facility/Equipment Requirements
	Reconstitution Time
	Skilled Labor

MIBP uses the FaC methodology to complete data-driven analyses of the defense industrial base. This methodology incorporates both qualitative and quantitative data collection to identify industrial base risks and issues and involves subject matter experts in a sustained process of identifying and assessing the most vulnerable sectors, with breakdowns by sector tier and subtier. This methodology is intended to serve as a model for other agencies.

[14] For more information on MIBP Assessments, visit http://www.businessdefense.gov/Programs/Industrial-Base-Assessments/.

The Department completed multiple industrial capabilities assessments during FY 2017 and initiated new projects and studies to identify industrial base risks:

- MIBP led assessments of the current status of the industrial base for multiple sectors and areas of interest as part of the efforts initiated in FY 2017 to meet the requirements of EO 13806. Based on sectors and areas of interest, the Services and agencies created working groups to identify risks and issues.
- MIBP conducted a hardware assurance study to assess the presence, scope, and effect of counterfeit electronic parts on DoD operations. This report has been delivered to Congress
- MIBP led a study to optimize munitions resources for DoD sustainment and surge requirements. This assessment will continue during FY 2018.
- MIBP initiated a FaC assessment for semiconductors in FY 2017. This assessment includes three DoD-relevant commercial semiconductor market segments (memory, mixed signal, and software). This assessment will be completed in FY 2018.

7.2.4 Business Intelligence and Analytics

Central to MIBP’s approach is the development of a business intelligence and analytics (BI&A) capability for analysis of the defense industrial base. The intent of 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 Big Data principles, MIBP is leading efforts to provide effective and timely analytics on the global and domestic defense industrial base.

MIBP developed the initial business intelligence platform “DIBNow” in FY 2016. The initial version of the platform securely integrated data from government, commercial, and open sources. MIBP utilized data science techniques to index, refine, and connect diverse data sources to provide new and impactful analysis of the defense industrial base. A view of the DIBNow monitor page is shown in Figure 9.

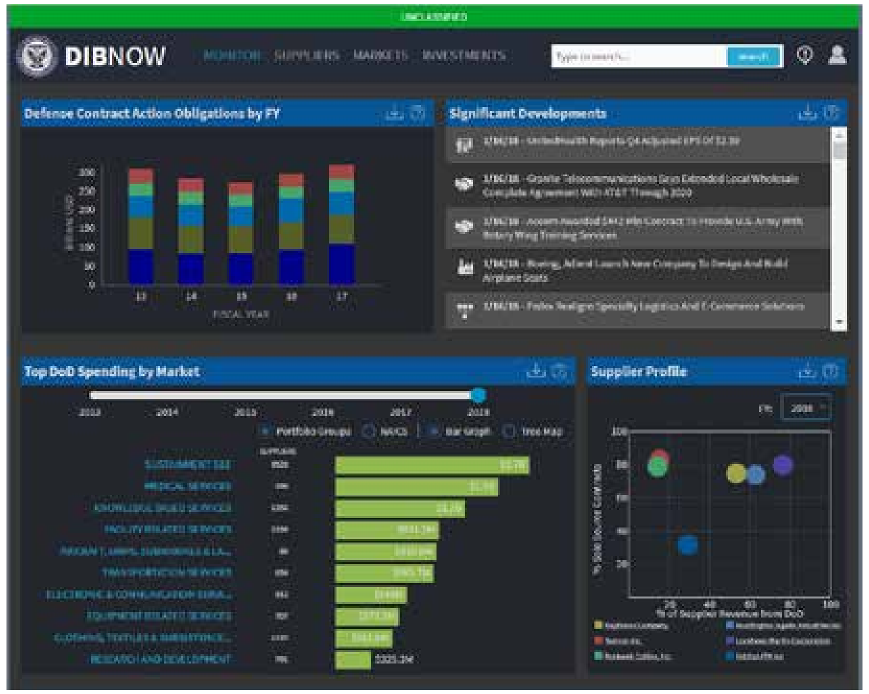


Figure 9: DIBNow Monitor Page

To deliver this capability, MIBP developed a secure web-based platform, allowing users of the platform to monitor and explore defense industrial base suppliers, markets, and transactions using the latest available data.

Development of the DIBNow platform continued in FY 2017. Efforts were concentrated on refining existing data sources as well as incorporating new data feeds from government and commercial sources, developing platform features, and conducting the required security reviews and remediation to operate on DoD networks. MIBP also continued collaborative efforts with other agencies, fostering data-sharing agreements and exchanging analytic best practices to ensure a holistic view of the defense industrial base across the Department.

DIBNow received authorization to operate on the DoD network in early FY 2018, and on boarded a community of test users from MIBP and other DoD organizations. MIBP will continue platform development in FY 2018, incorporating initial user feedback and using it to inform development priorities. Specific areas of focus include elevating platform security to ingest proprietary/For Official Use Only (FOUO) data sources; gaining better visibility into defense supply chains; and improved analytics on mergers, acquisitions, and other transactions that impact the Department. These features will support a wide variety of industrial base analyses and provide new insight to analysts and senior DoD leadership.

MIBP's ultimate goal will be to offer DIBNow as a resource for a broad community of Department and intragovernmental industrial base stakeholders, providing a common platform for analysis of the defense industrial base.

7.3 Mitigating Industrial Base Risks

The Department continues to implement initiatives and utilize existing authorities and programs to mitigate risks to the industrial base. Altogether, these authorities and programs maintain the resilience of the industrial base by addressing the diverse challenges facing critical suppliers. The main mitigation initiatives and programs are described below.

7.3.1 Defense Production Act Title III[15]

DPA[16] Title III provides the President broad authority to ensure the timely availability of essential domestic industrial resources to support national defense and homeland security requirements by authorizing economic incentives to create, expand, and modernize production capacity. DPA Title III is an authority, not an automatic source of funds. This authority provides for investments in domestic manufacturing that spur innovation by leveraging existing private sector investment in the domestic aerospace and defense industry. The military departments, defense agencies, or other Federal agencies serve as sponsors for specific Title III efforts.

> In 2017, the President signed two landmark determinations authorizing the use of DPA Title III to address shortfalls in the space sector, 3D microelectronics, next-generation soldier protection, Adenovirus production, and secure cargo shipping containers.

Over the past six decades, this authority has been used to forge new military capabilities and push the boundaries of science and technology. DPA Title III is unique among DoD programs because its central focus is to address challenges facing domestic production capacity. This program has a well-established record as an exceptionally effective tool for transitioning new technologies from research and development to production. By providing industry with a variety of incentives to reduce the risks associated with establishing the needed capacity, the program is able to facilitate the expansion of domestic capacity and ensure the production of critical defense technology.

DPA Title III projects meet the following criteria as required by law:

- The industrial resource, material, or critical technology item is essential to the national defense;

[15] For more information on DPA Title III, visit http://www.businessdefense.gov/Programs/DPA-Title-III/.
[16] The Defense Production Act of 1950, as amended (Public Law 81-774).

Solid Rocket Motors Project

DPA TITLE III ASSISTS IN ADVANCING DIGITAL FACTORY

In 2017, Title III completed a 2-year partnership with Aerojet Rocketdyne, a rocket and missile propulsion manufacturer. This project assisted in the establishment of a digitally based manufacturing environment through the procurement and installation of state-of-the-art equipment and digital interconnectivity tools. This effort involved the procurement and installation of more than 20 pieces of major equipment and tooling. Currently, 80% of the equipment is operating in a production environment, actively supporting production programs at Aerojet Rocketdyne, such as the Standard Missile 3 Throttleable Divert Attitude Control System, and contributing to the affordability and producibility goals within its DoD programs.

The results of this project are significant. New robotics technology is enabling extremely precise operations in the manufacturing and inspection processes. Robotics is also allowing remote operation of hazardous propellant and explosive operations, thereby eliminating threats to personnel safety. Additive manufacturing (3D printing) and fully digital-capable equipment are creating new and more efficient manufacturing capabilities that in some cases lower operation costs by 50% and reduce cycle times by margins greater than 70%. Ultimately, Title III's investment advances the Digital Factory vision and accelerates its deployment to other sites. In the end, DoD customers realize tangible gains thanks to this Title III investment.

- Without Presidential action under this section, U.S. industry cannot reasonably be expected to provide the capability for the needed industrial resource, material, or critical technology item in a timely manner; and
- Purchases, purchase commitments, or other action pursuant to this section are the most cost effective, expedient, and practical alternative method for meeting the need.

Across the DPA Title III portfolio, the program's core impact areas intend to:

- Sustain critical production;
- Commercialize research and development efforts; and
- Scale emerging technologies.

The DPA Title III office manages a portfolio of over $1B in combined government investment and industry cost-share. In 2017, the DPA Title III program actively managed 22 projects and oversaw 7 projects in the monitoring phase. Three projects were completed, eight projects were in active acquisition, and seven projects were explored as potential future efforts.

For details about these specific projects, see Appendix D of this report.

7.3.2 Industrial Base Analysis and Sustainment[17]

The IBAS program gives the Department a tool to achieve its strategic goal of strengthening the industrial base by funding projects that address critical issues relating to urgent operational needs. 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 avoidances to the Department.

The authorities[18] of the IBAS program include the following four functional areas:

- Monitor and assess the industrial base;
- Address critical issues in the industrial base related to urgent-operational needs;
- Support efforts to expand the industrial base; and
- Address supply chain vulnerabilities.

> Since program inception, IBAS has sponsored 21 major efforts from FY 2014 through FY 2017. These programs have preserved fundamental capabilities across the industrial base in all four of the IBAS functional areas.

[17] For more information on IBAS, visit http://www.businessdefense.gov/Programs/IBAS/.
[18] IBAS authorities are directed in title 10 U.S.C., section 2508.

The IBAS program maintains and improves the health of critical and fragile industrial base capabilities. Sustainment of these capabilities has shown great success in maintaining critical industrial capabilities, enhancing the readiness and effectiveness of our national defense, and lowering total cost to DoD. See Appendix D for descriptions of the IBAS projects.

IBAS project ideas come from a variety of different sources. A general call for proposals can be sent to Department service acquisition executives and agencies. Sector-specific working groups, such as the Space Industrial Base Working Group or the Critical Energetics Material Working Group, can engage the IBAS program office directly. Additionally, industrial base assessment results can be used to target specific areas of concern.

7.3.3 Manufacturing Technology (ManTech)[19]

Manufacturing technologies and processes underpin the ability to turn emerging and disruptive technologies into cutting-edge capabilities ready for acquisition and integration into existing or new military weapon systems. While science and technology (S&T) investments provide ripe opportunities to provide the warfighter with increased lethality and capabilities, these investments need to transition reliably, affordably, and in a timely manner. Under the policy and oversight of MIBP, the Department ManTech program serves as an enabler of technology transition. In fulfilling MIBP's mission to ensure robust, secure, resilient, and innovative industrial capabilities upon which the Department can rely, the ManTech program brings affordable technologies to acquisition program managers through new manufacturing production processes and equipment.

The ManTech program's mission is to anticipate and close gaps in manufacturing capabilities for a more affordable, timely, and low-risk manufacturing process of U.S. defense systems. To achieve this end, the program focuses on initiatives beyond the normal risk of industry and direct investments. The ManTech program helps to enhance the United States technological edge in an evolving threat environment by improving the technology, business practices, and workforce that provide the goods and services to DoD.

There are six components that execute the DoD ManTech program: the Departments of the Army, Navy, and Air Force; the Defense Logistics Agency (DLA); the Missile Defense Agency (MDA); and OSD, as shown in Figure 10. Each component ManTech program has unique focus areas to meet their mission

[19] For more information on OSD ManTech, visit http://www.businessdefense.gov/Programs/OSD-Manufacturing/.

capability needs that, when combined, provide a comprehensive set of common goals for the entire Department of Defense.

The directors and senior managers of these component ManTech programs coordinate through the auspices of the Joint Defense Manufacturing Technology Panel (JDMTP) to identify and integrate requirements, conduct joint program planning, and develop joint strategies. The JDMTP charges four joint-Service, technology-based subpanels (metals, electronics, composites, and advanced manufacturing enterprise) with coordinating investments, annually evaluating subpanel projects, and developing Joint Technology Pursuit Areas.

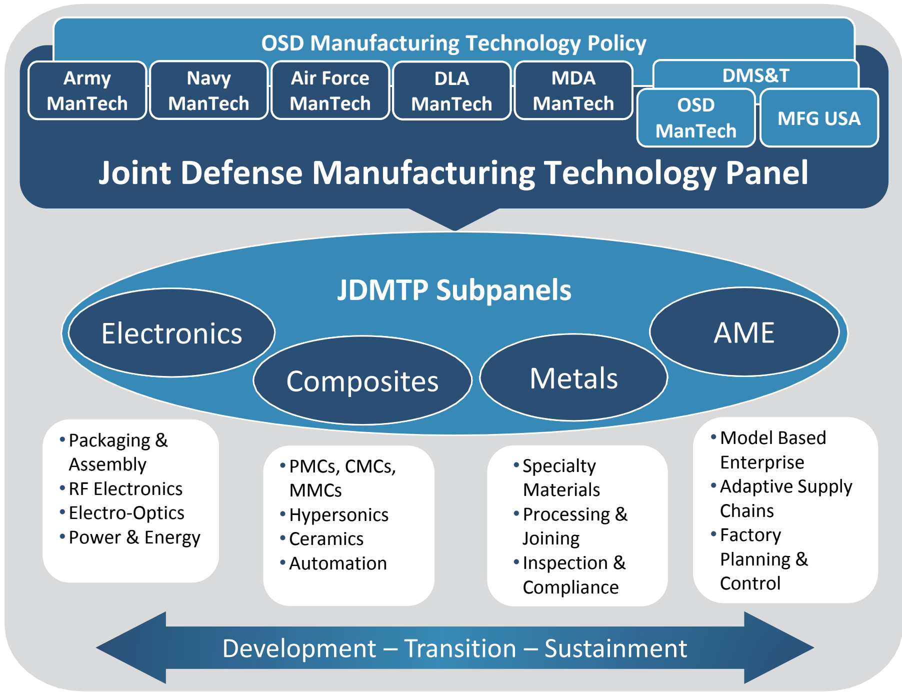


Figure 10: DoD ManTech Program Organization

The OSD ManTech program focuses on developing cross-cutting and revolutionary manufacturing technologies, processes, and capabilities. The defense-wide investments made through the OSD ManTech program help improve the performance, affordability, and cycle timelines of many of the Department's most essential products and systems. Because these investments typically are beyond the scope or risk of any one military department, agency, or program, the OSD ManTech program offers a unique service that benefits the entire Department.

The Defense-wide Manufacturing Science and Technology (DMS&T) program element comprises two programs: the OSD ManTech program and the DoD

Manufacturing Innovation Institutes (Manufacturing USA). These programs support DoD efforts to stimulate innovative manufacturing technologies and processes.

Key DMS&T technical areas for investment in the OSD ManTech programs include:

- Advanced Electronics and Optics: Advanced manufacturing technologies for a wide range of applications such as sensors, radars, power generation, switches, and optics for defense applications.
- Advanced Materials: Advanced manufacturing technologies for a wide range of materials such as composites, metals, ceramics, nanomaterials, metamaterials, and low observables.
- Advanced Energetics Manufacturing: Newly developed energetic ingredient production as well as advancements in the highly specialized production of propellant, explosives, and pyrotechnic compositions.
- Manufacturing Process Advancements: Advanced manufacturing technologies, data management and utilization, and enterprise business practices for defense applications.

As the Department seeks to improve its manufacturing capabilities and S&T, DMS&T leads the way in ensuring timely, affordable adoption and deployment of emerging technologies needed to maintain U.S. warfighting dominance.

7.3.4 Manufacturing USA Institutes[20]

The Manufacturing USA network is responsible for coordinating public and private investments to improve the competitiveness and productivity of U.S. manufacturing. The mission of the Manufacturing USA network is to connect people, ideas, and technology to solve industry-relevant advanced manufacturing challenges, thereby enhancing industrial competitiveness and economic growth and strengthening U.S. national security. Formally established in 2014, Manufacturing USA is made up of a robust network of manufacturing innovation institutes. Each institute is a public-private partnership focusing on a specific, promising advanced manufacturing technology area. These institutes collectively advance American manufacturing innovation by creating an effective research and development, technology transition, and education and workforce development infrastructure for industry and academia to solve problems.

Currently, there are 14 Manufacturing USA institutes, 8 of which were established by DoD, 5 by the Department of Energy, and 1 by the Department of Commerce under the National Institute of Standards and Technology (NIST). In total, the Federal investment exceeds $1 billion, matched by over $2 billion in funding by industry, academia, and State and local governments.

On behalf of DoD institutes, the Army, Navy, and Air Force provide the OSD ManTech program office with Government program managers committed to ensuring that Manufacturing USA institutes provide services that benefit the Department of Defense. With the help of the Government program management team, the institutes engage with professionals throughout the Department and Military Services. Key DoD stakeholder groups include leaders in the research, development, test, and evaluation (RDT&E); acquisition; and operations and sustainment communities. These relationships help secure the future of Manufacturing USA institutes as tools utilized by DoD to enhance the capabilities of the U.S. warfighter.

> Since 2012, DoD has established eight Manufacturing USA institutes, combining $600 million in Federal investment with $1.2 billion in matching funds from industry, academia, and State governments to form centers of excellence promoting U.S. competitiveness.

The OSD ManTech program office also works closely with agency partners across the Federal Government. The Manufacturing USA network consists of agency representatives from the Department of Commerce, Department of Energy, Department of Education, National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), Department of Agriculture, and the White House. These relationships help ensure that Manufacturing USA provides a holistic approach to helping improve U.S. manufacturing capabilities.

Tenets of DoD Manufacturing USA institutes:

- Industry-driven public-private partnerships
- Regional hubs for manufacturing excellence
- Investments in applied research and industrially relevant manufacturing technologies
- Required focus on education and workforce development needs

Manufacturing USA institutes provide strategic impacts by:

- Building a true national network of public-private partnerships;
- Creating an industrial commons for manufacturing R&D and workforce education and development;
- Marshalling the best talent across industry;
- Strategically aligning resources to address critical technologies; and
- Catalyzing ecosystems across the Nation.

[20] For more information on Manufacturing USA Institutes, visit http://www.businessdefense.gov/Programs/Manufacturing-USA-Institutes/.

In FY 2017, DoD established two institutes: Advanced Robotics Manufacturing (ARM) and BioFabUSA.

ARM is a Pittsburgh-based, public-private partnership led by Carnegie Mellon University. ARM actively develops, demonstrates, and facilitates early adoption of robotic solutions in an effort to grow the national manufacturing ecosystem. ARM focuses on critical growth sectors that are ripe for rapid adoption of robotics in manufacturing, including: aerospace, automotive, electronics, textiles, logistics, and composites.[21] The objective of ARM is to improve U.S. competitiveness in manufacturing through advancements in smart collaborative robotics.

BioFabUSA is sustained by the Advanced Regenerative Manufacturing Institute (ARMI), a nonprofit organization located in Manchester, NH. ARMI's mission is make practical the large-scale manufacturing of engineered tissues and tissue-related technologies, to benefit existing industries and grow new ones. To that end, the technical scope for BioFabUSA work includes innovations across five thrust areas: (1) cell selection, culture, and scale-up; (2) biomaterial selection and scale-up; (3) tissue process automation and monitoring; (4) tissue maturing technologies; and (5) tissue preservation and transport.[22]

DoD Manufacturing USA institutes collectively represent nearly 1,000 organizations including defense and commercial manufacturers of all sizes, startups, universities, community colleges, and State or local economic developers in active partnership with the U.S. Government. The eight DoD institutes are summarized in Figure 11.

Manufacturing USA Education and Workforce Development

The Manufacturing USA Education and Workforce Development (E/WD) team consists of over 50 individual members (up from 20 in FY 2016) from all 14 institutes and multiple Federal agencies (DoD, NIST, DOE, DOL, NSF, etc.). The team teleconferences monthly and meets in person quarterly to share opportunities for partnership, success stories, and lessons learned and to work on joint initiatives. Since August 2016, the E/WD team has set annual strategic goals for the group to work toward in support of joint E/WD efforts that promote advanced manufacturing writ large.

[21] www.arminstitute.org.
[22] www.armiusa.org.

America Makes: The National Additive Manufacturing Innovation Institute
Youngstown, OH | www.americamakes.us
America Makes strengthens U.S capabilities in 3D printing and additive manufacturing.

Digital Manufacturing and Design Innovation Institute (DMDII)
Chicago, IL | dmdii.uilabs.org
DMDII leads the nation's research into applying cutting-edge digital technologies.

LIFT: Lightweight Innovations for Tomorrow
Detroit, MI | lift.technology
LIFT speeds development of new lightweight metal manufacturing processes.

AIM Photonics: American Institute for Manufacturing Integrated Photonics
Albany and Rochester, NY | www.aimphotonics.com
AIM Photonics accelerates development of the photonic integrated circuit industry.

NextFlex: America's Flexible Hybrid Electronics Institute
San Jose, CA | www.nextflex.us
NextFlex innovates electronic packaging and printing to produce flexible electronic products.

AFFOA: Advanced Functional Fabrics of America
Cambridge, MA | go.affoa.org
AFFOA accelerates widespread commercialization of highly functional fabrics.

BioFabUSA: Advanced Tissue Biofabrication Institute
Manchester, NH | www.armiusa.org
BioFabUSA develops next-generation techniques for cell and tissue biofabrication.

ARM: Advanced Robotics Manufacturing (ARM) Institute
Pittsburgh, PA | www.arminstitute.org
ARM improves U.S. competitiveness through advancements in the smart collaborative robotics.

Figure 11: Manufacturing USA Institutes Established by DoD

At the end of FY 2017, the E/WD team set two strategic goals for FY 2018, the most significant being creation of a common narrative communicating the institutes' E/WD efforts in the advanced manufacturing ecosystem. Longer term, the institutes, in partnership with Government leads, will be working on the second strategic FY 2018 goal: to find effective data management strategies, with the possibility of utilizing the data for building out an E/WD portal on the Manufacturing USA public website, hosted by the DOC NIST Advanced Manufacturing National Program Office (AMNPO).

Over the past 2 years, knowledge sharing among the E/WD team provided a cohesive platform for newer institutes to partner up with older institutes and utilize models that yielded successful results. For example, roadmapping models created by older institutes helped newer institutes rapidly stand up workforce development advisory committees and get E/WD quick-start programs initiated within the institutes' first year. Partnering across institutes also led to FY 2017 NDAA funding of three projects. One of the funded projects, led by Lightweight Innovations for Tomorrow and in partnership with America Makes, the Digital Manufacturing and Design Innovation Institute, and the Institute for Advanced Composites Manufacturing Innovation, built off an FY 2016 joint effort to create a multi-skilled technician competency model; the FY 2017 project furthers the competency model by developing and implementing a replicable and scalable foundational curriculum.

The Manufacturing USA E/WD team launched a collaborative shared services portal for knowledge management in partnership with the DOC NIST AMNPO, which hosts the collaborative portal as a subsite of the Manufacturing USA shared services portal. The development of the E/WD portal supported the FY 2016 strategic goal to increase knowledge sharing across the Manufacturing USA E/WD team. The portal holds more than 316 items including institute workforce assessment reports, project call guides, presentations, meeting reports, industry reports, and more. This intra-network collaboration facilitates communication for all institute and agency partners.

Four key areas of the portal are:

- A calendar that captures key E/WD events hosted by the institutes, agencies, and industry;
- Three libraries that share documents, including operational procedures, best practices, and success stories;
- Topic-based collaborative sections, such as discussion boards, that allow users to work together to develop partnerships, discuss program scalability, plan meetings, etc.; and
- A directory of all E/WD leads, across the institutes, and partner agencies.

THE IMPACT OF MANUFACTURING USA

Manufacturing USA is working!

Every day, Manufacturing USA leaves its mark on the United States by bringing together manufacturing, academia, and government to fuel a skilled U.S. workforce.

These collaborations galvanize domestic manufacturing supply chains; grow centers of technological excellence across the country; move products from lab to market in record time; revitalize regional and national economies; and affirm U.S. global leadership.

Excerpts from a third-party assessment by Deloitte:

"The first eight advanced manufacturing institutes, established between 2012 and 2016, have reached a critical mass of valuable connections among 1,200 participating companies, universities, and government agencies. Those connections are accelerating the innovation needed to develop new products and markets, helping alleviate a shortage of technically trained manufacturing workers and building a sustainable national manufacturing research infrastructure. "

The institutes have already attracted hundreds of members, including "influential U.S. companies such as Boeing, GE, Johnson & Johnson, Lockheed Martin, Ford," and others of various sizes and at different points along the supply chain and R&D pipeline.

The Manufacturing USA institutes have created "true public-private partnerships that are successfully uniting academia, industry and government across the country."

Furthermore, the network offers "numerous examples of companies connecting and working together in ways that would not have occurred independent of the institutes." These various projects are helping to reduce the cost and risk of experimentation, which means that each member's investment goes farther.

For more detailed information about the Manufacturing USA program, please refer to Manufacturing USA: A Third-Party Evaluation of Program Design and Progress at https:www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-mfg-manufacturing-USA-program-and-process.pdf.

7.3.5 MD5 National Security Technology Accelerator[23]

Established in 2016, the MD5 National Security Technology Accelerator (MD5/NSTA) creates new communities of innovators that solve national security problems. MD5 builds these persistent communities through deep collaboration with the academic and venture communities to export translatable, dual-use problem sets from DoD and import new ideas, talent and technology to help solve those problems. This approach enriches the Defense Industrial Base by broadening the ways in which non-traditional solution providers can engage, interact and ultimately do business with the DoD.

MD5 is building a people-centric innovation pipeline that underwrites the development of technology-focused ventures relevant to national security and the economic and social imperatives of the Nation. MD5 approaches this objective by addressing the human dimension of innovation based on the education of internal customers (e.g., DoD operators, planners, acquisition professionals) and external partners (e.g., researchers, postdocs, students, entrepreneurs). The overarching goal of MD5's portfolio of programs is to create a steady stream of innovators who are:

- Exposed to military problems and technologies;
- Prepared to formulate insights that apply these technologies in novel ways relevant to national security; and
- Capable of cultivating successful ventures that reduce insights to practice in the broader economic or social context.

The MD5 innovation pipeline consists of a portfolio of programs designed to synchronize the civilian and military markets through venture creation. These programs are organized in three broad categories: education, collaboration, and acceleration. Figure 12 outlines current MD5 programs.

[23] For more information on MD5, visit http://www.businessdefense.gov/Programs/MD5/. For information about eligibility and registration, please visit www.md5.net/about.

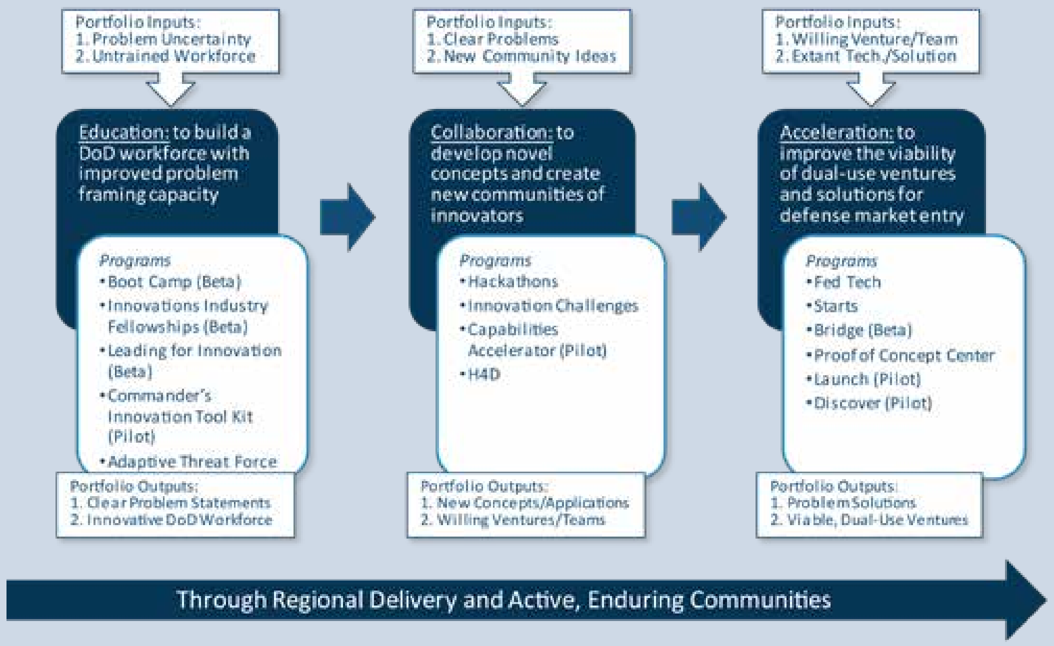


Figure 12: MD5 Programs

Hacking for Defense (H4D)

Originally piloted at Stanford University in 2015, H4D has become a flagship DoD program that is currently being offered at more than 10 universities around the country as of Spring 2018. Deeply rooted in Lean philosophy, the course emphasizes a "flipped classroom" approach wherein teams of students are matched with real-world, warfighter problems and spend most of the semester conducting customer discovery with DoD entities to better inform their proposed solution or concept. At the conclusion of the course, student teams "pitch" the original DoD problem sponsor and determine whether to transform their original idea into a new, dual-use venture.

Although venture formation is not the primary purpose of the program, to date more than half a dozen ventures have formed based upon original, H4D problem solutions; some of those have already raised millions of dollars in venture capital funding.

7.3.6 Defense Innovation Unit Experimental

Defense Innovation Unit Experimental (DIUx) serves as a bridge between those in the U.S. military executing on some of our Nation's toughest security challenges and companies operating at the cutting edge of technology. The goal of DIUx is to increase the speed and efficiency of the Department by tapping into the rapid evolution of commercial technology and to help facilitate the integration of those ideas into military systems and concepts of operation. Ultimately, DIUx creates innovative 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.

> "There is no doubt in my mind that DIUx will not only continue to exist, it will actually grow in its influence and its impact on the Department of Defense."
>
> Secretary of Defense James Mattis
>
> Remarks at DIUx, August 10, 2017

Established in 2015, the unit now has 25 contracts that range from a communications technology that will allow communication in noisy areas to unmanned sailboats for collecting intelligence.[24] DIUx expanded it base of operations from its headquarters in Mountain View, CA, to offices in Austin, TX, and Boston, MA.

7.3.7 Industrial Base Council

MIBP continued to raise the visibility of defense industrial base issues within the Department through the Industrial Base Council (IBC). The IBC provides an executive-level forum for senior DoD leaders to review and discuss key defense industrial base trends and issues to:

- Inform and facilitate enterprise-wide program investment decisions;
- Develop policies, programs, and business incentives to mitigate industrial base vulnerabilities and attract innovative technology suppliers; and
- Seek ways to diversify investments to attract new and innovative technology suppliers.

The IBC consists of three-star level representatives from the Services, relevant agencies, and OSD organizations focused on industrial base matters. The IBC, which met twice in FY 2017, is depicted in Figure 13.

[24] For more information on DUIx, visit https://www.diux.mil/.

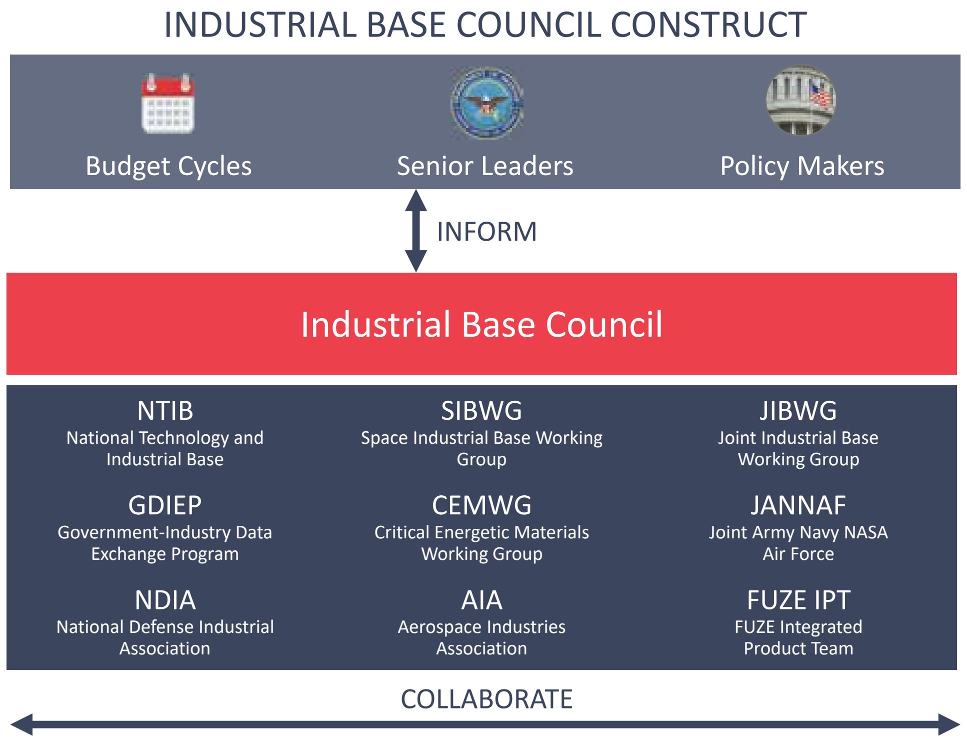


Figure 13: Industrial Base Council

7.3.8 Defense Priorities and Allocations System[25]

The Defense Priorities and Allocations System (DPAS) ensures the timely availability of industrial resources to meet national defense and plays a vital role in quickly resolving schedule and delivery constraints. DPAS establishes procedures for placement of priority ratings on contracts, defines industry's responsibilities, and establishes compliance procedures. Title I of the DPA provides the President the authority to require performance on contracts and orders, as necessary, to meet national defense and emergency preparedness program requirements. The DOC is the delegated authority to implement these priorities and allocate provision of industrial resources. Commerce has then delegated this authority to DoD as well as other agencies to place priority ratings on contracts or orders necessary, or appropriate, to promote the national defense.

In addition, DoD may request the DOC provide Special Priorities Assistance to resolve conflicts among both rated and unrated (including nondefense) contracts and orders, as well as to authorize priority ratings for other U.S. Federal agency

[25] For more information about DPAS, visit http://www.businessdefense.gov/Programs/DPAS/.

and friendly nation defense-related orders in the United States when such authorization furthers national defense interests.

Although the DPAS is largely self-executing, if problems arise and/or defense priorities change, DoD can request the DOC to direct U.S. suppliers to perform particular rated orders ahead of any or all other rated or unrated orders—even if those other orders previously were designated to be of higher priority.

7.3.9 Security of Supply Arrangements

Security of Supply Arrangements (SOSAs) are conducted under the overarching Declarations of Principles[26] for Enhanced Cooperation in Matters of Defense Equipment and Industry that have been signed by multiple nations. SOSAs implement the "Meeting National Defense Requirements" section of these documents, which recognize the potential for a certain degree of mutual interdependence of supplies needed for national security and call for the parties to explore solutions for achieving assurance of supply. Reciprocal industrial priority systems encourage partner nations to acquire defense goods from each other, promote interoperability, and provide assurance of timely delivery during peacetime, emergency, and armed conflict.

The Department has entered into arrangements with several nations to ensure the mutual supply of defense goods and services. These bilateral arrangements allow the Department to request priority delivery for its contracts, subcontracts, or orders from companies in these countries. Similarly, the arrangements allow the signatory nations to request priority delivery for their contracts and orders with U.S. firms.

Currently, the Department has entered into SOSAs with the United Kingdom, Sweden, the Netherlands, Italy, Spain, Finland, and Australia. These arrangements commit each government to facilitate the supply of contractor-furnished defense goods and services to the other government as necessary to meet its national security and foreign policy commitments. The United States and Canada have a similar, long-standing agreement.

7.3.10 Priority Allocation of Industrial Resources

The Priority Allocation of Industrial Resources (PAIR) Task Force's mission is to ensure industrial resources are allocated to DoD programs in accordance with operational priorities when requirements create competing demands among Services. The task force utilizes DPA Title I provisions to allocate the resources

[26] http://www.businessdefense.gov/security-of-supply/.

through special priorities assistance requests (15 Code of Federal Regulations, part 700, subpart H). These requests are sent to the Department of Commerce, which (through a directive) instructs the supplier to allocate materials or expedite deliveries of defense items in accordance with PAIR determinations.

In FY 2017, the PAIR Task Force was heavily involved in prioritizing deliveries necessary to solve issues impacting the munitions and missiles sector caused by critical materials obsolescence. For further details of this case, please refer to section 8.6.4.

The Department needs to receive notification of potential supply disruptions as early as the risk is identified by the sub-tier suppliers. Effective communication with industry, supply-chain analysis, and acquisition programs reviews will help the Department to identify potential disruptions and proactively mitigate the risks.

7.4 Monitoring Industrial Base Risks

MIBP programs and initiatives play a key role in monitoring risks. DoD stakeholders involved in these efforts evaluate the effectiveness of the risk mitigation strategy selected or determine if other actions are required to manage the risk previously identified. Changes in the national defense and security strategies, Presidential budgets, technology, the global economy, industry trends, threats, etc., may require the Department to modify its original risk mitigation strategy.

8. Sector Assessments

MIBP assesses the health of the industrial base by sector. The following sectors are covered in the report: aircraft; command, control, communications, and computers (C4); electronics; ground vehicles; materials; munitions and missiles; radar and electronic warfare; shipbuilding; space; and the organic industrial base.

Subsections 8.1 through 8.10 provide a summary of each sector's performance, risks, and mitigation strategies.

8.1 Aircraft Sector

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

- **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, defenseunique design and manufacturing skills are needed to meet the requirements of military weapon systems, produce next-generation aircraft, and maintain technological advantage.
- **Vertical Lift** 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.
- **Unmanned Aircraft Systems/Vehicles (UASs/UAVs)** include the necessary components, equipment, network, and personnel to control an unmanned aircraft; in some cases, UASs 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.

The overall outlook for the aircraft industry is stable with strong U.S. defense procurement spending and new acquisition programs helping to sustain aircraft integrators. However, challenges still remain with respect to the lower tier suppliers supporting the sector.

8.1.1 Programs and Suppliers

Six companies provide the majority of aircraft platforms and possess the full range of capabilities to bring a new system from the research, design, and development phases into full production. The six firms are Boeing, Lockheed Martin, Northrop Grumman, Textron, Airbus, and General Atomics. Three new aircraft programs are expected to start in the next 4 years. Table 3 provides a list of these programs.

Table 3: Future Aircraft Programs

PROGRAM	TYPE	LEAD SERVICE	AWARD YEAR
Trainer (T-X)	Fixed Wing	Air Force	2018
Carrier-Based Air Refueling System (CBARS)	UAS	Navy	2018
Future Vertical Lift (FVL)	Vertical Lift	Army	2022

The Air Force is expecting to award a contract for the T-X program in the spring of 2018. The T-X program objective is to replace the current T-38 trainers, which entered service about 50 years ago, with a new two-seat aircraft that can be used to train pilots flying the fourth- and fifth-generation jet fighters. The new aircraft will satisfy training requirements that are not currently covered by the T-X in areas like the cockpit and sensor management. The AF is planning to buy around 350 aircraft. The T-38 will be one of the four largest programs supporting the fixed wing subsector. Northrop Grumman is currently working on the B-21 Long Range Strike-Bomber (LRS-B) development phase. The B-21 program is part of the nuclear triad modernization program. Boeing is working on the development and testing of the KC-46 tanker, and Lockheed Martin continues production of the F-35 Joint Strike Fighter.

The Navy is introducing a new UAS system, known as the Carrier-Based Air Refueling System. CBARS is being retooled as primarily a carrier-based unmanned aerial refueling platform. It replaces the Navy's Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) effort.

The Army is developing a new vertical lift capability under the FVL program. 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. The FVL program 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. The aircraft currently in service or development are listed by prime contractor in Table 4.

Table 4: Prime Contractors for Major Aircraft Acquisition Programs

PRIME	DIVISION	TYPE OF AIRCRAFT	PROGRAM
Boeing	Boeing Defense, Space & Security (BDS)	Fixed Wing Fighter	• A-10 Thunderbolt* • F-15 Eagle* • F/A 18-E-F Super Hornet
		Fixed Wing Bomber	• B-52 Stratofortress* • B-1 Lancer*
		Fixed Wing Support	• EA-18G Growler* • KC-46A Pegasus • KC-135 Stratotanker* • P-8A Poseidon
		Vertical Lift	• CH-47F Chinook • V22 Osprey (JV with Textron) • AH-64D Apache New and Remanufacture
		UAS	• RQ-21 Blackjack
Lockheed Martin	Aeronautics	Fixed Wing Fighter	• F-35 Lightning II • F-22 Raptor* • F-16 Fighting Falcon
		Fixed Wing Support	• C-130J Hercules • HC-130J • KC-130J • MC-130J
	Rotary and Mission Systems (RMS)	Vertical Lift	• UH-60M Black Hawk • HH-60W • MH-60S • MH-60R • VH-92A Presidential Helicopter • CH-53K
	Aeronautics	UAS	• RQ-170 Sentinel*
Northrop Grumman	Aerospace Systems	Fixed Wing Bomber	• B-2 Spirit* • B-21 Raider
		Fixed Wing Support	• E-2D AHE • EA-6 Prowler* • T-38 Talon Trainer*
		UAS	• RQ-4 Global Hawk • MQ-4C Triton • MQ-8B Fire Scout
General Atomics	Aeronautical Systems	UAS	• MQ-1C Gray Eagle • MQ-1 Predator* • MQ-9 Reaper
Textron	Bell Helicopter	Vertical Lift	• V-22 Osprey (JV with Boeing) • AH-1Z • UH-1Y
	Beechcraft	Fixed Wing	• T-6 Texan II

** Not in production*

** Not in production*

8.1.2 Risk Assessment

One of the primary concerns in the aircraft sector has been the industry's ability to sustain the design and manufacturing skills and capabilities needed for future aircraft design and manufacture. In the lower tier suppliers, foreign dependency, single or sole sources, and financial viability continue presenting a risk for the aircraft sector. The aircraft sector risks have been partially addressed through new acquisition programs, modernization programs, and R&D initiatives. However, risks impacting the lower tier suppliers need to be further addressed.

8.1.3 Mitigation Efforts

The Department is focusing on addressing defense-unique capabilities that could be at risk and supporting initiatives to maintain air dominance. New programs for fixed wing and vertical lift are going to support the industrial base by exercising critical design and manufacturing skills and leveling demand fluctuations for lower tier suppliers. R&D investments in technology programs to satisfy future requirements will also allow DoD to sustain design teams, maintain competition in critical areas, and promote industry innovation. The Department will continue implementing mitigation strategies to support lower tier suppliers and monitor the health of the industrial base.

8.2 Command, Control, Communications, and Computers Sector

The command, control, communications, and computers (C4) sector is an integrated system of doctrine, procedures, organizational structures, personnel, equipment, facilities, and communications designed to support a commander's exercise of command and control across the range of military operations to ensure the warfighter receives jointly integrated and effective capabilities necessary to conduct operations.[27] C4 programs consist of Major Defense Acquisition Programs (MDAPs) and Major Automated Information Systems (MAIS) due to the larger network infrastructure.

C4 is comprised of the following functions:

- **Command and Control** provide the functional capabilities to control and manage sensors and weapons; connectivity to the global interface grid for Joint operations; establishing Engage on Network capabilities; and providing mission command capability.
- **Communications** systems ensure the ability to communicate both horizontally and vertically via voice and data within all mission areas and Combat Operational Environments, whether communicating with a ground, sea, air, or space platform.
- **Computers** process, coordinate, and distribute sensor and weapons data.

The C4 sector is dependent on global and commercial suppliers, which increases the risk of counterfeit material entering DoD systems. This makes in depth supply chain management and rigorous system testing particularly important.

[27] Army Regulation 73-1, Test and Evaluation Policy, 16 November 2016.

8.2.1 Industry Suppliers

A diverse set of vendors are qualified to design and build defense products within the C4 industrial sector. 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. The C4 industrial base is largely global below the prime contractor tier. Table 5 identifies the prime contractors for each major C4 program in FY 2017.

8.2.2 Risk Assessment

The long-term challenge for C4 systems is to reduce size, weight, and cost while improving performance and keeping up with technology. This is especially true for the warfighter, for whom improved Global Positioning System (GPS) and hand-held receivers are vital to perform both strategic and tactical maneuvers with a high degree of confidence and success.

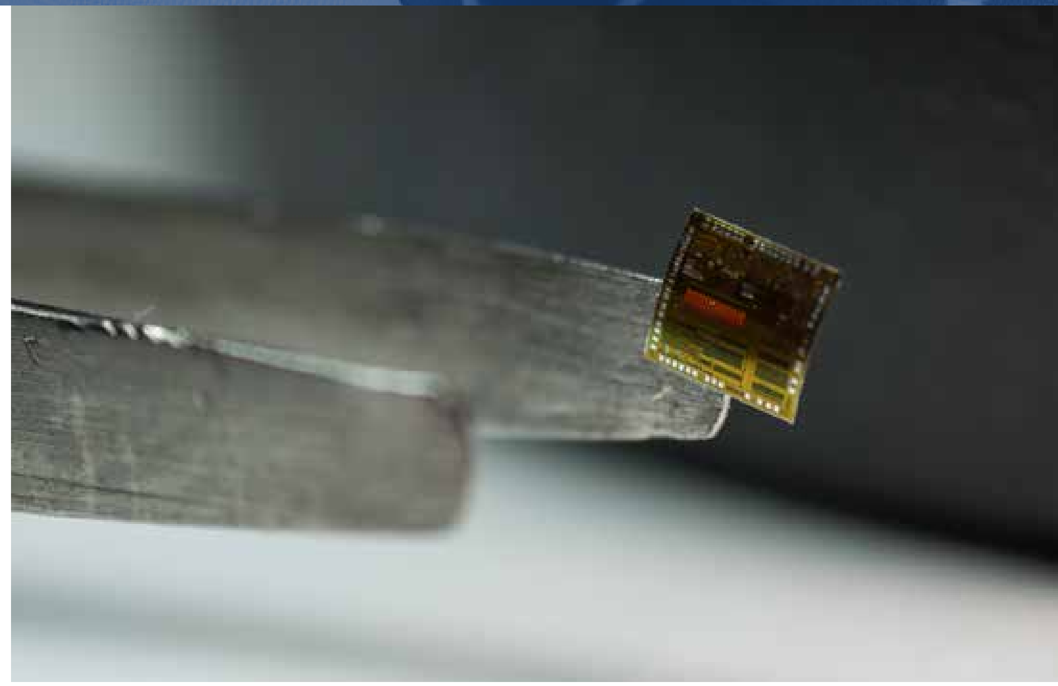
8.2.3 Mitigation Efforts

Defense-unique areas associated with military graded GPS receivers have been mitigated through DPA Title III. The Low Cost Military GPS Receivers Project created domestic production capabilities for essential subcomponents for the Defense Advanced GPS Receiver to pursue methods for reducing weight, size, power consumption, and cost while improving performance capabilities.

Table 5: Prime Contractors for Major C4 Programs

PRIME	DIVISION	TYPE OF PROGRAM	PROGRAM
Array Information Technology		MAIS	• Deliberate and Crisis Action Planning and Execution Segments (DCAPES)
Data Link Solutions*		MDAP	• Multi-Functional Information Distribution System (MIDS)
General Dynamics	Information Systems and Technology	MDAP	• Global Broadcast Service (GBS) • Airborne/Maritime/Fixed Station Joint Tactical Radio System (AMF JTRS) • Warfighter Information Network–Tactical (WIN-T)
		MAIS	• Common Aviation Command and Control System (CAC2S) • Distributed Common Ground System–Army (DCGS-A) • Tactical Mission Command (TMC)
L-3 Communications	Interstate Electronics Corporation	MDAP	• Military Global Positioning System User Equipment (MGUE)
Northrop Grumman	Mission Systems	MDAP	• Integrated Air and Missile Defense (IAMD)
		MAIS	• Air and Space Operations Center Weapon System (AOC WS) • Consolidated Afloat Networks and Enterprise Services (CANES)
Raytheon	Space and Airborne Systems	MDAP	• Cooperative Engagement Capability (CEC) • Family of Advanced Beyond Line-of-Sight Terminals (FAB-T) • Navy Multiband Terminal (NMT)
	Intelligence, Information and Services	MDAP	• Next Generation Operational Control System (OCX)
Multiple Integrators		MDAP	• Handheld, Manpack, and Small Form Fit (HMS) Radio†

** Data Link Solutions is a joint venture of BAE Systems – Communications and Control Solutions and Rockwell Collins Government Systems – Communication, Navigation, and Electronic Warfare Solutions.*
† Thales, Harris, Rockwell Collins, and General Dynamics are integrators for this program.



8.3 Electronics Sector

The electronics industry is a $1.5 trillion 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 weapon systems, global military production represents only 6% of a market that is dominated today by commercial devices.[28] This summary focuses on three aspects of the electronics supply chain: microelectronics (encompassing the design and fabrication of integrated circuits (ICs) at micrometer and below scales), supply chain, and electronic systems including Printed Circuit Board (PCB) manufacturing. The report will also discusses specific areas of particular importance to the Department: supply chain integrity, electronic obsolescence and counterfeit, and assured field programmable gate arrays (FPGAs).

Electronics is a key component of all modern defense programs, and so it is difficult to determine the percentage of the overall DoD budget that is spent on procurement in this area, and different sources can come up with varying numbers depending on how the market is segmented. An indication of its importance can be found in the Department FY 2018 budget request.[29] The themes listed in this document include "Recapitalize and modernize nuclear enterprise," "Prioritize key investments in cyber and space capabilities," and "Focus on innovation to maintain technological advantage." Each of these areas has a strong electronics component.

[28] "2018 Integrated Circuit Market Drivers," IC Insights, 2017.
[29] "Fiscal Year 2018 Budget Request," U.S. Department of Defense, May 2017.

Figure 14 shows the U.S. revenue trend for military and aerospace electronic systems, a segment that includes electronics specifically designed for military use.[30]

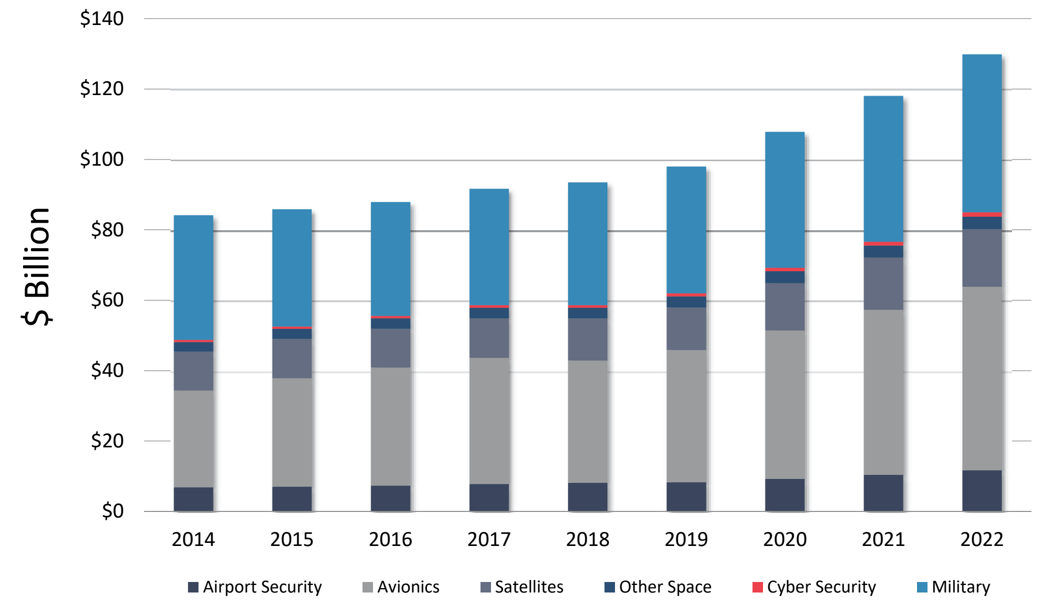


Figure 14: U.S. Military/Aerospace Electronics Revenue Forecast by Market Segment[31]

While total 2017 U.S. military sales revenue in electronic systems is significant compared to overall worldwide military revenue, it is insignificant compared to the overall military and aerospace marketplace, and the commercial market in general.[32] This gives DoD limited leverage over the direction of the electronics industry.

DoD also supports the electronics industrial base through R&D funding. The Department defines eight key capability areas, with six directly related to advanced electronics.[33] One area is Nuclear Deterrence, where a main goal is "continuing to invest in modernizing the triad's essential nuclear delivery systems." The availability of advanced strategically radiation-hardened electronics will be a key enabler in that area, for example. A second area is Missile Defense, where there will be a focus on investments in "discrimination capabilities and sensors."[34]

[30] "2017 Semiconductors in Military and Aerospace Electronics," Databeans, June 2017.
[31] Ibid.
[32] Ibid.
[33] "United States Department of Defense Fiscal Year 2017 Budget Request: Defense Budget Overview," February 2016.
[34] Ibid.

Beyond these areas, most R&D involves some level of electronics. A review of the DoD RDT&E budget for FY 2017 shows ~$1.7 billion in funding requests for projects directly related to electronics, which is approximately 2.3% of the total DoD RDT&E budget request.[35] As an example, in 2017, DARPA's Microsystems Technology Office announced a new Electronics Resurgence Initiative (ERI) to ensure far-reaching improvements in electronics performance well beyond the limits of traditional scaling. The ERI will draw on new and existing DARPA programs to make a significant investment in enabling circuit specialization and managing complexity. Building on the tradition of other successful government-industry partnerships, the ERI aims to forge forward-looking collaborations among the commercial electronics community, defense industrial base, university researchers, and DoD.[36]

8.3.1 Industry Suppliers

In electronics, staying competitive requires a significant investment in R&D, new plants, and new equipment. The U.S. semiconductor industry spends roughly 30% of its sales on R&D and capital. The 18.5% of sales dedicated to R&D as a percent of sales is more than any other U.S. industry with the exception of pharmaceuticals and biotechnology.[37] The high amount of capital required to stay competitive has driven industry consolidation and offshoring. At the prime contractor level, ~50% of contract expenditures related to computer and electronic product manufacturing went to the top five suppliers. These suppliers include major defense contractors such as Lockheed Martin, Raytheon, and Northrop Grumman.[38]

Below the prime contractor level, electronics is a global industry, with supply chains that span multiple countries and regions. This high degree of interdependency among suppliers has profound implications for DoD to meet its requirements.

Printed Circuit Board (PCBs)

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 2000 to $60 billion in 2015.[39] However, this growth has been mainly captured by China, which now owns 50% of the PCB global market share, while the U.S. share has reduced from 25% in 1998 to less than 5% in 2015.[40] This is driven by companies such as Foxconn (Hon Hai), which held 31% of the market for contract manufacturing in 2015, including PCB manufacture and design, as well as high-volume customers such as Apple Inc., which accounted for 50% of Foxconn's total sales in 2015.[41] The largest U.S.-owned contract manufacturing company currently holds ~4% market share.[42]

Microelectronics

Semiconductor ICs are the most technologically advanced level of the electronics supply chain. As discussed in the FY 2106 Industrial Capabilities Report, the semiconductor industry is globalized and highly interdependent.

Since 1996, the global market for semiconductors has grown from $132 billion to $339 billion in 2016. The Asia Pacific market outside of Japan accounts for the vast majority of this growth. This market has quintupled in size from approximately $39 billion to $208 billion in 2016, including a $107.6 billion market in China alone (~9% increase over 2014). Asia, where much of electronics production takes place, is by far the largest customer of U.S. semiconductor companies, accounting for approximately 65% of all U.S. sales. Sales to China alone account for slightly more than 50% of these. U.S. companies continued to hold a majority of the Chinese semiconductor market in 2016 with a 51% share, marking a drop from 56% seen in 2015.[43] Clearly, maintaining access to the Chinese market is a critical concern for U.S. semiconductor companies.

The United States continues to hold a strong position in semiconductor manufacturing, and is a leader in microelectronics design using the fabless model, focusing on IC design and outsourcing fabrication to dedicated foundries.[44] Increasingly, however, these fabless companies are investing in design capabilities and services offshore.

As shown in Figure 15, consumer products such as cell phones, computers, and automobiles drive global semiconductor sales. In 2015, semiconductors were the United States third-largest capital goods export by value (>$40 billion) after aircraft and industrial supplies.[45] It is estimated that the U.S. semiconductor industry accounts for approximately 250,000 direct U.S. jobs and indirectly supports over 1 million jobs.[46]

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[35] "RDT&E PROGRAMS (R-1)," Fiscal Year 2017 Department of Defense Budget, 2016.
[36] "DARPA Electronics Resurgence Initiative," DARPA, 2017.
[37] "2017 Factbook," Semiconductor Industry Association, May 2017.
[38] DIBNow data extraction, NAICS code 304, January 2018.
[39] "WECC Global PCB Production Report for 2015," World Electronic Circuits Council (WECC), October 2016.
[40] Ibid.
[41] "Worldwide Contract Manufacturing Review," Manufacturing Market Insider, July 2015.
[42] Ibid.
[43] "2017 Factbook," Semiconductor Industry Association, May 2017.
[44] A "foundry" is a semiconductor manufacturing facility that manufactures third-party designs.
[45] "U.S. Imports and Exports: Components and Statistics," Kimberly Amadeo, The Balance, July 2017.
[46] "2017 Factbook," Semiconductor Industry Association, May 2017.

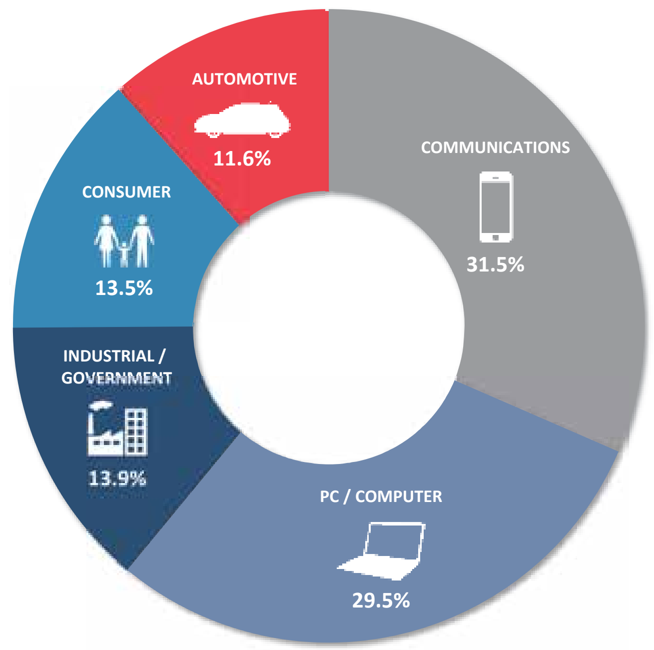

Figure 15: Global Semiconductor Market by Demand Segment[47]

The requirement for continually increased capital expenditure to remain competitive has driven industry consolidation, especially for the most advanced technologies. Figure 16 shows the consolidation of the semiconductor fabricators as technology has advanced, requiring fabricators to print features at smaller and smaller dimensions. In semiconductors, the minimum dimension determines the size and amount of transistors that can be placed on a single chip, which determines performance and functionality. Semiconductor manufacturers and equipment fabricators generally cluster around certain dimensions. The minimum dimension is known as the process node.

[47] "2017 Factbook," Semiconductor Industry Association, May 2017.

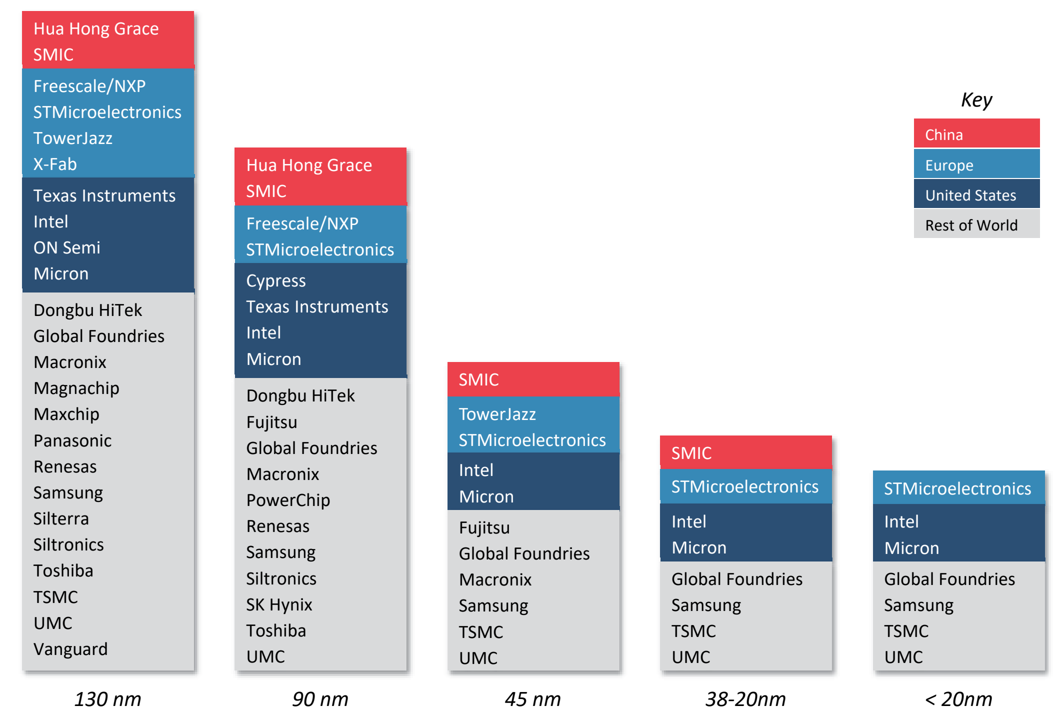

Figure 16: Semiconductor Fabricators by Process Nodes[48]

This consolidation continues, and at the most advanced process nodes (10nm and below) it is expected that at most four companies will compete.[49]

Industry consolidation can be seen at lower levels as well. Companies that supply equipment to advanced semiconductor fabrication facilities are called semiconductor manufacturing equipment suppliers (SMEs). SMEs produce extremely specialized and expensive equipment and thus require capital expenditures on the order of semiconductor fabricators. In one example, the cost of a single extreme ultra violet (EUV) lithography tool, which will be used to print features at the most advanced process nodes, has reached $110 million.[50]

Figure 17 shows market share by year for the top 10 SMEs versus total industry revenue.[51] Data shows the top 10 firms slowly gaining in combined market share (66% to 75% from 2012 to 2016) despite wide yearly variation in revenue.

DoD assesses the impact of foreign investments in the U.S. semiconductor industry through the CFIUS process. DoD is also investing millions of dollars to incentivize and grow onshore microelectronics and other advanced

[48] SEMICO Fab Database, June 2017.
[49] Ibid.
[50] "The Switch to ASML's EUV Lithography Will Impact the Entire Semiconductor Supply Chain," Robert Castellano, Seeking Alpha, March 2017.
[51] "Total IC Mfg Eqpt Revenues Market Share Yearly," VLSI Research, 2017.

manufacturing capabilities through the Manufacturing USA Institutes and other investments. Title III of the DPA allows DoD to improve industry's ability to preserve and expand supplies of defense critical microelectronics.

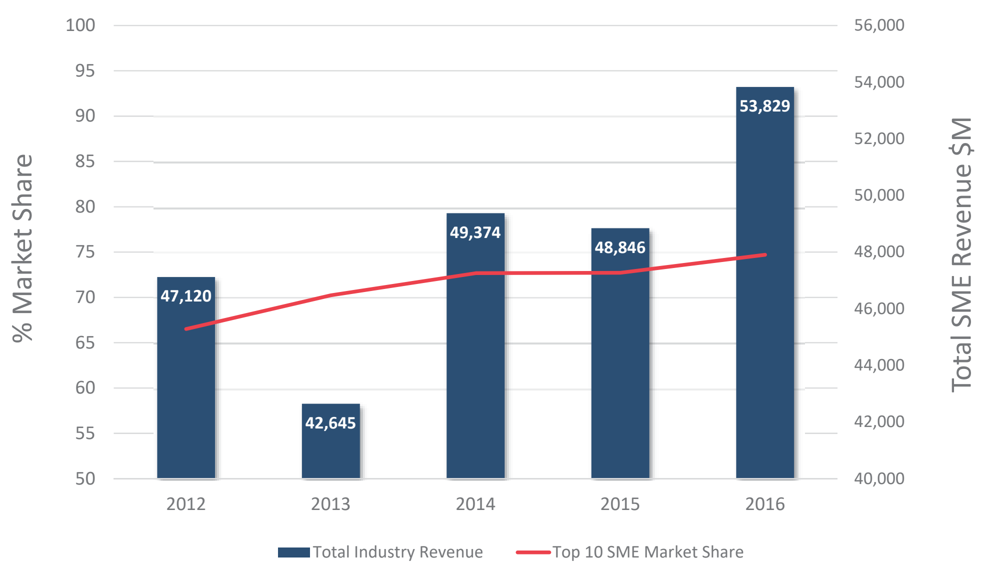

Figure 17: Semiconductor Manufacturing Equipment Suppliers Worldwide Revenue and Top 10 Firm Market Share[52]

8.3.2 Focus Topics

Supply Chain Integrity

Assuring the integrity of the Department microelectronics supply chain is becoming increasingly difficult. Globalization, increasing device complexity, low volumes, and small market share have increased the risk of supply chain attacks, placing DoD intellectual property at increased risk of theft by adversaries and increasingly challenging the Department's ability to access leading-edge technologies. DoD recognizes that trusted and assured microelectronics are a critical building block of secure military systems. To mitigate these supply chain risks, DoD has implemented a wide range of actions, described below.

Mitigation Efforts

The FY 2017 President's Budget initiated funding of the Department Trusted Foundry Long-Term Strategy, resulting in the Trusted and Assured Microelectronics program led by OASD(R&E). This program defines three goals for trust and assurance of defense microelectronics: access, assurance, and availability. Recognizing that trusted and assured supply of microelectronics is a United States Government (USG)-wide concern, this activity is interfacing with interagency partners to take into account interagency requirements, opportunities for collaboration, and strategic decisions that can be made to limit the overall cost of these requirements to the USG. It supports activities to ensure critical and sensitive integrated circuits are available to meet the Department's needs and implements three integrated, complementary solutions that (1) provide for intellectual property protection of microelectronics components; (2) improve capability to evaluate and validate trust and assurance of microelectronic parts and advance standards to incentivize the commercial marketplace to recognize hardware assurance as a competitive design standard; and (3) develop and demonstrate alternative approaches to assuring the trust of the microelectronics supply chain in order to enable broader DoD access to commercial state-of-the-art microelectronics technology.

The most pressing tactical electronics issue consists of maintaining options for domestic trusted manufacture of custom DoD microelectronics[53] and is the focus of the Department Trusted Foundry Program managed by the Defense Microelectronics Agency (DMEA). This program provides DoD, as well as the NSA and other agencies, with access to trusted microelectronics design and manufacturing capabilities designed to meet the confidentiality, integrity, availability, performance, and delivery needs of USG 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 the PCB Executive Agent (EA) to develop trust accreditation methodologies for PCB manufacture, board design, and electronic assembly as a part of the trust accreditation portfolio. There are currently 75 DMEA-accredited suppliers, including 19 suppliers that can provide full-service trusted foundry capabilities.[54]

The Department also takes a strategic view of electronics. The Department recognizes that most commercial-off-the-shelf (COTS) electronics used in DoD systems are fabricated overseas. This poses a significant tampering risk, one that extends beyond the Department and into the broader national security community as well as industries such as banking, critical infrastructure, and transportation.[55] The Department, in coordination with the interagency and

[52] "Total IC Mfg Eqpt Revenues Market Share Yearly," VLSI Research, 2017.

[53] "Assuring Microelectronics Innovation for National Security & Economic Competitiveness (MINSEC)," Jeremy Muldavin, TAME Forum, November 2017.

[54] As of January 2, 2018. For additional information see http://www.dmea.osd.mil/trustedic.html.

[55] "Assuring Microelectronics Innovation for National Security & Economic Competitiveness (MINSEC)," Jeremy Muldavin, TAME Forum, November 2017.

the NSC, has developed a Microelectronic Innovation for National Security and Economic Competitiveness (MINSEC) strategy to begin to address this significant challenge.[56] In FY 2018, the Department initiated budgeting for a DoD-specific portion of the MINSEC strategy that will deliver and protect disruptive R&D for the next generation of microelectronics technology in a domestic ecosystem, deliver modernization and new capabilities through rapid development of specialized and COTS microelectronics systems in partnership with industry, and deliver capabilities and sources for DoD-unique needs, such as radiation-hardened microelectronics that are important for nuclear and space modernization.

Secure Field-Programmable Gate Arrays

FPGAs increasingly provide system-on-chip functionality and are user programmable, making them effective replacements for custom hardware. Because FPGAs can provide a useful balance between performance, rapid time to market, and flexibility, they are used in ~72% of military and aerospace systems[57] and make up to 35% of microelectronic content in defense systems.[58] FPGAs inherently provide some critical security benefits because sensitive design information is not programmed onto the device until it reaches the end user, making it harder for adversaries to target specific applications.[59] However, significant security concerns associated with FPGAs remain, including threats to the integrity of the FPGA during manufacturing, unauthorized access to the design bitstream, and vulnerability to malicious design reconfiguration while in use. The United States has a strong position in FPGAs, as greater than 90% of the commercial market is shared by three U.S. suppliers. Each of these companies has an extensive global supply chain that could provide opportunities for malicious tampering during manufacturing, and the programmable nature of these devices is an inherent risk after the parts have been fielded.

Mitigation Efforts

Following a series of studies initiated by DMEA and the NSA in 2014,[60] the Joint Federated Assurance Center (JFAC) established an initiative to develop a strategy to address FPGA concerns. This strategy has three main elements: Improve FPGA Assurance, Focus and Align Assurance Resources, and Policy and guidance. The Improve FPGA Assurance element is aimed at transforming research into new FPGA assurance capabilities and investing in mitigation measures that will provide layers of protection across the entire FPGA lifecycle. This element will also intensify vendor engagement in assurance practices. Focus and Align Assurance Resources is aimed at improving collaboration across the USG, industry, and academia to leverage their respective efforts to the maximum extent possible, including finding a better understanding of users' FPGA needs in terms of numbers and kinds being purchased, as well as the requirements for different levels of assurance in those FPGAs. Policy and Guidance will develop and/or update policy and associated guidance, best practices, and standards as required to facilitate FPGA assurance in both the USG and industry.[61]

The two major communities that assisted with the strategy are the Joint Federated Assurance Center Hardware Assurance Technical Working Group and the Trusted and Assured Microelectronics program managers and performers, which are expected to lead major elements of the strategy's technical capabilities and deployment.[62] The effort marked a milestone when DoD formalized the JFAC as the FPGA assurance single point of contact for industry and academia through an OSD notice of collaboration signed in March 2017.[63]

In May 2017, Phase I of a DPA Title III effort kicked off with the objective "to develop and demonstrate an approach to ensure the availability of an advanced 'trusted' and space qualified reprogrammable FPGA technology to support DoD/IC applications, including satellite and strategic missile systems." In the first phase in FY 2017, FPGA vendors developed product strategies to assure FPGAs. Based on this result, two vendors were selected to begin implementation of their product strategies.[64] This work will continue throughout FY 2018.

Electronics Obsolescence/Counterfeit Parts and Materials

The median length of time required to develop an MDAP has held steady at roughly 8 years since the late 1980s.[65] At the same time, the Department has grown more and more dependent on electronics and on the commercial electronics market, which moves on a much accelerated timeframe. To take one example, the average replacement time of a smartphone was approximately 23 months in 2017 (up from 20 months in 2013).[66] Due to this disconnect, the U.S. Army Aviation and Missile Research, Development, and Engineering Center

[56] "To receive testimony on Department of Defense acquisition reform efforts," Senate Armed Services Committee Questions for the Record Hearing #17-92, December 2017.
[57] "Trusted FPGA & Programmable System on Chip (PSoC) Agile Research/Prototyping Initiative," NSA, May 2016.
[58] "Overview of DoD FPGA Assurance Activities," B. Cohen et al., GOMACTech, March 2018.
[59] "Managing Security in FPGA-Based Embedded Systems," Ted Huffmire et al., 2008.
[60] "Trust in FPGA Hardware Study," "Trust in FPGA Software Study," and "Trust in FPGA Feasibility Study," DMEA/NSA, 2014.

[61] "Overview of DoD FPGA Assurance Activities," B. Cohen et al., GOMAC, January 2018.
[62] Ibid.
[63] "Field Programmable Gate Array (FPGA) Assurance," B. Cohen, May 2017.
[64] Ibid.
[65] "Acquisition Cycle Time: Defining the Problem," David Tate, IDA, October 2016.
[66] "People are holding onto their smartphones longer," Jeff Dunn, Business Insider, March 2017.

(AMRDEC) estimates that 70% of electronics are obsolete prior to system fielding.[67]

Obsolete parts are no longer being manufactured, and may be unavailable from the original equipment manufacturer (OEM) or its sub-tier suppliers. This may force DoD to purchase from distributors where pedigree is less secure and provenance is more difficult to track.[68] Obsolete parts are a key driver of counterfeits entering DoD supply chain; it is estimated that between 50% and 80% of suspect counterfeit parts were obsolete when reported.[69]

Counterfeit parts have the potential to delay missions and ultimately endanger service members. An increasingly globalized electronics industry increases the risk that these parts will enter the Department supply chain. This risk has been recognized both inside and outside of DoD.[70]

Mitigation Efforts

DoD has implemented a wide range of actions to mitigate the risk of counterfeit electronic parts entering the supply chain. DoD takes a holistic, risk-based approach to prevent infiltration of counterfeit parts and materials into the supply chain through working with industry, establishing policy, and employee training and new technology. DMEA provides capabilities to mitigate obsolescence for critical components by reverse engineering and retargeting boards and components in conjunction with their flexible foundry, which is employed as a source of last resort.

In 2013, the Department established policy and assigned responsibilities with DoD Instruction (DoDI) 4140.67[71] to prevent the introduction of counterfeit materiel at any level of the supply chain, including special requirements prescribed by section 818 of Public Law 112-81. There has been substantial progress implementing DoDI 4140.67; for example, the Navy issued SECNAVINST 4855.20 in 2015 establishing a Counterfeit Prevention Policy and published a Counterfeit Materiel Process Guidebook (NAVSO P-70) in 2017. DoD policy requires DoD Components to report all occurrences of suspect and confirmed counterfeit materiel to DoD criminal investigative organizations and other law enforcement authorities at the earliest opportunity.

[67] AMRDEC MORE Tool, https://www.amrdec.army.mil/amrdec/pdf/MORE%20Tool.pdf.
[68] "Defense Science Board Task Force on Cyber Supply Chain," February 2017
[69] "Recent Trends in Counterfeit Electronic Parts," Fred Schipp, NSWC Crane, Diminishing Manufacturing Sources and Material Shortages (DMSMS) Conference, December 2017.
[70] GAO-16-236, "Counterfeit parts: DoD needs to improve Reporting and Oversight to reduce supply chain Risk," February 2016.
[71] http://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/414067p.pdf.

In addition, DoD Components must report occurrences of suspect and confirmed counterfeit materiel to deficiency reporting systems and the Government–Industry Data Exchange Program (GIDEP) within 60 days. DoD works with law enforcement on counterfeit investigations, and, where appropriate, to debar companies and prosecute counterfeiters. In addition, the Defense Federal Acquisition Regulation Supplement to the Federal Acquisition Regulation is continually updated to addresses counterfeit risk.[72]

The Department has strengthened its counterfeit parts mitigation capability through a number of technology initiatives. DLA checks and applies deoxyribonucleic acid (DNA) authentication technology to every microcircuit it procures (over 80,000 annually). The DNA mark enables rapid screening of the microcircuit throughout the supply chain and retrieval of pedigree information anytime throughout its life. Enhancements to the Past Performance Information Retrieval Service–Statistical Reporting software provides contracting specialists the capability to identify high-risk suppliers, parts that are at higher risk for counterfeiting, and parts that are overpriced prior to contract award. DARPA has multiple programs related to supply chain integrity, designed to address both trusted and assured microelectronics and counterfeit parts and materials. For example, the Supply Chain Hardware Integrity for Electronics Defense program seeks to make counterfeiting too complex and time consuming to be cost effective.

In 2017 the PCB EA conducted a study, per section 238 of the FY 2016 NDAA, on the effects of counterfeit electronic parts on field failures. This required the selection of a representative sample of electronic component types to determine the presence of counterfeit parts. The effort resulted in the definition of a methodology to evaluate counterfeit parts (involving physical and electronic techniques) that could be used as the basis of future work. Results from this study are expected to be published in FY 2018.

[72] DFARS Cases: (2012-D055) "Detection and Avoidance of Counterfeit Electronic Parts," (2013-002) "Expanded Reporting of Non-conforming Items," (2012-032) "Higher Level Contract Quality Requirements," and (2014-D005) "Detection and Avoidance of Counterfeit Electronic Parts–Further Implementation."

8.4 Ground Vehicles Sector

The ground vehicles sector provides defense-unique systems products for mobility, firepower, medical transport, evacuation, communication, and other general utilities in war zone areas. The vehicles produced for this sector are configured and equipped based on their intended operational use for Combat, Combat Support (CS), and Combat Service Support (CSS) missions.

- **Combat vehicles** include tanks, infantry fighting vehicles (IFV), armored personnel vehicles (APC), and light armored vehicles (LAV). Combat vehicles are in direct contact with the enemy.
- **Combat Support vehicles** directly support Combat vehicles and troops with firepower or mobility. They include self-propelled artillery, amphibious assault vehicles (AAV), and multiple launch rocket systems (MLRS). They may be armored and armed due to their proximity to the combat area.
- **Combat Service Support vehicles** include light, medium, and heavy truck fleets, utility vehicles, special purpose vehicles, and recovery vehicles. They may be armored or have applique armor packages depending on where they appear on the battlefield. They support logistics functions including supply, maintenance, explosive ordnance disposal, medical, human casualty evacuation, vehicle casualty evacuation, general transportation, communication, and general utility.

Each of these types of vehicles can be further divided into two categories: tracked and wheeled. Figure 18 shows the ground vehicle sector taxonomy.

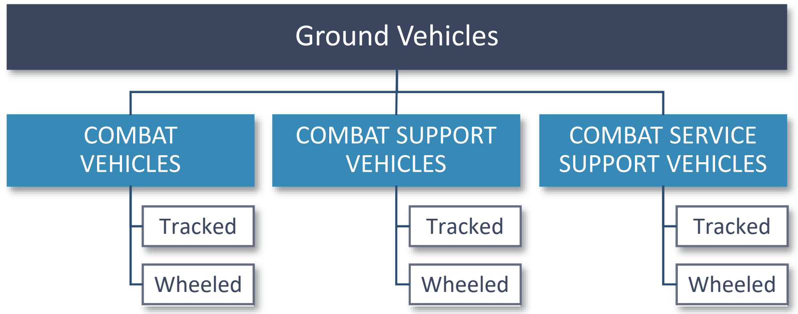

Figure 18: Ground Vehicles Sector Taxonomy

The ground vehicles sector remained stable during FY 2017. Acquisition and modernization programs over the past 10 to 15 years have provided stability to the prime OEMs in this sector.

Given the breadth, scope, and physical demands of combat, unique structural and hardware designs for combat vehicles are required, limiting the use of COTS systems. Some platform subcomponents and hardware have similarities with commercial heavy machinery, mining operations, and trucking, but with a strong dependence on whether the vehicle is wheeled or tracked. However, the survivability and maintainability requirements dictate custom-designed solutions.

8.4.1 Industry Suppliers

A list of ground vehicle programs is given in Table 6.

The ground vehicles sector is defined almost entirely by single prime OEM vendors, engaged solely in DoD production. The industrial base that designs, produces, and supports these vehicles is comprised of five primary OEM suppliers, with two OEMs securing over 90% of the production market share.

Wheeled vehicles are considered a defense-unique product. However, the industrial base supporting this subsector is highly dependent on commercial automotive technology and production capabilities. There has been consolidation of production to two manufacturers of tactical wheeled vehicles, Oshkosh and AM General. However, the repair, refurbishment, and modifications business for wheeled vehicles has multiple qualified competitors.

Table 6: Prime Contractors for Major Ground Vehicle Programs

PRIME	DIVISION	TYPE OF VEHICLE	PROGRAM
BAE	Systems Platforms & Services	Combat, Tracked	• Bradley Fighting Vehicle (BFV)
		Combat Support, Tracked	• Armored Multi-Purpose Vehicles (AMPV) (M113 Replacement) • Amphibious Assault Vehicle (AAV) • M109 PIM
		Combat Service Support, Tracked	• M88 Hercules
		Combat Support, Wheeled	• RG31 Medium Mine-Protected Vehicle (MMPV) • RG33 Medium Mine-Protected Vehicle (MMPV) • Amphibious Combat Vehicle (ACV 1.1)*
General Dynamics	Land Systems	Combat, Tracked	• M1 Abrams (M1A1 and M1A2)
		Combat, Wheeled	• Stryker Interim Armored Vehicle • Light Armored Vehicle (LAV)
		Combat Support, Wheeled	• Flyer 72 • Flyer 60 • Buffalo Mine Protection Clearance Vehicle (MPCV)
MacAndrew & Forbes	AM General	Combat Service Support, Wheeled	• High Mobility Multi-Purpose Wheeled Vehicle (HMMWV)
Navistar	Navistar Defense	Combat Support, Wheeled	• MaxxPro Dash Mine-Resistant Ambush Protected (MRAP)
Oshkosh	Oshkosh Defense	Combat Service Support, Wheeled	• Family of Medium Tactical Vehicles (FMTV) • Family of Heavy Tactical Vehicles (FHTV) • Joint Light Vehicle (JLTV) • Medium Tactical Vehicle Replacement (MTVR) • Logistics Vehicle System Replacement (LVSR) • M-ATV Mine-Resistant Ambush Protected (MRAP)
SAIC		Combat Support, Wheeled	• Amphibious Combat Vehicle (ACV 1.1)*

* *BAE and SAIC are competitors for ACV 1.1.*

The prime vendors and supply chains of the tracked vehicle systems have been focused on modifications, engineering change proposals, and foreign military sales (FMS) to sustain this capability. This subsector has condensed to two prime vendors dividing the tracked combat vehicles based on the material used for production. BAE currently produces aluminum armored vehicles, while General Dynamics produces steel fighting vehicles.

Figure 19: Ground Vehicle Manufacturing Locations

8.4.2 Risk Assessment

Over the course of Operation Iraqi Freedom and Operation Enduring Freedom, wheeled CS and CSS systems were in high demand, resulting in robust supply chains. Over the same period, tracked and wheeled combat and a few tracked CS systems had limited use. However, refocus of the NDS has resulted in expected increased demand for all systems, exposing fragility within the previously unexercised supply chains.

Many current wheeled CS and CSS vehicle fleets are in the middle of their lifecycles. For example, the HMMWV fleet was planned for a 20-year lifecycle with a rebuild at the 10-year mark. Overseas Contingency Operations (OCO) maintenance funding for maintenance allowed for rebuilds and modifications to be applied at the same time. Advances in technology and engineering innovation led to improvements in existing equipment, prolonging vehicle service life and increasing capability of legacy vehicles. Opportunities for new work, modernization, and recapitalization are important to keep prime vendors competitive. There is an upcoming Army competition for a replacement CSS vehicle, Family of Medium Tactical Vehicles (FMTV). Multiple competitors for this new program are expected as the previous CSS vehicle competition (Joint Light Tactical Vehicle (JLTV)) had four main competitors. The new program will exercise the wheeled vehicle industrial base design skills.

There are only a few active programs within various development phases for legacy systems in the tracked vehicles subsector, including armored multipurpose vehicles (AMPV), amphibious assault vehicles (AAV), M1 Abrams (M1A1/ M1A2) vehicles, M109 vehicles, and armored tank retriever variants. The ground systems suppliers have followed a strategy of incremental adoption of new technologies on older/legacy designs to maintain or modify current ground systems. This has allowed the military to defer new starts' long schedules and high costs. However, this has resulted in a generation of engineers and scientists who lack experience in designing and manufacturing new, technologically advanced combat vehicles. A new start combat vehicle will require engineers to have necessary design and manufacturing abilities to incorporate state-of-the-art technologies, materials, employment techniques, weapons, and protection systems to ground systems. Consequently, any new combat vehicle design will face cost, schedule, and performance challenges.

The lack of new development programs for tracked systems is challenging the U.S. ability to innovate in this subsector. For example, the M109 Paladin remains viable due to continuous improvement programs, such as M109 Paladin Integrated Management (PIM), that keep the vehicle subsystems current. However, the design is near or at its limit for range and rate of fire.

In lieu of a newly designed vehicle, DoD has focused on adopting and modifying foreign vehicles that have capabilities that their systems lack. This results in reduced costs and shorter schedules while only maintaining integration of current subsystems engineering skills. The LAV, Stryker, and Amphibious Combat Vehicle (ACV) programs are examples of adopting allied designs.

However, material and technological improvements within the capacity of the fielded vehicle designs are reaching physical limits. The M1 series tanks, Bradley IFV, and the AAV are at or near the limit of improvements in firepower and survivability. The M1 series tanks are also at their limit of transportability and recoverability.

Consolidation of the manufacturing base preceded the general decrease in production, providing a buffer to volatility in demand. Advances in technology and engineering innovation have led to improvements in existing equipment that prolonged vehicle service life and increased capability of legacy vehicles. FMS remain at a high level for combat vehicles and combat support vehicles. In addition to the purchase of equipment, foreign sales support the industrial base providing maintenance to the vehicles during their operations and sustainment phase.

8.4.3 Mitigation

The military industrial base has not produced a new tracked armored combat vehicle since the introduction of the M1 tank and the Bradley series of IFVs in the early 1980s. The last new start vehicle design to replace the Bradley, the Ground Combat Vehicle (GCV), was canceled. The alternative chosen by the Army is to replace the aging M113 APC vehicles with a Bradley derivative vehicle AMPV and upgrade the Bradley fleet.

The United States continued reliance on the AAV and foreign use of this vehicle helps its manufacturer and supply chain remain viable. A new vehicle based on a different concept is invariably in the future. Until then, the AAV continues to fill this battlefield niche. The ACV will supplement the AAV fleet. Two development contracts were awarded to U.S. vendors, which are modifying existing vehicles with their foreign partners. The ACV program is progressing rapidly since both vendors are modifying existing vehicles, and this provides a good opportunity to flex and maintain design and development skills. U.S.-specific modifications and assembly are performed domestically.

The legacy fleet has been successful at incremental adoption of new technologies on older designs while maintaining and modifying them, thus allowing the military to defer the long schedules and high costs associated with new starts'. A new start combat vehicle would permit engineers to develop the ability to bring state-of-the-art technologies, materials, employment techniques, weapons, and protection systems to the warfighter.

Increasing defense industrial base competitors' opportunities for maintenance and modification of existing ground vehicles is adequate to maintain competitors in the market. The two prime contractors and depots with accompanying supply chains will remain viable, with potential changes to existing practices and policy.

Any increased funding efforts in basic research into new armored protection concepts, new automotive innovations, and new weapons technology will speed up this realization. Unless deliberate research efforts are made, then improvements remain incremental to the inherent capability of existing combat vehicles. Worldwide, current combat vehicles are slowly approaching parity in lethality, survivability, mobility, and transportability. For example, the M1A1 tank community is facing a limitation of transportability due to weight and size while initiatives like active protection systems to increase survivability increase weight in a significant way.

8.5 Materials Sector

The Materials Sector for the U.S. defense industrial base is vital to national defense and U.S. economic security. Defense demand often represents a small fraction of the overall materials market (e.g., on average from less than 1% to about 3%), although there are some subsectors that are heavily defense dependent. In both instances, there are important interdependencies and risks to supply. It is imperative that producers and supply chains of materials deemed essential to U.S. defense and civilian demand are robust, resilient, competitive, and responsive to current and long-term economic security, present military operations, future wartime mobilization, and unanticipated surge demand.

The sector includes raw materials and "downstream" materials produced by subsequent value-added materials processing. These and others can be combined to produce subsequent raw materials as well as intermediate, semi-finished, and finished materials. Materials eventually are produced into end-items (e.g., parts, components, or structures) that are then incorporated into defense subsystems and integrated into complete weapon systems.

The range of materials include broad categories such as primary metals and nonmetallic mineral products. These are often produced from mining of geological materials from the earth as a primary product (e.g., an iron mine), or as a byproduct from mining other primary materials (e.g., extracting rhenium from copper mining waste), or by reclaiming usable materials from end-of-life products (e.g., recycling super alloys from jet engine components or rare earth elements from compact florescent lamp phosphors). Mined ores and other materials contain minerals with naturally occurring elements that are essential to the production of defense systems and their components. These types of materials are dependent on geologic and other resources located throughout the world and can be concentrated outside the United States, including in potential adversary or other unreliable countries.

Of equal and at times greater importance to this sector is the location of the industrial capabilities, unique expertise, and sustained commercial-scale production capacity to extract key elements from mined materials and to competitively process them into commercially useful value-added material products (e.g., separating natural elements, processing chemical compounds, smelting metal, and producing alloys).

Examples of natural resource-based materials and downstream production processes of particular importance to the defense industrial base include specialized material compositions and forms of oxides, compounds, chemicals, metals, and alloys: high-performance aluminum and high-strength steel plate for ground combat vehicle and Navy ship structures; lightweight titanium and beryllium metals and alloys for military aircraft structures and components; tungsten rhenium alloy ingots and wire used in microwave tubes for radar and communication systems; rare earth metals, alloys, and sintered magnets used in precision-guided munition actuator fins; and boron and silicon carbide ceramics used to produce body armor and combat aircraft ballistic protection panels. There is also an extensive array of different materials and processes that are essential to both commercial and defense-specific microelectronics manufacturing, including some of the metals and ceramics mentioned above as well as others.

Another materials subsector of high importance is the development and production of highly engineered synthetic (not naturally occurring) materials. Examples include carbon fibers used to produce advanced composite materials and structures for tactical and strategic missiles, manned and unmanned combat aircraft, space launch vehicles, and military satellites. Other examples include high-performance fibers and textiles for soldier protection (soft body armor and flame protection apparel) and high-performance fibers and their composites used to manufacture low observable (stealth) and thermal protection systems for aerospace applications. Another especially important synthetic materials subsector is energetic materials (e.g., explosives and propellants). Lastly, there are entirely new types of materials and related processes that are becoming increasingly important to civilian and defense sectors. These include carbon nanotubes and other new materials used in additive manufacturing.

8.5.1 Risk Assessment

While U.S. national defense demands for materials are seldom unmet, there exist risks to their supply now and risks are anticipated in the foreseeable future. Two broader trends impacting the supply risk include the growing use of different types of materials for new technologies and their scarcity, and growing U.S. reliance on foreign sources of supply coupled with increasing global resource competition. Examples include the increased use of key materials needed to produce microelectronics (from 12 minerals or their elemental components in the 1980s to more than 60 by 2000) and U.S. import reliance of critical minerals. (The United States was more than 50% import dependent for more than 20 nonfuel minerals in 1980, and that number doubled by 2014.)

Specific examples of the different types of risk to the supply of materials include: material shortfalls that impact the production of defense items needed to support current military operations (e.g., munitions); high U.S. import reliance on foreign countries who may become adversaries and cut off peacetime supply during future conflicts (trade embargo or war damage); reliance on single foreign sources of unique and proprietary materials whose supply for defense would be difficult to replace if lost (e.g., from a natural or manmade disaster); injurious foreign trade impacts on key U.S. material producers (e.g., foreign dumping and illegal subsidies); DoD reliance on commercial materials that become obsolete; and DoD dependence on domestic single-point-of-failure producers. Of similar concern are essential civilian shortfall risks during a major U.S. national emergency, including their importance to national defense for wartime mobilization and post-U.S. conflict recovery.

These risks can threaten both U.S. economic security and national defense. Some risks occur together, and many can impact multiple defense sectors and diverse weapon system supply chains at the same time (e.g., high-strength materials for armored vehicles and Navy ships). There are also multiple fundamental causes at the root of many risks. Examples include: underinvestment in U.S. materials-related industries by private and public sectors (uneconomic and/or other unaffordable domestic sourcing) coupled with a high reliance on foreign imports. The latter can include low-cost producers in developing nations who also use market-distorting trade practices (e.g., dumping and subsidies).

8.5.2 Mitigation

To help mitigate potential risks to the supply of strategic and critical materials, the Department relies first and foremost on diverse, globally competitive, open and fair markets. When the supply of materials is deemed insufficient for U.S. national security purposes, the Department (including many DoD Components, U.S. interagency partners, U.S. allies, and other security partner countries) has a number of authorities and related mechanisms to mitigate risks. These include:

- **Title I of the DPA and the Defense Prioritization and Allocation System (DPAS)**: Both help to ensure that U.S. defense demands for materials are prioritized at U.S.-based producers ahead of less essential civilian material demands;
- **National Defense Stockpile (NDS) Program**: The NDS program maintains inventories of strategic and critical materials whose supplies are estimated to be insufficient to meet U.S. defense and essential civilian demand during a major U.S. emergency. This is a DoD-wide program, overseen by OSD and operated by DLA Strategic Materials;
- **Defense Reciprocal Procurement Memoranda of Understanding (MOUs) and Security of Supply Arrangements**: These mechanisms assist the Department with increasing U.S. access to key foreign sources of strategic and critical materials available from especially reliable foreign sources;
- **Buy America Act, including the Specialty Metals Clause**: These authorities help to protect key domestic and foreign security partner country defense industrial base production capabilities and capacity;
- **Section 232 of the Trade Expansion Act**: This section provides a process for investigating potential risks to U.S. national security from foreign imports and developing mitigation options;
- **Committee of Foreign Investment in the United States (CFIUS)**: CFIUS is a U.S. interagency mechanism that assessing and mitigates the risk to U.S. national security from potential foreign acquisitions of U.S. companies and technologies, including those within materials-related sectors;
- **Interagency Collaboration**: The Department works with a variety of other U.S. Government agencies (e.g., Departments of the Interior, Commerce, and Energy) to identify, assess, and help mitigate strategic and critical materials risk. One example is the National Science and Technology Council's subcommittee on critical mineral supply chains; and
- The Department also actively supports a variety of defense industrial base investment programs to mitigate materials-related risks (e.g., DPA Title III, Manufacturing Technology Program, and the Industrial Base Analysis

and Sustainment Program). These programs are used in partnership with industry to develop, expand, improve, or sustain essential U.S. production capabilities and capacity including materials-related subsectors (e.g., metals, alloys, composites, and ceramics).

Strategic and critical material supply risks that have been assessed and mitigated by the Department in FY 2017 typically include sensitive information that is not releasable publicly because of operational security, vulnerability information, and business proprietary data.

8.6 Munitions and Missiles Sector

The munitions and missiles industrial sector is comprised of "smart" bombs, tactical (cruise, air-to-air, air-to-ground, surface-to-air) missiles, missile defense, and strategic missiles. It also includes "dumb" bombs, ammunition, mortars, and tank rounds, etc., but since most or all of the major issues lie within the missile industrial base, dumb bombs, ammunition, mortars, and tank rounds are not specifically addressed in this report. However, many of the issues listed for missiles are also applicable to other munitions, especially declining procurement numbers, which have led to production line shutdowns and plants that are being closed or consolidated into smaller footprints and smaller capabilities. The munitions and missiles industrial sector is primarily a defense-unique industrial sector.

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 and 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 nondefense markets to support their design and production skills. This risk manifests itself in multiple ways, from the inability to surge production quantities to meet munitions requirements, to key sub-tier suppliers exiting the business when they can no longer remain viable.

Over the past several decades there have been no new missile development programs that use solid rocket motors (SRMs) that have led to fielded systems (Tomahawk and JASSM-ER cruise missile designs are at least 20 years old). All "new" missile programs have been designed as, or have become, upgrades to existing systems. As a result, the design 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, damaging the readiness of the Department and negatively impacting a foundational national defense priority by placing the ballistic missile production capability at risk.

There are two new tactical missile programs that are entering development; the Advanced Anti-Radiation Guided Missile–Extended Range (AARGM-ER) and Long-Range Precision Fires (LRPF). If these programs continue, they would provide much needed work to exercise the missile industrial base design skills. There is also one new strategic missile program: Ground-Based Strategic Deterrent (GBSD), the Minuteman III Intercontinental Ballistic Missile (ICBM) replacement. Numerous demonstration/validation programs have been funded over the past several years, providing some design work to industry, particularly to the large SRM industrial base, which has not seen any new work in decades. The program just awarded the Technology Maturation and Risk Reduction (TMRR) contracts with two prime contractors, both of whom are using both SRM suppliers during this phase. The Air Force did not allow any of the primes to enter into an exclusive agreement with either SRM provider during TMRR in order to help sustain the health of the SRM industrial base.

The general missile taxonomy shown in Figure 20 breaks the missile into four functional areas: propulsion; armament; airframe; and guidance, navigation, and control (GNC). In the propulsion area, most missiles use SRMs. 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 GNC area, in many cases, comprises the most expensive components of the system (mostly missile seekers).

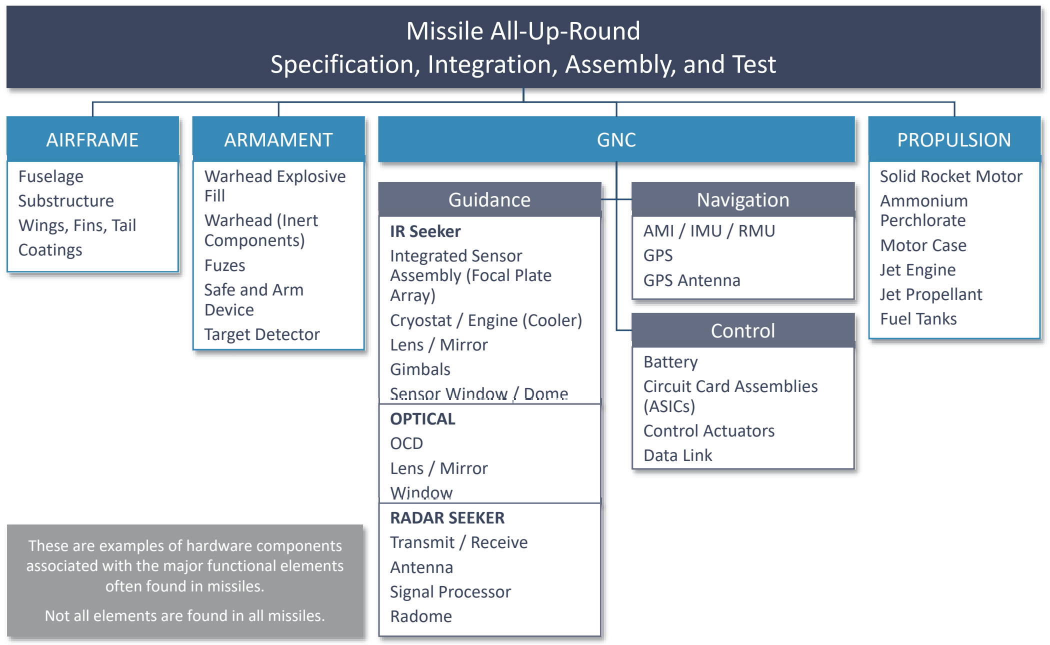

Figure 20: General Missile Subsystem Taxonomy

8.6.1 Industry Suppliers

Since the end of the Cold War, the munitions and missiles development and production market has declined, resulting in aggressive competition for limited new program opportunities. Within the munitions and missiles sector, two prime contractors, Raytheon and Lockheed Martin, account for roughly 97% of the Department's munitions and missile procurement funding. 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. The Department'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 current and next-generation weapon systems.

There are currently only two domestic suppliers for SRMs used in DoD missiles: Orbital ATK (OATK) and Aerojet Rocketdyne (AR). They supply the majority of missile systems, with a foreign supplier, NAMMO, making up the balance. NAMMO has also established a U.S. company, NAMMO Energetics Indian Head (NEIH), that is operating out of Naval Surface Warfare Center, Indian Head Division under a Special Security Agreement allowing for a public-private partnership. NEIH is utilizing existing capability (equipment and personnel) at Indian Head, while also investing in new/expanded capability. So far NEIH does not have any DoD contracts.

8.6.2 Risk Assessment

The munitions and missiles industrial sector is routinely impacted by significant shifts in DoD demand as a result of various factors. The initiation or drawdown of conflicts is definitely a major factor, but a marked increase in the use of munitions for counterterrorism and decades of underinvestment in munitions—using munitions as "bill payers" for other higher priority efforts—has led to depleted inventories for key munitions, especially precision-guided and low-collateral munitions. Resupply of these key munitions as well as surge requirements for those munitions during conflicts stress the industrial base. Numerous bottlenecks with critical sub-tier suppliers preclude a rapid response to these increases in requirements, causing delays in deliveries and increased cost to the Department. The Department continues to monitor the impact of reduced demand on the sub-tier supplier base through continuing assessments in close cooperation with the Military Departments and the MDA. In FY 2017 the Department was directed to conduct a study, which is still underway, titled "Munitions Industrial Base Resiliency: Optimizing for Sustainment and Surge." This study should assist the Department in identifying a growing number of industrial capability risk areas as sub-tier suppliers realign and adjust their industrial capacities to DoD budget realities, while suggesting ways to improve the resiliency of that industrial base—enabling it to surge more rapidly and cost effectively, and to survive downturns in production, while maintaining capability.

In addition, the Department conducted a deep dive on the industrial base factors that were preventing certain key munitions from increasing capacity and surging production. This included an analysis of long lead-time items, and how DoD could work with industry to overcome some of the bottlenecks and limitations to allow for increased deliveries. Some of the solutions required funding; in some cases industry was willing to make investments since the Department was buying more munitions, and in some cases DoD funded extra capacity and extra deliveries.

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 missiles industrial segment that continually face excess capacity challenges include thermal batteries, SRMs, 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 these items. 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 IMU, GPS receiver, and seeker product sectors—while others are more unique to the munitions and missiles industrial sector. MIBP continues to monitor the health of the sub-tier suppliers and address known industrial base challenges. These challenges fall into two broad categories: (1) sustaining design and engineering teams and (2) sustaining the sub-tier supplier base.

The following missile industrial base issues are 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. This is particularly true 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 (SLS) have resulted in significant underutilization of existing capacity in this segment.

Maintaining a healthy and competitive SRM industrial base is also of concern to the Department. SRMs for tactical missiles are produced in a nearly even split between the two domestic suppliers, OATK and AR. However, in the very near future all the large SRMs for strategic missiles and space launch will be produced by OATK. AR has managed to maintain their large SRM capability for now with production of the boosters for the United Launch Alliance (ULA) Atlas V space launch vehicle, and small development investments from the GBSD program. But ULA has chosen OATK's boosters to replace AR's on Atlas and future launch vehicles, leaving AR with no large SRM production. AR has chosen to close their Sacramento large SRM production facility. While they have plans to reconstitute this capability at their Camden facility, they may not do so if they are not part of the winning team for GBSD, producing at least one SRM stage. This potentially leaves the United States with a single large SRM supplier, which can lead to cost increases due to lack of competition, decreases in internal research and development efforts, and risk of security of supply if a catastrophic accident should occur.

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, mostly due to low production quantities. The other domestic companies that produce thermal batteries constitute less than 20%

of the Department's thermal battery market. The dependency on a dominant supplier of thermal batteries makes this industry at risk. Investments in improvements to battery technologies are also lacking due to low production quantities and profit margins.

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 current and future systems. This has contributed to an excess capacity in the fuzes sector. Excess capacity limits manufacturers from being cost competitive and limits investment in improvements to fuze technologies, including sustaining a viable design engineering cadre. The United States 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.

Small Turbine Engines

There are currently two suppliers of small turbine engines: Teledyne Turbine Engines (TTE) and Williams International (WI). TTE business has decreased drastically over the years to a point where they cannot sustain themselves any longer. Williams International, which works for mostly commercial applications, can withstand the Department's fluctuating procurement cycles, and has the revenue to keep their technology current, which helps them win new work. TTE has stated it will exit the business in 2018, which leaves only one supplier for this small but vital area.

8.6.3 Long-Term Challenges

Most current missile development activity consists of modifications to existing missile systems, such as the Rolling Airframe Missile (RAM) Blk 2, Patriot Advanced Capability (PAC) 3 Missile System Enhancement (MSE), and AARGM-ER. Most of the research and development funding in the munitions and missiles 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 were previously 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 DARPA demonstration project to integrate significant modification to legacy 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. AARGM-ER is also an upgrade to a current system, but will include a new SRM. The only true new missile system will be the LRPF, which will require a completely new design.

The Department remains concerned that the design engineering capabilities needed for tactical and strategic missile 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. The Air Force has been funding some early demonstration/validation work for GBSD to help mitigate this. Table 7 provides a sampling of U.S. missile programs, their dates of development, and their current program variants. It is worth noting that with the exception of RAM Blk 2, the last missile development program was JASSM, which began over two decades ago. The one before that was the Advanced Medium-Range Air-to-Air Missile (AMRAAM), which began nearly 40 years ago.

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 missile research and development 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.

Table 7: History of DoD Missile Development Programs

MISSILE PROGRAM	DEVELOPMENT START	PRODUCTION OR DELIVERY START	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	1970s	1983	Block IV
JASSM	1995	2001	JASSM-ER
RAM	2006	2014	Blk 2

8.6.4 Critical Issues

MIBP collaborated with the OSD-chartered Critical Energetics Materials Working Group 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 which 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 weapon systems.

Ammonium Perchlorate (AP)

The Department must find a long-term solution to mitigate the high cost and schedule risk to missile programs resulting from the fragility of a sole domestic supplier for AP. Numerous studies and reports to Congress have identified the Department's supplier, American Pacific (AMPAC), as a critical sub-tier supplier. AMPAC-produced AP is used in virtually all of the Department's missile programs. However, due to decreasing demand, AMPAC is currently operating at 10% to 15% of facility capacity, resulting in large overhead expenses distributed among a small volume of customers. To date, there have been large increases in the price per pound of AP and projections are for this to continue to increase until the GBSD program comes online in the 2020s.

Dimeryl Diisocyanate (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 due to an unfavorable business case, leaving DoD with no qualified source.

Dechlorane Plus 25

Nearly all DoD missile systems use Dechlorane as a component in the insulation for their SRMs. There is no domestic supplier for this material; the sole source is Occidental Chemical in Belgium. Even more concerning is that the pre-cursor to make Dechlorane came from China. The Chinese source can no longer produce that pre-cursor and so there is now no source for Dechlorane in the world.

Cyclotrimethylene Trinitramine (RDX)

RDX is a high explosive used in many DoD weapon systems, including bombs, warheads, and some missile systems. Resupply and surge requirements for certain munitions have highlighted a capacity shortfall for RDX manufacture, which will delay delivery of those munitions.

Visibility Into Sub-Tier Suppliers and Notification of Obsolescence Issues

Material obsolescence has become a critical issue for the munitions and missiles sector. A recent study of 35 "key" munitions in production found that the industrial base is dominated by single/sole-source suppliers. For second-tier suppliers, there were 253 critical components (121 suppliers), and 98% of them were single/sole source, and for third-tier suppliers there were 131 critical components (73 suppliers) and 98% were also single/sole source. With the decline in usage of materials that make up these weapon systems, some companies have stopped making these materials, mostly due to unfavorable business cases to continue production. In most cases there is not a viable alternative drop-in replacement, so there is cost to find or develop a new material. Even if there a replacement, the requalification costs for the new materials can be prohibitive, especially for larger missile systems. DDI and Dechlorane 25 are just two examples of the myriad materials that have become obsolete recently. This issue is also not limited to legacy systems, as materials can and do become obsolete even during development programs. Most programs do not plan or budget for obsolescence, and the Department and industry do not have a coordinated mitigation approach for this issue. Programs and companies operate independently, which leads to the Services and agencies paying to solve the same issue(s) multiple times. A more coordinated approach would be less costly to the Department.

Learning about obsolescence issues in a timely manner continues to be a challenge for the Department. For the most part, programs delegate responsibility to manage the sub-tier supply chain to the prime contractor. The primes then delegate this responsibility down to their first-tier suppliers, who delegate it to the second-tier suppliers, and so on. When an obsolescence issue occurs at a sub-tier supplier that is low in the chain, it is often months or even years before the Department is made aware. This leads to insufficient time to mitigate the problem efficiently and cost effectively. A severe case occurred in 2017 when a fifth-tier supplier had to switch sub-suppliers after the original supplier was purchased and subsequently closed. The Department did not find out until 2 years later, and by then what the fifth-tier supplier thought was a 3- to 5-year end-of-life buy of components was really a 6-month supply. MIBP initiated the PAIR process (described in section 7.3.10) to allocate the remaining items to the munitions that most needed them, those being used in current operations. Had the Department known sooner, they would have increased the end-of-life quantity, which would have allowed all the programs to have a large enough supply of old parts, and plenty of time to requalify a replacement part.

8.6.5 Mitigation Efforts

Activities by the Services and MDA that potentially help mitigate issues in the missile sector are listed below.

The Department of the Navy

The Department of the Navy (DoN) is implementing a Cruise Missile Strategy, as follows:

1. Sustainment of Tomahawk Land Attack Block III and Tactical Tomahawk (TACTOM) Block IV weapons through their anticipated service lives.
2. Integration of modernization and obsolescence upgrades to BLK IV TACTOM weapons. On October 3, 2016, the Assistant Secretary of the Navy for Research, Development, and Acquisition (ASN(RDA)) approved a Maritime Strike Tomahawk (MST) Rapid Deployment Capability (RDC) to provide TACTOM with an anti-surface warfare capability. Additional anti-access/area-denial navigation and communications upgrades will be integrated into TACTOM during an FY 2019 mid-life recertification program which also adds 15 years of increased service life to all BLK IV TACTOM weapon all-up-rounds.
3. Fielding of the LRASM as the Offensive Anti-Surface Warfare (OASuW)/ Increment 1 material solution to address near- to mid-term anti-surface warfare threats.
4. 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 conventional standoff strike capabilities. NGSC will address the Next Generation Land Attack Weapon (NGLAW) to initially complement, and then replace, current land-attack cruise missile weapon systems and OASuW/Increment 2 to counter long-term anti-surface warfare threats. On November 28, 2016, the Under Secretary of Defense for Acquisition, Technology, and Logistics approved the DoN's request for NGLAW to enter the Milestone-A phase and initiate the formal Analysis of Alternatives. With FY 2017 congressional approval, the DoN plans to complete OASuW/ Increment II acquisition planning.

Additionally, ship self-defense weapon systems are migrating to integrate active seeker capabilities, leveraging common-guidance section architecture from the joint AMRAAM C-7 into SM-6/Block 1 and the Evolved Sea-Sparrow Missile (ESSM)/Block 2. This family of missile systems approach leverages previous design efforts to reduce overall weapon system development costs, applies common technologies to new/different warfighting mission areas, and decreases weapon unit costs via more efficient production quantities.

Air Force

The Air Force is beginning early RDT&E efforts for the AGM-86B Air-Launch Cruise Missile replacement, the Long-Range Standoff Weapon.

MDA

THAAD Get-To-Excellence Program: The Missile Defense Agency's Terminal High Altitude Area Defense (THAAD) Program Office conducts an on-going industrial base risk identification and mitigation program through its Joint Improvement Teams (JITs). The THAAD prime contractor conducted surveys of its suppliers and reviewed metrics on quality on delivery performance to identify the drivers of disruption to its final assembly, integration, and test (FAIT) facility. The THAAD program office selected nine suppliers for review in FY 2017. The program office, working jointly with the prime contractor, conducted a complete manufacturing assessment of each selected supplier to identify delivery and quality risks and implement appropriate mitigations.

The THAAD program office uses the JIT program as a tool to identify industrial base risk and to achieve a smooth and efficient flow to its FAIT operations. Assessments reveal other suppliers for reviews and identify other potential risks including reliance on sole/single-source suppliers and foreign suppliers of critical components. The THAAD Program Office's JIT program is part of its holistic approach to industrial base risk identification and mitigation.

THAAD Supplier Lead-Time Study: MDA's THAAD program office retained an independent team to analyze its weapon system industrial base and identify key lead-time drivers. The team identified a subset of the program supplier base that exhibited longer lead times and surveyed each for insights on its procurement, production, and testing processes.

The review team consolidated and analyzed the information and provided the Program Office with recommendations for improving supplier base efficiency and reliability. The THAAD Program Office consolidated the analysis results with industrial base risks identified through other assessments to maintain a detailed database of suppliers used to conduct early identification and mitigation of risks to its production and fielding schedule.

Standard Missile (SM)-3 Capacity Study: MDA's Aegis BMD program office worked with its FAIT supplier to conduct a detailed capacity analysis in preparation for planned production rate increases. The analysis focused on the existing production site and considered both facility and workforce constraints. MDA and the supplier developed a descriptive computer simulation of the production process using stochastic discrete event modeling. The simulation enabled MDA and the supplier to incorporate real-world conditions to analyze factory performance and conduct data-driven decisions based on resource constraints (manpower, equipment, bottlenecks, capacity, scheduling, etc.). The supplier will be able to implement planned improvements to support future rate increases.

IBAS

During 2017, MIBP led activities to develop, plan, and execute several IBAS projects intended to mitigate missile sector issues.

Fuzes

Without intervention, loss of industry design and production expertise is expected for Electronic Safe and Arm Device (ESAD)-based fuzes. ESADs are most commonly used in missile fuzing, but 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 was awarded in FY 2017. In this phase, the work from Phase I will be applied against a post-Milestone C munition, which can benefit the most from an upgraded fuze capability. Additionally, ESAD component technology awards were made to both advance the capability of some existing vendors as well as to expand the sub-tier supplier base.

HTPB

The Army funded a Phase II Small Business Innovation Research (SBIR) project to establish a second source for this material. IBAS funding was 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 is also 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 included identifying approaches to reduce the capacity in the existing facility and analyzing cost/schedule for development of a new right-sized facility. Reducing the requalification cost burden for DoD weapon systems that experience an ingredient change was also 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. The market, however, is not stable, with the price of U.S. AP rising substantially in the past few years. The Department is therefore working with NASA, the other principal consumer of AP, to develop a long-term solution that stabilizes the market and reduces cost.

DDI

MIBP worked with BASF to help them understand the importance of this item to weapon systems—coordinating with the Services and industry to identify usage data to help BASF with their business case analysis. BASF agreed to additional production campaigns and continued production of BASF material (albeit with a different process).

Dechlorane Plus 25

The Department and industry are working to find a replacement material. MIBP is driving a more coordinated approach for this effort, establishing a Dechlorane Working Group to ensure that all the Services and programs that use this material are communicating with each other on Government and industry mitigation activities, and leveraging efforts to arrive at a more efficient and cost-effective solution. This is the beginning of what could serve as a model for mitigating material obsolescence in the future.

RDX and IMX

The Department has funded a project to increase capacity for these materials at Holston Army Ammunition Plant, an Army-owned, contractor-operated facility, to meet current and future demand, and to allow for the ability to surge capacity if required.

8.7 Radar and Electronic Warfare Sector

Military radars and electronic warfare (EW) systems play a significant role in meeting national security objectives. Radar is a system for detecting the presence, direction, distance, and speed of aircraft, ships, and other objects by sending out pulses of high-frequency electromagnetic waves that are reflected off the object back to the source. Radars have become integral to the performance needs of all military weapon systems as they can detect and identify aircraft and missiles and control flight and weaponry. These systems have to work in the harshest environments that a military system can be exposed to due to combat and theater of operations, and therefore military radars must be light, rugged, and powerful.

Electronic warfare is any action involving the use of the electromagnetic spectrum or directed energy to control the spectrum, attack of an enemy, or impede enemy assaults via the spectrum. The purpose of EW is to deny the opponent the advantage of, and ensure friendly unimpeded access to, the electromagnetic spectrum. EW can be applied from air, sea, land, and space by manned and unmanned systems, and can target humans, communications, radar, or other assets.

Military radar and 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 modules, subassemblies, and beam formers in multiple frequency bands.

8.7.1 Industry Suppliers

The Department has 17 radar programs in procurement, five programs in development, and 73 radar programs in sustainment. These radar systems perform radar functions in three operational domains: land, air, and sea. They provide the following mission/functional capabilities:

- Fire Control
- Terrain Following
- Search
- Imaging/Target ID
- Track
- GMTI (Ground Moving Target Indication)
- SAR (Synthetic-aperture radar)
- Environment/Weather

Three domestic manufacturing suppliers dominate the market:

- Raytheon (5 procurement, 2 RDT&E, 19 sustainment)
- Northrop Grumman (6 procurement, 13 sustainment)
- Lockheed Martin (1 procurement, 1 RDT&E, 16 sustainment)

The Department supports a number of EW systems that provide electronic attack, EW support, and electronic protection capabilities. EW provides the following mission/functional capabilities:

- Radio Frequency Jammer
- Countermeasures
- Radar Warning Receiver
- Laser Jammer
- Laser Detector
- Missile Warning System

Four domestic prime manufacturers dominate the EW market (Raytheon, Northrop Grumman, Harris, and BAE Systems). Table 8 lists major radar and EW programs and their prime contractors.

Table 8: Prime Contractors for Major Radar/EW Programs*

PRIME	DIVISION	TYPE OF SYSTEM	PROGRAM
BAE	Electronic Systems	Electronic Warfare	• F-15 Eagle Passive Active Warning Survivability System (EPAWSS)[78] • Integrated Defensive Electronic Countermeasures (IDECM)[79]
Harris	Electronic Systems	Electronic Warfare	• Integrated Defensive Electronic Countermeasures (IDECM)
Lockheed Martin	Rotary and Mission Systems	Radar	• Space Fence Ground-Based Radar System • Long Range Discrimination Radar (LRDR)
Northrop Grumman	Aerospace Systems	Electronic Warfare	• B-2 Defensive Management System–Modernization (B-2 DMS-M)
	Mission Systems		• Common Infrared Countermeasure (CIRCM)
	Mission Systems	Radar	• Ground/Air Task Oriented Radar (G/ATOR)
Raytheon	Space & Airborne Systems	Electronic Warfare	• Next Generation Jammer (NGJ)
	Integrated Defense Systems	Radar	• Three-Dimensional Expeditionary Long-Range Radar (3DELRR) • Air and Missile Defense Radar (AMDR)

* *Includes current Radar/EW MDAPs.*

8.7.2 Risk Assessment

The radar and EW industrial base issues fall into two issue areas: those common to other industrial sectors and those specific to this sector. Many of the radar and EW industrial base issues are common to those identified in the electronics industrial sector. These issues include trusted foundries, counterfeit parts, and obsolescence (which is also referred to as diminishing manufacturing sources and material shortages (DMSMS)). With so many legacy systems in sustainment, DMSMS issues can have a significant impact on cost and schedules for programs that must develop a replacement and then qualify the new part. For further discussion on these issue areas, see the electronics section.

73 Boeing is prime integrator for the EPAWSS program. EW development is being performed by BAE Electronic Systems.

74 BAE Electronic Systems is prime for IDECM Block 3, which consists of an onboard electronic frequency converter (EFC) and a fiber-optic towed decoy (ALE-55) that will incorporate IDECM ALQ-214, an RF countermeasure system developed by Harris.

The Department faces a risk of reduced competition and innovation for legacy, current, and future systems for tactical active electronically scanned array (AESA) radar systems. Radar production for all but the F-35 tactical AESA radar will stop within the FYDP. At that time, the DoD will have a single qualified source. Without stable funding for a development effort through the FYDP, the next generation of radar systems will not be ready for future fighter aircraft and there will not be a competitive industrial base for advanced radar systems.

Other significant radar and EW industrial base issues for current and future systems include:

- Attracting and retaining software coders, as it takes many years to develop the software talent pool for defense-specific radar and EW systems;
- Sole domestic source for chaff countermeasures; and
- Capacity issues for flare countermeasures.

Some of the sector-specific industrial areas are associated with our legacy radar and EW systems. These risk areas include:

- Single domestic source for high-frequency traveling wave tubes (TWTs) (mostly impacts older high-frequency EW systems);
- Foreign dependency source for tungsten – 3% rhenium wire (does not impact our digital systems);
- Sole domestic source of samarium-cobalt (SamCo) magnets; and
- Single domestic source for high-temperature ceramic packaging for AESA transmit/receive modules.

8.7.3 Mitigation Efforts

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 engineers, software coders, 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.

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

There have been several successful Title III projects supporting radar and EW. Currently there are two projects supporting MMICs:

GaN Advanced Electronic Warfare MMIC

The purpose of this $17.1 million project is to establish a domestic, economically viable, open-foundry merchant supplier production capability for Ka-band gallium nitride (GaN) MMICs.

GaN MMIC Production Initiative

The purpose of this $19.5 million project is to increase GaN power amplifier performance and yield and reduce cost for the Next Generation Jammer.

8.8 Shipbuilding Sector

The shipbuilding defense industrial base consists primarily of seven shipyards owned by four companies and their suppliers. The shipyards and locations are identified in Figure 21. The defense industrial base supporting shipbuilding is segmented by ship type: aircraft carriers, submarines, surface combatants, amphibious warfare, combat logistics force, and command and support vessels.

Figure 21: Primary U.S. Shipyards (Constructing Ships for Department of the Navy)

The shipyards engaged in naval construction in the United States are identified in Table 9.

Table 9: Prime Contractors for Major Shipbuilding Programs

SHIPBUILDER	SHIPYARD	TYPE OF SHIP	PROGRAM
General Dynamics	Bath Iron Works (BIW)	Surface Combatant	• Arleigh Burke Class Destroyer (DDG 51) • Zumwalt Class Destroyer (DDG 1000)
	Electric Boat (EB)	Submarine	• COLUMBIA Class Submarine • VIRGINIA Class Submarine
	NASSCO	Command/ Support	• Expeditionary Transfer Dock (ESD) • Expeditionary Mobile Base (EMB) • Expeditionary Sea Base (ESB)
		Combat Logistics	• TAO Fleet Oiler
Huntington Ingalls	Newport News	Aircraft Carrier	• Gerald R. Ford Class (CVN)
		Submarine	• COLUMBIA Class Submarine (SSBN) • VIRGINIA Class Submarine (SSN)
	Ingalls	Surface Combatant	• Arleigh Burke Class Destroyer (DDG 51)
		Amphibious Warfare	• San Antonio Class Amphibious Transport Dock (LPD 17) • America Class Amphibious Assault (LHA 6)
Fincantieri	Marinette Marine (MM)	Surface Combatant	• Littoral Combat Ship (LCS)
Austal	Austal	Surface Combatant	• Littoral Combat Ship (LCS) • Expeditionary Fast Transport (EPF)

The shipbuilding sector remained stable during FY 2017. The Navy shipbuilding industrial base delivered 10 ships throughout the year: 2 Arleigh Burke Class Destroyers (DDG 113 and 115), 3 Littoral Combat Ships (LCS 9, 10, and 12), 1 Gerald R. Ford Class aircraft carrier (CVN 78), 2 VIRGINIA Class nuclear attack submarines (SSN 787 and 788), 1 San Antonio Class amphibious transport dock (LPD 27), and 1 expeditionary fast transport ship (EPF 8). In FY 2018, 14 ships are expected to be delivered: 1 ESB, 2 SSNs, 5 LCS, 2 EPFs, 3 DDG 51s, and 1 DDG 1000.

In FY 2017, the Navy procured 9 ships, awarded a detail design and initial production contract for the COLUMBIA[75] Class Submarine (SSBN) to Electric Boat, and awarded Long Lead Time Material (LLTM) contracts for VIRGINIA

[75] In FY 2017, the OHIO replacement program was redesignated as the COLUMBIA class program.

Class Submarines (SSN), Amphibious Transport Docks (LPD), Carriers (CVN), and Fleet Replenishment Oilers (TAO). Four of the ships were procured utilizing existing multiyear contracts: two DDG 51 Arleigh Burke Class Guided Missile destroyers[76] and two VIRGINIA Class submarines (SSN). Five ships were procured via new Detail Design and Construction (DD&C) contracts as follows: one DDG 51 Arleigh Burke Class Guided Missile destroyer to Bath Iron Works, one Littoral Combat Ship (LCS) to Austal USA, one Expeditionary Sea Base (ESB)[77] platform to NASSCO, one Amphibious Assault Ship to Ingalls Shipbuilding, and one San Antonio Class Amphibious Transport Dock, also to Ingalls Shipbuilding. The Navy also released the Request for Information for the Guided Missile Frigate Program FFG(X) and will continue to refine the Conceptual Design with industry through FY 2019 to support a full and open competition with a single-source award in FY 2020. According to the Federal Procurement Data System Next Generation, the Navy awarded approximately $15 billion in shipbuilding procurement contracts in 2017. Around $11.5 billion were awarded to the primary[78] shipyards. As stated in the Navy's Annual Long-Range Plan[79] for Construction of Naval Vessels for FY 2019, the Navy is planning to procure 54 ships across the FYDP. The Navy will continue to utilize acquisition strategies and procurement profiles that allow them to sustain competition and increase efficiency while support the shipbuilding industrial sector.

8.8.1 Industry Suppliers

The number of domestic suppliers at the lower tiers declined in the last 20 years. The limited availability of suppliers requires the Navy to consider the workload and financial health of the supply chain when making procurement decisions. In the lower tiers of the supply chain, the size of the market results in the selection of single or sole sources of supply for critical products to promote resiliency during low production periods. In a study completed by the Navy using the purchase orders from each of the primary shipbuilders, of the 139 identified critical suppliers, 50% of them were single-source providers.

[76] The two destroyers bought under the multiyear contract incorporated the Flight III configuration upgrade, which brings enhanced mission capability centered around the new Air and Missile Defense Radar (AMDR) system.

[77] The Expeditionary Sea Base (ESB) platform to NASSCO and the Amphibious Transport Dock (LPD) were part of the FY 2016 budget, but awarded in FY 2017.

[78] Primary is defined as yards that regularly participate in U.S. Navy new construction programs. Other shipyards occasionally build auxiliary ships for the U.S. Navy and are not dependent on U.S. Navy new construction or repair contracts.

[79] The Navy's long-range plan for construction of naval vessels plan calls for 54 ships to be procured across the FYDP and puts the Navy on a path to 326 ships by FY 2023 and 355 ships by the early 2050s.

8.8.2 Risk Assessment

The increase in ship construction to reach a Navy fleet of 355 ships will strain the current U.S. shipbuilding sector. The COLUMBIA Class program remains one of the top priorities for the Department of Defense and is part of the National Defense Strategy to modernize the sea-based strategic deterrent submarine. This program is expected to start production in 2021. In addition, the Navy has added 11 more surface ships to their procurement plans across the FYDP and the production output for VIRGINIA Class increased to 2 ships per year in 2016.

This expected increase in submarine demand and the steady growth in the Navy's long-range plan for construction of naval vessels represents great news for the U.S. shipbuilding industry. The additional workload is a significant increase from current production levels. One of the challenges for the Department of Defense is to maintain a healthy industrial base capable of supporting the fleet growth. The Navy is working with industry to prepare the industrial base to support this ramp-up.

8.8.3 Mitigation Efforts

The Navy's long-range plan for construction of naval vessels will help stabilize the industrial base and mitigate industrial base risks. This plan provides scalable acquisition profiles that promote a stable workload and efficient operations while encouraging industry investment in capital improvements, capital expansion, and a properly sized world-class workforce. Additionally, the steady, sustainable baseline shipbuilding profiles of the Navy's long-range plan for construction of naval vessels will establish industrial efficiency and agility.

DoD will continue to work closely with shipbuilding contractors to ensure that equipment, system, and component suppliers are able to support the increased demand associated with building a larger fleet. The Navy is using contracting tools such as multiyear procurement contracts, block buy contracts, economic order quantity (EOQ) buys, capital expenditure (CAPEX) incentives, and shipbuilding capability preservation agreements to support industry partners while focusing on affordability and cost control.

The shipbuilders, in conjunction with the Navy, are working to develop a skilled workforce that is able to support the future workload without creating a shortage in critical trades. Shipbuilders are investing in recruitment activities, training, apprentice programs, and other initiatives that will help to meet the increased demand for critical trades.

8.9 Space Sector

The National Security Space (NSS) sector is increasingly dependent on commercial markets including satellites, launch services, ground systems, satellite components and subsystems, networks, engineering services, payloads, propulsion, and electronics.

Space systems provide an emergent capability and strategic advantage to U.S. forces yet, due to market trends, supply chain globalization, and manufacturing costs, future access to space qualified domestic industrial sources such as microelectronics is uncertain. Increasing cyberthreats, questionable (nontrusted) supply chains, foreign acquisitions, reliance on vulnerable foreign sources, and erratic demand is threatening the loss of essential space capabilities and critical skills. This will result in no or degraded domestic supply of qualified critical materials and components to support the NSS space industrial base missions.

NSS increasingly leverages the commercial space industry; however, there are certain performance requirements and capabilities that are more demanding or unique to NSS and are not supported by the growing commercial/civilian space ecosystem. DoD and USG-wide studies and analyses have identified at-risk capabilities, fragile suppliers, and stress in the lower tiers of the space industrial base. The Department space industrial base remains a niche market with very specialized and capital-intensive capabilities that are not efficiently managed through individual program investments. Many systems currently in planning and development are relying on dated technology and skills and fragile sources. Individual programs are reluctant to invest in and qualify new technology and sources. This creates both a need to sustain fragile domestic sources and to qualify new technologies and sources for next-generation systems, which are essential to address ever-increasing threats in the space domain.

Reliance on the commercial market provides many benefits to DoD, including sources of new technology, but also imposes sources of vulnerability. The Department must remain vigilant of sources of vulnerability and maintain critical capabilities that are specialized for military applications, which typically require cutting-edge technology and stringent requirements but often have very low production quantities when compared with commercial products. Figure 22 and Figure 23 provide a tier-based taxonomy for launch services, satellites, and sensors.

TIER 4	TIER 3	TIER 2	TIER 1	PRIME
HARDWARE AND MATERIALS	COMPONENTS AND PARTS	ASSEMBLIES	SUBSYSTEMS	DESIGN AND INTEGRATION OF FINAL SYSTEM OR SERVICE
Adhesives Ceramics Coatings and paints Couplings Electrolytes Gaskets Hoses, Pipes, and Fittings Fuels Magnets Neoprene Nuts, Bolts, Fasteners, and Rivets Nylon Oxidizers Polyethylene Polystyrene Polyvinylchloride Rare Earth Materials/Minerals Rayon Resin Rubber Semiconductors/IC Transistors	Accelerometers Amplifiers Ball Screws Bellows Battery Cells Capacitors Carbonized Cloth Converters Diodes Engine Components Fairing Separation Devices Hydraulics Initiators Potentiometers Precision Ball Bearings Pyro actuators Relays Separation/Release Actuators Solid Rocket Propellant Vehicle Sensors	Guidance, Navigation, and Control • Automatic Destruct System • GPS Receivers • Gyroscopes Payload Faring • Fairings • Pyro Bolts Payload Adapter • Control Command Interface • Payload Parts Power • Batteries • Fuel Cells Propulsion • Combustion Chambers • Engine Controllers • Nozzles • Thrust Vector Control System Structures • Booster Tanks • Engine Mounting Structures • Propellant Feed-Lines	Guidance, Navigation, and Control Payload Faring Payload Adapter Power Propulsion 	Launch Vehicle 

Figure 22: Space Sector Taxonomy: Launch Services

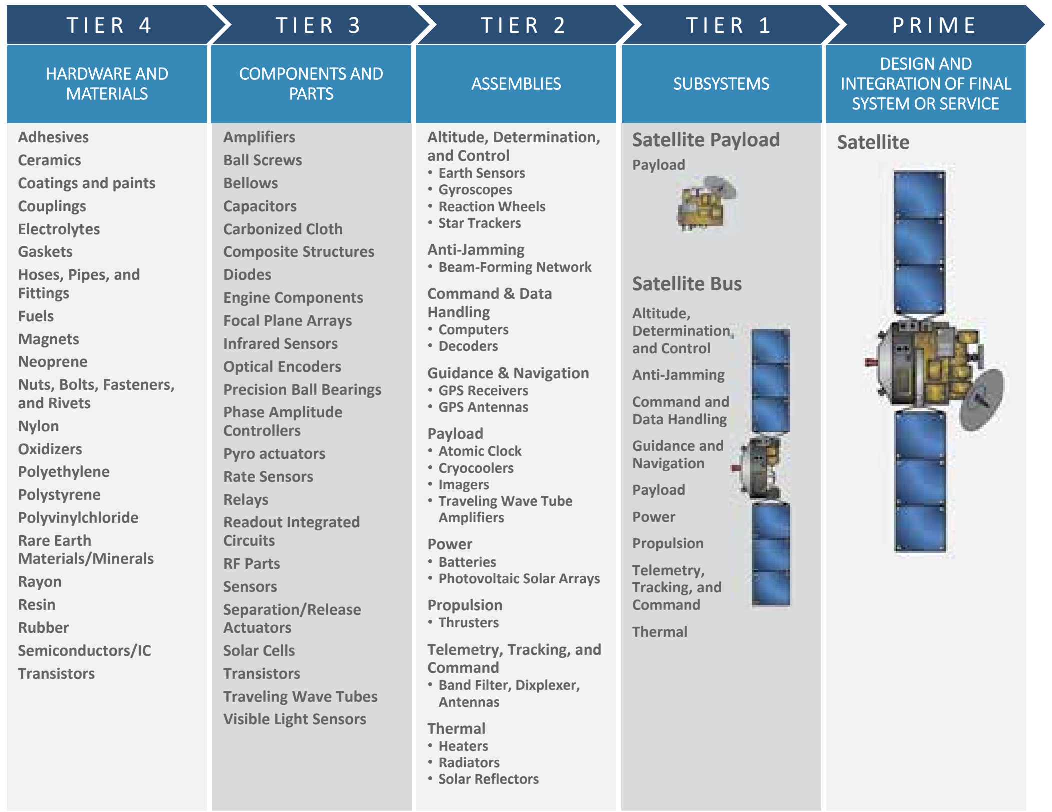

Figure 23: Space Sector Taxonomy: Satellites and Sensors

8.9.1 Risk Assessment

The Space Critical Technology Working Group (CTWG) is the executing body for the Space Industrial Base Capability Investment Program. It has leveraged previous MIBP-led Space Sector Fragility and Criticality Assessments, Department of Commerce-led Space Deep Dive (SDD) studies, and updated studies by working group members to update its assessment of the most critical space industrial base capabilities and fragile suppliers.

The CTWG assesses the following space industrial base areas to have the highest risk. Maintaining these industrial resources and critical technology items is essential to the national defense.

Aerospace Structures and Fibers

Incentives are needed to create a domestic capability to qualify and produce aerospace structures and fibers. Established programs are not incentivized to take on the cost and risk of qualifying a new domestic source, as the savings are not typically offset enough by the effort and risk of introducing a new supplier. This is particularly the case for low-production-rate programs (e.g., satellites, unmanned aircraft used for surveillance and reconnaissance, and missile defense systems). Unless a timely investment to establish a domestic capability is made, the United States will be at high risk of putting multiple NSS programs in jeopardy. Investments in the domestic capability may also spur innovation and leverage existing private sector investment in the domestic aerospace-grade structures and fibers industry.

Radiation-Hardened Microelectronics

The United States relies on a single source for radiation-hardened microelectronics. The NSS enterprise needs to design, develop, and fabricate trusted, radiation-hardened, high-reliability, and space-qualified components. Planned investments target increasing the capability and manufacturability of space-qualified, radiation-hardened microelectronics that will be required by future NSS systems. The objective of these investments is to enhance design flow, optimize design, test, qualify devices, and increase performance to help the supply chain, keep it domestic/trusted, expand product lines, and keep domestic companies viable.

Radiation Test and Qualification Facilities

The ability to quantify and qualify the radiation hardness of electronic components in radiation test facilities is a critical requirement to NSS programs and all of the Department. This effort upgrades and sustains radiation test facilities to fulfill this need. Without the current test infrastructure, DoD would be significantly under capacity for this capability.

Satellite Components and Assemblies

Reliability issues and other factors have resulted in a limited and decreasing number of domestic qualified providers. Loss of low-cost, low-vibration satellite components and assemblies increases dependence on foreign suppliers. The mitigation strategy is to implement a scalable, multiple-phase next-generation project to provide a systematic, comprehensive, and low-cost/risk investment to revive domestic competitors or to expand the existing suppliers' product lines.

8.9.2 Mitigation Efforts

A Deputy Secretary of Defense Management Advisory Group (DMAG) decision in December 2013 approved the request from the USD (AT&L) and other DMAG principals to establish a Space Industrial Base Capability Investment Program. This program was established to fund a systematic, sector-wide, interagency approach to identify, assess and mitigate risk in the space industrial base. In addition, this effort is intended to 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 Space CTWG, as the executing body for the Space Industrial Base Capability Investment Program, recognized that effective space industrial base risk mitigation is best shared among enterprise partners where you can target investments at the most important elements and, through a shared effort, maximize efficiency of investments. The Department continues to synergize implementation of space industrial base risk mitigation efforts. Consistent with titles 10 and 50 U.S.C., which require interagency collaboration in industrial and supply base risk assessments and mitigations, DoD has renewed the existing NSS Space Industrial Base Risk Management Program.

The Space CTWG, as an interagency 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. A coordinated strategy was established among MDA, OUSD(AT&L)/MIBP, AF, OGA, NASA, and other agencies to subsidize and to reduce duplication and other inefficiencies in the planned program executions for funding periods.

The Space CTWG, acknowledging previous and on-going space industrial base mitigation efforts, as well as the limitations thereof, to proactively address risks and requirements across Service and agency programs, used its FY 2017 planning cycle to both re-scope its existing efforts based on progress to date, and identify additional prioritized space industrial base needs.

Risk mitigation programs have been defined but not yet executed for enterprise-wide space capabilities and technologies that affect NSS programs in the areas of aerospace structures and fibers; space-qualified, radiation-hardened, trusted electronics; radiation test facilities; satellite components and assemblies; and additive manufacturing for large liquid rocket engines. These mitigation efforts are consistent with previous years, and the 2017 Presidential determination on the U.S. space industrial base.[80] The mitigation efforts address issues as prioritized by the interagency Space CTWG under the NSS Space Industrial Base Risk Mitigation Program Memorandum of Agreement process. Several space mitigation efforts are outlined in Table 10.

[80] "Presidential Determination Pursuant to Section 4533(a)(5) of the Defense Production Act of 1950 – Memorandum for the Secretary of Defense," Determination No. 2017–08, the White House, June 13, 2017.

Table 10: Space Sector Mitigation Efforts

TITLE III PROJECTS

PROJECT	EXPECTED ACCOMPLISHMENT	PROJECT	EXPECTED ACCOMPLISHMENT
Electronic Beam Direct Write	Develop new method to manufacture ICs at a lower cost without masks	Star trackers	Develop next gen medium-accuracy star trackers using the U.S.-sourced CMOS imager
Rad Hard Digital/Analog Technology P&Q	Advanced IC technology nodes for next-generation systems	Visible sensors	Develop a cost effective CMOS visible sensor with low background noise and low dark current
RH Trusted FPGAs	Assessing supplier practices to achieve acceptable trusted status for FPGAs	Additive manufacturing	Develop additively manufactured processes for Inconel (nickel alloy), aluminum alloys, and copper alloys to support launch missile propulsion systems
Rad Hard Transistors and Diodes	Diversify BPT supply base, diode dies, new diode packaging, opto devices	ROIC	Improve yield of unique space processes
Radiation Test Facilities	Sustain proton capability, investigating hospitals	Reaction wheels	Develop next gen Class B Wheel
Germanium Substrates	Create domestic source of high-quality space-grade Germanium substrates for solar cells	Solar cells	Higher efficiency solar cell productization and qualification

IBAS PROJECTS

PROJECT	EXPECTED ACCOMPLISHMENT
Solar Qualified Infrared Sensors	Productization and qualification of subsystems and materials

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 (fair and open competition) access to foreign suppliers for critical space components against the vulnerability of relying on nondomestic 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.

8.10 Organic Industrial Base

DoD Organic Industrial Base (DOIB), a subset of the larger defense industrial base, is composed of resource providers, acquisition and sustainment planners, and manufacturing and maintenance performers. While commercial industry is the dominant component of the defense industrial base, DOIB maintenance depots, manufacturing arsenals, and ammunition plants are key components of the overall defense industrial base. DOIB provides a maintenance function in the depots as well as manufacturing capabilities for unique items in the arsenals.

The critical support role DOIB plays in the National Security Strategy has been apparent over the past two decades as DOIB facilities surged to sustain warfighting equipment deployed to support the Iraq and Afghanistan contingency operations. To meet this challenge, organic maintenance providers and organic manufacturers have surged to double, and in some cases, triple output in terms of production and direct labor hours compared to pre-surge levels. The requirement to rapidly repair defense materiel establishes the need for a DOIB that is agile, effective, forward deployable, and able to meet current and future surge requirements. This need is critical to ensure continuity of operational readiness during times when the private sector may not be able to meet surge requirements.

Legislation

Within chapter 146 of U.S.C. title 10, five key laws help to define the business domain of the organic sector. Section 2460 defines depot level work. Section 2464 states that it is essential for the national defense that the Department of Defense maintain a core logistics capability that is Government owned and operated (including personnel, equipment, and facilities). This capability ensures the ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, or other emergency requirements. Section 2472 mandates that the size of the workforce performing that work is commensurate to the available and funded workload. Section 2466 sets limitations on outsourcing that work. Section 2476 dictates that the Secretary of a military department shall invest in the capital budgets of the covered depots of that military department a total amount equal to not less than 6% of the average total combined maintenance, repair, and overhaul workload funded at all the depots of that military department for the preceding three fiscal years to maintain capability and modernize. Together these laws serve as an insurance policy to maintain readiness, meet production requirements, and supplement industry's capabilities.

Policy

The military components provide oversight to ensure compliance with this legislation through policy-driven review of required capabilities, capacity utilization, and facility recapitalization. They also develop annual budgets that reflect the actual workload requirements of their fleets. The management framework founded in policy keeps the organic industrial base focused on the scope and scale of work needed to engage and prevail in specifically defined military operations and contingencies.

Operating Environment

Given clear mandates and enabling governance, the organic industrial base should operate from a position of strength; unfortunately, this is not the case. Twenty years of intermittent conflict and war have driven a very high operating tempo and unprecedented system usage that has changed previously accepted formulas that compute maintenance requirements. One solution increased reliance on contracted support, which has compromised the DOIB's position of strength. The levels of funding and the manner in which funding has been made available and allocated to sustainment operations have degraded the Department's ability to achieve expected performance results. The DOIB has suffered from overuse and underfunding in its infrastructure and the evidence is clearly reflected in materiel readiness levels and facility condition indices. For example, a September 2017 GAO report, "Naval Shipyards, Actions Needed to Improve Poor Conditions that Affect Operations," found that "partly as a result of their poor condition, the shipyards have not been fully meeting the Navy's operational needs. In fiscal years 2000 through 2016, inadequate facilities and equipment led to maintenance delays that contributed in part to more than 1,300 lost operational days—days when ships were unavailable for operations—for aircraft carriers and 12,500 lost operational days for submarines."[81]

8.10.1 Industry Suppliers

The scope of DoD maintenance is enormous. DoD sustains approximately 440,000 vehicles, 780 strategic missiles, 278 combatant ships,[82] and almost 14,000 aircraft.[83] The maintenance costs are equally enormous. Of $588 billion total DoD expenditures in FY 2015,[84] $73 billion was for maintenance. Aircraft represented the greatest expenditure at $25 billion, followed by ships at $16.8 billion and vehicles at $7.7 billion.[85]

DoD maintenance uses a robust structure of maintenance facilities and equipment to service and repair the Department's weapon systems. As these weapon systems become more complex, more technically advanced maintenance facilities are required to support these technologies. System Integration Laboratories (SILs) are one example of the increasingly complex facilities required. In addition to SILs, newer technologies typically require more tools, modeling, and simulation to adequately sustain the weapon systems, mission support, ground support, and lab software. Innovative maintenance capabilities must keep pace with rapidly evolving and emerging weapon system technology advances. DoD currently operates 17 major organic (government owned and operated) depot maintenance facilities and 3 manufacturing arsenals.

Maintenance Workforce

DoD materiel maintenance is performed at different levels, ranging in complexity from daily system inspection to rapid removal and replacement of components to the complete overhaul or rebuild of weapon systems. Depot-level maintenance entails the major overhaul or complete rebuild of weapon systems and requires skills or equipment that is not commonly available at lower levels of maintenance. Depot-level maintenance also includes software maintenance and sustainment, which incorporates correcting defects, improving performance, upgrading, and modifying the software to adapt the fielded software baseline to a changing or changed environment. The bulk of this workload is associated with ships and aircraft, and the rest with missiles, vehicles, ground support equipment, mission support, space, and ground systems.

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[81] Naval Shipyards: Actions Needed to Improve Poor Conditions that Affect Operations, GAO-17-548, Government Accountability Office, September 2017.
[82] Naval Vessel Register, http://www.nvr.navy.mil/.
[83] Vehicle, missiles, and aircraft numbers derived from Service Property Book data repositories.
[84] Log Cost Baseline calculation.
[85] Maintenance and Availability Warehouse.

The provision and management of the Department depot maintenance workforce has been a subject of concern for many years. It is DoD's policy and priority to retain a highly skilled workforce at its depot maintenance facilities to provide the needed support for core capability requirements and core sustaining workloads.

Workload requirements largely drive the size and composition of the organic depot workforce. Section 2472 of title 10, U.S.C., specifies that the civilian depot maintenance workforce may not be managed using any constraint or limitation in terms of man-years, end strength, full-time equivalent positions, or maximum number of employees.

If workforce behavior over the next 3 years is similar to that of the previous 3 years, the current workforce will experience a 21% loss rate during FY 2017–19, or about 1 in 5 overall. Army and Marine Corps have the oldest workforces with the highest projected service loss rates (25%, or 1 in 4). The shipyard workforce, Navy (Sea), is the youngest because of considerable recent hiring and has the lowest projected loss rate (17%, approximately 1 in 6). Both the Air Force and Navy (Air) workforces are relatively close to the system-wide average. Historically the projected loss rate has been much higher than the actual loss rate.[86]

8.10.2 Risk Assessment

Materiel readiness of the Armed Forces has been degraded by unfulfilled infrastructure needs and workforce challenges across the organic industrial base. It is essential to the national security that the United States possesses and sustains an effective and efficient capable organic industrial base. Historically, readiness priorities have supplanted allocating resources for infrastructure modernization of depots, shipyards, and arsenals. In the short run, these deferrals for infrastructure modernization have helped with keeping the cost of depot maintenance to manageable levels. However, it also has led to a slow degradation of the organic industrial base infrastructure. As a result, much of the organic industrial base infrastructure needs modernizing, specifically in terms of the material condition of the facilities, process improvements, and technology developments.

Infrastructure

Although a framework exists to recapitalize most DoD industrial activities, pressure to provide more readiness within constrained budgets conflicts with this framework. In many cases, this conflict results in leadership decisions to allocate more resources toward immediate weapon system readiness, and less toward maintaining the infrastructure where related maintenance occurs. As a consequence, military construction, capital equipment investments, technology refresh, facility modernization programs, and supporting infrastructure such as electrical grid, sanitation, environmental, and communication grid have lagged.

[86] Based on Logistics Management Institute Analyses.

Naval Shipyard Infrastructure: The average age of Naval shipyard capital equipment is 22 years old (7 years beyond industry standards). Each year a significant number of work stoppages are attributable to the age and condition of this equipment, a number that is growing from year over year. Additionally, the condition, configuration, and location of supporting facilities, dry docks, and equipment have a direct impact on shipyard performance and fleet readiness. The naval shipyards are comprised of infrastructure from the 19th and 20th centuries, primarily designed for ship construction using early 20th-century industrial models. This outdated facility model creates significant production inefficiencies for the maintenance mission on 21st-century nuclear-powered naval assets. There have been no major recapitalization efforts since the early 20th century. The average material condition of naval shipyard facilities is poor, and shipyard facilities and supported functions are not arranged or configured to best support nuclear submarine or aircraft carrier depot maintenance throughput.

Naval Aviation Depot Infrastructure: Naval aviation depots support Navy and Marine Corps aviation aircraft and weapon systems, and support equipment depot requirements. Despite the modernization of the majority of the service's aviation element over the last decade, minimal investment has been made to modernize and recapitalize the sustainment infrastructure of the aviation depots. The average age of the facilities footprint is 59 years old, which is well beyond the 40-year useful life limit. Compounding the issue is that average age of equipment supporting production is in excess of 24 years old.

Marine Corps Depot Infrastructure: The average age of Marine Depot Maintenance Command (MDMC) facilities is 31 years. The average age of MDMC equipment is 13 years old, near the end of life expectancy. Without additional funding and obligation authority, increased sustainment costs of antiquated facilities, infrastructure, and equipment will inhibit the Marine Corps ability to posture depot maintenance capabilities to support future weapon systems.

Air Force Depot Infrastructure: The Air Force organic industrial base is a significant component of the defense industrial base. The Air Force continues to face difficult resourcing decisions to balance infrastructure investment needs against re-establishing readiness, increasing lethality, and modernizing the aging fleet. MILCON cycle times contribute to the aging facilities.

Workforce

As a result of sequestration-level budgets, gaps in hiring over the past decade, and ever-increasing weapon system sophistication and complexity, deficiencies exist in critical artisan maintainer skill areas. Many of these skill areas require advanced specialized experience over a number of years to develop, resulting in continual capability gaps.

8.10.3 Mitigation Actions

Infrastructure

Remedies to infrastructure challenges within the organic industrial base will have to come through adjustments to the balance between funding for numerous competing requirements. The need to maintain readiness of the fighting force, and the need to modernize its warfighting capabilities continue to dominate spending priorities within the Department, and so the road to recovery of infrastructure will not be a short journey, nor will it be without significant detours along the way.

Workforce

As a Government employer, the OIB is in many ways at a disadvantage in its ability to recruit, hire, train, educate, and retain talent. The industrial activities are overcoming this disadvantage through partnerships with academia, coupled with internships and apprentice programs to help feed the pipeline. Once on board, the challenge becomes one of leadership—keeping employees well focused on career progression, and well exposed to the rewarding experiences that are unique to an environment that directly supports the Nation’s warfighters.

9. Conclusion

The defense industrial base and its supply chain support the U.S. economy, military readiness, and unanticipated surge requirements. Therefore, the defense industrial base is vital to the U.S. national security and defense strategies and it must be robust, secure, resilient, and innovative in order to support warfighter requirements.

In FY 2017, the Department continued identifying industrial base risks and finding solutions to mitigate their impact.

The Department’s achievements during FY 2017 included the following:

- As directed by EO 13806, DoD began work with its interagency partners and industry in July 2017 to identify risks in the manufacturing and defense industrial base. The final report for the EO is expected to be submitted to the White House in April 2018.
- MIBP established a PAIR Task Force that successfully prioritized deliveries necessary to meet requirements of the munitions and missiles sector when a supply chain issue caused a shortfall.
- DPA Title III addressed shortfalls in the space sector, 3D microelectronics, next-generation soldier protection, Adenovirus production, and secure cargo shipping containers.
- The IBAS program supported seven new projects to preserve fundamental capabilities across the industrial base, primarily in the materials, missile, and space industrial sectors.
- Manufacturing USA established the ARM Institute and BioFabUSA to develop new technologies and improve U.S. competitiveness in manufacturing.
- MD5 expanded its Hacking 4 Defense course to several new universities and conducted numerous Hackathons, including one that gathered practitioners, technologists, and the military to assess opportunities to use functional fabrics to address emergency response in challenging environments.
- MIBP, OASD(R&E), and the Office of Human Capital Initiatives began collaborating with AIA on workforce development challenges.

- The DIBNow analytics platform development efforts continued during the year. DIBNow received an Authorization to Operate on the DoD network in early FY 2018 and began onboarding users to test and evaluate the platform.
- MIBP's industry outreach efforts continued to increase in breadth and depth, fostering a collaborative dialogue between all stakeholders in support of our national security requirements. DoD held two roundtable discussions with the three major defense industry associations during FY 2017 and established a robust plan for industry engagement sessions with small, medium, and large companies for FY 2018.

APPENDICES

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 Department 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 defense industrial base 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 (S2T2) assessment of the industrial base undertaken by DoD. The S2T2 assessments were discontinued due to challenges implementing the methodology. The Department developed the Fragility and Criticality methodology in 2013 to replace S2T2.

This report simultaneously satisfies the requirements pursuant to title 10 U.S.C., section 2504, which requires the Department 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: DoD Authorities to Support the Industrial Base

MIBP is responsible to assess and address the health and resiliency of the defense industrial base. The office uses title 10 U.S.C., sections 2501, 2503, 2505, and 2506 to support industrial base assessments and risk mitigation. MIBP uses the following specific authorities:

- Title 10 U.S.C., section 2372, Independent Research and Development;
- Title 10 U.S.C., section 2521, Manufacturing Technology (ManTech) program;
- Title 15 U.S.C., section 18a, Hart–Scott–Rodino Antitrust Improvements Act of 1976;
- Title 50 U.S.C., DPA Title I, Defense Priorities and Allocations System (DPAS);
- Title 50 U.S.C., DPA Title III program, Expanding Production Capability and Supply;
- Title 50 U.S.C., DPA Title VII, section 721, Committee on Foreign Investment in the United States (CFIUS); and
- Title 50 U.S.C., section 2508, Industrial Base Fund.

Appendix C: Key Industrial Capabilities Assessments Completed During FY 2017

Appendix C contains information for official use only, business confidential, and proprietary. This appendix will be provided separate from this report.

Appendix D: Title III, IBAS, and ManTech Projects

Appendix D contains information for official use only, business confidential, and proprietary. This appendix will be provided separate from this report.

Appendix E: List of Acronyms

AARGM-ER	Advanced Anti-Radiation Guided Missile–Extended Range
AAV	Amphibious Assault Vehicle
ACV	Amphibious Combat Vehicle
AESA	Active Electronically Scanned Arrays
AFFOA	Advanced Functional Fabrics of America
AIA	Aerospace Industries Association
AMDR	Air and Missile Defense Radar
AMF	Airborne & Maritime/Fixed Station
AMNPO	Advanced Manufacturing National Program Office
AMPAC	American Pacific
AMPV	Armored Multi-Purpose Vehicle
AMRAAM	Advanced Medium-Range Air-to-Air Missile
AMRDEC	Aviation and Missile Research, Development, and Engineering Center
AOC	Air and Space Operations Center
A&S	Acquisition and Sustainment
AP	Ammonium Perchlorate
APC	Armored Personal Vehicle
AR	Aerojet Rocketdyne
AT&L	Acquisition, Technology, and Logistics
BAE	British Aerospace Systems
BI&A	Business Intelligence and Analytics
C4	Command, Control, Communication, and Computers
CAC2S	Common Aviation Command and Control System
CANES	Consolidated Afloat Networks and Enterprise Services
CAPEX	Capital Expenditure
CBARS	Carrier-Based Air Refueling System
CEC	Cooperative Engagement Capability
CEO	Chief Executive Officer
CFIUS	Committee on Foreign Investment in the United States
CIRCM	Common Infrared Countermeasures
CMO	Chief Management Officer
COTS	Commercial Off The Shelf
CVN 78	Gerald R. Ford Class
DAGR	Defense Advanced GPS Receiver
DARPA	Defense Advanced Research Projects Agency
DASD	Deputy Assistant Secretary of Defense
DCGS-A	Distributed Common Ground System-Army
DCMA	Defense Contract Management Agency
DD&C	Detail Design and Construction
DDG 1000	Zumwalt Class Destroyer
DDG 51	Arleigh Burke Class Destroyer
DDI	Dimeryl Diisocyanate
DHS	Department of Homeland Security
DIB	Defense Industrial Base
DIUx	Defense Innovation Unit Experimental
DLA	Defense Logistics Agency
DMAG	Deputy's Management Action Group
DMEA	Defense Microelectronics Activity
DMSMS	Diminishing Manufacturing Sources and Material Shortages
DMS&T	Defense-wide Manufacturing Science and Technology
DMS-M	Defensive Management System Modernization

DNA	Deoxyribonucleic Acid
DOC	Department of Commerce
DoD	Department of Defense
DoE	Department of Energy
DoI	Department of Interior
DOIB	DoD Organic Industrial Base
DoJ	Department of Justice
DoL	Department of Labor
DoN	Department of the Navy
DPA	Defense Production Act
DPAS	Defense Priorities and Allocation Systems
DPG	Defense Planning Guidance
DRP	Defense Reciprocal Procurement
EA	Executive Agent
EBITDA	Earnings Before Interest, Taxes, Appreciation, and Amortization
EMB	Expeditionary Mobile Base
EMD	Engineering and Manufacturing Development
ERI	Electronics Resurgence Initiative
ESAD	Electronic Safe and Arm Device
ESD	Expeditionary Transfer Dock
ESSM	Evolved Sea Sparrow Missile
EO	Executive Order
EOQ	Economic Order Quantity
EW	Electronic Warfare
E/WD	Education and Workforce Development
EUV	Extreme Ultra Violet
FAB-T	Family of Advanced Beyond Line-of-Sight Terminals
FAIT	Final Assembly Integration Test
FaC	Fragility and Criticality
FDI	Foreign Direct Investment
FFRDC	Federally Funded Research and Development Center
FHTV	Family of Heavy Tactical Vehicles
FIRRMA	Foreign Investment Risk Review Modernization Act
FMS	Foreign Military Sales
FMTV	Family of Medium Tactical Vehicles
FPGA	Field Programmable Gate Array
FTC	Federal Trade Commission
FVL	Future Vertical Lift
FY	Fiscal Year
FYDP	Future Years Defense Program
G/ATOR	Ground/Air Task Oriented Radar
GBS	Global Broadcast Service
GBSD	Ground Based Strategic Deterrent
GCV	Ground Combat Vehicles
GIDEP	Government-Industry Data Exchange Program
GNC	Guidance, Navigation, and Control
GOCO	Government Owned and Government Operated
GOGO	Government Owned and Contractor Operated
GPS	Global Positioning System
HD4	Hacking for Defense
HD	Homeland Defense
HHS	Health and Human Services
HMMWV	High Mobility Multi-Purpose Wheeled Vehicle
HMS	Handheld, Manpack, and Small Form Fit
HTPB	Hydroxyl-Terminated Polybutadiene
IAMD	Integrated Air and Missile Defense
IBAS	Industrial Base Analysis and Sustainment
IBC	Industrial Base Council

IC	Integrated Circuit
ICBM	Inter-Continental Ballistic Missile
IDECM	Integrated Defensive Electronic Countermeasures
IFV	Infantry Fighting Vehicles
IMU	Inertial Measurement Units
IP	Integrated Photonics
IPT	Integrated Project Team
ISR	Intelligence, Surveillance, and Reconnaissance
ITV	Internally Transportable Vehicles
JAGM	Joint Air to Ground Missile
JANNAF	Joint Army Navy NASA Air Force
JASSM-ER	Joint Air-to-Surface Standoff Missile–Extended Range
JDMTP	Joint Defense Manufacturing Technology Panel
JIBWG	Joint Industrial Base Working Group
JIT	Joint Improvement Team
JLTV	Joint Light Tactical Vehicle
JMR	Joint Multi-Role
JTRS	Joint Tactical Radio System
JSF	Lighting II Joint Strike Fighter
LAV	Light Armored Vehicle
LCS	Littoral Combat Ship
LED	Light Emitting Diode
LHA 6	America Class Amphibious Assault
LLTM	Long Lead Time Material
LPD 17	San Antonio Class Amphibious Transport Dock
LRASM	Long-Range Anti-Ship Missile
LRDR	Long Range Discrimination Radar
LRPF	Long Range Precision Fires
LVSR	Logistics Vehicle System Replacement

M&A	Mergers and Acquisitions
MAIS	Major Automated Information Systems
ManTech	Manufacturing Technology
MD5	Military District 5
MDA	Missile Defense Agency
MDAP	Major Defense Acquisition Program
MGUE	Military Global Positioning System User Equipment
MIBP	Manufacturing and Industrial Base Policy
MIDS	Multi-Functional Information Distribution System
MINSEC	Microelectronic Innovation for National Security and Economic Competitiveness
MOU	Memoranda of Understanding
MRAP	Mine Resistant Ambush Protected
MSE	Missile System Enhancement
MST	Maritime Strike Tomahawk
MTVR	Medium Tactical Vehicle Replacement
NASA	National Aeronautics and Space Administration
NDAA	National Defense Authorization Act
NDIA	National Defense Industrial Association
NDS	National Defense Stockpile
NGJ	Next Generation Jammer
NGLAW	Next Generation Land Attack Weapon
NGSC	Next Generation Strike Capability
NIST	National Institute of Standards and Technology
NTIB	National Technology and Industrial Base
NSF	National Science Foundation
NSS	National Security Space
NSTC	National Science and Technology Council
OASD	Office of the Assistant Secretary of Defense
OASuW	Offensive Anti-Surface Warfare

OATK	Orbital ATK
OCO	Overseas Contingency Operations
OCX	Operation Control System
ODASD	Office of the Deputy Assistant Secretary of Defense
OSD	Office of the Secretary of Defense
OTMP	Office of Trade and Manufacturing Policy
OUSD	Office of the Under Secretary of Defense
PAC 3	Patriot Advanced Capability 3
PAIR	Priorities Allocation of Industrial Resources
PCB	Printed Circuit Board
PIM	Paladin Integrated Management
PSC	Professional Services Council
R&D	Research and Development
R&E	Research and Engineering
RAM	Rolling Airframe Missile
RDC	Rapid Deployment Capability
RDT&E	Research Development Test and Evaluation
RDX	Cyclotrimethylene Trinitramine
REE	Rare Earth Elements
S&T	Science and Technology
SAE	Service Acquisition Executive
SAR	Synthetic-Aperture Radar
SBIR	Small Business Innovation Research
SBIRS	Space Based Infrared System
SCO	Strategic Capabilities Office
SDD	Space Deep Dive
SM-3	Standard Missile 3
SOSA	Security of Supply Arrangement
SRM	Solid Rocket Motor
SSN 774	Virginia Class Submarine
STEM	Science Technology Engineering Mathematics
TACTOM	Tactical Tomahawk
THAAD	Terminal High Altitude Area Defense
TMC	Tactical Mission Command
TMRR	Technology Maturation and Risk Reduction
TOR	Terms of Reference
TTR	Teledyne Turbine Engines
TWT	Traveling Wave Tube
UAS	Unmanned Aircraft Systems
UA	Unmanned Aircraft
UCLASS	Unmanned Carrier-Launched Airborne Surveillance and Strike
ULA	United Launch Alliance
U.S.C.	United States Code
USD(AT&L)	Under Secretary of Defense, Acquisition Technology, and Logistics
USG	U.S. Government
Win-T	Warfighter Information Network–Tactical
WS	Weapon System

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