



West Virginia

Defense Industry Research Report

April 2018

West Virginia Defense Industry Research Report

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EXECUTIVE SUMMARY

Rapid and ongoing changes within the defense industry make it imperative that West Virginia thoroughly understand the far-reaching assets, opportunities and impacts of its defense-related supply chains. To support this effort, the Center for Regional Economic Competitiveness (CREC) conducted a comprehensive inventory and supply chain mapping analysis of the state's defense industry. The findings from this analysis indicate that West Virginia should actively promote a robust Defense & National Security industry cluster to provide businesses and workers more economic opportunities.

A large potential market exists in Department of Defense (DOD) contract awards. The DOD awarded nearly \$325 billion in contracts in the most recent fiscal year. Figure 1 shows that Texas, California, Virginia, Florida, Maryland are among the states receiving the largest dollar amounts from contract awards. West Virginia has the 40th largest state economy but ranks 48th in DOD contracts as a percent of state Gross Domestic Product. To increase West Virginia's market share in defense requires a dedicated focus on the part of the state and stakeholders.

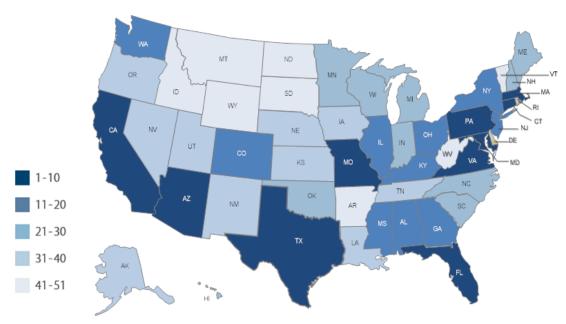


Figure 1: Ranking of Total Defense Spending by State, 2017

Source: USASpending.gov, Fiscal Year 2017

Many more West Virginia companies could capitalize on DOD contracts than currently do so. There are 4,700 companies (accounting for over 67,000 jobs) in industries that provide goods or services to the defense sector. However, with \$267 million in defense contracts in 2017 (see Figure 2), DOD contractors (plus their spin-off activities) support about 2,300 jobs and \$370 million in investment.

Employment in West Virginia's defense cluster fluctuated in the past decade, with job declines since 2013 that run counter to the national trend. However, defense awards to West Virginia reached its highest level in 2017 at \$267 million. DOD work in the state is largely focused on



Figure 2: Total Value of DOD Awards, West Virginia, FY 2013 - FY 2017

Source: USAspending.gov, all DOD sources. Millions of dollars

advanced manufacturing, building, and innovation-oriented industries. Leading DOD contracting work includes Ammunition Manufacturing, Construction, R&D, Computer Design, and Engineering Services.

While DOD contract activity is relatively modest, a broader look at the state's Defense & Homeland Security sectors reveals a much larger cluster with a significant impact on the state's economy. Total West Virginia business contracts with DOD, Department of Justice (DOJ), Department of Energy (DOE), Department of Homeland Security (DHS) and NASA topped \$1.1 billion in 2017. This represents two percent of total jobs in West Virginia. While it represents a

smaller share of the economy than larger industries like coal, this sector represents an important growth opportunity for the state due to expected increases in federal spending and continued shifts in consumer energy purchasing habits.

The Defense & National Security cluster is expected to grow. After years of budget constraints tied to sequestration,¹ Congress negotiated a two-year budget agreement in 2018 that would allow defense spending to rise by a total of \$165 billion in 2018 and 2019.² This would mark the highest levels of defense spending in a decade. Among the top priorities for the DOD connected to this added funding is to restore military readiness and build a more lethal force. This will require a more capable and resilient national defense industrial base. Some of the benefit from added military spending may "trickle down" to West Virginia businesses and workers. However, to fully realize the state's economic potential will require state leaders to leverage key assets and take advantage of opportunities.

Assets and Opportunities

West Virginia firms have attracted nearly \$1 billion in DOD contracts during the past five years, but much more opportunity exists, especially in key sectors in which the state's firms have been successful, including Ammunition Manufacturing, Construction, R&D, Computer Design, and Engineering Services. The first step in this process should be to encourage DOD contractors to diversify their customer base so as not to be dependent on DOD contracting.

At the same time, since West Virginia does so poorly in attracting defense contracts relative to the size of the state's economy, more companies should be able to take advantage of the DOD as a growth market. About 4,700 companies operate in the industries related to DOD requirements. They might serve as the target for efforts to leverage more DOD contract activity in the state. One way to think about this is to leverage West Virginia's strength in broader Homeland Security-related activities (which represent nearly 2.5 percent of the state's GDP) as well as the state's traditional strengths in coal and metallurgy – sectors that share product and service demands with DOD.

¹ Budget sequestration refers to the automatic spending cuts to United States federal government spending meant as an austerity fiscal policy stemming from the Budget Control Act of 2011.

² Seamus P. Daniels and Todd Harrison, "Making Sense of the Bipartisan Budget Act of 2018 and What It Means for Defense," Center for Strategic and International Studies. February 20, 2018. https://www.csis.org/analysis/making-sense-bipartisan-budget-act-2018-and-what-it-means-defense

The state should take a proactive role in helping the state's small defense contracting base find new customers and markets. In some cases, this will involve helping contractors find new commercial markets, but in other cases, this may mean helping defense firms find new contracting opportunities. The small West Virginia defense sector could readily be supplemented with the state's broader Defense and Homeland Security and coal & metallurgy firms. With expanded DOD contracting likely in 2018 and 2019, these companies could be key to the state's ability to leverage new contract opportunities and more markets by implementing initiatives focused on four strategies.

- 1. Leverage its defense related assets for procurement opportunities.
- 2. Pursue initiatives to capture more subcontracting activity to fill cluster gaps.
- 3. Identify market opportunities for defense-related businesses among contractors located in border states.
- 4. Leverage strengths in coal and metallurgical businesses to expand its opportunities for federal (especially DOD) contracting.

West Virginia Defense Industry Research Report

Background

The Center for Regional Economic Competitiveness (CREC), in partnership with the West Virginia Defense Industry Alliance (WVDIA), is supporting the state of West Virginia in the development of a high-quality, statewide supply chain map of defense-related industries, economic impact assessment, and recommendations to both strengthen and diversify businesses in this sector. Defense manufacturing engages an intricate supply chain that links prime contractors delivering programs, products, and services for the Department of Defense to hundreds of suppliers and subcontractors. In recent years, the volatility in defense contracting has made it difficult for company decision makers to plan. This is also true for regional and statewide policymakers. This study reveals West Virginia-specific and defense industry-specific competitive advantages and gaps that can guide policymakers in making public investments to promote defense industry cluster and firm growth.

Obtaining, organizing, and making sense of this information is a challenging task. While information about primary defense contractors and identified subcontractors is readily available, there is little known about other suppliers (representing the entire supply chain). Contractor reporting requirements are limited so small and medium-size businesses that may be part of the defense industry supply chain are not readily identifiable. Fully understanding these networks requires a multi-step approach, starting with an analysis of available public and proprietary data sources and then making direct contact with likely defense industry subcontractors. With these insights, we can identify the firms most likely to participate in a defense cluster initiative as well as the direct, indirect and induced impacts from defense procurement taking place in the state.

The Department of Defense's Office of Economic Adjustment (OEA) Defense Industry Adjustment (DIA) program provided funding for this project, which includes research on related businesses and an assessment of the state's defense-related economic activity. OEA is currently supporting West Virginia University and other DIA grantees with research to better understand a state or region's existing defense landscape and to map the local defense supply chain. OEA supports supply chain mapping efforts like this one in other ways, such as efforts to:

- Help identify suppliers and sectors at risk in the event of a company or plant closure
- Reveal potential new markets for existing firms
- Provide insights about local gaps in the supply chain where an Original Equipment
 Manufacturer (OEM) can substitute local companies for overseas suppliers
- Determine which existing assets can best respond to supply chain issues
- Understand the national defense industry supply chain infrastructure

The following report represents CREC's and its partners' work to understand the current defense landscape in West Virginia and to map the state's defense supply chain.

Study Design & Defense Cluster Defined

Supply chain mapping involves understanding the businesses, organizations, people, activities, information, and resources needed to move a product or service from supplier to customer. Mapping the defense sector is especially difficult. Defense manufacturing involves supply chains that link prime contractors to hundreds of suppliers and subcontractors, many of whom may not realize how their products are ultimately used.

To better understand the full extent of the nation's defense supply chain, CREC has identified a set of critical industries supplying the nation's Defense Industrial Base.³ These industries provide the military with material, raw materials, and other goods that are essential to national security. While not all businesses and workers in the identified Defense Cluster are directly engaged in DOD work, they operate in industries critical to the nation's overall defense industrial base and thus would potentially have opportunities to contribute to the DOD mission or be impacted by changes in defense spending.

Given that a healthy defense industrial base and resilient supply chains are essential to the economic strength and national security of the United States, it is vital to understand the array of businesses potentially supportive to national security efforts. As the July 2017 Trump Administration's Executive Order states, "The ability of the United States to maintain readiness,

³ Defense Cluster defined using North American Industry Classification System (NAICS) codes. See Appendix B for a more detailed discussion of the methodology used to identify industries in the Defense Cluster.

and to surge in response to an emergency, directly relates to the capacity, capabilities, and resiliency of our manufacturing and defense industrial base and supply chains."⁴

Furthermore, understanding the broader Defense Cluster landscape provides opportunities for businesses, whether currently working on DOD contracts or not, to explore new market diversification opportunities and to assess their current and potential competitive positioning in the nation's defense supply chain. Budding entrepreneurs and start-ups may also find in the Defense Cluster new avenues to sell innovative technologies and grow their businesses. Appendix A provides a complete listing of the industries comprising the Defense Cluster, and the recent performance of these industries in West Virginia. DOD is interested in market diversity within their supply chain because it ensures a stronger supply chain that can weather the ebb and flow of Defense procurement needs and it brings greater innovation into the supply chain to ensure the Department maintains the most technologically advanced warfighting capabilities.

Besides looking at the state's Defense Cluster, using both public and proprietary datasets, CREC with the expert assistance from partners in the state supplemented this data with additional quantitative and qualitative research to better identify companies in West Virginia who are presently, or have recently, worked on DOD contracts. The study approach included conducting a statewide survey to gather targeted information from defensedependent and defense-related companies related to their supply

WEST VIRGINIA Defense Supply Chain Research

- Defense Cluster Analysis
- High-Growth Business Analysis
- Defense Contracts Analysis
- **❖** Defense Contracts Economic Impact
- Defense Supply Chain Business Survey
- Defense Value Chain Analysis
- Analysis of Opportunity Areas
- ❖ Web Tool

⁴ www.whitehouse.gov/the-press-office/2017/07/21

chain relationships, operating environment, and market diversification opportunities and potential. A unique time-series dataset was also employed to track the growth patterns of all business establishments (i.e. individual business locations) located in West Virginia, those within a broadly defined West Virginia defense industry, and companies in targeted defense industry segments in target communities. This allowed us to track and measure changes over time in the number, size, location, and performance of business entities. Industry cluster analysis, along with targeted value chain analysis for select defense sector industries, allowed our research team to identify industries and firms that have extensive trading relationships with the state's defense dependent industries and to identify those that are experiencing growth (and thereby may offer opportunities for diversification).

These value chain patterns help promote industry clusters by focusing on those with the most significant buying and selling relationships. Helping core defense industries identify alternative growth markets makes it more likely that these industries will diversify successfully. The value chain analysis was further augmented by interviews with stakeholders and businesses to better understand the existing innovation ecosystem and business support assets in place. Additionally, an economic impact assessment was conducted, which summarizes the total economic impact, including direct, indirect and induced effects, of military contracts performed in West Virginia. Appendix B provides a more complete description of the research methodologies used in this study.⁵

West Virginia Defense Economy Overview

There are 4,700 companies employing more than 67,000 workers in the state's defense industry landscape. Employment in West Virginia's Defense Cluster fluctuated in the past decade, with job declines since 2013 that run counter to the national trend. Since 2007, employment in West Virginia declined by 5 percent, but the job loss in the Defense Cluster was

⁵ A web tool highlighting the West Virginia defense supply chain is available on the West Virginia Defense Industry Alliance webpage: www.WVDIA.org

⁶ However, many are not actively involved in the defense supply chain. CREC identified 270 industries that are important to maintaining the nation's defense industrial base – Defense Cluster. Businesses in these industries have the potential to be part of the defense supply chain. Actual DOD contract awards were also analyzed to identify which West Virginia businesses are currently a part of the defense supply chain.

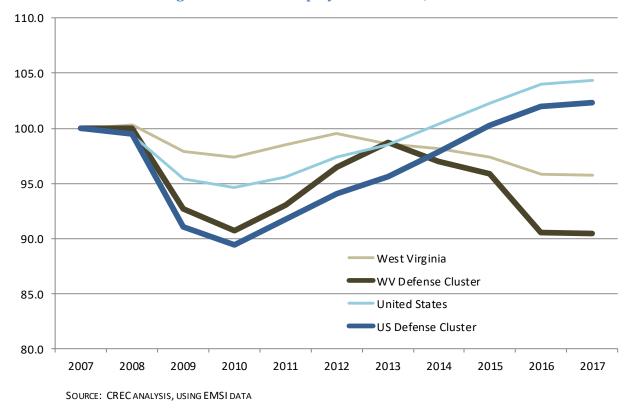


Figure 3: Index of Employment Growth, 2007-2017

even greater at 10 percent. The decline in the state's Defense Cluster was particularly sharp since 2013 as illustrated in the Figure 3. This corresponds closely to when the United States federal government-imposed budget sequestration – the automatic spending cuts and budget control measures activated in 2013 that continued through fiscal year 2017. By comparison, U.S. employment grew during that same time by roughly 5 percent – the opposite direction from West Virginia. Likewise, U.S. Defense Cluster employment growth began to grow after the Great Recession of 2008-2009, and employment in 2017 is nearly 3 percent higher than a decade earlier despite job losses during the recession.

The cluster map of defense industries in Figure 4 provides important information about the dynamics of the West Virginia defense economy and the importance of diversification. Large bubbles (reflecting large concentrations of total employment in the cluster) on the chart represent industry clusters like Pharmaceuticals, Plastics, Oil & Gas Pipeline Construction, and Manufacturing (i.e. guided missile, aluminum). Changes in employment in these clusters significantly influence the employment prospects for West Virginians. Recognizing

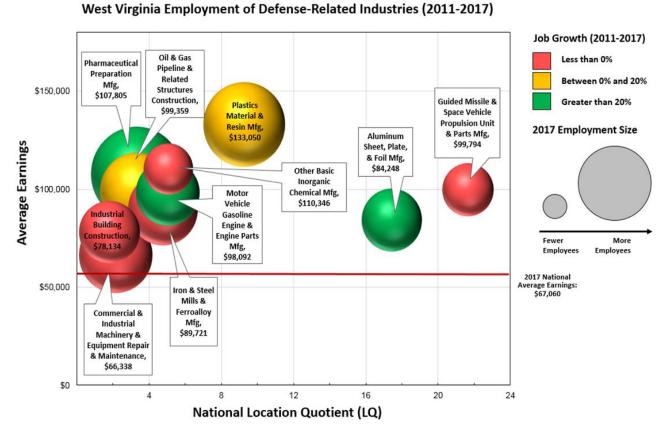


Figure 4: West Virginia Defense Cluster Industries with High Specializations

Source: EMSI

opportunities to grow market share and to diversify the customer base from products or services offered for defense purposes to meet commercial needs is an effective strategy to maintain strong economic performance. Likewise, commercial applications drive many of these sectors, but they offer opportunities to provide innovative new products or services in response to defense needs.

Understanding where current DOD work is coming to the Mountaineer State provides even more specific intelligence on vital industries and business tied to the Defense economy. Businesses in West Virginia received over \$1 billion in Department of Defense contract awards between 2013 and 2017. The leading awards were for Ammunition Manufacturing, Construction, R&D, Computer, and Engineering Services. Figure 5 shows the Top 20 defense

contracting industries in the state in the past five years. More than \$3 of every \$4 of DOD contract dollars (77 percent) flow to these 20 industries in West Virginia.

Figure 5: Defense Contracts by Industry in West Virginia, 2013-2017

NAICS	Industry	D	OD Contracts
332993	Ammunition (Except Small Arms) Manufacturing	\$	222,597,098
237990	Heavy and Civil Engineering Construction	\$	105,090,191
236220	Commercial and Institutional Building Construction	\$	101,141,412
541712	Research and Development in the Physical, Engineering, and Life Sciences	\$	63,949,007
541330	Engineering Services	\$	52,454,275
541512	Computer Systems Design Services	\$	27,456,512
332994	Small Arms, Ordnance, and Ordnance Accessories Manufacturing	\$	25,611,234
562910	Remediation Services	\$	24,514,393
332510	Hardware Manufacturing	\$	23,249,037
541611	Administrative Management and General Management Consulting Services	\$	23,096,299
561210	Facilities Support Services	\$	18,739,972
541519	Computer Related Services	\$	17,552,611
336419	Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	\$	16,611,910
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	\$	16,466,555
334419	Electronic Component Manufacturing	\$	15,939,157
325920	Explosives Manufacturing	\$	15,284,930
324110	Petroleum Refineries	\$	13,511,079
611699	Miscellaneous Schools and Instruction	\$	10,607,871
332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing	\$	7,549,530
335314	Relay and Industrial Control Manufacturing	\$	7,432,405
	Top 20 Total	\$	808,855,477
	Top 20 as % of Total West Virginia DOD Contracts		77% 1,047,700,182
	West Virginia DOD Contracts Total		

SOURCE: USASPENDING.GOV, BASED ON DOD CONTRACTS "PLACE OF PERFORMANCE"

Besides the Department of Defense, other federal agencies also contribute to the nation's defense and national security. The combined work of the Departments of Defense, Energy, Justice, Homeland Security, and the National Aeronautics and Space Administration activities represent a broader Defense & National Security Cluster. In West Virginia, there were 856 total companies and 556 with \$10,000 or more in federal contracting from DOD, DOE, DOJ, DHS and NASA in last 5 fiscal years.

Roughly 300 businesses in the state had contract work specifically tied to DOD. This includes the state's top federal contract awardee in recent years, Alliant Techsystems, which operates out of Rocket Center, WV. Heeter Construction and Allied Defense Industries are also in the Top 10 (see Figure 6). West Virginia businesses serving the Department of Energy made up an additional three, DOJ two, DHS one, and one tied to NASA rounded out the Top 10.

Figure 6: Leading Federal Contracting Businesses in West Virginia, 2013-2017

Company	Agency	Primary Product Provided	City	F	/ 2013-2017
ALLIANT TECHSYSTEMS OPERATIONS LLC	DOD	Ammunition Manufacturing	ROCKET CENTER	\$	276,672,806
KEYLOGIC SYSTEMS, INC.	DOE	Engineering Services	MORGANTOWN	\$	110,508,091
ALLEGHENY SCIENCE & TECHNOLOGY CORPORATION	HMS	General Management Consulting Services	WESTON	\$	94,264,214
MONONGAHELA POWER COMPANY	DOJ	Fossil Fuel Electric Power Generation	FAIRMONT	\$	46,556,156
HEETER CONSTRUCTION, INC.	DOD	Heavy and Civil Engineering Construction	SPENCER	\$	44,630,112
ALLIED DEFENSE INDUSTRIES INC.	DOD	Instruments for Industrial Processes	KEARNEYSVILLE	\$	43,254,310
WEST VIRGINIA UNIVERSITY RESEARCH CORPORATION	DOE	Facilities Support Services	MORGANTOWN	\$	40,915,629
GOLDBELT EAGLE, L.L.C.	DOE	Facilities Support Services	MORGANTOWN	\$	36,031,486
VIRGINIA WEST UNIVERSITY HOSPITALS INC	DOJ	General Medical and Surgical Hospitals	MORGANTOWN	\$	33,989,862
TMC TECHNOLOGIES OF WEST VIRGINIA CORP.	NASA	IT and Telecommunications Services	FAIRMONT	\$	24,636,142

SOURCE: USASPENDING.GOV, BASED ON THE CONTRACTORS' IDENTIFIED "PLACE OF PERFORMANCE"

West Virginia Defense Contracts Analysis

Department of Defense spending in West Virginia reached its highest level in 2017 at \$267 million. This includes more than \$250 million in defense contract awards for the fiscal year. The map in Figure 7 shows the distribution of these awards by the actual place of work performance for the five West Virginia Department of Commerce-specified geographic regions.

Within West Virginia, the Eastern Panhandle/Potomac Highlands area (Region 2) is the primary destination for nearly 62 percent of the total dollar value of defense work. Region 2 includes the work performed at Rocket Center by Alliant Techsystems. This is followed by the Northern Panhandle/Morgantown area (Region 1) at more than 20 percent. Together, Regions 1 and 2 capture more than 80 percent of DOD contracting activity. Region 5 (Charleston-Huntington area) received the next highest percentage (13.5 percent). A significantly smaller amount of defense contract work went to companies in West Virginia Commerce Regions 3 and 4.

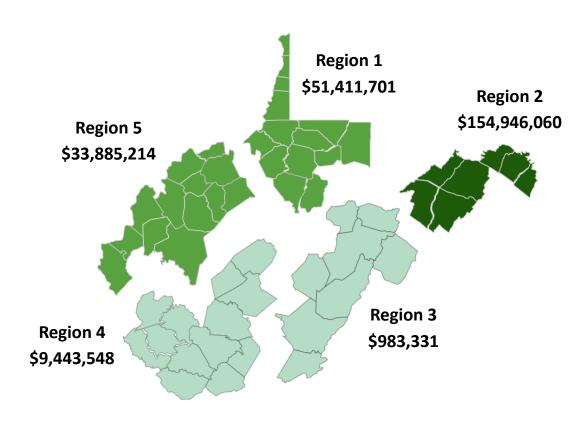


Figure 7: DOD Contract Performance by West Virginia Commerce Region, FY 2017

SOURCE: USASPENDING.GOV, BASED ON DOD CONTRACTS "PLACE OF PERFORMANCE"

DOD contracts awarded to West Virginia businesses are concentrated in a handful of industries and contractors. In fact, companies in just ten industries received nearly 80 percent of West Virginia's defense contract dollars in 2017. Topping the list includes Ammunition manufacturing, Communications Equipment manufacturing, and Engineering Services. Figure 8 lists the Top Ten defense industry sectors in West Virginia by total contracted dollar amounts. As the list shows, DOD contract work in the state is largely focused on advanced manufacturing, building, and innovation-oriented industries. These are critical industry sectors to maintain and grow, as they provide high economic multiplier effects and many skilled and well-paid job opportunities.

Figure 8: Top Ten Defense Industry Sectors in West Virginia (by \$ amount), FY 2017

Rank	Industry	Obl	igated Dollar Amount	% of Total Value
1	Ammunition (except Small Arms) Manufacturing	\$	58,478,535	22.8%
2	Communications Equipment Manufacturing	\$	38,931,122	15.2%
3	Engineering Services	\$	37,416,181	14.6%
4	Guided Missile and Space Vehicle Parts & Equipment Manufacturing	\$	18,574,491	7.2%
5	Heavy and Civil Engineering Construction	\$	14,964,669	5.8%
6	Research and Development in Physical, Engineering, and Life Sciences	\$	11,559,369	4.5%
7	Guided Missile and Space Vehicle Propulsion Unit Manufacturing	\$	7,614,133	3.0%
8	Hardware Manufacturing	\$	5,834,756	2.3%
9	Relay and Industrial Control Manufacturing	\$	4,471,633	1.7%
10	Administrative Management and General Management Consulting	\$	3,935,627	1.5%
	Top Ten Industries Total	\$	201,780,517	78.7%
	All Other	\$	54,468,673	21.3%
	Total	\$	256,249,190	100.0%

Figure 9 reveals that manufacturing production activities account for more than \$6 of every \$10 dollars of DOD contract awards to West Virginia companies. This sector has struggled in the state and declines in the defense sector have contributed to the economic challenges. The state has nearly 48,000 manufacturing jobs as of 2017, a decline of more than 20 percent since 2007. The state's manufacturing businesses must diversify into new markets, given these trends. At the same time, professional, scientific, and technical services make up nearly one-quarter of defense awards. More than 28,000 West Virginia jobs fall into this sector, and related employment has remained steady over the past decade. However, West Virginia has many fewer high-paying service jobs than might be expected. The West Virginia economy's share of these technology-driven jobs is nearly half that of the U.S., reflecting the need for policymakers to continue to build this sector across the state.

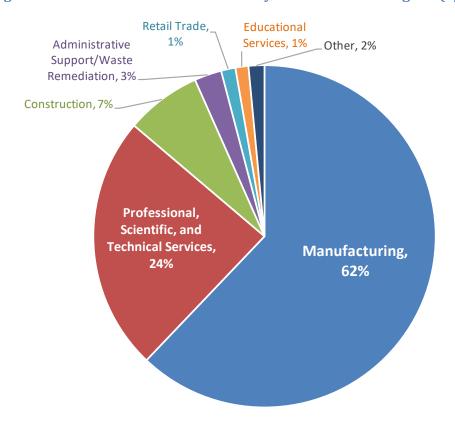


Figure 9: Distribution of Defense Industry Sectors in West Virginia (by %), FY 2017

In 2017, West Virginia defense companies primarily provide DOD with Alarm Systems, Bombs, and Vehicle Repair. Figure 10 shows the Top Ten defense products and services provided by West Virginia companies. These ten specific defense products and services account for nearly \$3 of every \$4 dollars of DOD contract awards to West Virginia companies. Knowing the types of products and services that DOD looks for from the state's businesses reveals valuable insights about the industry specializations. These ten are important contributors to the nation's defense industrial base and can form the basis for targeted strategies of support. For instance, how can policy makers capitalize on the state's specialization in missiles and rockets to develop new West Virginia supplier opportunities and capture a larger market share in the national and international defense and commercial marketplaces.

Figure 10: Top Ten Defense Products or Services Provided by West Virginia Companies, FY 2017

Rank	Defense Product / Service	Obl	igated Dollar Amount	% of Total Value
1	ALARM, SIGNAL, AND SECURITY DETECTION SYSTEMS	\$	38,945,776	15.2%
2	BOMBS	\$	37,993,869	14.8%
3	MAINT/REPAIR/REBUILD - VEHICULAR EQUIPMENT COMPONENTS	\$	33,958,220	13.3%
4	FUZES AND PRIMERS	\$	21,086,816	8.2%
5	GUIDED MISSILE AND SPACE VEHICLE EXPLOSIVE PROPULSION UNITS	\$	18,573,221	7.2%
6	CONSTRUCTION OF DREDGING FACILITIES	\$	11,369,101	4.4%
7	ROCKETS, ROCKET AMMUNITION AND ROCKET COMPONENTS	\$	7,613,375	3.0%
8	DEFENSE SYSTEM: MISSILE/SPACE SYSTEMS (ADVANCED DEVELOPMENT)	\$	7,058,487	2.8%
9	MARINE HARDWARE AND HULL ITEMS	\$	5,301,183	2.1%
10	PROFESSIONAL: ENGINEERING/TECHNICAL SUPPORT	\$	4,700,411	1.8%
	Top Ten Products/Services Total	\$	186,600,459	72.8%
	All Other	\$	69,648,731	27.2%
	Total	\$	256,249,190	100.0%

To help with economic development strategy and to better focus when reaching out to key DOD service branch contacts, Figure 11 looks at DOD contract awards in West Virginia by the awarding service branch. Two-thirds of total contract awards to West Virginia companies are made by the Army. Fifteen percent of defense awards are from the Air Force. The Defense Logistics Agency provides 10 percent of the total contract dollars. The Navy provides 5 percent of contract awards in West Virginia.

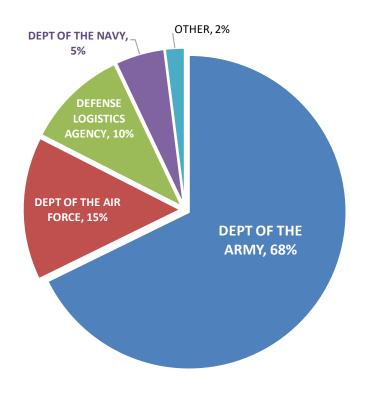


Figure 11: DOD Contract Awards in West Virginia, by Service Branch, FY 2017

Ten companies received the majority of defense contract dollars awarded to West Virginia in 2017. DOD awarded more than \$200 million in new contract awards in 2017 to just four companies: Alliant Techsystems, STS International, Allied Defense Industries, and Amherst Madison. As shown in Figure 12, the Top Ten companies accounted for nearly \$9 of every \$10 dollars of DOD contract awards to West Virginia companies.

In addition to these state-based prime DOD contractors, there is also contract work flowing into West Virginia from other states. West Virginia is a subcontracting location for many DOD awards to companies in other states. Maryland, Minnesota, Virginia, Florida, and Alaska are primary out-of-state sources for defense contracts performed in West Virginia.

Figure 12: Top West Virginia Defense Contractors, by Contract Value, FY 2017

Rank	Vendor Name	Obl	igated Dollar Amount	% of Total Value
1	ALLIANT TECHSYSTEMS OPERATIONS LLC	\$	95,905,032	37.4%
2	STS INTERNATIONAL, INCORPORATED	\$	73,296,243	28.6%
3	ALLIED DEFENSE INDUSTRIES INC.	\$	16,115,490	6.3%
4	AMHERST MADISON, INC	\$	15,800,670	6.2%
5	BE AEROSPACE, INC.	\$	5,541,920	2.2%
6	FCX SYSTEMS, INC.	\$	4,869,130	1.9%
7	NEXTGEN FEDERAL SYSTEMS, LLC	\$	4,455,608	1.7%
8	HMS TECHNOLOGIES, INC.	\$	4,376,364	1.7%
9	NORTH AMERICAN CONSULTING SERVICES, INC.	\$	3,641,825	1.4%
10	A-ZONE ENVIRONMENTAL SERVICES, LLC	\$	3,229,231	1.3%
	Top Ten Vendors Total	\$	227,231,514	88.7%
	All Other	\$	29,017,676	11.3%
	Total	\$	256,249,190	100.0%

West Virginia Defense Contracts Economic Impact

DOD contracts are important to West Virginia because they bring Federal dollars back to the state and can have an enormous impact through the recycling of those funds in the local community. To determine just how much of an impact, it is possible to estimate the total contribution of different types of economic activities to a state or regional economy. Economic impacts result when an infusion of spending in one sector of the economy spurs additional economic activity in other sectors as the money is re-spent, generating a "multiplier" effect. Multipliers quantify direct industry impacts that result from the DOD contract itself, and then combines that with the spin-off activities that result from inter-industry linkages. The DOD contract is used to hire local workers, employ local subcontractors, and pay for other direct costs that the business may incur. These dollars are then recycled elsewhere in the community, and each successive "round of spending" reverberates within the regional economy in the form

of indirect expenses (i.e., contracts to local suppliers to support business activities) or induced expenses (i.e., local consumption by workers on rent, groceries, and other household goods). But, not all the direct impact of the contract award dollars is spent locally, and this external spending is said to "leak" from the local economy in the form of goods or services bought from elsewhere, taxes paid, or dollars parked in savings for later spending. The total economic contribution of this added spending is estimated by tracing the flow of money between industries and households until the initial investment eventually leaves the regional economy.

Total DOD direct contract spending in the state in fiscal year 2017 topped \$250 million. Figure 13 summarizes the total economic impact, including direct, indirect and induced effects, of military contracts performed in West Virginia. Based on the FY 2017 level, DOD contract spending in West Virginia supports more than 2,300 jobs and \$370 million in overall economic impact. To put this in context, this represents about 0.5 percent of the state's \$77 billion economy. In addition, state businesses providing DOD goods and services, with the ripple effect, generate more than \$11 million in state and local tax impact.

Figure 13: Economic impact of DOD contract spending in West Virginia, 2017

Output	Employment State and Local Tax Impact		Total Labor Income	
\$ 371,080,038	2,335	\$ 11,168,429	\$ 111,379,584	

SOURCES: USASPENDING.GOV, IMPLAN, CENTER FOR REGIONAL ECONOMIC COMPETITIVENESS

⁷ See Appendix B for definitions of these types of impacts and a description of the economic impact methodology.

Given the significance of DOD contracts to the West Virginia economy, looking for opportunities to either increase the amount of contract awards, or to help existing defense supply chain businesses diversify into new markets can be an effective strategy for both economic growth and economic resiliency in West Virginia. For instance, an increase of just \$50 million in DOD contract awards to West Virginia businesses would result in adding 470 new jobs, \$75 million more in economic output, and \$2.2 million in tax revenue.

Figure 14: Economic impact of Defense & National Security Cluster contract spending in West Virginia, 2017

Output	Employment	State and Local Tax Impact	Total Labor Income	
\$1,783,703,504 12,681		\$62,194,485	\$678,713,834	

SOURCES: USASPENDING.GOV, IMPLAN, CENTER FOR REGIONAL ECONOMIC COMPETITIVENESS. INCLUDES ECONOMIC IMPACT OF DOD, DOJ, DOE, DHS and NASA CONTRACT SPENDING IN WEST VIRGINIA, FY17.

Likewise, focusing efforts on engaging businesses and developing effective support and diversification services for the broader Defense & National Security Cluster would prove fruitful for policymakers. In FY 2017, total direct government contract spending in the state by DOD, DOJ, DOE, DHS and NASA topped \$1.1 billion. Figure 14 summarizes the total economic impact, including direct, indirect and induced effects, of the broader array of defense & national security cluster contracts performed in West Virginia. Based on the FY 2017 level, Defense & National Security Cluster contract spending in West Virginia supports almost 12,700 jobs and \$1.8 billion in overall economic impact, representing 2.3 percent of the state's Gross Domestic Product (GDP). Moreover, state businesses providing goods and services to this cluster, with the ripple effect, generate more than \$62 million in state and local tax impact. The state's Defense & National Security Cluster also accounts for 2 percent of total West Virginia jobs.⁸

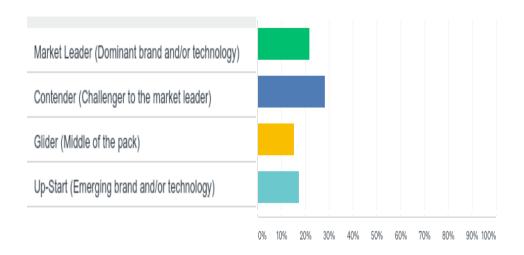
⁸ Accounting for more than 12,000 jobs, the D&NS cluster is about the same in number as the current level for coal mining jobs in the state.

Perspectives from West Virginia Defense Contractors

In 2017, West Virginia University, TechConnect West Virginia and the West Virginia Development Office in partnership with the Center for Regional Economic Competitiveness gathered input from over 60 defense-contributing members of West Virginia's economy. The goal in obtaining this input from West Virginia businesses engaged or interested in becoming part of the defense industrial base is to identify ways to improve the business climate and strengthen the state's defense industry. Of these 60 companies, 90 percent are currently working on or have done DOD work in the past. Additionally, almost one-quarter were womenowned, veteran-owned, or a small disadvantaged owned business according to the Small Business Administration's definition.

As Figure 15 shows, nearly 30 percent of the business executives described their company's competitive position as being a market Contender, challenging a bigger market leader in their industry. One-fifth of firms identified themselves as a Market Leader, being the dominant brand or technology. Over 15 percent are Up-Start companies which are emerging in their fields. The remainder of the respondents are in the middle of the pack or responded as none of the above. In general, the best positions, in terms of growth and survivability, is to be an Up-Start in a Rapid Growth industry, or a Market Leader in either a Rapid Growth or Mature market.

Figure 15: Which definition below best describes your company's competitive position in your industry or market sector:



SOURCE: WEST VIRGINIA DEFENSE BUSINESS SURVEY 2017, CREC ANALYSIS

Fast and sustained growth businesses dominate in all these critical market positions. Fast and sustained growth businesses are the primary generator of new employment and wage growth across states and regions.⁹ Yet, they are few and far between. At the national level, only about 1 percent of surviving businesses add net new employment twice or more over a five-year period; the rest stagnate or decline. This 1 percent is responsible for about three-fourths of all net new jobs created during that time. In West Virginia, this top 1 percent created 22 percent of all net jobs.

Across West Virginia, "Sustained Business Growers" grew on average from 7 to 23 employees, while all other businesses stayed flat over the five years. Sustained Growers' sales grew by

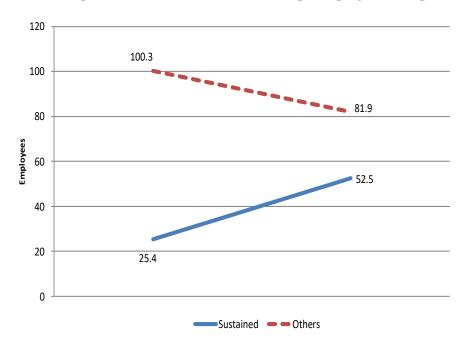


Figure 16: West Virginia Defense Contractors Average Employee Change, 2012-2017

SOURCE: WEST VIRGINIA DEFENSE BUSINESS SURVEY 2017, CREC HITS ANALYSIS

⁹ CREC's High Impact Targeting System (HITS) process employs a newly developed database using current and recent historical information on individual company performance that can be used to glimpse the future. **Sustained Growth** measures the frequency of growth, or the net number of years a business adds net new jobs. Sustained Growers expanded employment at least twice over the previous five years. **Fast Growth (Cheetah)** firms at least doubled employment over the previous five years.

343% while others grew by 16%, a magnitude difference of 22-times. As Figure 16 depicts, Sustained Growers in defense industries doubled in size while Others lost about one-fifth of their size. Defense Fast Growth Firms accounted for 6 percent of all West Virginia "cheetah" companies and added nearly 2,500 new jobs.

Besides being a critical source for new jobs, there is evidence that Sustained Growth Firms are significantly more embedded in their supply/value chains than other businesses (Others). An average of 50 percent of

Sustained Growth
Defense Firms
doubled in size while
all other businesses
in defense lost about
1/5 of their size.

Sustained Growth Firms outsource work to contractors, compared to 35 percent for Others.

Figure 17 shows that most defense businesses in the state expect to stay with the same with subcontractor utilization over the next year, with 15 percent expecting to increase their outsourcing. However, 25 percent of Sustained Growth Firms expect their outsourcing to increase over the next 12 months.

Le Increasing
Le Staying the same
Le Decreasing
O% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Figure 17: Company's Anticipated Subcontractor Utilization in the NEXT 12 Months for Defense-Related Products

SOURCE: WEST VIRGINIA DEFENSE BUSINESS SURVEY 2017, CREC ANALYSIS

Sustained Growth Firms are also physically located closer to their value chain partners. Sustained Growth Firms reported that 14 percent of outsourcing work goes to contractors in West Virginia, compared to 6 percent for Others. In addition, an average of 30 percent of Others' inputs are from suppliers located outside the U.S., whereas none of the Sustained Growth Defense Firms' inputs come from abroad.

West Virginia defense-related firms focused extensively on issues associated with acquiring new customers (diversification). For Sustained Growth Defense Firms, they primarily face barriers related to growth. Maintaining and developing new high-margin products and services are their biggest challenges. As a firm grows – adding new people, equipment, and facilities – margins are often diluted. Growth also increases cash flow problems as goods-in-process expand and the distance between accounts payable and receivable spreads. Past studies of

Retain High Value Customers*

Enter New Export Markets

Manage Brand

Customer Preference Change

Obtain Growth Capital

Unexpected Demand Change*

Acquire New Customers

Navigate Legal & Reg Rules*

Develop New High Margins

Maintain High Margins***

2 2.5 3 3.5 4

* = Significant at 0.1 level; *** = Significant at 0.01 level

Figure 18: Comparing Barriers to Growth Encountered by Sustained Growth Firms and Other Defense Firms

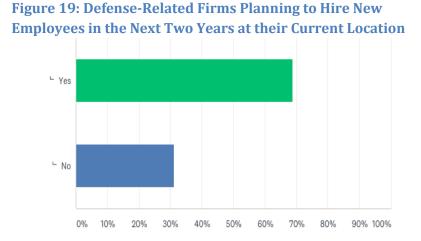
SOURCE: WEST VIRGINIA DEFENSE BUSINESS SURVEY 2017, CREC HITS ANALYSIS

sustained growth firms note that they tend to finance their expansions through retained earnings rather than debt, meaning that margin pressures and cash flow crunches can restrict their ability to continue growth. Thus, it is logical that these firms would be constantly focused on increasing their margins as a primary source of growth capital.

As Figure 18 shows, the most severe barrier faced by Other Defense Firms (Others) is unexpected demand change. These firms also have significantly more problems than Sustained Growth Firms in retaining high value customers and in not being able to acquire new customers. This indicates that Others are frequently caught off-guard on issues such as buying habits, sales timing and amount, marketing, and customer loyalty. This would explain why unexpected demand changes, retaining high value customers, and acquiring new customers are such headaches for them. These are signs that these businesses may not be effective planners.

Despite these challenges, a wide majority of West Virginia defense businesses are optimistic

about their future market competitiveness and profitability. This translates into potential new job opportunities for West Virginians, with nearly 70 percent of West Virginia defense contractors indicating that they plan to hire new full-time employees in the next two years (see Figure 19).



SOURCE: WEST VIRGINIA DEFENSE BUSINESS SURVEY 2017, CREC ANALYSIS

These companies have unique needs for workers. As they seek to hire new employees, the focus is on recruiting high skill workers in occupations that require advanced technical expertise. Among defense-related businesses, Industrial and Aerospace Engineers are the two top "In-Demand" occupations. As part of its research, CREC analyzed job postings data for the period April 2016 through March 2017 for West Virginia's major defense contractors. The results of this analysis are listed in Figure 20.

Having access to a highly skilled workforce is a key to any company's success. Many of the indemand job postings are for Engineers and Engineering Technicians, Information Technology (IT)-related, Analysts, and Mechanics or Repair workers. Production Supervisors, Accountants, Technical Writers, and Chemists also made the Top 20 list. The state can help support the growth and diversification of these defense businesses by ensuring a skilled workforce to support company needs. This requires effective coordination among the numerous economic and workforce development policies and programs within the state.

Figure 20: West Virginia Top 20 In-Demand Occupations among Leading Defense Contractors

Rank	Occupation (SOC)	Unique Postings
1	Industrial Engineers	65
2	Aerospace Engineers	61
3	First-Line Supervisors of Production and Operating Workers	57
4	Management Analysts	33
5	Software Developers, Applications	33
6	Computer Systems Analysts	32
7	Industrial Engineering Technicians	32
8	Electrical Engineers	31
9	Light Truck or Delivery Services Drivers	31
10	Bus and Truck Mechanics and Diesel Engine Specialists	30
11	Accountants and Auditors	29
12	Software Developers, Systems Software	29
13	First-Line Supervisors of Transportation & Material-Moving Machine & Vehicle Operators	29
14	Mechanical Engineers	27
15	Computer User Support Specialists	24
16	Technical Writers	23
17	First-Line Supervisors of Mechanics, Installers, and Repairers	22
18	Electrical and Electronics Engineering Technicians	20
19	Chemists	20
20	Maintenance and Repair Workers, General	19

SOURCE: CREC ANALYSIS OF EMSI AND CAREERBUILDER DATA, APRIL 2016-MARCH 2017

Analyzing West Virginia's Defense-related Supply Chains

CREC used our signature value chain analysis methodology to further examine these strategic opportunities and identify the industries on which West Virginia is best poised to capitalize. CREC employed a two-tiered approach to identify and illustrate supply-side industries that are most closely tied to the state's established defense sector and the strong defense related economy in the multi-state region surrounding West Virginia. The CREC team also cross-walked the defense related value chains with the coal industry value chain to identify potential synergies and opportunities for business expansion and diversification. In addition to its geographic proximity to defense related economic powerhouses like Virginia, Maryland and Pennsylvania, the state's legacy of coal and metallurgical industries provides a unique opportunity for West Virginia to position itself as an important economic partner for the United States defense industrial base.

Key supply chain opportunities within West Virginia relate to its defense-related strengths in three industries: guided missile propulsion and ammunition manufacturing; military armored vehicle, tank, and tank component manufacturing, and the state's coal and metallurgical industries. In the following section, the CREC team provides a synopsis of each cluster and its core industry linkages as well as identifying key players in the cluster.

Guided Missile Propulsion and Ammunition Manufacturing

The guided missile propulsion and ammunition manufacturing industries are vital components of West Virginia's defense sector. West Virginia businesses in guided missile propulsion and ammunition manufacturing generated more than \$250 million for the state in DOD contracts between Fiscal Year 2013 and Fiscal Year 2017, representing about one-quarter of the state's DOD contract dollars during that period. The strength of this core industry represents a strategic asset for the state. Guided missile propulsion unit manufacturing is West Virginia's most specialized defense manufacturing industry, relative to the rest of the nation, with an employment base of over 1,000 jobs, 22 times higher than what might be expected in an economy of the state's size. Among the state's most prominent employers, Orbital ATK has key establishments in West Virginia that serve the United States defense industrial base in the guided missile propulsion and ammunition manufacturing industries. The strength of West Virginia's linked industries can enhance supply chain efficiencies for firms like Orbital ATK and bolster the state's economy.

Paperboard container manufacturing ↑ All other chemical product and preparation Guided Missile Propulsion and Ammunition Manufacturing manufacturing Nonferrous metal (except copper and alum rolling, drawing, extruding and alloying Nonferrous metal foundries All other forging, stamping, and sintering, and crown and closure manufacturing Machine shops Turned product and screw, nut, and bolt Ammunition manufacturing manufacturing Coating, engraving, heat treating Turbine and turbine and allied activities generator set units mfg Power, distribution, and specialty Computer terminals and other **Guided Missile** transformer manufacturing computer peripheral equipment mfg Sand, gravel, clay, and ceramic and refractory Aircraft mfg minerals mining and quarrying Paint and coating manufacturing Guided missile and space vehicle mfg Manufacturing Propulsion units and parts for space Ferrous metal foundries vehicles and guided missiles Ammunition manufacturing Guided missile and space vehicle manufacturing Market Opportunities -Propulsion units and parts for space vehicles an guided missiles → Supplier Opportunities Software publishers

Figure 21: Guided Missile Propulsion and Ammunition Manufacturing Value Chain Map

Supplier opportunities

As illustrated in Figure 21, West Virginia is highly specialized in four key industries on the guided missile propulsion and ammunition manufacturing value chain. The state's high concentration of workers in nonferrous metal industries; machine shops; coating, engraving, heat treating; and propulsion unit manufacturing allows the potential for guided missile and ammunition manufacturers to increase efficiencies and decrease costs by localizing their supply chains. Most of the industries supplying the sector are seeing employment declines, with the exceptions of paperboard container manufacturing, paint and coating manufacturing, and software publishing (note the green arrows, which indicate the direction of employment growth).

The state also has a particularly high share of employment in machine shops; coating, engraving, heat treating and allied activities, as well as missile propulsion units (note the green color of the text boxes). Suppliers in these industries, primarily metallurgical, have an opportunity to diversify and remain important drivers of West Virginia's economy, while supporting the nation's defense industrial base. A key challenge facing the industry is that most potential West Virginia-based purchasers of products from this industry (ammunition and propulsion unit manufacturing firms) are shedding jobs. So, companies in the sector must diversify to markets in other states or to new industries not already identified.

Military Armored Vehicle, Tank, and Tank Component Manufacturing

The State of West Virginia is located within a key multi-state region that has a sizable Defense-related industry sector. Each of West Virginia's five border states were in the Top 20 in total DOD spending during Fiscal Year 2017 (Kentucky, Ohio, Maryland, Pennsylvania, and Virginia). The CREC team analyzed the top defense manufacturing industries in Ohio, Pennsylvania, and Virginia in terms of defense spending, to highlight key supplier opportunities for West Virginia based firms. Military armored vehicle, tank, and tank component manufacturing appeared in the Top 10 in DOD spending for all three of the states, with over \$1 billion in combined contract awards related to this industry in the past five fiscal years. Figure 22 illustrates the Military Armored Vehicle, Tank, and Tank Component Manufacturing Value Chain Map populated with data specific to West Virginia.

Supplier opportunities

West Virginia is well equipped to serve the military armored vehicle, tank, and tank component manufacturing industry. This industry relies on many of the same supply side sectors as guided missile propulsion and ammunition manufacturing. West Virginia has a particularly high concentration of jobs in important industries connected to the value chain, such as plastics product manufacturing; metal rolling, drawing, extruding, alloy; and machine shops. With more than 30 military armored vehicle, tank, and tank part manufacturing firms in nearby states,

10	USASpendir	ng.gov

11 ibid

Plastics product MFG. ተ Metal rolling, drawing, ₩ Military Armored Vehicle, Tank, and Tank Component extruding, alloy Manufacturing Ornamental and Architectural metal MFG. Machine shops Turned product and screw Motor vehicle parts manufacturing Coating, engraving, and heat treating Power, distribution, and Scientific research and transformer MFG development services Scientific research and development services Market Opportunities -Supplier Opportunities Management of companies Bolded Industries > 1000 jobs and enterprises

Figure 22: Military Armored Vehicle, Tank, and Tank Component Manufacturing Value Chain Map

there is potential for West Virginia suppliers in highly specialized fields to provide valuable support to strengthen the regional defense industrial base. The one highly concentrated and growing industry is plastics product manufacturing, and efforts to expand the sector may also have positive impacts on key industries such as metal rolling, drawing, extruding, and alloy manufacturing as well as machine shops. The most promising potential market for many of the components for this cluster is the motor vehicle parts manufacturing industry (note the green arrow indicating employment growth).

¹² Reference USA

Connecting to West Virginia's Coal and Metallurgical Industries

The coal mining and natural gas extraction sectors represent 15 percent of the state's GDP (down from 17 percent in 2011). Declines in this sector have been particularly severe and have impacted many aspects of the state's economy, including defense-related firms that were hit by cuts in both the coal and defense sectors. Many defense-related cluster components are industries that are also important to the coal sector. For instance, losses from downsizing of coal have impacted scientific research and development services; coating, engraving, heat treating, and allied activities; forging, stamping, sintering, and crown and closure manufacturing; and turned product and screw, nut, and bolt manufacturing.

While in recent years, West Virginia has seen a decline in jobs available in these supplier industries, it is important to note that West Virginia's highly specialized and established workforce can provide support in key aspects of the supply chain for defense related firms in the state and region.

Increasing the number of defense suppliers in these key specialized industries will help to bolster economic opportunity in West Virginia and enhance efficiency for firms in the region that operate complex and widespread supply chains.

Firms in the key supply-side linked industries that already receive government contracts

Several key supplier opportunities to DOD align with the coal industry value chain

- Scientific research and development services (97 WV establishments)
- Coating, engraving, heat treating, and allied activities (29 WV establishments)
- Forging, stamping, sintering, and crown & closure mfg. (6 WV establishments)
- Turned product & screw, nut, and bolt mfg. (6 WV establishments)

have a distinct opportunity to diversify their operations and expand capacity. West Virginia firms in coal and metallurgical industries that do not currently serve federal agencies can also expand their operations to strengthen the region's defense industrial base, by coordinating with the DOD Office of Small Business Programs.¹³

¹³ http://business.defense.gov/Acquisition/Subcontracting/Subcontracting-For-Small-Business/

Report Findings & Recommendations

West Virginia has a specialized defense sector that could be much larger than it currently is. While the state has the 40th largest state economy, it ranks 48th in DOD contracts as percent of GDP. Consequently, the state has only a few large defense firms, and they are relatively isolated geographically from their counterparts elsewhere. To build a more robust defense and national security industry cluster, West Virginia needs to help firms in the sector to find more economic opportunities – within and outside the state.

Key West Virginia Defense-related Assets

- West Virginia has several training facilities used for defense and national security purposes, including the Joint Interagency Training and Education Center (including the Center for National Response Memorial Tunnel) and the U.S. Customers Border Protection Advanced Training Center.
- 2. Nearly \$1 billion in DOD contracts has been awarded to West Virginia firms during the past five years.
- 3. DOD work in the state is largely focused on advanced manufacturing, building, and innovation-oriented industries, including in Ammunition Manufacturing, Construction, R&D, Computer Design, and Engineering Services.
- 4. Employment in West Virginia's defense cluster fluctuated during the past decade, with job declines since 2013 that run counter to the national trend.
- 5. West Virginia has many more firms that operate in industries from which DOD purchases products or services. About 4,700 companies operate in these industries, employing more than 67,000 people.
- 6. Border states represent a significant market opportunity for the state's defense contractors.

Key Takeaways from Our Research

- 1. West Virginia's defense-related sector employment is smaller than might otherwise be expected, and few firms in the state have achieved significant size.
- 2. The state's defense-related industry lost substantial sales and jobs due to recent defense procurement cuts combined with declines in related industries.
- 3. A broader view of West Virginia's defense sector should consider National Security-related activities. Combined, Defense and National Security accounts for nearly 2.5 percent of the state's GDP.

4. West Virginia's coal industry declines have also impacted the defense sector with companies from the same industries serving both coal and defense, so the state's economy has suffered a double whammy from cuts in defense procurement and changes in consumer demand for coal.

Opportunity Areas for Growth

In a rapidly shifting economic landscape, West Virginia cannot afford to be complacent. The state should take a proactive role in helping the state's small defense contracting base find new customers and markets. In some cases, this may mean helping defense firms find new contracting opportunities, but in other cases, it will involve helping them find new markets. The West Virginia defense sector is a small, but important part of the state's economy and the skills its firms and workers provide could represent an important contribution to future state economic growth.

The CREC team's quantitative and qualitative research identified a variety of challenges that inhibit West Virginia's ability to expand its economy, stabilize state businesses, and strengthen its defense industry base. To overcome these challenges, West Virginia should implement four strategic opportunities:

1. Leverage its defense related assets for procurement opportunities.

With expected increases in future Defense procurement and growing demand for security services, the Defense and National Security market is expected to grow. Future DOD work in West Virginia is likely to focus on highly coveted advanced manufacturing, building, and innovation-oriented industries.

2. Pursue initiatives to capture more subcontracting activity to fill cluster gaps.

West Virginia is starting at a competitive disadvantage due to the limited size of the state's defense-related cluster. To increase market share in defense requires a dedicated focus on the part of the state and stakeholders.

3. Identify market opportunities for defense-related businesses among contractors located in border states.

Efforts to promote diversification in the economy and among West Virginia companies can be an effective strategy for economic resilience. West Virginia firms may not receive large prime contracts, but they could take better advantage of being located near prime contractors. Success by prime contractors in neighboring states could offer opportunities for local firms if they remain vigilant in pursuing subcontracting opportunities.

4. Leverage strengths in coal and metallurgical businesses to expand its opportunities for federal (especially DOD) contracting.

West Virginia's coal-related businesses are struggling due to changing market demand, but many of the capabilities that these firms possess could be used to meet DOD needs. West Virginia should take a more proactive approach to connecting these coal-dependent businesses to defense-related supply chains.

Appendix A: Key Characteristics of Defense Industry Cluster Component Industries

Defense-Cluster	2017	Job Change	% Job Change		2017	
Component Industry	Jobs	(2011-2017)	(2011-2017)	LQ	Establishments	Average earnings
Industrial Building Construction	1,495	(596)	(29%)	1.84	65	\$86,266
Commercial and Institutional Building Construction	2,602	(298)	(10%)	0.80	299	\$61,423
Water and Sewer Line and Related Structures Construction	766	(57)	(7%)	0.86	65	\$73,912
Oil and Gas Pipeline and Related Structures Construction	3,033	1,024	51%	4.48	106	\$106,461
Power and Communication Line and Related Structures Construction	1,462	216	17%	1.65	101	\$78,430
Other Heavy and Civil Engineering Construction	746	(223)	(23%)	1.28	60	\$76,509
Bottled Water Manufacturing	78	0	0%	1.06	4	\$54,929
Fiber, Yarn, and Thread Mills	26	(28)	(52%)	0.19	1	\$40,741
Nonwoven Fabric Mills	20	Insf. Data	Insf. Data	0.29	1	\$69,127
Textile and Fabric Finishing Mills	35	19	119%	0.32	1	\$64,080
Textile Bag and Canvas Mills	40	(41)	(51%)	0.32	5	\$31,390
All Other Miscellaneous Textile Product Mills	59	(28)	(32%)	0.34	14	\$16,627
Cut and Sew Apparel Contractors	61	(39)	(39%)	0.28	4	\$31,231
Men's and Boys' Cut and Sew Apparel Manufacturing	39	(18)	(32%)	0.31	3	\$36,509
Paperboard Mills	133	4	3%	0.92	2	\$85,415

Defense-Cluster Component Industry	2017 Jobs	Job Change (2011-2017)	% Job Change (2011-2017)	ιq	2017 Establishments	Average earnings
Corrugated and Solid Fiber Box Manufacturing	70	Insf. Data	Insf. Data	0.16	3	\$58,736
Commercial Printing (except Screen and Books)	570	(175)	(23%)	0.36	59	\$40,000
Commercial Screen Printing	364	44	14%	0.97	23	\$44,748
Books Printing	305	85	39%	3.48	2	\$43,516
Petroleum Refineries	339	0	0%	1.03	3	\$131,389
Other Basic Inorganic Chemical Manufacturing	942	(104)	(10%)	5.12	10	\$109,992
Cyclic Crude, Intermediate, and Gum and Wood Chemical Manufacturing	257	47	22%	14.41	3	\$96,186
All Other Basic Organic Chemical Manufacturing	623	54	9%	3.51	11	\$129,175
Plastics Material and Resin Manufacturing	2,498	(3)	(0%)	9.27	15	\$129,683
Medicinal and Botanical Manufacturing	142	54	61%	1.06	1	\$196,013
Pharmaceutical Preparation Manufacturing	3,172	525	20%	3.31	7	\$107,790
Paint and Coating Manufacturing	130	11	9%	0.68	4	\$65,204
Adhesive Manufacturing	53	5	10%	0.52	1	\$75,948
Custom Compounding of Purchased Resins	146	(8)	(5%)	1.74	4	\$55,179
Photographic Film, Paper, Plate, and Chemical Manufacturing	40	(342)	(90%)	0.76	3	\$52,785
All Other Miscellaneous Chemical Product and Preparation Manufacturing	142	79	125%	0.79	6	\$73,805

Defense-Cluster Component Industry	2017 Jobs	Job Change (2011-2017)	% Job Change (2011-2017)	LQ	2017 Establishments	Average earnings
Plastics Bag and Pouch Manufacturing	143	80	127%	0.92	3	\$46,062
Plastics Packaging Film and Sheet (including Laminated) Manufacturing	239	(72)	(23%)	2.44	2	\$63,027
Plastics Pipe and Pipe Fitting Manufacturing	122	(64)	(34%)	0.93	1	\$47,967
Polystyrene Foam Product Manufacturing	25	(69)	(73%)	0.16	0	\$92,373
Urethane and Other Foam Product (except Polystyrene) Manufacturing	262	24	10%	1.54	6	\$70,124
Plastics Plumbing Fixture Manufacturing	22	(50)	(69%)	0.34	3	\$59,904
All Other Plastics Product Manufacturing	2,035	100	5%	1.45	21	\$47,303
Tire Retreading	16	(31)	(66%)	0.55	3	\$37,862
Rubber and Plastics Hoses and Belting Manufacturing	10	(29)	(74%)	0.09	2	\$86,982
All Other Rubber Product Manufacturing	242	24	11%	2.03	3	\$64,331
Clay Building Material and Refractories Manufacturing	179	34	23%	1.55	2	\$63,082
Flat Glass Manufacturing	52	12	30%	0.99	1	\$30,252
Other Pressed and Blown Glass and Glassware Manufacturing	115	(119)	(51%)	1.61	5	\$39,072
Glass Product Manufacturing Made of Purchased Glass	55	(44)	(44%)	0.25	3	\$39,099
Iron and Steel Mills and Ferroalloy Manufacturing	1,853	(237)	(11%)	4.85	9	\$90,008

Defense-Cluster Component Industry	2017 Jobs	Job Change (2011-2017)	% Job Change (2011-2017)	ιq	2017 Establishments	Average earnings
Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	14	(27)	(66%)	0.12	1	\$33,495
Rolled Steel Shape Manufacturing	158	72	84%	1.72	1	\$63,722
Secondary Smelting and Alloying of Aluminum	42	Insf. Data	Insf. Data	1.64	1	\$85,166
Aluminum Sheet, Plate, and Foil Manufacturing	1,399	246	21%	18.15	5	\$86,511
Copper Rolling, Drawing, Extruding, and Alloying	157	(90)	(36%)	1.21	1	\$104,420
Nonferrous Metal (except Copper and Aluminum) Rolling, Drawing, and Extruding	526	(149)	(22%)	8.39	1	\$95,920
Iron Foundries	63	(85)	(57%)	0.38	5	\$46,939
Steel Investment Foundries	12	Insf. Data	Insf. Data	0.21	1	\$47,437
Other Nonferrous Metal Foundries (except Die- Casting)	38	(52)	(58%)	0.67	1	\$54,025
Nonferrous Forging	38	23	153%	1.08	1	\$41,650
Metal Crown, Closure, and Other Metal Stamping (except Automotive)	141	(36)	(20%)	0.58	2	\$64,302
Metal Kitchen Cookware, Utensil, Cutlery, and Flatware (except Precious) Manufacturing	39	4	11%	0.85	1	\$61,329
Saw Blade and Handtool Manufacturing	19	Insf. Data	Insf. Data	0.14	3	\$56,286
Prefabricated Metal Building and Component Manufacturing	96	(37)	(28%)	0.67	3	\$70,442

Defense-Cluster	2017	Job Change	% Job Change		2017	
Component Industry	Jobs	(2011-2017)	(2011-2017)	LQ	Establishments	Average earnings
Fabricated Structural Metal Manufacturing	537	(119)	(18%)	1.29	38	\$50,225
Plate Work Manufacturing	130	(38)	(23%)	0.63	8	\$58,992
Metal Window and Door Manufacturing	76	64	533%	0.26	3	\$49,195
Sheet Metal Work Manufacturing	241	(262)	(52%)	0.47	14	\$53,350
Power Boiler and Heat Exchanger Manufacturing	13	(15)	(54%)	0.14	1	\$49,466
Metal Can Manufacturing	402	(313)	(44%)	4.42	5	\$90,730
Other Fabricated Wire Product Manufacturing	19	Insf. Data	Insf. Data	0.15	2	\$43,185
Machine Shops	1,635	(763)	(32%)	1.24	119	\$62,666
Precision Turned Product Manufacturing	14	(24)	(63%)	0.07	1	\$54,979
Bolt, Nut, Screw, Rivet, and Washer Manufacturing	167	11	7%	0.90	6	\$61,255
Metal Heat Treating	23	(13)	(36%)	0.26	1	\$98,982
Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers	458	20	5%	1.70	17	\$90,106
Electroplating, Plating, Polishing, Anodizing, and Coloring	225	(89)	(28%)	0.80	12	\$57,045
Small Arms Ammunition Manufacturing	21	(4)	(16%)	0.40	1	\$82,070
Small Arms, Ordnance, and Ordnance Accessories Manufacturing	25	5	25%	0.26	5	\$33,325
Fabricated Pipe and Pipe Fitting Manufacturing	86	Insf. Data	Insf. Data	0.56	7	\$65,149

Defense-Cluster Component Industry	2017 Jobs	Job Change (2011-2017)	% Job Change (2011-2017)	LQ	2017 Establishments	Average earnings
All Other Miscellaneous Fabricated Metal Product Manufacturing	21	(18)	(46%)	0.05	7	\$57,841
Other Industrial Machinery Manufacturing	18	6	50%	0.07	3	\$74,972
Optical Instrument and Lens Manufacturing	17	(24)	(59%)	0.18	1	\$80,792
Industrial Mold Manufacturing	13	(22)	(63%)	0.07	2	\$91,912
Special Die and Tool, Die Set, Jig, and Fixture Manufacturing	24	Insf. Data	Insf. Data	0.08	3	\$59,629
Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing	12	Insf. Data	Insf. Data	0.22	1	\$77,110
Measuring, Dispensing, and Other Pumping Equipment Manufacturing	146	22	18%	1.09	4	\$100,162
Conveyor and Conveying Equipment Manufacturing	199	70	54%	1.35	4	\$58,542
Industrial Process Furnace and Oven Manufacturing	27	(27)	(50%)	0.59	3	\$65,859
Fluid Power Cylinder and Actuator Manufacturing	51	(10)	(16%)	0.68	3	\$62,636
Fluid Power Pump and Motor Manufacturing	68	(33)	(33%)	0.81	7	\$58,186
All Other Miscellaneous General Purpose Machinery Manufacturing	50	(122)	(71%)	0.27	6	\$52,390
Other Communications Equipment Manufacturing	17	(26)	(60%)	0.20	2	\$109,353
Semiconductor and Related Device Manufacturing	51	(32)	(39%)	0.06	1	\$54,573

Defense-Cluster Component Industry	2017 Jobs	Job Change (2011-2017)	% Job Change (2011-2017)	LQ	2017 Establishments	Average earnings
Printed Circuit Assembly (Electronic Assembly) Manufacturing	31	(135)	(81%)	0.12	3	\$41,355
Other Electronic Component Manufacturing	12	(50)	(81%)	0.04	1	\$22,220
Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use	49	Insf. Data	Insf. Data	0.60	3	\$84,228
Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	630	(179)	(22%)	2.20	9	\$63,002
Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	76	(53)	(41%)	0.43	1	\$98,616
Irradiation Apparatus Manufacturing	13	Insf. Data	Insf. Data	0.21	1	\$60,412
Software and Other Prerecorded Compact Disc, Tape, and Record Reproducing	11	(39)	(78%)	0.21	1	\$72,971
Power, Distribution, and Specialty Transformer Manufacturing	25	(54)	(68%)	0.21	3	\$98,122
Motor and Generator Manufacturing	171	(15)	(8%)	1.04	6	\$65,318
Switchgear and Switchboard Apparatus Manufacturing	56	(7)	(11%)	0.36	2	\$89,945
Relay and Industrial Control Manufacturing	55	(111)	(67%)	0.26	4	\$71,728
Storage Battery Manufacturing	19	(13)	(41%)	0.23	1	\$40,767

Defense-Cluster Component Industry	2017 Jobs	Job Change (2011-2017)	% Job Change (2011-2017)	LQ	2017 Establishments	Average earnings
Carbon and Graphite Product Manufacturing	102	(97)	(49%)	2.80	1	\$72,036
Heavy Duty Truck Manufacturing	209	140	203%	1.55	2	\$62,290
Motor Vehicle Body Manufacturing	106	55	108%	0.40	5	\$50,971
Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	1,569	438	39%	5.18	3	\$95,726
Motor Vehicle Electrical and Electronic Equipment Manufacturing	686	264	63%	2.33	3	\$53,375
Motor Vehicle Brake System Manufacturing	62	44	244%	0.50	2	\$43,618
Motor Vehicle Metal Stamping	497	418	529%	1.19	4	\$80,656
Other Motor Vehicle Parts Manufacturing	399	288	259%	0.55	8	\$44,038
Aircraft Manufacturing	24	2	9%	0.02	1	\$99,774
Aircraft Engine and Engine Parts Manufacturing	382	(175)	(31%)	1.01	1	\$107,855
Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	1,052	(168)	(14%)	22.54	1	\$103,335
Boat Building	171	148	643%	0.89	2	\$46,194
Surgical Appliance and Supplies Manufacturing	831	26	3%	1.74	11	\$73,083
Dental Laboratories	124	(44)	(26%)	0.51	17	\$48,785
Automobile and Other Motor Vehicle Merchant Wholesalers	293	(156)	(35%)	0.52	26	\$53,875

Defense-Cluster Component Industry	2017 Jobs	Job Change (2011-2017)	% Job Change (2011-2017)	LQ	2017 Establishments	Average earnings
Motor Vehicle Supplies and New Parts Merchant Wholesalers	585	73	14%	0.72	45	\$44,631
Tire and Tube Merchant Wholesalers	94	9	11%	0.68	11	\$52,443
Motor Vehicle Parts (Used) Merchant Wholesalers	54	(71)	(57%)	0.49	13	\$40,793
Transportation Equipment and Supplies (except Motor Vehicle) Merchant Wholesalers	52	8	18%	0.34	7	\$69,237
General Warehousing and Storage	3,785	2,663	237%	0.92	63	\$36,606
Refrigerated Warehousing and Storage	18	(1)	(5%)	0.07	0	\$49,212
Other Warehousing and Storage	304	(42)	(12%)	1.40	15	\$53,692
Software Publishers	103	86	506%	0.06	36	\$102,271
Wireless Telecommunications Carriers (except Satellite)	102	73	252%	0.17	22	\$53,715
Telecommunications Resellers	261	(53)	(17%)	1.03	27	\$69,648
Engineering Services	2,763	(52)	(2%)	0.60	353	\$83,374
Geophysical Surveying and Mapping Services	81	(41)	(34%)	1.10	23	\$48,741
Surveying and Mapping (except Geophysical) Services	368	(103)	(22%)	1.54	75	\$52,894
Testing Laboratories	763	(223)	(23%)	0.97	78	\$55,431
Industrial Design Services	66	14	27%	0.57	4	\$79,186
Other Specialized Design Services	11	(2)	(15%)	0.09	3	\$39,312
Custom Computer Programming Services	1,297	(170)	(12%)	0.29	323	\$88,708

Defense-Cluster Component Industry	2017 Jobs	Job Change (2011-2017)	% Job Change (2011-2017)	LQ	2017 Establishments	Average earnings
Computer Systems Design Services	3,001	1,240	70%	0.63	668	\$92,103
Computer Facilities Management Services	96	(15)	(14%)	0.27	13	\$70,579
Other Computer Related Services	37	(58)	(61%)	0.06	17	\$87,761
Administrative Management and General Management Consulting Services	1,930	233	14%	0.57	313	\$81,208
Human Resources Consulting Services	201	16	9%	0.46	41	\$62,521
Marketing Consulting Services	487	152	45%	0.34	110	\$56,533
Process, Physical Distribution, and Logistics Consulting Services	88	(104)	(54%)	0.14	51	\$70,601
Other Management Consulting Services	150	124	477%	0.28	22	\$67,966
Environmental Consulting Services	410	157	62%	0.87	63	\$86,375
Other Scientific and Technical Consulting Services	584	(210)	(26%)	0.52	148	\$78,203
Research and Development in Nanotechnology	19	(87)	(82%)	0.18	2	\$66,362
Research and Development in Biotechnology (except Nanobiotechnology)	105	(378)	(78%)	0.12	15	\$65,351
Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)	847	(97)	(10%)	0.44	48	\$73,365
Research and Development in the Social Sciences and Humanities	372	210	130%	1.23	19	\$47,788

Defense-Cluster	2017	Job Change	% Job Change		2017	
Component Industry	Jobs	(2011-2017)	(2011-2017)	LQ	Establishments	Average earnings
Investigation Services	94	(35)	(27%)	0.47	29	\$45,117
Security Guards and Patrol Services	3,313	(556)	(14%)	0.98	136	\$27,803
Armored Car Services	115	11	11%	0.82	5	\$38,670
Security Systems Services (except Locksmiths)	293	34	13%	0.47	53	\$54,165
Locksmiths	55	23	72%	0.51	10	\$23,677
Cosmetology and Barber Schools	83	(17)	(17%)	0.96	10	\$38,099
Flight Training	13	(5)	(28%)	0.15	5	\$74,624
Apprenticeship Training	95	(27)	(22%)	1.36	20	\$36,904
Other Technical and Trade Schools	196	(35)	(15%)	0.66	36	\$58,525
Consumer Electronics Repair and Maintenance	45	5	13%	0.58	6	\$35,455
Computer and Office Machine Repair and Maintenance	154	(32)	(17%)	0.63	35	\$35,232
Communication Equipment Repair and Maintenance	52	(4)	(7%)	0.62	13	\$47,921
Other Electronic and Precision Equipment Repair and Maintenance	80	(115)	(59%)	0.42	23	\$62,918
Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	2,294	(948)	(29%)	1.97	287	\$63,543
Other Personal and Household Goods Repair and Maintenance	323	61	23%	0.71	13	\$14,499

SOURCE: CREC ANALYSIS OF EMSI DATA

Note: Table includes Defense Cluster industries with 10 or more jobs in the state in 2017.

Appendix B: Research Methodologies

Defense Cluster Methodology

The Center for Regional Economic Competitiveness (CREC) scanned the research literature for industry-based definitions utilized in past studies for identifying defense targeted industries. This included previous studies by CREC and other organizations. This scan resulted in CREC identifying 270 industries that are important to maintaining the nation's defense industrial base – Defense Cluster. The industries are categorized using the North American Industry Classification System (NAICS), which is a 6-digit code system used by federal statistical agencies to classify business establishments. NAICS is the recognized standard for researchers, businesses, and governments to classify and measure economic activity in the United States, Canada, and Mexico. Each business establishment in the state is classified to an industry according to the primary business activity taking place there. While not all businesses in the many industries comprising the Defense Cluster are directly involved in DOD contract work, they are operating in industries that are critical to the overall defense supply chain – and therefore may benefit from defense sector growth and market diversification opportunities in their states and regions.

Survey Research Methodology

In support of the statewide Supply Chain Mapping of West Virginia's Defense Industries, the Center for Regional Economic Competitiveness, in partnership with Outlier LLC, conducted quantitative primary research to gather targeted information from defense contractor companies related to their supply chain relationships, operating environment, and market diversification opportunities/potential.

The primary research among West Virginia companies engaged in defense-related activities (prime contractors and Tier 1, 2, and 3 suppliers) was done via online survey administration following the mailing of an introductory letter from West Virginia University, TechConnect West Virginia and the West Virginia Development Office.

Specific project activities performed included the following:

- Refinement and management of the recruitment list
- Development of the content of the online survey instrument

- Translation of the content of the survey instruments to SurveyMonkey™ online software and designing/formatting the online instruments appropriately
- Pre-testing the online instruments for functionality and clarity
- Management of respondent recruitment
- Sending of mail and email invitations to the recruited respondents with appropriate links to the online survey
- Collection of survey response data
- Management of data cleaning and manipulation for subsequent analysis
- Analyzing of all response data
- Generation of an in-depth research & analysis report

A total of 62 respondents were recruited from the sampling frame of 245 companies.

High Growth Firm Methodology

This project utilized data from the InfoGroup Historical Data File via a collaborative arrangement between CREC and the Business Dynamics Research Consortium. BDRC sponsors research on economic trends and is based at the University of Wisconsin- Madison. CREC partnered with Dr. Gary Kunkle of Outlier LLC to use this unique time-series dataset to track the growth patterns of all business establishments (i.e. individual business locations) across West Virginia and within the West Virginia defense industry.

The Historic Data File provides time-series information on nearly every business establishment that has existed in the U.S. for over a decade. This allows researchers to track and measure changes over time in the number, size, location, and performance of business entities. Although the data is disaggregated down to the establishment level (i.e. individual business address), variables included in the dataset can be used to link establishments together, such as branches and headquarters, to study activities at the firm level as needed. The dataset also contains detailed descriptions of each establishment's industry in several different coding formats.

CREC and Outlier LLC focused on two different methods of determining exceptional firm performance. The most commonly used measure in growth studies is 'Fast Growth', which is defined as an establishment that doubled employee size over a five-year period (i.e. 100% employee growth rate). We also used a relatively new measure, 'Sustained Growth' which measures the net number of times a business expanded employees over a study period. Thus,

while 'Fast Growth' measures the *intensity* of growth, 'Sustained' measures the *frequency* of growth.

DOD Contracts Analysis

The federal defense contracts data are extracted from USAspending.gov, a searchable website established by the Office of Management and Budget. The federal contracts data shown on USASpending.gov are provided directly by each federal agency. USAspending.gov receives and displays data pertaining to obligations (amounts awarded for federally sponsored projects during a given budget period), not actual cash disbursements made against each project.

The defense contract data were analyzed from two aspects for this project. First, we examined all contracts awarded by the Department of Defense from FY2013 to FY 2017 to companies located in West Virginia. Second, we looked at all defense contracts performed in the State of West Virginia from FY 2013 to FY 2017, regardless of the address of the prime contractor receiving the award. The process was repeated for the Department of Justice, Department of Energy, Department of Homeland Security, and NASA contracts.

The federal contract awards were then analyzed by value, industry, and contractor for the state and each of the five West Virginia Commerce Regions. The industry sector analysis was based on the principal NAICS code for the contractor. Top contractors were identified by a unique DUNS number. Summary data of the value of contracts, top industry sectors, and leading companies has been provided. Data for contracts performed in West Virginia were also used as an IMPLAN model input for the defense economic impact analysis.

Economic Impact Analysis

Economic impact analysis attempts to estimate the total contribution of various economic activities on state, regional or local economies. An infusion of spending in one sector of the economy spurs additional economic activity in other sectors as the money is re-spent, generating a "multiplier" effect. Multipliers quantify direct industry impacts but also recognize inter-industry linkages and the successive rounds of spending that occur within an economy. The total economic contribution of this added spending is estimated by tracing the flow of money between industries and households until the initial investment eventually leaves a region through foreign or domestic trade or is collected as a tax.

The IMPLAN (IMpact analysis for PLANning) modeling system is used in this analysis to estimate the economic contribution of defense contract awards to West Virginia. IMPLAN, a widely used

proprietary software, is specifically tailored to reflect the expenditure patterns and industry mix of West Virginia and to make estimates of the direct, indirect, and induced effects from various economic activities.

- *Direct effects* refer to the gross expenditures and employment of the studied industry.
- *Indirect effects* are the spending and employment of suppliers and contractors to produce inputs for the industry.
- Induced effects include household spending on goods and services by both industry employees and the employees of contractors and suppliers (both direct and indirect employees).

Total economic impact is the sum of direct, indirect, and induced effects.

Value Chain Analysis Methodology

Value chain analysis identifies inter-industry linkages by tapping federal statistics about industry input-output flows. This approach to understanding a regional economy looks not only at growth trends of specific firms but also at the industry more broadly. Specifically, we are interested in how the industry of focus interacts with other industries by tracing buying and selling relationships.¹⁴

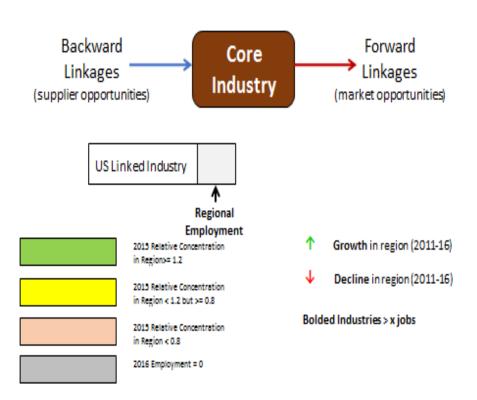
The resulting linkages between the core industry and other industries (referred to as a value chain) allows the Research Team to determine which specific industries are likely to be connected to one another through forward (sales made by the core industry, or market opportunities) or backward linkages (purchases made by the core industry, or supplier opportunities). Through this research, we can begin to understand how industries interact in three ways:

¹⁴ The model is based upon the U.S. Census Bureau's Economic Census and Benchmark Input-Output data, developed by the U.S. Bureau of Economic Analysis. It therefore attempts to account for all the buying and selling between all industries in the U.S. economy. In an ideal world this model would be based on global buying and selling patterns but those data are unavailable. However, the U.S. economy is a reasonable proxy because it is well developed and deeply integrated. As a result, the diagrams represent the buying and selling relationships of U.S. industries.

- The directionality of the flows Are industries buying from or selling to other industries?
- The structure of the flows Which industries are most closely tied to our core defense industry through direct purchases or sales?
- The volume of flows How important these buying and selling relationships are in terms of volume of sales?

The Figures in the report developed by using this method illustrate the results of the analysis by visualizing the results in a value-chain diagram. With the core industry being an important defense sector, the diagram conveys not only the relative size of the key industry, but also the structure of its relationships with the most critical suppliers and private sector customers. The diagram also provides insights about trends in employment and the relative importance of linked industries within the state.

Explanation of Value Chain Graphs



The purpose for conducting this analysis is to identify industries and firms that have extensive trading relationships with the state's targeted defense industries and to identify those that are experiencing positive employment growth (and thereby may offer opportunities for diversification). These value chain patterns help promote industry clusters by focusing on those with the most significant buying and selling relationships. By helping core defense industries identify alternative growth markets it is more likely that these industries will diversify successfully. Linked industries that are growing or that are already highly concentrated in the state or region reinforce the potential value chain strengths of the core defense industry. Conversely, where linked industries are not present or not highly concentrated, the industry may have some disadvantages that will need to be tackled.