CREC CENTER FOR REGIONAL ECONOMIC COMPETITIVENESS

TEXAS

Aerospace & Defense Industry Research Report

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Contents

EXECUTIVE SUMMARY

When it comes to the aerospace and defense industries, it is hard to get bigger than Texas. Nearly ten percent of all U.S. defense spending occurs in the state. Texas is home to some of the military's most important installations, and it hosts major operations for nearly all of the U.S.'s most important defense contractors. Put simply, the defense business is a cornerstone of Texas' current and future prosperity.

The defense industry has a long history in Texas, and it has enjoyed rapid growth for much of that time, especially over the past ten years or so. However, more recent times have seen a defense downturn, with overall procurement spending in Texas declining by 11 percent since Fiscal Year 2012. This drop, which totaled more than $3.7 billion in contract spending, generated painful job loss and retrenchment for many companies. But, it also triggered growing interest in developing a better understanding of the defense industry's role in the Texas economy and a search for new strategies that can help these companies thrive in Texas and continue to provide our military with world class products, services and technologies.

As part of this effort, the Texas Manufacturing Assistance Center (TMAC) and the Texas Foundation for Innovative Communities received funding from the Department of Defense's Office of Economic Adjustment (OEA) to help state and local policymakers mitigate the impact of recent defense spending cuts and to identify and assist affected businesses. This research report, prepared by the Center for Regional Economic Competitiveness (CREC), is a core part of this work. In addition to providing new data and research on the Texas defense economy, it seeks to aid economic planning by analyzing how regions are being affected, and facilitating high-impact entrepreneurship and technology acceleration activities in those regions.

The study assesses the Texas aerospace and defense industry through multiple "lenses." These research approaches include:

- A broad overarching review of recent defense contracting activity across the state of Texas
- A survey of Texas defense contractors to better understand state and national supply chain connections
- An assessment of business growth trends among defense contractors, along with related research to assess the types of firms most likely to grow quickly
- An assessment of core regional markets within the Texas Triangle, with a special focus on Dallas-Fort Worth, Houston, and San Antonio-Austin

- A review of major supply chain opportunities, focused on aerospace manufacturing, cybersecurity, energy and space technology in these regional markets

This research yields a number of important insights about the role and impact of Texas' aerospace and defense industry. Texas is home to a very diverse set of defense activities. In addition to its major military installations, it hosts major operations and headquarters for many of the world's largest original equipment manufacturers (OEMs), such as General Dynamics, Lockheed Martin, and Raytheon. Yet, the Texas defense sector is not just focused in traditional areas such as weapons manufacturing. Other sectors with traditional ties to Texas, such as energy and information technologies, also do a large amount of business selling to DoD.

In addition to its scale and scope, the Texas defense sector is tightly linked, with close in-state connections between and among firms. Surveyed firms do business around the globe, but they also do much of their business closer to home. In fact, surveyed managers noted that they purchase more than 54% of their inputs from companies based in Texas.

These close value chain connections vary by sector and by region. Several important supply chains operate within the Texas Triangle. Sectors such as aerospace manufacturing (Dallas-Ft. Worth), cybersecurity (San Antonio and Austin), energy, and space technologies (Houston) present special opportunities for growth.

Beyond these specific industry targets, the overall potential for growth among Texas defense firms is impressive. Our surveys found that the Texas defense sector is a hotbed for the creation of new high growth companies that rapidly create new jobs and revenue. Between 2010 and 2015, roughly ten percent of Texas' defense firms achieved high growth, i.e. they doubled their total employment levels. This concentration of high growth firms is twice the level found among all firms in Texas.

Many Texas defense firms are growing, and, despite recent declines in government contracting activity, many remain bullish about their future growth prospects in both military and commercial markets. Our surveys found that 45 percent of surveyed managers expected to see business activity grow in coming years.

While aerospace and defense have long been big business in Texas, regional or local economic development organizations have not placed a heavy emphasis on supporting defense-related industry growth. Many factors were at play. State defense contracting activity was growing organically, so local leaders focused instead on other emerging industry clusters. At the same

time, many traditional sectors—such as energy and space in Houston—were also thriving and viewed DoD as one customer among many. However, as other energy and aviation markets stagnate and federal procurement spending levels decline, a renewed focus on the state's competitive advantage in capturing DoD procurement—and the defense sector more generally—as a core customer makes sense.

These pockets of opportunity offer promising targets for enhanced defense diversification support efforts. Working with these companies to assist them in entering new markets can offer benefits in the form of new revenues and jobs as well as help to strengthen A&D clusters across Texas. New market and product development further benefits Texas' economy as companies and communities become better partners to DoD. The result of this private investment is better technologies, deployed more efficiently, to pioneer new innovations for the future.

Also, while fast-growing firms are job-creators, the fast-growing defense contractors may "fall through the cracks" in various regional ecosystems. Their importance to the local economy may not be fully understood, and existing business service providers—public and private—may not be tailoring their work to these important economic engines.

Texas' defense sector would also benefit from better integration of economic and workforce development efforts in each of the regions. Texas is home to many Chambers of Commerce and economic development organizations (EDOs) that view the defense sector as a target industry or key economic driver. However, these efforts are small and fragmented. Few unified or coordinated regional efforts currently exist to promote the defense industry or to support its further expansion.

As Texas seeks to further strengthen its already impressive A&D sector capacities, it should consider the following options:

- Develop strong defense sector innovation capabilities
- Create strategies that tap new defense market capabilities in emerging sectors, like cybersecurity, UAVs, and space tech, to enter new markets, especially overseas
- Continue strong programming in workforce development
- Better understand and capitalize on regional supply chain opportunities

These new directions do not require major new investments or large-scale shifts in policies. However, they do necessitate a public recognition of the Texas aerospace and defense sector as not only an important guarantor of our national security, but also as an important driver of innovation, job creation and wealth creation in Texas and beyond.

Introduction

Project Objective

For several years after the 2008-2009 recession ended, the Texas economy boomed, growing twice as fast between 2009 and 2015 as the U.S. economy when measured by GDP.[1] However, in 2016, the state's economic miracle stalled, and the Texas economy contracted even as the U.S. economic continued to grow. Big statewide declines in key economic sectors such as oil and gas and manufacturing led the way. This turnaround occurred after a few years of very rapid sectoral growth. For instance, the oil and gas sector doubled in size during the first half of the 2010s, and the much larger manufacturing sector grew by 10 percent during the same period. It is notable, however, that this growth occurred despite the downward push of traditional petroleum extraction in some regions as markets offset those energy sources with natural gas extracted from other parts of the state.

Clearly, Texas represents an important case study for the importance of economic diversification to ensure that the economy is not reliant on too few economic options in the event of a cyclical change in the growth of any individual industry. Furthermore, both the oil and gas as well as the manufacturing sectors are important components of the defense industrial base in Texas. Defense procurement in the state is tied very closely to high-volume fuel purchases and to the construction of large durable goods like helicopters, turbines, and heavy equipment. With Department of Defense (DoD) spending cuts during the mid-2010s, companies in certain areas of Texas (including the Texas Triangle, representing the state's four largest metropolitan areas) are at risk due to falling revenues. Just how much of a risk, this study is designed to determine. The study also seeks to identify alternative opportunities and strategies for leveraging those opportunities for the benefit of the warfighter and DoD's mission.

Texas is one of the most significant states when it comes to supporting the nation's defense supply chain and national security. Nearly 10 percent of total U.S. defense spending occurs in Texas.

[1] Source: US Bureau of Economic Analysis, GDP by State.

DoD is re-orienting the agency's mission focus on building its lethality in response to "high-end" global competitors, improving capabilities through advanced equipment procurement, and improving readiness to support the force – all while keeping the faith with the service members and their families. These shifts have important implications for Texas as the agency re-aligns its resources to work that is related to the business systems that support these priorities.

Since Fiscal Year (FY) 2012, DoD acquisitions authority declined by $65.5 billion or 18 percent.[2] In Texas, this was reflected by a $3.7 billion reduction in procurements, an 11 percent decline. These cuts affect many key programs in the state. The greater Dallas area produces the V-22 Osprey, one of Bell Helicopter's mainstay DoD products as well as the serving as the headquarters, training center and maintenance, repair, and operating supplies (MRO) location for Airbus light utility helicopters. Likewise, the greater Houston area provides a substantial share of the aviation and regular fuel for military use as well as a source for advanced technologies for space exploration that might be adapted to military uses. Likewise, San Antonio is also a major source for energy contracts, but it has emerged as a key data processing and cybersecurity hub for the military as well. DoD relies on an active and vibrant supply chain to maintain America's competitive technical advantage that ensures success on the battlefield.

U.S. military interests demand that we understand defense supply chain issues and challenges in Texas, and DoD needs community partners to help monitor the health of thousands of small defense contractors. The Office of Economic Adjustment (OEA) is providing resources to the Texas Manufacturing Assistance Center (TMAC) to understand and mitigate the impacts of changing weapon systems needs and other DoD procurement strategies on Texas companies and communities. These resources are being used to help workers, businesses, and communities seek out alternative commercial markets – an important source of revenues as a strategy for ensuring that those companies remain

The DoD's Office of Economic Adjustment (OEA) works with communities adapting to major shifts in defense procurement. In Texas, TMAC is using OEA funds to help small and medium-sized defense contractors:

- Support new R&D investments
- Develop new products, services, and technologies
- Become leaner and more cost-efficient
- Reduce operating costs
- Capture new market intelligence
- Compete and win in new markets.

[2] Source: Department of Defense Comptroller.

successful even as military procurement declines or shifts (so they are available when needed again to supply our troops).

To accomplish its goals of helping defense companies, TMAC must first understand which defense-related companies are in Texas – beyond the major OEMs. Then, TMAC can use those insights to help the smaller firms innovate their product offerings, capture new investment, train their workers, purchase the latest equipment, and develop new technologies that will ensure Texas-based defense suppliers remain competitive in the event their expertise is called upon to help equip or serve U.S. troops on the battlefield.

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. In these cases, supply chain mapping becomes a complex analytical exercise.

The Center for Regional Economic Competitiveness (CREC), in partnership with TMAC and the Texas Foundation for Innovative Communities, is supporting the state of Texas in mitigating the impact of reduced defense spending and sequestration on the state economy by identifying and assisting affected businesses, aiding economic planning by analyzing how regions are being affected, and facilitating high-impact entrepreneurship and technology acceleration activities in those regions. This project is being funded by the Department of Defense's Office of Economic Adjustment (OEA) through its Defense Industry Adjustment (DIA) program. This study reflects the results of research on related businesses and an assessment of the state's defense-related economic activity.

OEA is currently supporting DIA grantees in many activities, including 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 because they:

- 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

- Help state, local and regional policy makers determine which existing assets can best respond to supply chain issues
- Support DoD efforts to better 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 Texas and to map the state's defense supply chain.

To better understand 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 all of the businesses potentially supportive to national security efforts. As the Trump Administration's Executive Order issued in July 2017 states, "The ability of the United States to maintain readiness, 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 Texas.

[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.

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

Besides looking at the state's Defense Cluster, using both public and proprietary datasets, CREC supplemented this data with additional quantitative and qualitative research, and with the expert assistance from partners in the state, to better identify companies in Texas who are presently, or have recently, worked on DoD contracts. The study approach included conducting a statewide survey to gather targeted information from defense-dependent and defense-related companies related to their supply chain relationships, operating environment, and market diversification opportunities and potential. More than 120 Texas defense contractors responded to the survey. A unique time-series dataset was also employed to track the growth patterns of all business establishments (i.e. individual business locations) across Texas, within the Texas defense industry, and within targeted defense industry segments and target cities. 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 focus groups and interviews with stakeholders and businesses to better understand the existing innovation ecosystem and business support assets in place. Appendix B provides a more complete description of the research methodologies used in this study.

The following sections of the report describe the results of the study's effort to describe the defense industry context for the state of Texas, as well as the specific context for its three largest Texas mega-regions: Dallas-Fort Worth, greater Houston, and San Antonio-Austin. The state section includes the results from a survey of defense industry businesses along with an analysis highlighting the importance of high-growth defense cluster firms. The regional sections include a defense sector overview, and detailed value chain analysis of a core or emerging defense cluster industry specific to the region. The report concludes with key findings from the study and how to use the data to strengthen and diversify the highly impacted Texas aerospace and defense industries.

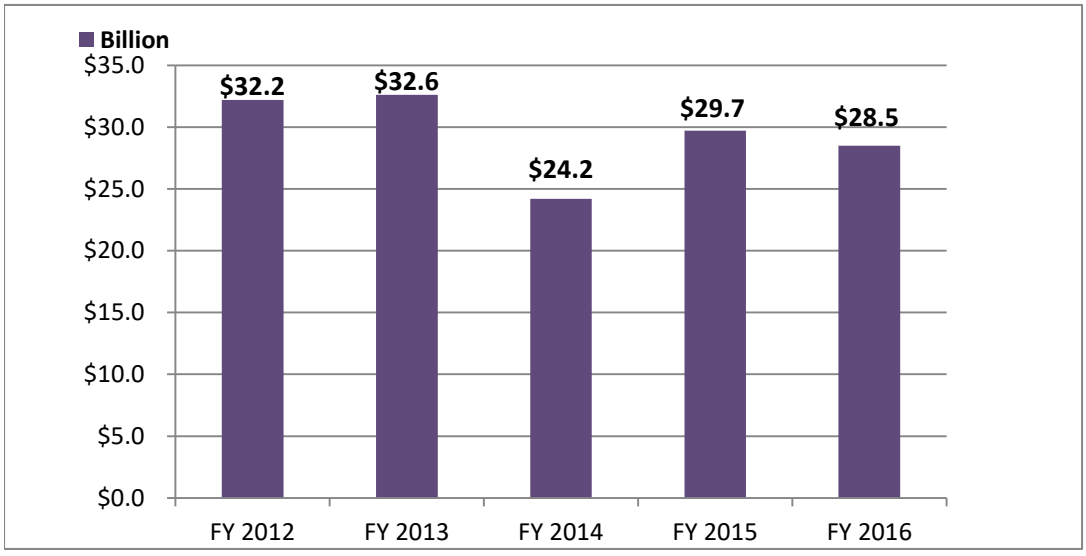
Texas Defense Economy Overview

This section provides a review of the structure of the Texas defense sector and the key economic segments that make up the defense-related supply base in the state. The goal is to demonstrate the importance of A&D to the state's economy, but more importantly the distinctive areas of economic focus that make Texas a lynchpin for the defense industrial base.

Texas: National Aerospace & Defense Industry Powerhouse

Texas is one of the most significant states when it comes to supporting the nation's defense supply chain and national security. Nearly 10 percent of total U.S. defense spending occurs in Texas when considering defense supply chain businesses and the number of military, DoD civilian, reserve and National Guard personnel in the state.[5] In Fiscal Year 2016, the state ranked third in DoD prime contract awards to companies at $28.5 billion (see Figure 1).[6] This is down from the DoD totals of recent years, but thousands of Texas businesses, large and small, remain actively engaged in providing products and services to the Department of Defense.

Figure 1: Total Value of DOD Contracts, Texas, FY 2012 - FY 2016



SOURCE: USASPENDING.GOV, BASED ON DOD CONTRACTS "PRIME AWARDS"

[5] DOD Office of Economic Adjustment, *Defense Spending by State* Annual Report

[6] Texas was behind only California and Virginia for total value of DoD contract awards

Likewise, the more than 200,000 direct defense personnel and $10 billion in payroll tied to these positions provide an enormous boost to the overall Texas economy.

Businesses in Texas directly performed nearly $90 billion in Department of Defense contract awards between 2013 and 2016.[7] More than half of the awards were for Aircraft Manufacturing and Aircraft Parts. The broad range of aerospace activities in Texas includes fighter plane and helicopter assembly, navigation instrument development, advanced space-flight research, military pilot training, and commercial space travel. Texas, both for defense and commercially, is one of the most important locations for the global aerospace and aviation industry. The aerospace, aerospace, and defense sectors combine to employ more than

Figure 2: Major Aerospace & Aviation Companies in Texas

CREDIT: 2017 TEXAS AEROSPACE, AVIATION AND DEFENSE, TEXAS OFFICE OF THE GOVERNOR

[7] Source: CREC calculated data from www.USAspending.gov based on DOD contracts calculated by "place of performance"

135,000 Texas workers at approximately 1,300 firms.[8] The Texas Governor's Office of Economic Development reports that Texas can boast major operations for 17 of the 20 largest aerospace manufacturers in the world. Figure 2 illustrates many of the major aerospace & aviation companies in the state, including top defense contractors like Lockheed Martin, Bell Helicopter, Boeing, L3 Communications, Equilon Enterprises, Raytheon, Valero, Airbus, Textron, Gulfstream, and Lockheed Martin. These companies provide a wide array of defense related products and service specializations, such as engineering and technical support, rotary wing aircraft, guided missiles, electronic countermeasures, liquid propellants and fuels, and program management.

CREC conducted an analysis of key industries represented among defense contractors in the state. After reviewing defense-related activity in the form of large and small contracts held between DoD and Texas-based firms during the period between 2013 and 2016, CREC identified nearly 8,000 Texas companies that have or recently held DoD contracts. Manufacturing companies represent 39 percent of Texas' defense contractors, led by Computer and Peripheral Equipment Manufacturing (9%). Other leading industries for DOD contracts include Professional, Scientific, and Technical Services (13%) and Administrative Support Services (8%). The companies working on DOD contracts are concentrated in the state's three largest MSAs (Dallas with 31%, Houston with 20%, and San Antonio with 14%). The remaining 35% of companies that had won DoD contracts were located throughout the rest of the state.

Texas has nearly 1.5 million jobs and 82,000 businesses operating in Defense Cluster related industries. This represents 12 percent of total state employment and business establishments.

Across the broader Texas Defense Cluster, which includes all direct and potential defense supply chain businesses, the state has more than 1.45 million jobs and 82,000 businesses operating in Defense Cluster related industries. This represents 12 percent of total state employment and business establishments. While not all the businesses and workers are directly engaged in DoD work, they operate in industries critical to the nation's defense industrial base.[9]

[8] State of Texas, Texas Aerospace, Aviation and Defense 2017

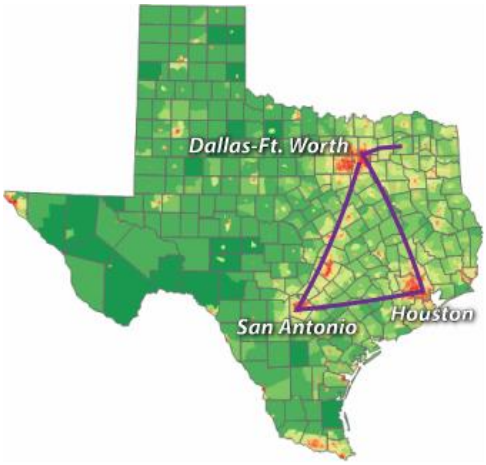
[9] CREC identified 270 industries based on past studies of defense targeted industries that are important to maintaining the nation's defense industrial base – Defense Cluster.

Employment growth in Texas and the state's Defense Cluster has grown consistently since 2011, and at a faster rate than the United States. Both Texas' overall employment and for the Defense Cluster are nearly 14 percent higher than in 2011.

Texas Business Climate Overview

The $1.6 trillion Texas economy is ranked only behind California in size. The state has consistently been among the leaders as a "Best Place for Business" and in new business startup activity, which is reflected in Texas experiencing rapid economic and job growth over the past five years.[10] With five metropolitan areas above 1 million or more residents, Texas has more big cities per capita than every other large U.S. state except Florida and Ohio.[11] Dallas–Fort Worth and Houston rank among the top five largest metropolitan areas in the U.S. in terms of both population and economic output. These two cities, along with Austin and San Antonio, form a 60,000 square-mile region dubbed the "Texas Triangle" (see Figure 3). About three-fourths of all Texans (nearly 20.6 million people) live in the 66 counties that comprise the triangle, and this area has grown much faster than the rest of the state since 2010.[12]

Figure 3: Texas Triangle



CREDIT: AMERICAN LEGEND AIRCRAFT COMPANY

Many major companies make their home in Texas, with 109 of the 1,000 largest public and private companies in the U.S. based in the state.[13] Government, retail trade, and health care are the largest employing industries (See Figure 4). These three sectors together accounted for nearly one-third of total state employment in 2016. The manufacturing sector employed over

[10] Forbes and Kauffman Foundation

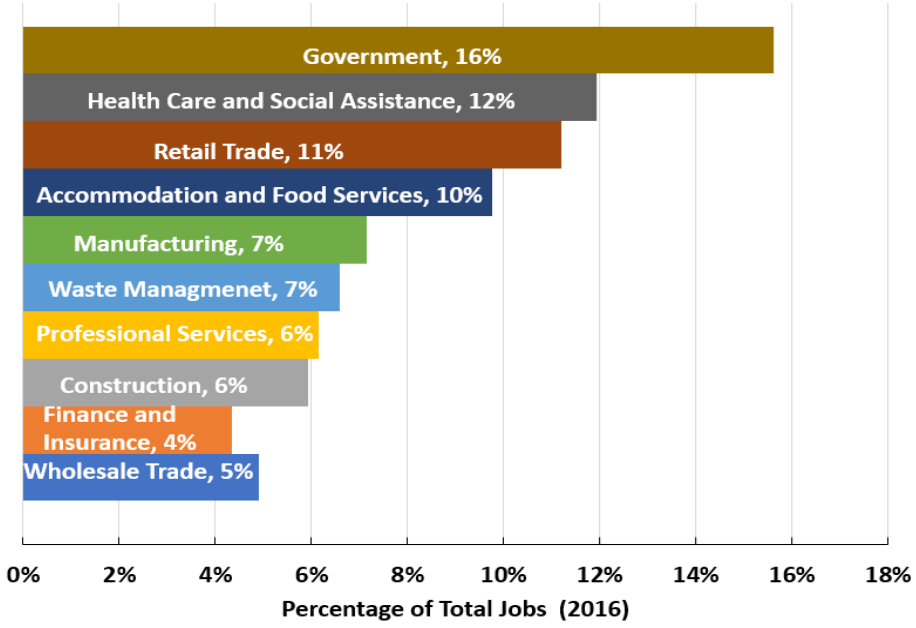
[11] Federal Reserve Bank of Dallas

[12] Census Bureau.

[13] Forbes

920,000 workers in 2016, or 5.5 percent of total employment for Texans. Professional, scientific, and technical services, which include jobs critical to the innovation economy, accounted for 6.7 percent of all jobs in Texas in 2016. This equates to more than 1.1 million Texans working in this sector.

Figure 4: Distribution of Texas Employment by Industry Sector, 2016



The October 2017 Texas unemployment rate (3.9%) is below the national rate (4.1%).[14] The state's unemployment rate has steadily fallen steadily in recent years, down by more than 2.5 percentage points since 2012. The earnings for workers across all industries in the state averages $65,880, which is on par with the national average of $66,205.[15]

Texas is specialized in fourteen standardized industries using 3-digit North American Industrial Classification System (NAICS) codes (Figure 5). This specialization is determined by location

[14] U.S. Bureau of Labor Statistics, 2016 annual averages

[15] EMSI, 2016 average earnings

quotients.[16] Six of the industries and the businesses operating within these industries are either performing defense related contract work or are part of the broader defense industry value chain: Petroleum and Coal Products Manufacturing (NAICS 324), Heavy and Civil Engineering Construction (NAICS 237), Leather and Allied Product Manufacturing (NAICS 316), Merchant Wholesalers, Durable Goods (NAICS 423), Construction of Buildings (NAICS 236), and Telecommunications (NAICS 517). Together these "Defense Cluster" related industries accounted for 740,000 jobs in 2016.

Figure 5: Texas Industries with High Specializations, 2016

NAICS Code	Industry	2016 Jobs	LQ
211	Oil and Gas Extraction	94,906	6.33
213	Support Activities for Mining	122,286	5.34
486	Pipeline Transportation	18,321	4.46
324	Petroleum and Coal Products Manufacturing*	22,925	2.47
491	Postal Service	1,087	1.97
237	Heavy and Civil Engineering Construction*	144,464	1.83
316	Leather and Allied Product Manufacturing*	4,372	1.79
481	Air Transportation	60,410	1.54
488	Support Activities for Transportation	81,015	1.47
423	Merchant Wholesalers, Durable Goods*	327,719	1.34
532	Rental and Leasing Services	61,102	1.34
518	Data Processing, Hosting, and Related Services	32,911	1.31
236	Construction of Buildings*	158,638	1.29
517	Telecommunications*	81,881	1.22

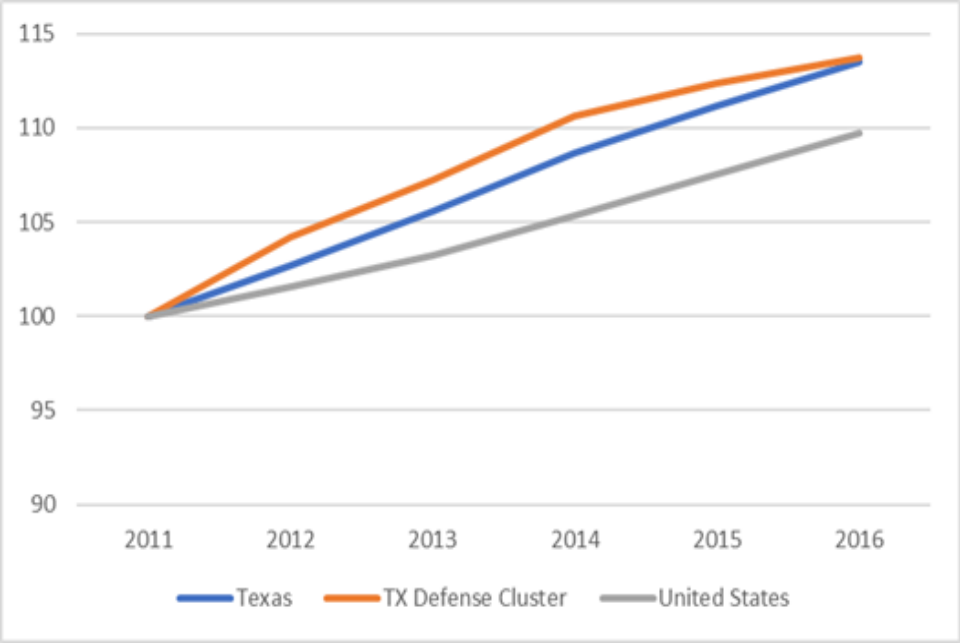
*DEFENSE VALUE CHAIN (CLUSTER) INDUSTRIES SOURCE: EMSI

[16] Location quotients (LQs) are a measure consisting of ratios that compare a region's distribution of employment to a reference region (U.S.). Industries with LQs greater than 1.20 are interpreted as indicating a regional concentration or industrial specialization.

Recent Texas Defense Economy Performance

Employment growth in Texas and the state's Defense Cluster has grown consistently since 2011, and at a faster rate than the United States. Both Texas overall employment and for the Defense Cluster are nearly 14 percent higher than in 2011. The rate of growth in the Texas Defense Cluster, however, has slowed since 2014 as illustrated in Figure 6. This corresponds closely to when the United States federal government imposed budget sequestration, which are the automatic spending cuts and budget control measures activated in 2013 and continue through today. The U.S. employment level is roughly 10 percent higher than in 2011. Texas has added more than 1 million new jobs over the period.

Figure 6: Index of Employment Growth, 2011-2016

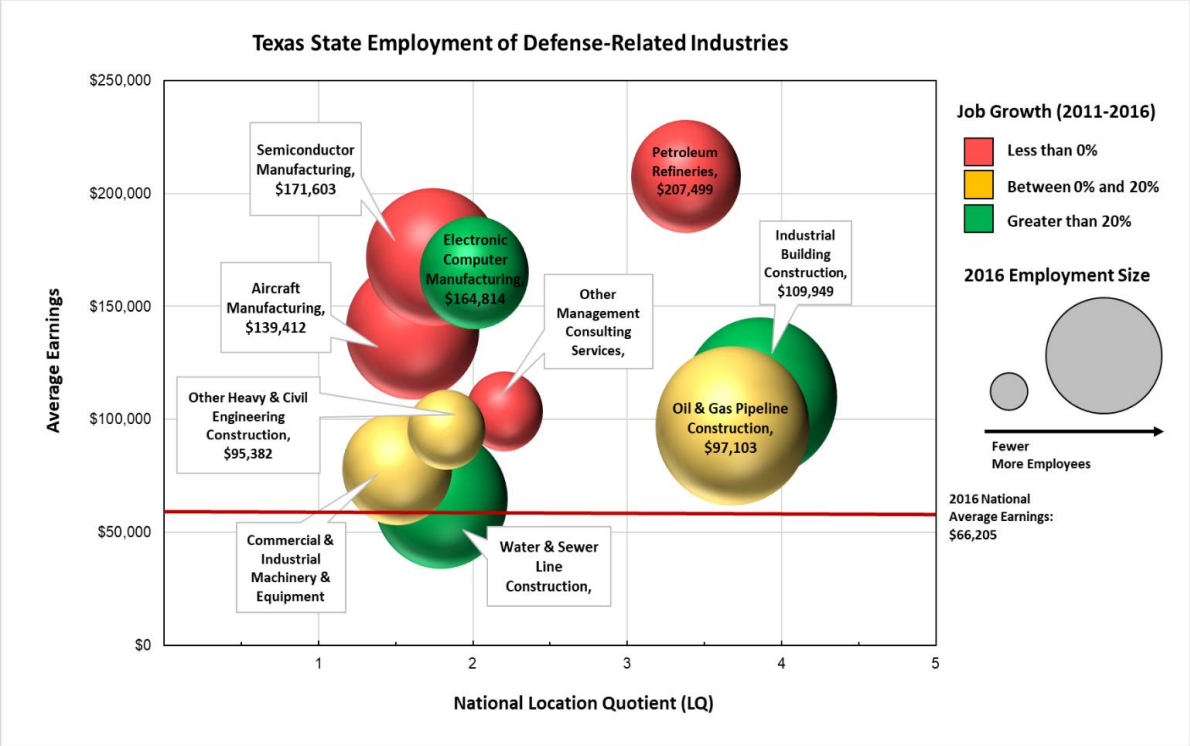


When looking at the defense sector, Texas' specialties can be identified by examining the location quotient for those industries (which represents a measure of the relative concentration of those activities relative to the rest of the nation). The state's greatest specialty is Industrial Building Construction, with nearly 4 times the national concentration in employment. Both Oil and Gas Pipeline Construction and Petroleum Refineries have large numbers of Texas jobs in addition to being highly specialized. Workers in Petroleum Refineries have the highest average earnings per worker among the leading Texas defense cluster

industries topping $207,000. In fact, all the top defense cluster industries in the state, except for water and sewer line construction, pay average earnings higher than the state average of $65,880.

The ten largest defense cluster related industries account for nearly 273,000 Texas jobs. Aircraft Manufacturing and Semiconductors account for almost 60,000 Texas jobs, although both industries have seen employment declines since 2011, with drops of 5 and 9 percent respectively. Electronic Computer Manufacturing, by contrast, has experienced rapid job growth of 38 percent in recent years. As Figure 7 shows, three of the top 10 defense cluster industries in Texas had rapid job growth since 2011, three others made positive gains, and four of them showed declines.

Figure 7: Texas Defense Cluster Industries with High Specializations



The cluster map of defense industries provides important information about the dynamics of the Texas defense economy and the importance of diversification. Large bubbles on the map, covering industries like Construction (i.e. industrial building, water & sewer), Oil & Gas (i.e. refineries, pipeline construction), Information Technologies (i.e. semiconductors, computer

production), and Manufacturing (i.e. aircraft, machinery) drive significant movements in the employment prospects for Texans. Recognizing opportunities to grow market share and to diversify the customer base from products or services offered for defense purposes to meet commercial applications is an effective strategy to maintain strong economic performance.

Understanding where current DoD work is coming to the Lone Star State provides even more specific intelligence on vital industries and business tied to the Defense economy. Businesses in Texas received nearly $90 billion in Department of Defense contract awards between 2013 and 2016.[17] More than 60 percent of the awards were for Aircraft Manufacturing or Aircraft Parts. Petroleum refineries in Texas are an important resource to power our military efforts.

Figure 8: Defense Contracts by Industry in Texas, 2013-2016

NAICS	Industry	DOD Contracts
336411	Aircraft Manufacturing	$44,962,062,395
336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing	$10,207,426,810
324110	Petroleum Refineries	$ 8,013,579,605
488190	Other Support Activities for Air Transportation	$ 4,591,064,254
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	$ 3,267,086,192
336414	Guided Missile and Space Vehicle Manufacturing	$ 2,441,609,240
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	$ 1,756,958,608
541330	Engineering Services	$ 1,506,820,593
541712	Research and Development in the Physical, Engineering, and Life Sciences	$ 1,438,059,811
336412	Aircraft Engine and Engine Parts Manufacturing	$ 838,914,560
236220	Commercial and Institutional Building Construction	$ 778,644,945
541614	Process, Physical Distribution, and Logistics Consulting Services	$ 511,868,051
524114	Direct Health and Medical Insurance Carriers	$ 408,013,000
483111	Deep Sea Freight Transportation	$ 391,459,825
611512	Flight Training	$ 379,379,051
561210	Facilities Support Services	$ 353,286,567
561720	Janitorial Services	$ 335,386,175
722310	Food Service Contractors	$ 320,922,609
333319	Other Commercial and Service Industry Machinery Manufacturing	$ 292,425,664
336992	Military Armored Vehicle, Tank, and Tank Component Manufacturing	$ 279,148,174
	Top 20 Total	**$83,074,116,131**
	Top 20 as % of Total Texas DOD Contracts	***93%***
	Texas DOD Contracts Total	**$89,751,296,043**

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

[17] www.USAspending.gov, based on DOD contracts "place of performance".

Texas is also the home to NASA mission control and dozens of related spaceflight contractor firms. As Figure 8 shows, a significant amount of contract work is directed by DoD to Guided Missile and Space Vehicle Manufacturing. Overall, the Top 20 industries in Texas received about 93 percent of DoD contract awards.

The businesses that comprise those industries, especially those with a significant footprint in DoD-related work, are particularly critical for targeting efforts to help these firms innovate their product offerings, capture new investment, train their workers, purchase the latest equipment, and develop new technologies that will ensure those companies remain competitive. A robust innovation ecosystem includes effective support services for businesses to aid with talent attraction, capital, markets, and technology opportunities. These services help to build the capacity of local firms to remain resilient and compete for future opportunities. State, regional, and local economic development initiatives can help spur the innovation ecosystem by offering a menu of programming and services leveraging the state's entrepreneurship and innovation networks.

Economic developers and community leaders should also aggressively reach out to talk with defense contractors and to identify their region's high growing defense firms. CREC has contributed to this outreach. Below are the highlights from our statewide defense contractors survey and analysis of high growth businesses. The findings indicate that fast growing defense firms are prevalent in Texas, and offer large scale benefits in terms of generating new jobs and revenue. These firms would benefit from closer ties to various business support programs operating across Texas. It also reveals many Texas defense firms are growing, and, despite recent declines in government contracting activity, many remain bullish about their future growth prospects in both military and commercial markets.

Perspectives from Texas Defense Contractors

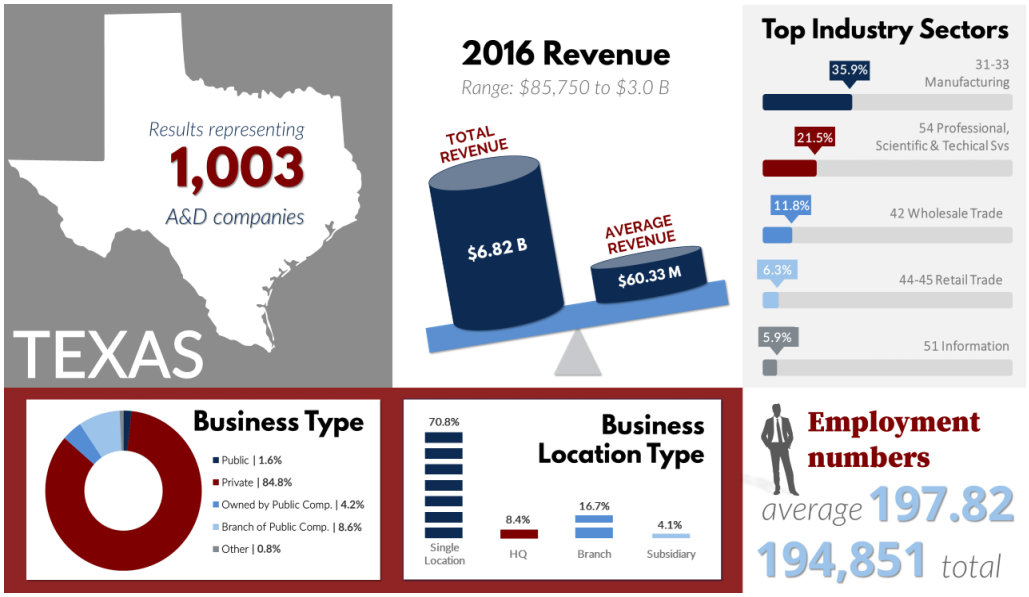
To better understand the performance of businesses in the state's defense economy and insights about anticipated future performance, CREC conducted a survey in partnership with ResearchIQ of existing companies in the DoD supply chain. The Texas A&D Industry Survey was targeted to firms that held prime contracts with the Department of Defense (DoD) or who were part of a larger Aerospace & Defense related supply chain, firms that are often defined as

operating in the 2nd, 3rd, or 4th tiers of the defense industrial base.[18] Roughly half of survey respondents were engaged in manufacturing, and an additional 30 percent were engaged in professional, scientific or technical activities. The remaining 20 percent of respondents comprised a variety of other industries and disciplines. Surveyed firms operated in 33 different Texas counties.

Most of these firms are solidly connected to Texas, with important operations in the state. A large share of respondents reported their current location as a U.S. headquarters (42.3%), a global headquarters (39.8%), or a production/manufacturing plant (26.8%). In terms of ownership, 28 percent of responding establishments were women-owned, 22 percent were minority owned, and 15 percent were owned by military veterans.

In terms of scale and scope, these firms are a diverse lot. The smallest respondent reported

Figure 9: Texas Company Survey Demographic Infographics



SOURCE: RESEARCHIQ, TEXAS AEROSPACE & DEFENSE INDUSTRY SURVEY REPORT

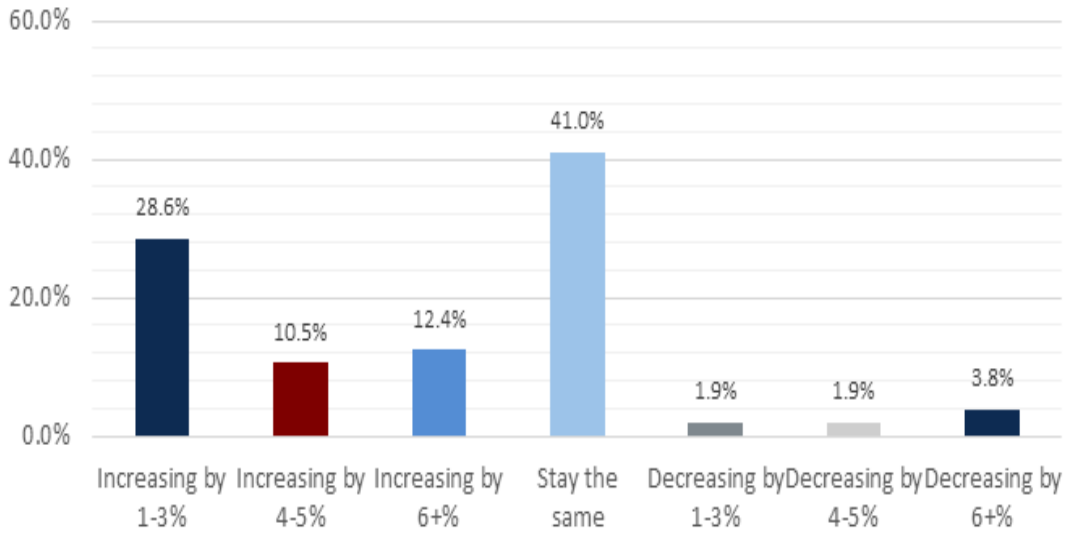
[18] As part of its analysis of Texas' defense industry supply chain, the Center for Regional Economic Competitiveness partnered with the University of Northern Iowa's ResearchIQ team to undertake a survey of Texas companies engaged in defense related activities. This survey engaged 123 companies across the state of Texas. The complete survey findings are available in the report: *Texas Aerospace & Defense Industry Survey Report* prepared by CREC and the University of Northern Iowa's ResearchIQ, 2017.

annual revenues of only $85,000 while the largest tallied annual revenue of nearly $3 billion. However, in general, those firms responding to the survey were relatively large, reporting annual average sales of $60.33 million with a larger than average employment. As a group, the respondents employed 30,933 people, averaging 198 employees per firm.

Texas defense supply chain firms remain optimistic. Over half (51.5%) of survey respondents expect to add jobs in the state in the coming year.

Most firms (60.3%) had not grown over the past year, but more than half expected to add jobs in 2018 - with 51.5 percent expecting to add jobs in the coming year. As shown in Figure 10, more than 12 percent of respondents expect significant employment growth of 6 percent or more in the coming year. This optimism in the state's defense economy for increased employment opportunities highlights the importance of have a well-skilled and available workforce to feed this level of job growth.

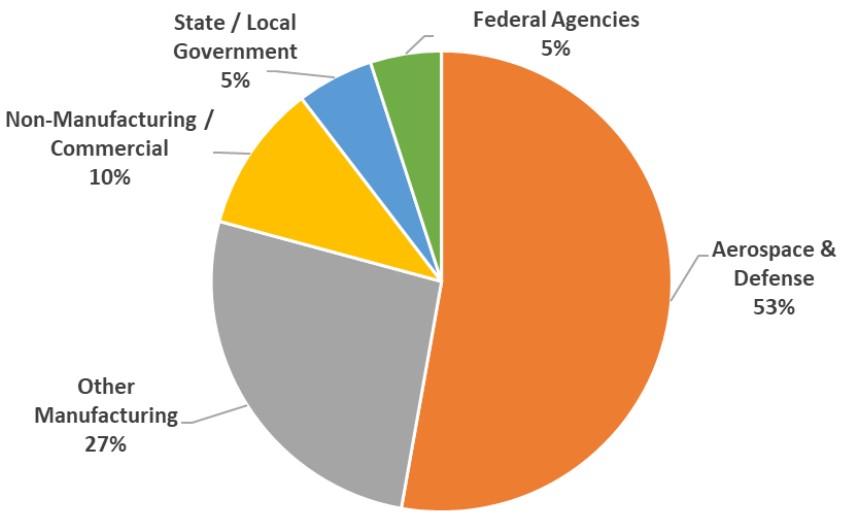
Figure 10: Anticipated Next 12-Month Employment Trend



SOURCE: RESEARCHIQ, TEXAS AEROSPACE & DEFENSE INDUSTRY SURVEY REPORT

Survey respondents typically operate in a diverse set of markets as well. Better than half of their 2016 revenue was generated in the Aerospace & Defense (A&D) industry (see Figure 11), followed by Other Manufacturing (26.4% of 2016 revenue), Non-Manufacturing/Commercial (10.4%), State/Local Government (5.4%), and other Federal Agencies (5.0%).

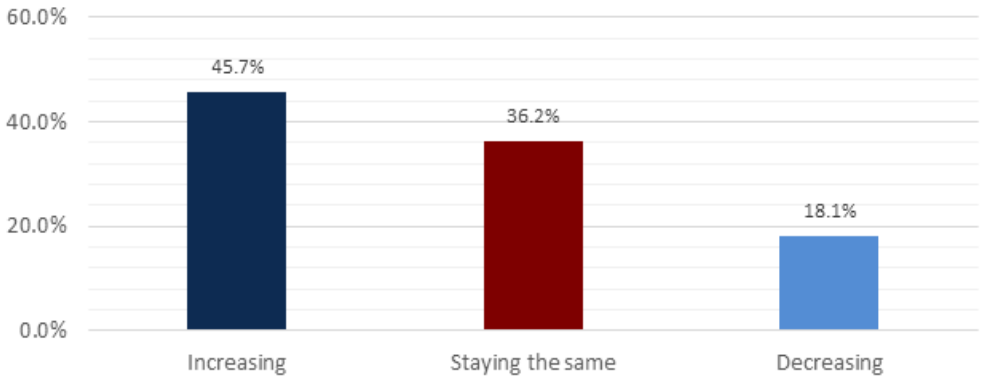
Figure 12: Distribution of Revenue Sources for Defense Firms



SOURCE: RESEARCHIQ, TEXAS AEROSPACE & DEFENSE INDUSTRY SURVEY REPORT

Most of the surveyed firms (83.5%) have worked directly with the U.S. government on A&D related projects as a prime contractor. Of this group, 61.1 percent are currently engaged in direct contracts with DoD or the military services. The firms are bullish on the prospects for future work. Forty-six percent expect their A&D related contract base to grow, and only 18% project declining work over the next year (See Figure 12).

Figure 11: Anticipated Growth Trend for Next 12 Months Derived from Defense Work

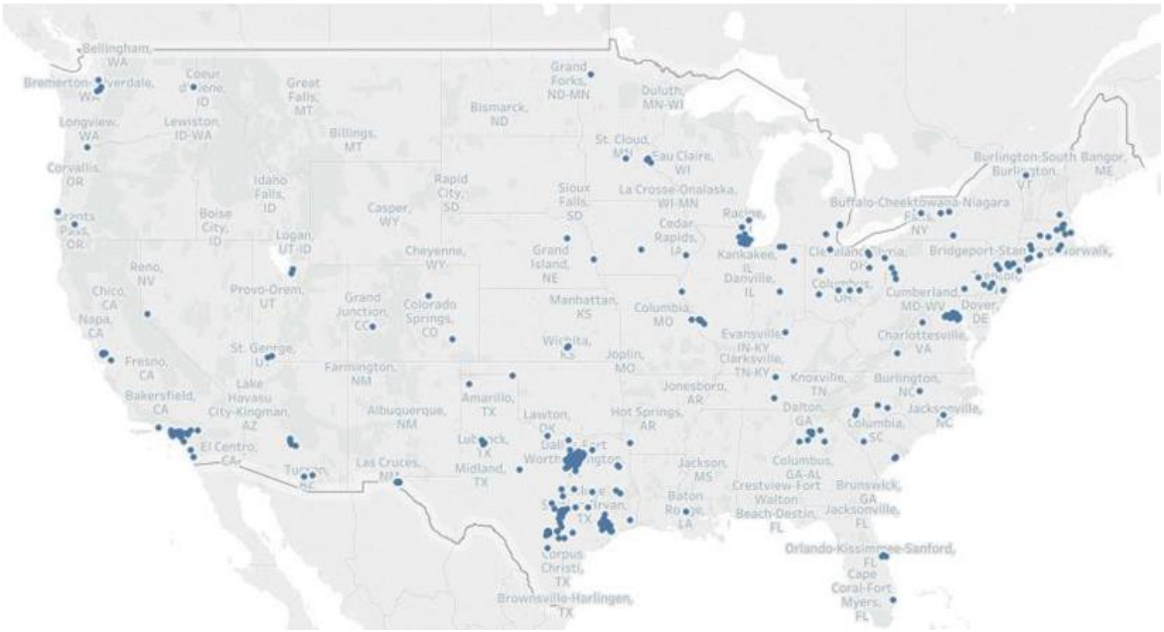


SOURCE: RESEARCHIQ, TEXAS AEROSPACE & DEFENSE INDUSTRY SURVEY REPORT

Additionally, most Texas defense contractors operate with a mix of prime contracts, subcontracts and a diverse set of supplier and customer relationships. Surveyed firm adhere to this pattern as well. Nearly 65 percent had worked on subcontracts with prime contractors or OEMs in the past, and half are currently engaged in subcontracting work. Respondents are also optimistic about subcontracting work with more than half projecting increased work over the next 12 months. Only 12.6 percent project a reduction in their contracting work in the next year.

A&D work has always operated via far flung supply chains, with hundreds, if not thousands, of suppliers and subcontractors providing parts, equipment, technology, and other services that are integrated into a final product or weapons systems. Survey respondents operate in this fashion, with most firms linked into complex and multi-faceted supply chain relationships. Figure 13 depicts the locations (U.S. only) of major suppliers to firms tracked via our surveys. As a group, the responding firms engage a total of 1,423 subcontractors, and the average company works with 32 different subcontractors. While these firms are linked into global supply chains, much of their work is also "Made in Texas." Surveyed firms access inputs from

Figure 13: Texas Major Input Suppliers Location Map—US Only

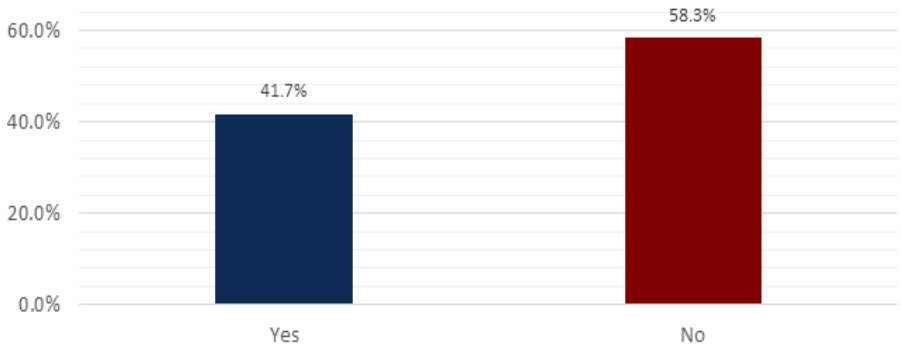


SOURCE: RESEARCHIQ, TEXAS AEROSPACE & DEFENSE INDUSTRY SURVEY REPORT

35 states and 18 foreign countries. But, as shown in the figure, they remain closely linked to suppliers in Texas. In fact, 54% of all inputs were purchased from suppliers operating in Texas.

More than forty percent of respondents outsource significant work to subcontractors (See Figure 14). Most expect that this outsourcing activity will remain stable or grow over the next year. This pattern varies by company size, as larger firms are more likely to outsource work to subcontractors. But even the smallest companies (i.e. those with less than ten employees) use subcontractors for an average of 38% of their work.

Figure 14: Work Outsourced to Subcontractors on Defense or Aerospace-Related Products



SOURCE: RESEARCHIQ, TEXAS AEROSPACE & DEFENSE INDUSTRY SURVEY REPORT

Survey participants were also asked to identify their company's primary product or service. The most commonly identified products or services by 3-digit NAICS were:

- 541: Professional, Scientific & Technical Services (36)
- 334: Computer & Electronic Products Manufacturing (14)
- 333: Machinery Manufacturing (12)
- 336: Transportation Equipment Manufacturing (11)
- 339: Other Misc. Manufacturing (7)

Firms were also asked to identify their major inputs, i.e. what types of supplies do they purchase? The most commonly identified major inputs fell into the following 3-digit NAICS:

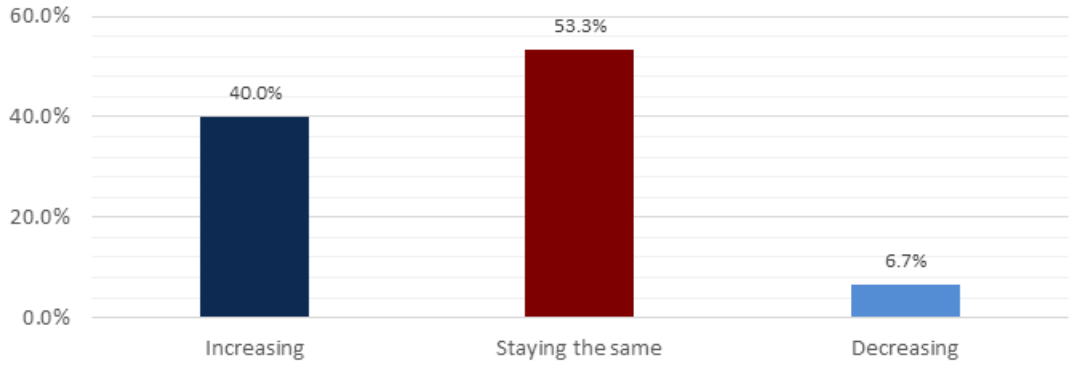
- 325: Chemical Manufacturing (43 major inputs)
- 331: Primary Metals Manufacturing (50 major inputs)
- 332: Fabricated Metal Product Manufacturing (46 major inputs)
- 333: Machinery Manufacturing (29 major inputs)

- 334: Computer & Electronic Products Manufacturing (88 major inputs)
- 335: Electrical Equipment & Component Manufacturing (20 major inputs)
- 541: Professional, Scientific & Technical Services (56 major inputs)

Not surprisingly, each of these industries showed evidence of unique supply chain relationships and patterns. As a group, all the sectors did most of their purchasing within the U.S. In sectors like primary metals manufacturing, fabricated metals manufacturing, and machinery manufacturing, more than 90 percent of inputs came from U.S. suppliers. In these cases, a large group of suppliers—roughly two-thirds in each case---were based in Texas. Electrical equipment and components was the sector with the highest concentration of foreign inputs (nearly 13%), with Japan serving as the dominant source of overseas suppliers.

For those companies looking break into the defense supply chain in Texas, there is potential opportunities based on the results from the survey. Figure 15 shows that 40 percent of respondents indicated they were expecting to increase their utilization of subcontractor firms over the next year.

Figure 15: Anticipated Subcontractor Utilization for Next 12 Months



SOURCE: RESEARCHIQ, TEXAS AEROSPACE & DEFENSE INDUSTRY SURVEY REPORT

The survey results suggest that many of Texas' defense contracting businesses are optimistic about their near-term prospects, despite recent Federal procurement cuts. The opportunities available to businesses to grow market share and to diversify product lines is most evident for companies that have added jobs rapidly or over a sustained period. These growth-oriented companies are especially important to the defense economy landscape. Extensive economic research about job creation and economic development yields one clear conclusion: fast growing companies, which make up about five percent of all firms, are the primary creators of

new jobs, new wealth and new innovations. Places that succeed in spurring development of high-growth companies will have more prosperous local economies and more success with economic development. Industry sectors with higher concentrations of high growth firms generate similar benefits as well.

Texas High-Growth Firms

To better understand the entrepreneurial dynamism of Texas' A&D sector, CREC assessed high growth companies to determine regions and industries where these companies are commonly found. The research examines time-series data on the performance of more than 1.7 million business establishments operating across the state between 2010 and 2015.[19] The research further assesses the performance of businesses in Texas's defense industry at the state level and in three target regions: Dallas-Fort Worth, Houston, and San Antonio-Austin.

In the Texas defense sectors, 10 percent of establishments are high-growers. This rate is twice the level found among all Texas firms.

More than half of the 1.7 million business establishments operating in Texas in 2016 started since 2010. Within this sample, 704,144 establishments maintained operations between 2010 and 2015. This group served as the core sample for the research work.[20] The research sought to identify "high grower" firms from the core of firm survivors. High grower firms must exhibit one of two characteristics:

1) Fast Growth—Firms that doubled employment over the 2010 to 2015 time frame.
2) Sustained Growth—Firms that added net new employees in at least two of the five years between 2010 and 2015.

Using these criteria, CREC identified 37,481 high grower firms operating in the state of Texas (Figure 16). This group represents five percent of all Texas establishments, and they have posted impressive returns between 2010 and 2015. Over this period, the average high-grower added an average of 15.2 jobs, compared to all establishments which lost jobs over this time

[19] Center for Regional Economic Competitiveness and Gary Kunkle, *Texas Aerospace & Defense Industry High Growth Firm Report*, 2017. See Appendix A for additional details on research methodology.

[20] Analyses in this section are based on the 2010-2015 firm survivors.

frame. As a group, this cohort of high-growers created 571,141 new jobs in Texas between 2010 and 2015.

Figure 16: Component of High-Growers - All Texas Industries (2010-2015)

All Industries	Sustained	Fast-Growers	Both	High-Growers
Establishments	6,891	35,054	4,464	37,481
Average Size	27	28	29	28
Total Employment Growth	131,145	544,656	104,660	571,141
Average Employment Growth	19.0	15.5	23.4	15.2

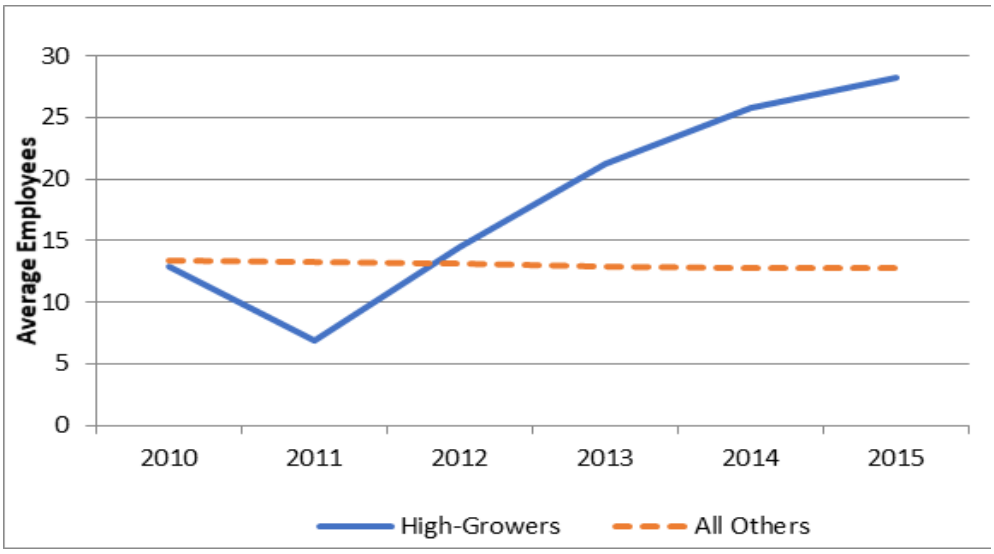
SOURCE: CREC AND KUNKLE, TEXAS AEROSPACE & DEFENSE INDUSTRY HIGH GROWTH FIRM REPORT

The high-growers were responsible for nearly all new jobs created in the state in that period, creating jobs at a rate 4.5 times higher than the statewide average as shown in Figure 17.

High-grower firms operate in all sectors and industries, and they form a sizable group that operate in the A&D sector.

Within our sample, we identified 3,182 establishments in defense-related industries in Texas, representing around 0.5 percent of establishments that survived over the 2010 to 2015 time frame.

Figure 17: Average Employment Size: Texas High-Growers vs. All Establishments



SOURCE: CREC AND KUNKLE, TEXAS AEROSPACE & DEFENSE INDUSTRY HIGH GROWTH FIRM REPORT

This small group of businesses contains a high concentration of high-growers as 319 firms (or ten percent) of these establishments in defense-related industries met the criteria for high growth (See Figure 18).

This suggests that establishments in defense-related industries are twice as likely to achieve high-grower status when compared to all Texas establishments.

Figure 18: Texas High-Growing Companies in Defense and Non-Defense Industries

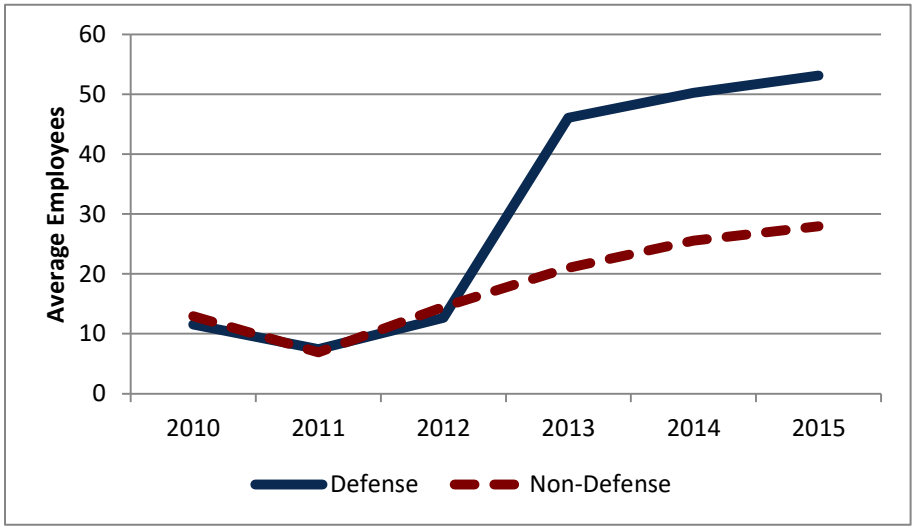
Industry		High-Growers	All Others	Totals
Defense-related	**Establishments**	319	2,863	3,182
	Average Size	53.1	21.4	24.6
	Total Employment Growth	13,264	-7,114	6,150
	Average Employment Growth	41.6	-2.5	1.9
Non-Defense	**Establishments**	37,162	663,800	700,962
	Average Size	28.0	12.7	13.5
	Total Growth	557,877	-435,444	122,433
	Average Employment Growth	15.0	-0.7	0.2

SOURCE: CREC AND KUNKLE, TEXAS AEROSPACE & DEFENSE INDUSTRY HIGH GROWTH FIRM REPORT

High-grower defense firms as a group were also powerful job creators. The average defense high-grower added 41.6 new jobs between 2010 and 2015. As a group, they created 6,150 jobs across Texas.

Furthermore, high-growing Texas firms in defense-related industries entered an unexpected growth spell in 2013 (as illustrated in Figure 19) just as DoD procurement levels were declining due to sequestration. This suggests that these firms may either have been successful in identifying new markets just as their customer based changed or that the fast-growing firms

Figure 19: Average Employment – Texas High-Growers in Defense-related and Non-Defense Industries



SOURCE: CREC AND KUNKLE, TEXAS AEROSPACE & DEFENSE INDUSTRY HIGH GROWTH FIRM REPORT

before that time left the market, leaving behind the most aggressive companies in the defense-related industry.

Within the group of Texas' defense high-grower firms, some interesting differences emerge when comparing fast-growing firms versus sustained growing firms. Past research has found that fast-grower firms often follow a more volatile growth pattern, with periods of rapid growth that coincide with or are succeeded by periods of offsetting job loss.[21] Meanwhile, sustained growers follow a steadier and less volatile growth pattern that may produce better long-term outcomes. This pattern emerged during the first half of the 2010 as sales growth for sustained growers was much more rapid (878% compared to 195% for fast growers, and their average sales per employee (a key measure of productivity) was also much higher.

This review of high growth companies in Texas suggests several core findings. First, it confirms that Texas is a highly dynamic economy. Its high business churn rates indicate that the state is spawning many new companies that are enjoying consistent growth in productivity and firm

[21] See for example: http://exceptionalgrowth.org/insights/AVirtuousGrowthCycle.pdf, http://exceptionalgrowth.org/insights/Kunklepaper1_2013.pdf

performance. Between 2010 and 2015, roughly 5% of Texas firms achieved high-growth, and this small group was the primary driver in net new job creation that exceeded more than 571,000 jobs.

Second, Texas' competitive economic position is widely recognized across the U.S. The strong growth performance of its defense sector is perhaps less well understood. In fact, the Texas defense industry was even more dynamic than the overall Texas economy –at a time of general decline in defense spending due to budget sequestration and other factors. In the Texas defense sectors, ten percent of establishments are high-growers. This rate is twice the level found among all Texas firms, of which 5% achieve high-growth. With a large concentration of high-growers in defense-related sectors, Texas may benefit greatly by treating defense firms as high potential entrepreneurial ventures that could be a foundation for the state's future.

Finally, while fast-growing firms are job-creators, the fast-growing defense contractors may "fall through the cracks" in various regional ecosystems. Their importance to the local economy may not be fully understood, and existing business service providers—public and private—may not be tailoring their work to these important economic engines. The Texas innovation ecosystem, led by TMAC and others, could make a significant contribution to Texas economic development potential by focusing assistance to high-growth defense firms because they are lynchpins in complex defense supply chains affecting companies across the state and nation. The project's supply chain analysis highlights huge new opportunities within Texas based A&D supply chains. Previous OEA-sponsored grantee research sought to better understand supply chain dynamics, focusing on efforts to identify "at-risk" companies. This research flips that script to focus on "high potential" companies that could benefit DoD while also spurring local economic development. The potential for deepening the defense supply chain relies on the strength of these high potential companies.

Texas Defense Industry Summary

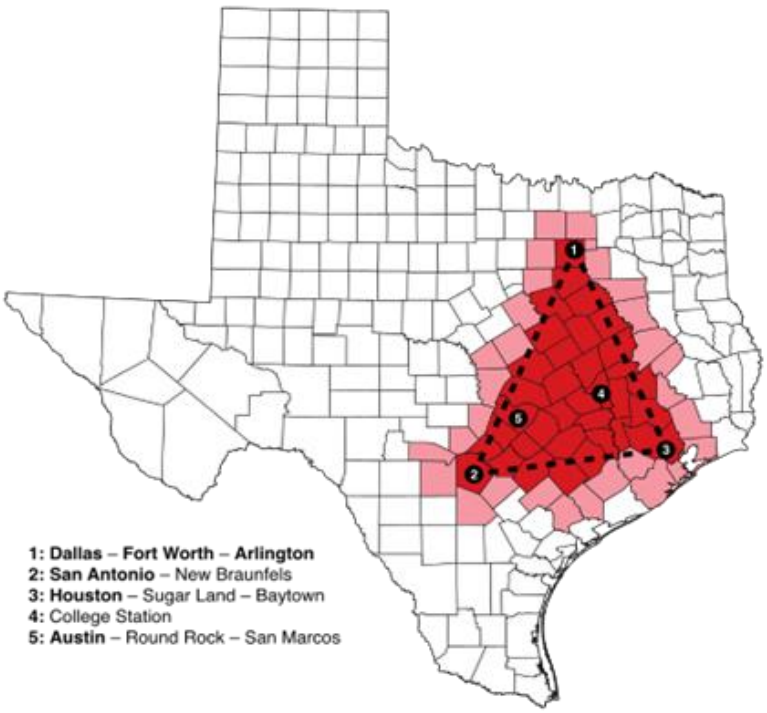
Texas is home to a set of the largest and most complex A&D supply chains in the world. It hosts large OEMs who operate in a diverse set of defense markets, along with a diverse set of suppliers as well. Texas-based defense firms already do a significant amount of business in the state of Texas. The research completed for this project indicates that Texas defense firms generate $25 to $30 billion annually in defense-related procurements. Not all of those funds stay in the state. A survey of defense contractors found that half of the supplies these firms purchase come from other Texas-based firms. This number is impressive, but could always be

improved—especially since Texas is home to such a diverse array of A&D companies. State and local economic development leaders need to better understand current supply chain structures and develop new capacities that help link Texas based firms in new business relationships with each other.

Across Texas, there is a major presence in the defense-related industries for construction of industrial buildings and pipelines as well as electronics and semiconductors. About 70 percent of Texas' $90 billion defense contracting in recent years was in aircraft and missiles manufacturing; another 10 percent in providing fuel to the military. About 40 percent of the state's defense supply chain firms contracted with other firms; key suppliers and markets outside the state are in southern California and the DC metro area. Although, more than half of the defense subcontract work is supplied by other Texas-based businesses.

Within Texas, we have identified a strong core of high growing defense firms that not only contribute to a stronger defense industrial base, but also serve as potential "target customers" for state and local economic development efforts. High growth defense firms are critical job creators. As they succeed, Texas communities will prosper, and the U.S. military will also benefit from a stronger and competitive base of suppliers.

Figure 20: Metro Areas and Counties in the Texas Triangle



Looking more closely at the geographic distribution of Texas' defense economy, much of it is located within the Texas Triangle. Together, Dallas-Fort Worth, Houston, along with the combined San Antonio and Austin metropolitan areas, form the Texas Triangle, a 60,000-square mile urban 'megaregion' spanning much of East Texas. The Texas Triangle represents about 75 percent of the state's GDP and two-thirds of the state's population, but the area has captured roughly

80 percent of the state's population growth since 2000.[22] It is estimated the megaregion's population will double by 2050 to 38 million residents.[23] The Texas Triangle is an economic growth and innovation engine for the state. This is true for the defense economy of Texas as well. Nearly 87 percent of DoD contract dollars wind up with businesses located within the triangle. However, the cities that make up the three points of triangle have very different drivers when it comes to the A&D companies. The following section looks specifically at the unique Defense Cluster Industries and assets driving the economies of DFW, Houston, and San Antonio-Austin[24].

Besides providing an overview of each region's economy and its specific strengths related to the defense economy, the profile also includes a value chain analysis that examines either a leading defense cluster industry or one that is emerging in importance. In Dallas-Fort Worth, the focus is on Aircraft Manufacturing – a long-standing regional strength. Houston has long been a center for petroleum production, but the regional profile considers another important industry within the region's defense landscape - Turbine & Turbine Generator Manufacturing. The Houston profile also discusses the possibilities for the region from its connection to NASA and space exploration. Finally, the cities of San Antonio and Austin are fast becoming a combined megaregion as the economic success of each increasingly erases the distance between the two. Both cities are known for IT related innovation, and the value chain analysis focuses on cybersecurity as the defense economy strength emerging within the megaregion.

Each regional section ends with a discussion of current innovation assets and potential areas of both strengths and weaknesses. The profiles of Dallas-Fort Worth, Houston, and San Antonio-Austin reveal that these regions are not monolithic, especially as it relates to the defense economy. Each region has important and unique niches, and potential future contributions, to make to the nation's defense industrial base.

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[22] Hendricks, David. Texas' triangle cities make up the 'economic guts' of the state. San Antonio Express-News. September 18, 2017. Accessed at: http://www.expressnews.com/business/local/article/Texas-triangle-cities-make-up-the-economic-12206493.php

[23] Texas Triangle. Regional Planning Association: America 2050. Accessed at: http://www.america2050.org/texas_triangle.html

[24] Appendix C provides additional details on defense cluster related industries with the highest specializations for each of the regions.

An Assessment of the Defense Sector in the Dallas-Fort Worth Region

With defense contractors in the region receiving $64 billion, or roughly 70 percent of all DoD contract awards to Texas, the Dallas-Fort Worth region is a hotbed for A&D companies and the epicenter for much of the state's defense economy. This section provides a profile of the structure of the Dallas-Fort Worth defense sector and the key economic segments that make up the defense-related supply chain in the region. Besides providing an overview of the region's economy and its specific strengths related to the defense economy, the profile also includes a value chain analysis that examines a leading defense cluster industry. In Dallas-Fort Worth, the focus is on Aircraft Manufacturing – a long-standing regional strength. The regional profile ends with a discussion of current innovation assets and potential areas of both strengths and weaknesses.

Dallas-Fort Worth Economic Overview

The economic center of North Texas, the Dallas-Fort Worth metropolitan (DFW) region, often known as the Metroplex, is the largest metropolitan area in Texas by population, and the fourth largest in the United States. In 2016, the DFW's economy reached $516B in real gross domestic product (GDP), ranking it fourth among all U.S. metropolitan regions, according to the Bureau of Economic Analysis.[25]

With 3.7 million workers, the Metroplex is home to 22 Fortune 500 companies including Exxon Mobil, American Airlines, Southwest Airlines, and AT&T. The region's economy is robust, diverse, and growing, and it boasts strengths in numerous areas including manufacturing, tourism/entertainment, and healthcare/medical research. Between 2015 and 2016, the Metroplex's average unemployment rate fell from 4.1 to 3.6 percent, well below the national average of 5.3 percent for U.S. metros. By October 2017, the unemployment rate had fallen to 3.0 percent, below the 3.9 percent national average.[26] Altogether, the average wage for

[25] U.S. Bureau of Economic Analysis, accessed at: https://www.bea.gov/newsreleases/regional/gdp_metro/2017/pdf/gdp_metro0917.pdf

[26] U.S. Bureau of Labor Statistics, accessed at https://www.bls.gov/web/metro/laummtrk.htm.

workers across all industries in DFW is $70,276, which is significantly above the national average of $55,823.[27]

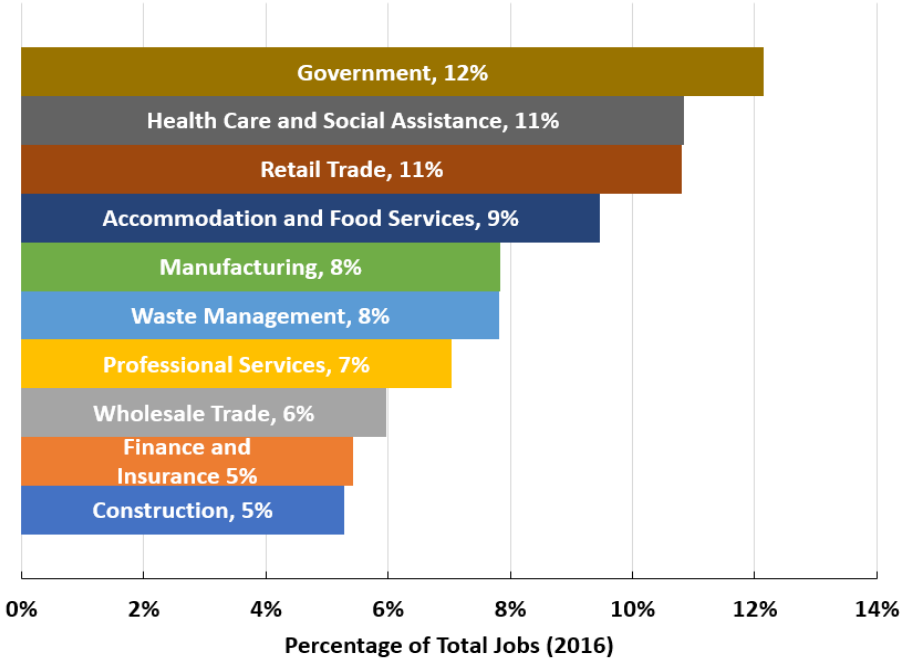
Unto itself, Dallas is a global city that attracts millions of domestic and international tourists annually. *Visit Dallas* estimates that in 2015, tourism provided $8.5 billion in economic impact to the DFW region, of which $1 billion was attributed to international tourism.[28] DFW's manufacturing base specializes in both telecommunications hardware and software production and military, commercial, and private aircraft production. In the northeastern section of the Metroplex, is the Telecom Corridor, a 7-mile strip of land along Route 75 through Richardson, Texas, that hosts the highest concentration of information technology companies in Texas. Occupants include AT&T, Alcatel-Lucent, Ericsson, Raytheon, Samsung, and Verizon. Across town, large aircraft manufacturers such as Boeing, Sikorsky, Airbus, and Bell Helicopter have major operations outside of the Dallas-Fort Worth International Airport. The region's healthcare and medical research industries are supported by non-profit organizations such as the Arlington-based Texas Health Resources and Baylor Health Care System and for-profit companies such as, the Dallas-based, Tenet Healthcare Corporation.

Like the State of Texas and neighboring regions, DFW's three largest employment sectors are Government, Healthcare, and Retail Trade industries, employing one-third of the total regional workforce (see Figure 21). Healthcare is the region's fast-growing sector, followed by the Accommodations and Food sector. While these lower-paying sectors are growing, higher paying sectors such as manufacturing are holding steady or declining.

[27] U.S. Bureau of Labor Statistics, 2016 Occupational Employment Statistics. Accessed at: https://www.bls.gov/oes/current/oes_19100.htm https://www.bls.gov/regions/southwest/news-release/occupationalemploymentandwages_dallasfortworth.htm

[28] Fink, Jack. "Dallas Sees Big Increase in Overseas Visitors". CBS Dallas Fort Worth. December 22, 2016. http://dfw.cbslocal.com/2016/12/22/dallas-sees-big-increase-in-overseas-visitors/

Figure 21: Distribution of Dallas-Fort Worth Region Employment by Industry Sector (2016)



SOURCE: EMSI

Overall, DFW-based manufacturing firms employ over 260,000 workers, or roughly 7 percent of the total regional workforce. Since 2011, the DFW Manufacturing sector has added only 8,200 jobs equating to 1,366 jobs per year, a below-average mark among the region's industries. However, when compared to the nation, the Metroplex's manufacturing industry is growing at a faster pace. Although its new job creation numbers are dwarfed by the region's healthcare and retail industries, DFW manufacturing is robust, stable, and diverse with a wide range of capabilities and products. Notable in the DFW region is the size and scale of the region's Professional, Scientific, and Technical Services and Construction industries. These jobs are central to the region's telecommunications industry and innovation economy and account for 7 percent of DFW's total employment base. According to commercial real estate representatives,

the growth of the professional services sector, particularly in technology and financial services, is a driving force in the expansion of DFW's construction industry.[29]

Dallas-Fort Worth Defense Economy

As seen in Figure 22, the Dallas-Fort Worth regional economy has 'specializations' within twenty-four 3-digit NAICS industries. This specialization is determined by each industry's regional employment concentration as compared with the nation (e.g., location quotient or LQ). Eight of DFW's 24 industry specializations provide either defense-related contract work or support the broader defense industry supply-chain, including: Telecommunications (517); Computer and Electronic Manufacturing (334); Merchant Wholesalers, Durable Goods (423);

Figure 22: Dallas-Fort Worth Region Industries with High Specializations

NAICS	Industry	2016 Jobs	LQ
491	Postal Service	542	3.47
481	Air Transportation	34,578	3.11
211	Oil and Gas Extraction	11,731	2.77
521	Monetary Authorities-Central Bank	984	2.23
518	Data Processing, Hosting, and Related Services	14,434	2.03
517	**Telecommunications***	**35,408**	**1.87**
522	Credit Intermediation and Related Activities	103,343	1.69
334	**Computer and Electronic Product Manufacturing***	**40,962**	**1.65**
533	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	881	1.59
423	**Merchant Wholesalers, Durable Goods***	**104,299**	**1.51**
213	Support Activities for Mining	9,483	1.46
492	Couriers and Messengers	21,196	1.44
488	Support Activities for Transportation	22,196	1.43
493	**Warehousing and Storage***	**29,715**	**1.40**
531	Real Estate	51,175	1.40
327	**Nonmetallic Mineral Product Manufacturing***	**12,979**	**1.36**
484	Truck Transportation	46,448	1.36
237	**Heavy and Civil Engineering Construction***	**29,582**	**1.33**
524	Insurance Carriers and Related Activities	69,326	1.29
561	**Administrative and Support Services***	**255,825**	**1.27**
532	Rental and Leasing Services	16,383	1.26
336	**Transportation Equipment Manufacturing***	**47,528**	**1.24**
424	Merchant Wholesalers, Nondurable Goods	58,454	1.21
442	Furniture and Home Furnishings Stores	13,362	1.21

SOURCE: EMSI, 2016 DATA

[29] Brown, Steve. "Tech and Financial Services Are Driving Dallas-area Office Boom". Dallas Morning News: Accessed at: https://www.dallasnews.com/business/real-estate/2017/09/15/tech-financial-services-driving-big-ds-office-boom

Warehousing and Storage (493); Nonmetallic Mineral Product Manufacturing (327); Heavy and Civil Engineering Construction (237); Administrative and Support Services (561); and Transportation Equipment Manufacturing (336). In all, these "Defense Cluster" related industries accounted for approximately 317,000 jobs in 2016, or approximately 9 percent of the total regional workforce.

The defense industry is big business in North Texas. In fact, Dallas-Fort Worth is among the most heavily defense-dependent regions in the US. For decades, the A&D sector has been a prime economic driver, and the industry is deemed one of the region's "star" clusters by researchers at the Federal Reserve Bank of Dallas.

North Texas is home to some of the world's largest defense firms, and has become a leading location for technology development and weapons systems production. Major local employers include:

- Lockheed Martin (14,126 employees)
- Naval Air Station Ft. Worth/Joint Reserve Base (11,350 employees)
- Raytheon (8,700 employees)
- Bell Helicopter (4,953 employees)[30]

Few regions compete with North Texas in terms of employment concentration and depth of expertise in A&D. Employment concentrations in the DFW A&D sector are roughly 5 times higher than the national average. [31] Roughly 78,000 people are employed by A&D firms in North Texas, accounting for approximately 1 of 6 jobs in the region.[32] Altogether, the Dallas-Fort Worth Metroplex has several different "mini-clusters" A&D business activity. In Fort Worth, Lockheed Martin continues to dominate, with its major fighter-jet production facility at the Naval Air Station Joint Reserve Base Forth Worth. In Greenville, intelligence, surveillance, and reconnaissance provider, L3 is the community's largest employer. Richardson, Texas is at the center of defense electronics activities, with major facilities for Raytheon and a thriving optics sector led by Texas Instruments. Bell Helicopter operates its main production plant in Fort Worth. Recently, Grand Prairie, Texas has also become a major center for defense

[30] http://www.destinationdfw.com/Largest-Employers-in-Dallas-Fort-Worth-Texas/

[31] TX Aerospace Report 2014, p11

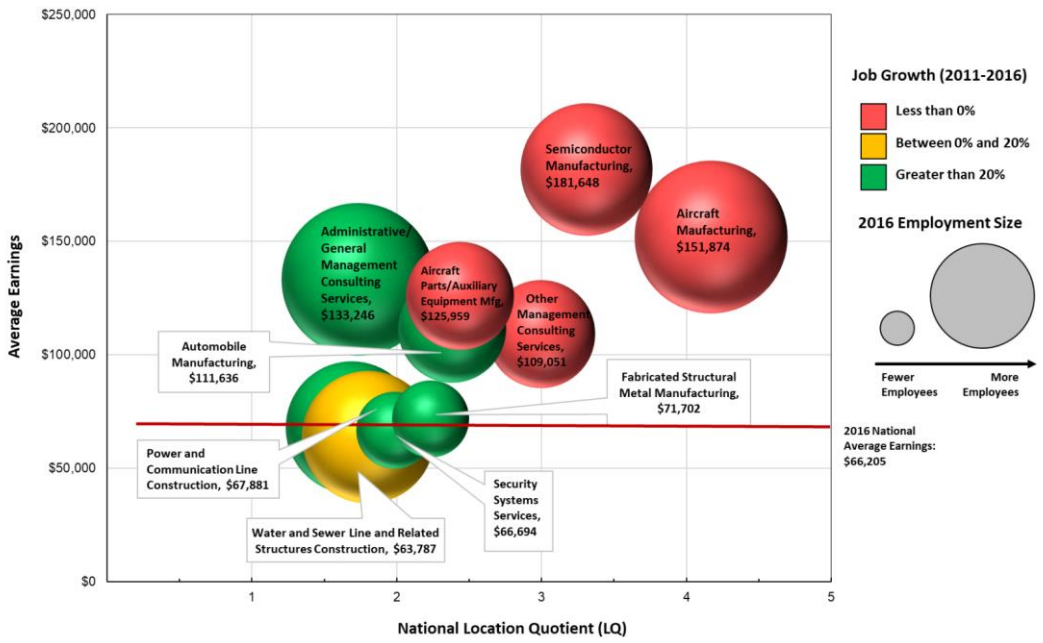
[32] http://www.nctcog.org/CEDS/docs/NCTCOG_CEDS.pdf p. 18

manufacturing, hosting large operations for Bell Helicopter, Lockheed Martin, Safran, and American Eurocopter. These OEMs are further supported by a diverse supply chain that provides the firms with a vast array of products, services, and technologies.

These defense manufacturing and technology centers are further bolstered by the large regional presence of firms focused on commercial aviation, space, telecommunications, and transportation/logistics. In addition to serving as a global center for defense manufacturing, North Texas also hosts one of the world's largest concentrations of air transportation assets. With 27,000 employees American Airlines is the region's second largest employer (behind Walmart), and Southwest Airlines has nearly 10,000 workers ranking it in the region's top 15 employers.[33] The area is home to numerous other firms operating in this cluster. AllianceTexas and the Fort Worth Alliance Airport are also emerging as major centers for global logistics activities.

Beyond aircraft production, the Metroplex has specializations within dozens of other defense cluster industries. Shown in Figure 23, are the Metroplex's most highly specialized (e.g. location

Figure 23: Dallas Fort-Worth Region Employment of Defense-Related Industries



SOURCE: CREC, USING EMSI DATA

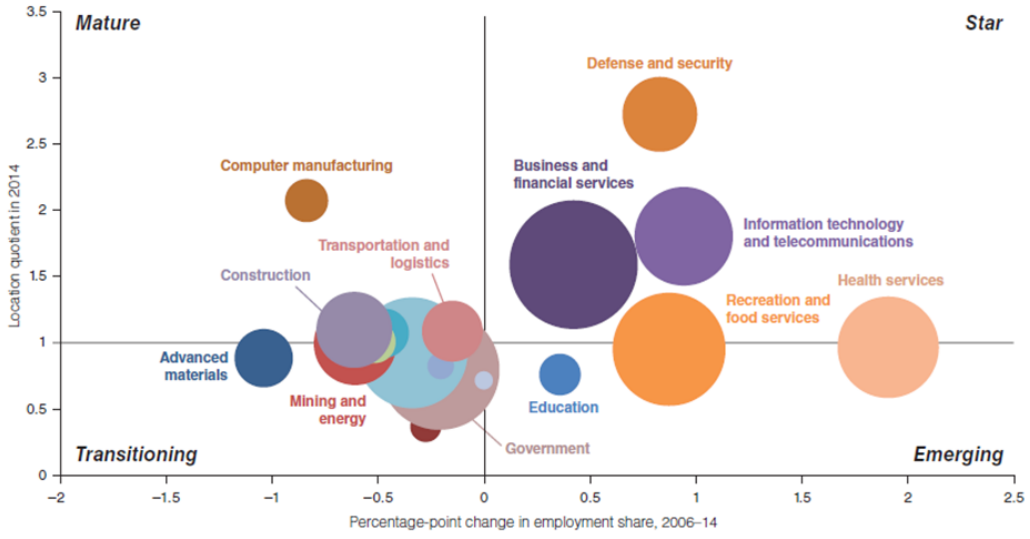
[33] Bill Hethcock, American, "Southwest Airlines' employee counts climbing," Dallas Business Journal, August 18.

quotient) and compensated industries as compared to the nation. Not surprisingly, the DFW region's greatest specialty lies within Aircraft and Aircraft Equipment Manufacturing, meaning the wealth of industry knowledge, expertise, and manpower within the Metroplex ranks among the top in the nation. Secondly, Figure 23 also reveals that job declines since 2011 have marred the largest clusters, including Aircraft and Aircraft Equipment Manufacturing, Semiconductor Manufacturing, Aircraft Parts, and Management Consulting Services. These represent four of the top six DFW industry specializations and reflect most directly the impacts of defense downsizing on the regional economy as well as larger market forces.

Recent Trends

According to the Texas Workforce Commission (TWC), however, defense and security represent one of several "Star" industries in the Dallas-Fort Worth region. Because TWC combines industries in a very different way than the CREC analysis above, the state's analysis shows not only a high specialization in the region based on location quotients, but it also shows an increase in employment share. Figure 24 summarizes the data which looks at the data over a longer time period (including the rapid expansion in the industry that occurred before 2008-2009 recession.

Figure 24: Defense and Security is a "Star" DFW Industry Cluster



NOTE: Bubble size represents cluster share of metropolitan statistical area employment.

SOURCE: TEXAS WORKFORCE COMMISSION AND BUREAU OF LABOR STATISTICS

As the region's defense manufacturers have grown since the early 2000s, several challenges have emerged for area companies. Finding needed workforce talent is undoubtedly the most pressing task facing the region's defense manufacturers. Texas ranked 8th among US states in a

Figure 25: Defense Contracts in Dallas Fort-Worth Region (2013-2016)

NAICS	Industry	DOD Contracts
336411	Aircraft Manufacturing	$ 38,625,265,763
336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing	$ 7,639,860,287
488190	Other Support Activities for Air Transportation	$ 4,459,708,926
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	$ 3,262,367,090
336414	Guided Missile and Space Vehicle Manufacturing	$ 2,441,606,641
334511	Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	$ 1,706,993,652
541330	Engineering Services	$ 1,272,497,080
541614	Process, Physical Distribution, and Logistics Consulting Services	$ 506,983,257
541710	Research and Development in the Physical, Engineering, and Life Sciences	$ 432,176,874
541712	Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)	$ 431,797,159
611512	Flight Training	$ 344,644,991
324110	Petroleum Refineries	$ 333,401,984
333319	Other commercial and service industry machinery manufacturing	$ 274,277,464
336992	Military Armored Vehicle, Tank, and Tank Component Manufacturing	$ 237,718,696
524114	Direct Health and Medical Insurance Carriers	$ 213,625,000
333318	Other Commercial and Service Industry Machinery Manufacturing	$ 179,612,778
541511	Custom Computer Programming Services	$ 161,893,006
424480	Fresh Fruit and Vegetable Merchant Wholesalers	$ 112,514,545
332993	Ammunition (except Small Arms) Manufacturing	$ 109,058,148
333314	Optical Instrument and Lens Manufacturing	$ 104,254,572
	Top 20 Total	**$ 62,850,257,912.04**
	Top 20 as % of Total Dallas Fort-Worth DOD Contracts	**98%**
	Dallas Fort-Worth Contracts Total	**$ 64,387,249,379.02**

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

recent assessment of state aerospace competitiveness; however, the state received its lowest ratings in "workforce availability" where Texas ranked 33rd among US states for the quality and availability of aerospace workers.[34]

As seen in Figure 25, since 2013, Metroplex-based defense contractors have received over $64 billion or roughly 70% of all U.S. Department of Defense (DoD) contracts awarded in Texas. Among the industries receiving defense contracts, the top 20 industries awarded DoD contracts between 2013 and 2016, 98% located their activities in either the City of Dallas or City of Fort

[34] PWC Ranking report Aug 2017

Worth proper. Among the $64 billion awarded, nearly 75% went to aircraft and aircraft parts manufacturing industries. Aircraft production, assembly, and research dominates the regional defense economy. These industries are involved in production of military aircraft (e.g., the F-35 and F16), weapons systems, rocket and missile technology, guidance/control systems, research and development, and military flight training. The region's aerospace and aviation industries servicing the military directly employ more than 40,000 workers across 350 establishments throughout the region. Furthermore, aircraft manufacturing in Dallas Fort-Worth employs over 20,000 workers alone.

Dallas-Fort Worth Value Chain Analysis: Aircraft Manufacturing

The Aircraft Manufacturing industry (NAICS 336411) drives the defense sector in Dallas-Fort Worth. Aircraft manufacturing firms may assemble complete aircraft, implement major modifications to aircraft and aircraft systems, or overhaul, refurbish or restore older aircraft to original specifications. The industry within Dallas Fort-Worth includes major operations of large original equipment manufacturers (OEMs) such as Airbus, Bell Helicopters, Boeing, Lockheed Martin, and Northrop Grumman, among others.[35]

DFW has a higher concentration of aircraft manufacturing industry jobs than the nation, with 22,825 industry jobs in 2016. The total employment number of aircraft manufacturing jobs, however, has declined since 2011, as defense procurement spending has declined and demand for some locally-produced aircraft, such as the F-16 fighter jet, has slowed. As F-16 production moves to South Carolina, industry watchers expect to see a continued loss of local jobs at both prime contractor and subcontractor operations.[36] According to EMSI data, the region is projected to lose another 1,100 aircraft manufacturing jobs between 2016 and 2021.

Even with these pessimistic short-term job and growth projections, the aircraft manufacturing sector represents a major opportunity for medium and long-term growth in the DFW region. The high concentration of activity already in the region and the large employer base means that this sector continues to be vital as a source for job opportunities available to skilled workers,

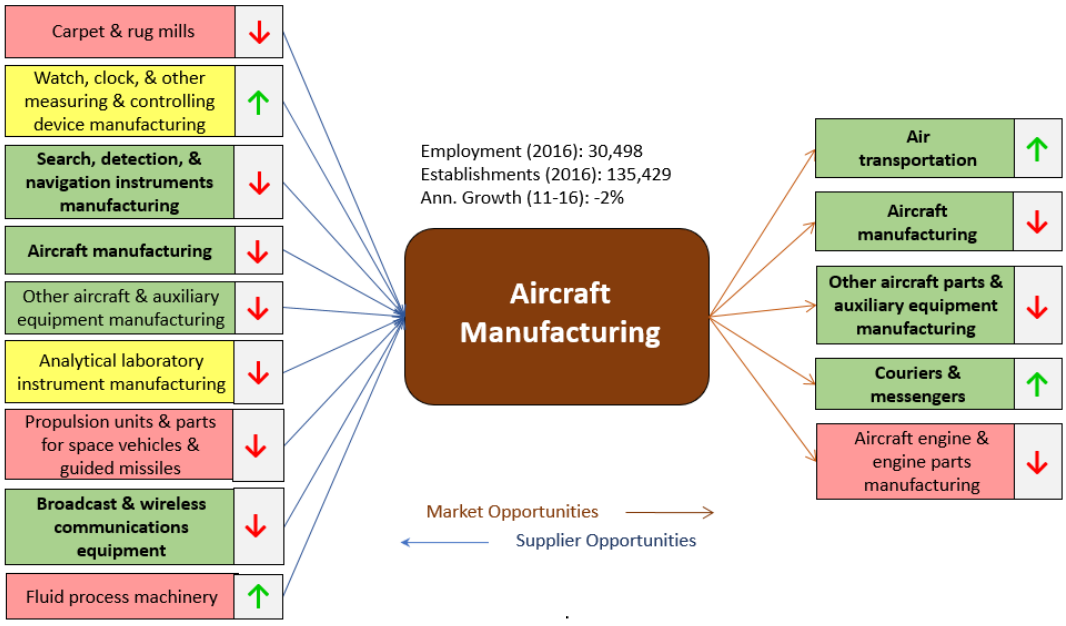
[35] ReferenceUSA

[36] See, for example, Boeing to Dismiss Hundreds of Engineers as Sales Slow Down. Dallas News. April 18, 2017.; Karen Robinson-Jacobs. Up to 400 Laid Off as Vought Shuts Down West Dallas Plant. Dallas News. December 2013; Kerry Lynch. Associated Air Center to Shut Its Doors at Years-End. Aviation International News. September 21, 2017.

ranging from manufacturing technicians to engineers to headquarters management staff. While short-term employment levels are predicted to decline slightly, fast job growth opportunities are likely with the planned ramp up of F-35 production. Finally, the sector provides numerous supply chain opportunities for small and medium-sized enterprises in the region because the F-35 program already provides work for more than 1,400 domestic suppliers, including many in the DFW area.[37]

The following section provides a more detailed analysis of potential value chain opportunities related to the aircraft manufacturing sector in Dallas-Fort Worth. This analysis is based on federal statistics about industry input-output flows used to determine which industries are likely to be connected to one another through buying and selling relationships. The intent is to identify industries and firms that have extensive trading relationships with the state's defense dependent industries and identify those that are experiencing growth or may offer

Figure 26: Aircraft Manufacturing in the DFW Region Core Industry Linkages



SOURCE: CREC, USING EMSI DATA

[37] Lockheed Martin, Powering Job Creation for America and its Allies, https://www.f35.com/about/economic-impact

opportunities for diversification. The analysis focuses on two sets of opportunities—those for firms and industries that supply the region's aircraft manufacturers (Supplier Opportunities) and those firms and industries that purchase goods, services, and technology from the aircraft manufacturing industry (Market Opportunities). Figure 26 summarizes the industries that are most closely tied to aircraft manufacturing as suppliers and customers.

Supplier Opportunities

North Texas and the DFW region have many strengths on the supply side of the aircraft manufacturing industry. The region is among the most densely concentrated regions for aircraft and aircraft parts production in the country. As a result, virtually all aspects of aircraft manufacturing are well-represented within the region, which is home to a deep base of related industries and suppliers.

A host of sectors serve as core suppliers to the DFW aircraft manufacturing industry. One of which is Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing (NAICS 33422) – represented by large companies such as Texas Instruments, CommScope, and Qualcomm – is especially important. These firms supply telecommunications hardware and software services. This line of business is also a core component of unmanned aerial systems (UAS), which supports the region's growing unmanned aerial vehicles (UAV) sector.[38] As the UAV sector grows, it will create major new opportunities for the broadcast and wireless sectors, and in turn benefit from the region's strong competencies in this industry.

Other significant growth opportunities may emerge within the Watch, clock, and other measuring and controlling device manufacturing industry (NAICS 334518) which experienced the greatest net addition of employees between 2011 and 2016, gaining 150 jobs. This is one of the few regional supplier sectors that has grown in recent years. The industry's employment concentration is moderate within the region and is represented by companies such as Hoffman Controls Corporation, Dallas-based Ipico Sports and WilliamsRDM in Fort Worth. Among other things, they manufacture the electrical components and panel display fabrication for aircraft flight instruments.

[38] North Central Texas Council of Governments, *Unmanned Aircraft: Policy, Operations and Local Integration*. April 2015.

Market Opportunities

Military aircraft and related component manufacturing is the DFW region's most important aviation output. While the Dallas-Fort Worth area is home to major commercial airliners such as American Airlines and Southwest, these companies do not purchase military aircraft and related components. Although, purchasing decisions may occur in DFW, nearly all commercial airline production occurs in Seattle, Washington and Greenville, South Carolina.

On the market side, the greatest opportunity for further growth may emerge with the Couriers and Messengers industry sub-sector (NAICS 4921 and 4922). Courier and messenger companies provide intercity and/or local delivery of parcels and documents without operating under a universal service obligation. The industry has added over 6,000 jobs in the Dallas Fort-Worth region alone over the past five years and has a relatively high employment concentration as compared to both the state of Texas and the nation. As the courier and messenger industry continues to evolve and grow, the aircraft manufacturing sector will experience increased market-side opportunity, specifically with unmanned aerial vehicles (UAVs) or 'drones.' Companies such as Amazon, Google, and Uber are currently preparing to implement drone delivery services, and this new form of customer delivery services could provide a robust market for aircraft manufacturing firms in the DFW region who are involved in UAV technology, such as Lockheed Martin, Boeing, Northrup, and a plethora of smaller entities.

The greatest room for improvement among the market side industries may lie with aircraft engine and engine parts manufacturing (NAICS 336412). Like the aircraft manufacturing sector, this industry is technically complex and highly concentrated. It is dominated by a few key players, such as GE Aviation and Pratt & Whitney. Their operations are typically located in the Northeast, and the sector has a small employment footprint in Texas. The Aircraft Engine and Engine Parts Manufacturing sector employs less than 1,000 workers in the Dallas Fort-Worth metro area and has a relatively low employment concentration when compared with the state and nation. Building out the engine and engine part manufacturing sector in Dallas Fort-Worth could provide greater opportunity for the regional aircraft manufacturing industry.

Aerospace and Defense Firms and the North Texas Innovation Ecosystem

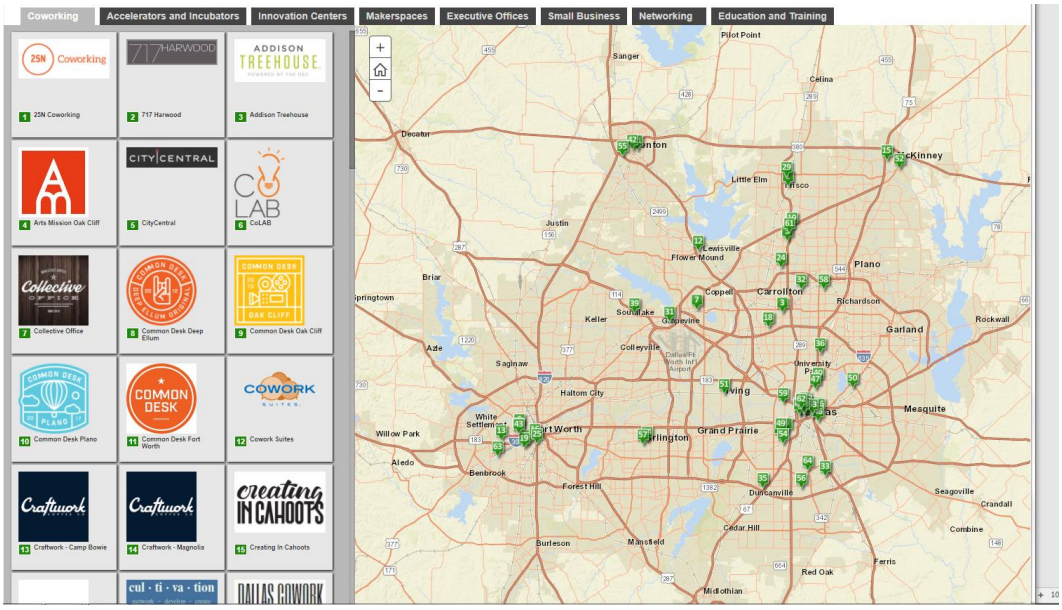
Beyond the pressures generated by rapid industry growth in North Texas, the region's defense firms, especially small and medium-sized subcontractors, face business development challenges like their colleagues in other parts of the U.S. These challenges include identifying new markets and supply chain opportunities, maintaining a technological edge, diversifying their current

customer base, and building more sustainable business models that can persist over the long term.

These challenges are not unique to the A&D sector. They affect most small to medium-sized firms, whether they work in technology, services, retail, or manufacturing. Local firms seeking support to address these challenges can tap into North Texas' deep innovation ecosystem that provides a wide range of services and support for companies at all points of the life cycle. However, many of these offerings may not be adequately targeted to the unique circumstances facing the region's A&D firms.

North Texas has always been home to a strong base of large corporations, banks, and OEMs, and a deep base of related consulting expertise has developed in tandem with these industries. More recently, the region has become a hotbed of entrepreneurial activity, and a whole new set of support organizations, such Tech Ft. Worth, Launch DFW, and others, have emerged.

Figure 27: Dallas-Fort Worth Region Innovation Ecosystem Map



SOURCE: HTTPS://DALLASINNOVATES.COM/INTERACTIVE-MAPS-SHOWCASE-NORTH-TEXAS-INNOVATION/

Within the North Texas Innovation Ecosystem, several categories of support are especially important for defense suppliers and subcontractors:

- Workforce Talent
- Capital
- Business Development and Know-How
- Technical/Engineering Support
- Market Development

Figure 27 is an existing website providing a listing of resources on the region's innovation ecosystem. Figure 28 below provides a snapshot of key service needs and service providers operating in North Texas.

Workforce Talent

Workforce intermediaries providing help to aerospace firms can and should be considered as essential cogs in the regional innovation ecosystem, with services and programs addressing strategies for growth in A&D and related sectors. North Texas A&D industry firms indicate that they cannot find the talent and skill sets they require. This challenge is not unique, but its scope is unparalleled because of the size of the regional industry. As the region grows quickly, Metroplex's talent demand and talent supply gap is becoming increasingly severe. With several recent corporate expansions and relocations to North Texas, local leaders expect these talent pressures to worsen.

Figure 28: Dallas-Fort Worth Region Strategic Innovation Assets

Issue Area	Types of Support Services	Area Service Providers/Resources
Talent Development	Workforce Training, Classes, HR services	North Texas Workforce Consortium, Local WIBs, Colleges, K-12 systems
Capital	Loans, Equity Investments, Working Capital, Coaching	Banks, VCs, angels, SBIR
Business Development and Know-How	Peer Networks, Professional Development, Training Programs	TMAC, SBDC, colleges, Chambers of Commerce
Technical/Engineering Support	Access to equipment, engineering support, technology development and commercialization	TMAC, colleges, accelerators/incubators
Market Development	Export promotion, Supply chain connections	SBDC, TMAC

The severity of the region's talent shortages prompted concerted and consequential actions from a strong public private partnership based at the Dallas-Fort Worth Regional Leadership Council. The DFW Regional Aerospace Consortium has been working since 2003 to encourage young people to consider and pursue careers in A&D-related fields. This effort engages representatives from major OEMs, such as Lockheed Martin and Bell Helicopter, and is nationally recognized for programmatic excellence.[39]

The Consortium has developed a host of programs and tools to spark interest in aerospace careers. These include a gaming app (FlyBy), several career awareness programs for local schools, and new aviation training programs developed in a partnership between Lockheed, Tarrant County Community College, and the Community Learning Center.

The Consortium and its partners now provide a diverse array of services and workforce training/placement programs that are actively used by the region's defense contractors. [40] Beyond the career awareness and training programs cited above, other initiatives include:

- On-the job training for incumbent workers and engineers
- The Engineer Job Connect program established to find employment for displaced local engineers and to reduce the need for importing foreign engineering talent.
- A regional industry forum where corporate leaders can share talent needs and challenges
- A Career-Technical Education Committee where industry leaders can provide inputs on new curriculum for the K-12 system

However, these programs have not been sufficient because they cannot meet local demand levels and local leaders recognize that additional efforts are needed, especially as local demand for skilled workers does not appear to be slowing.

Capital

When compared to other industries, capital does not pose the most pressing challenge for most defense contractors. Large firms can tap into finance markets as needed, and smaller firms typically rely on progress payments to support their working capital needs. However, newer

[39] A new survey of regional talent challenges in the A&D sector will be released in December 2017.

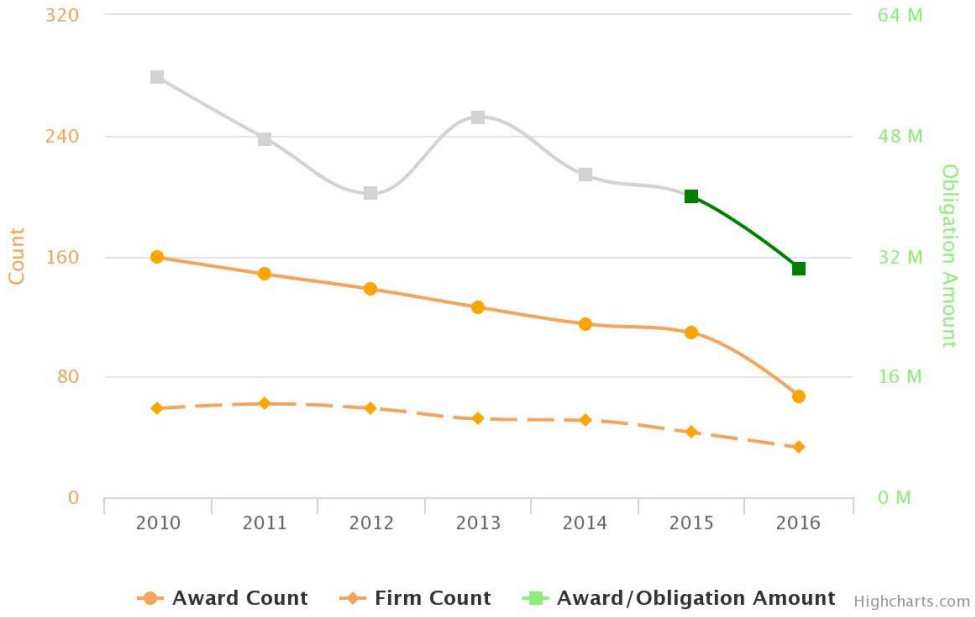
[40] See their annual report at : http://www.wfsdallas.com/resources/docs/board/2015%20rwlc.pdf also http://www.nawb.org/forum/documents/workshops/GrowingTalentPipeline.pdf

technology-based companies and firms operating in both defense and commercial markets may face challenges in obtaining funds for growth and expansion.

The North Texas ecosystem is rich with potential sources of both debt financing as a regional banking center with several community development financial institutions and certified development corporations. The area also has a sizable equity financing network as well, with numerous local venture capital firms and several large angel networks operating in the region.

However, the region's recent performance in accessing equity capital markets has been underwhelming. A recent Baker Institute analysis found that, over the past decade, venture capital investment in Texas declined by 19 percent at a time that national VC investments jumped by more than 100 percent.[41] Dallas' performance was especially weak with the number of local firms receiving VC investments each year declining from around 20 to ten per year. By comparison, Austin sees roughly 30-40 private equity placements each year even though the community is significantly smaller in size. Regional data on angel investments is not available

Figure 29: DoD SBIR-STTR Awards in Texas, 2010-2016



SOURCE: SBIR DASHBOARD, WWW.SBIR.GOV

[41] https://www.bakerinstitute.org/files/10556/

while Austin and Houston have much more active angel investor groups.[42]

Data also suggests that Texas, and the Dallas/Fort Worth region, could improve efforts to help defense suppliers access other sources of public funds. In this arena, the Small Business Innovation Research (SBIR) is an excellent resource. Yet, Texas firms do a poor job in accessing SBIR grants, and as illustrated in Figure 29, the number and volume of SBIRs have declined rapidly during the past several years.

Business Development and Community Know-How

Owners of small and medium-sized enterprises, especially in fields like manufacturing, face significant challenges in key areas like business development, marketing and operations. Many firms lack established systems for planning, human resources development, and marketing/sales, and firm managers often lack the time or resources to obtain new skills or to upgrade existing competencies.

Company owners can acquire new skills and state of the art knowledge in multiple ways. At the most formal level, professional education resources, such as executive MBA programs, are an option. Seminars and workshops for professional skills, such as those offered by the Texas Manufacturing Assistance Center and local Chambers of Commerce, are a more frequently-used option. Finally, networking, coaching and mentoring offer valuable opportunities to dig deeper and learn directly from peers and industry experts.

The Dallas/Fort Worth region has an extensive network of business development resources. Higher education partners include the University of North Texas, UT-Dallas, UT-Arlington, and other area colleges and universities. These institutions operate relevant programs and research centers, such as UT Dallas's Center for Innovation and Entrepreneurship and UNT's Center for Logistics Education and Research. A host of business service providers complement these institutions with regularly sponsor workshops and training programs on important business issues. These groups include TMAC, local Small Business Development Center programs, local Chambers of Commerce, and industry-specific groups like the Dallas County Manufacturers Association and the Lone Star Chapter of the National Defense Industrial Association.

Despite the rich array of local resources, defense-focused entrepreneurs sometimes face obstacles in accessing business development resources and connections. Many of these

[42] Angel Resource Institute, ACA Halo Report 2016

programs are geared toward technology start-ups, focusing on business planning and other early stage issues that are less relevant to more established companies. At the same time, training and workshops offered to manufacturers have often targeted specific challenges like lean manufacturing or specific certifications. These workshops are essential, but new business development and company growth will require more than specific point solutions. They require deeper dives and deeper relationships, often via connections to a coach, mentor, or peers. These deeper ties can better aid managers in thinking more systematically about future trends, market developments, and how their companies can best capture them.

These connections are difficult to access in all regions, and Dallas/Fort Worth is no exception. A few model efforts are in place. For example, in Richardson, TX, the Richardson Economic Development Partnership enjoyed great success with a pilot Economic Gardening program that provides specialized services to local high growth companies. Several defense suppliers tapped these services, and enjoyed great benefits. For example, Optex Systems, a local producer of optical coatings, tapped the program for new market intelligence to help it grow in defense markets and target new commercial markets in the medical device sector.

Additionally, despite large corporations and OEMs thriving, and a more robust ecosystem targeting technology start-ups is emerging thanks to efforts like the Dallas Innovation Alliance and the Dallas Entrepreneur Center, specialized resources for more established companies in A&D, such as technology commercialization and new market development programs, remain somewhat limited. These A&D firms tend to be larger and more established: the average high grower Texas defense firm employs more than fifty people. These firms are not start-ups, and will instead require support services focused on second stage and middle market companies. Other pressing industry challenges also stem from the region's rapid growth. Infrastructure shortfalls are regularly highlighted in surveys of regional business leaders.[43]

Technical/Engineering Support

Defense suppliers and manufacturers operate in demanding markets where technological excellence in both products and processes is a core ingredient for success. Process excellence, in terms of speed, quality, and reliability, is a base requirement to operate in global supply chains. Once firms have built close connections to OEMs, they cannot rest on their laurels.

[43] http://www.nctcog.org/CEDS/docs/NCTCOG_CEDS.pdf See appendix/SWOT

They must constantly reinvent themselves and support continuous process improvements. At the same time, they must invest to develop new products, processes, and technologies.

Local firms would benefit greatly from assistance with technical and engineering challenges. Several types of services and support are needed. First, firms could tap into engineering advice and support to help optimize production processes. Second, they would benefit from low cost access to specialized equipment, such as testing tools or 3-D printers for prototyping. Finally, financing to help with high-risk R&D would also aid new technology development and deployment.

In recent years, the DFW metro has spawned a larger number of incubators, accelerators, maker spaces, and innovation centers.[44] At present, none of these emerging centers or workspaces is focused on opportunities in the aerospace or defense sectors. However, these new institutions are part of an emerging innovation ecosystem in the DFW metro area.

Local leaders are aware of regional shortfalls in this area of technology commercialization and development, and local leaders have attempted several approaches to addressing those challenges. For instance, the Texas Research Alliance, a regional collation, has pushed since 2014 to increase and enhance the role of local universities in supporting technology-based economic development. In addition, in 2010, the Arlington Chamber of Commerce announced an ultimately unsuccessful effort to support TechComm (Technology, Commercialization & Manufacturing), a partnership with the University of Texas at Arlington commissioned an ultimately unsuccessful effort to commercialize federal technologies in an eight-state area. TechCommm was also a cooperative high-tech business accelerator funded with support from the U.S. Department of Defense to translate defense technology research from the lab to the market in a way that would support the troops. Through this effort, the Arlington Chamber of Commerce was also working with the North Central Texas Council of Governments to build a stronger regional presence in the UAV sector.[45]

While TechComm was not successful as envisioned, it helped to support the capacity of the region to attract research and development investments. These and other efforts are starting

[44] See map at https://dallasinnovates.com/the-enterpreneurs-arsenal-interactive-maps-dfw-innovation-ecosystem/

[45] NCT COG UAV report, 2015

to pay dividends in other ways. For instance, in 2016, the three local universities achieved Carnegie Tier 1 research status for the first time.[46] Each of the universities is significantly upgrading their facilities and research capacities as well. For example, UT-Arlington is presently constructing a new $125 million science and research center, slated to open for business in 2018.

Market Development

A&D SMEs regularly identify new market development as one of their most pressing challenges. As a recent PwC analysis noted:

> *The combination of unexpected competitive pressures and a more frugal customer base is a one-two punch that the defense industry has never quite faced before. And it has prompted many A&D companies to pull in their horns, conserving their capital and returning cash to shareholders in the form of dividends and buybacks — rather than pursuing aggressive innovation or embarking on improving internal capabilities to better navigate shifting industry conditions.* [47]

Small and medium-sized contractors do not have the option of "pulling in their horns." They must find new markets or go out of business. This is often easier said than done, but firms can transform with the right mix of forward-thinking management and outside support services. Managers must address internal management, technology development, and process issues while also seeking new markets, customers, and partners.

As they seek to enter new markets, defense firms face several options. Exporting can and should be a high priority. While there are some potential limits on the size of overseas military markets,[48] many companies and regions in other states have enjoyed success in helping defense companies shift into foreign markets. For example, Virginia's Going Global Defense Initiative has proved highly successful, providing coaching and market intelligence to 280 different companies in recent years.

Other strategies involve entering new commercial markets or identifying new niches in domestic defense markets. Again, numerous potential opportunities, in sectors like

[46] https://www.texastribune.org/2016/02/02/unt-ut-arlington-and-texas-tech-reach-carnegie-tie/

[47] https://www.strategyand.pwc.com/trends/2016-aerospace-and-defense-industry-trends

[48] https://www.mckinsey.com/industries/aerospace-and-defense/our-insights/international-defense-sales

cybersecurity and UAVs, exist. In addition, DFW-based companies can also attempt to tap into opportunities emerging in Austin with its thriving technology ecosystem and an outpost of the DoD's Defense Innovation Unit-Experimental (DIUx) program. Formal programs or networks to build supply chain connections would also benefit the region's supplier base.

At present, the DFW metro area is not well positioned to provide these kinds of market development services to local A&D firms. Managers can tap into many traditional programs such as those led by SBDCs, TMAC, and local economic development agencies and Chambers of Commerce. However, many of the targeted support initiatives found in other parts of the U.S. do not presently exist in Texas. For example, North Texas is not home to a dedicated export promotion effort akin to those found in other regions and states like Pennsylvania, Virginia, or Washington. In addition, state leaders are just now developing capabilities to map statewide and global supply chains and to identify potential connections for smaller defense suppliers. However, there is no systematic means for smaller firms to learn about or tap into these emerging opportunities. The region's defense industry-focused initiatives are presently focused more on workforce development over other challenge areas.

Dallas-Fort Worth Innovation Ecosystem Summary

Dallas-Fort Worth is a global business center and a critical hub for the state's defense economy. North Texas is among the most heavily defense-dependent regions in the U.S.—home to some of the world's largest defense firms and a leading location for technology development and weapons systems production. Few other regions around the nation can compete with North Texas in terms of employment concentration and depth of expertise in Aerospace & Defense. Employment concentrations in the DFW A&D sector are roughly 5 times higher than the national average.

Despite having deep A&D specialization, and many organizations and services in the region to help support businesses and workers, more can be done to promote the North Texas innovation ecosystem and defense economy. This includes more opportunities to coordinate, expand, and promote services in the areas of workforce talent, capital, business development and know-how, technical/engineering support, and market development. With an increased focus on developing the region's innovation ecosystem, DFW will be in even better position to expand upon its many A&D assets and also to capitalize on the pockets of opportunity that offer promising targets for enhanced defense diversification support efforts.

An Assessment of the Defense Sector in the Houston Region

With defense contractors in the region receiving $6 billion, the Houston region is an important location for A&D companies and significant to much of the state's defense economy. This section provides a profile of the structure of the Houston defense sector and the key economic segments that make up the defense-related supply chain in the region. Besides providing an overview of the region's economy and its specific strengths related to the defense economy, the profile also includes a value chain analysis that examines an emerging defense cluster industry. Houston has long been a center for petroleum production, but the regional profile considers another important industry within the region's defense landscape - Turbine & Turbine Generator Manufacturing. The Houston profile also discusses the possibilities for the region from its connection to NASA and space exploration. The regional profile ends with a discussion of current innovation assets and potential areas of both strengths and weaknesses.

Houston Economic Overview

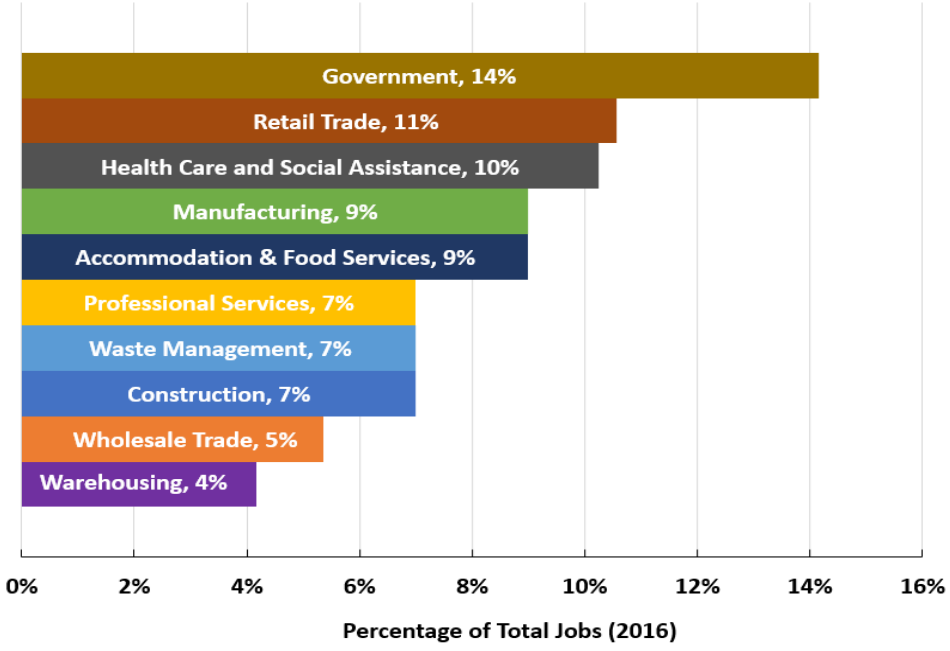
The Houston metropolitan region is the second largest population and employment center in Texas. The region is home to over 6.7 million Texans and in 2016, employed nearly 2.8 million workers, second to only the Dallas-Fort Worth Metroplex. The Houston economy was responsible for more than $478 billion in real gross domestic product according to the Bureau of Economic Analysis.

Figure 30 shows that government, health care, and retail trade are the largest employing industries in the state. These three sectors together accounted for more than one-third of total regional employment in 2016. The region's health care and social assistance industry, responsible for 10 percent or 313,346 jobs in the region, is underpinned by the Texas Medical Center (TMC), the world's largest medical center.[49] TMC is a 54-institution medical complex, employing upwards of 106,000 individuals and generating $25B in GDP.[50]

[49] Colliers International. 2016. "Houston Economic Outlook: Research & Forecast Report" http://www.colliers.com/en-us/texas/houstonoccupieradvisorsteam/marketnews/he2016

[50] Texas Medical Center. 2017. "Facts and Figures." http://www.tmc.edu/about-tmc/facts-and-figures/

Figure 30: Distribution of Houston Region Employment by Industry Sector (2016)



SOURCE: EMSI

The manufacturing sector is an invaluable aspect of employment in the Houston region, employing nearly 222,000 workers in 2016, or about 8 percent of total employment in Houston. The manufacturing sector includes jobs central to oil and gas refining that support U.S. military fuel consumption and other energy needs. Other jobs captured by the manufacturing industry include those leveraged by the presence of NASA's Johnson Space Center[51] which supports the International Space Station and space travel. Professional, scientific, and technical services, which include jobs critical to the innovation economy, accounted for more than 200,000 jobs or seven percent of all jobs in Houston in 2016.

The Houston-Woodlands-Sugar Land metro area is rich with economic assets, and with its geographic proximity to the oil reserves in the Gulf of Mexico, the region is a recognized leader in oil and gas production. In 2016, 36% of the nation's crude oil was produced in Texas, half of

[51] National Aeronautics and Space Administration. Nd. "Manufacturing Services: Manufacturing Planning Guide." https://www.nasa.gov/centers/johnson/pdf/639524main_Manufacturing_Planning_Guide.pdf

which was produced from offshore wells in the Gulf of Mexico.[52] The Houston region is well-positioned to continue to leverage these resources—boasting national assets important for both onshore and offshore oil and gas production and processing—to support the state of Texas and the nation more broadly in the production of energy.[53]

The Houston-Woodlands-Sugar Land metro has been described as "The Energy Capital of the World" and is the site of more than 5,000 energy-related firms.[54] Houston serves as the headquarters for 20 Fortune 500 companies, and while there are Fortune 500 companies in the region that are not energy related, such as Sysco, most of the list encompasses major energy sector companies. Energy-focused Fortune 500 companies in the Houston region include Phillips 66, Conoco Phillips, Enterprise Products Partners, Halliburton, and Anadarko Petroleum.[55] Other energy focused companies with operations in the area include ExxonMobil Chemical BP America, Shell Oil, and Citgo.[56]

Many of these companies are in Houston's Energy Corridor, a business improvement district in Harris County, spanning a 7-mile stretch of the Interstate 10 and responsible for 105,000 jobs.[57] The impact of the corridor is much broader though, with local communities within a 30-minute commute zone of the Corridor employing nearly 800,000 persons. This critical mass and demonstrated impact energy-related industry in the Houston region, suggests that energy-related industry plays a central role in the overall economic situation of the region. The

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[52] U.S. Energy Information Administration. 2016. "Where Our Oil Comes From. *Oil: Crude and Petroleum Products.* https://www.eia.gov/energyexplained/index.cfm?page=oil_where

[53] U.S. Energy Information Administration. 2017. "Gulf of Mexico Fact Sheet." https://www.eia.gov/special/gulf_of_mexico/

[54] Office of the Governor, Economic Development & Tourism Division. 2015. "Petroleum Refining and Chemical Products." *Texas Wide Open for Business.* https://businessintexas.com/sites/default/files/06/25/15/petroleum.pdf

[55] Greater Houston Partnership, "Corporate Headquarters," 2017.

[56]Colliers International. 2016. "Houston Economic Outlook: Research & Forecast Report" http://www.colliers.com/en-us/texas/houstonoccupieradvisorsteam/marketnews/he2016

[57] CDS Market Research. 2016. "The Energy Corridor District Land Use and Demographics." Databasehttp://energycorridor.org/sites/ecd/media/Resource%20Library%20Docs/Energy_Corridor_MD_2016_Report_Final-web.pdf

prevalence of such industry in the region also suggests Houston as the underpinning of Texas' position as the largest producer and consumer of energy by any state in the nation. [58]

A major component of the distribution for oil and gas is the Port of Houston, considered a hub for southeastern domestic oil production and the largest petrochemical port in North America.[59] The Port of Houston has long established itself as the preeminent economic driver for the Houston region and a significant contributor to bolstering the state of Texas' overall economic wellness. Houston's port ranked as the top U.S. port by Foreign Waterborne Tonnage and for moving steel, project cargo, and petroleum.[60] In 2016, the port was responsible for more than $250 billion of economic impact. [61] Labeled "the most irreplaceable port" in North America by Toronto commercial real estate brokerage Colliers International, the Port of Houston is the busiest port in the nation in terms of foreign tonnage, and the 13th busiest in the world; handling 13 million tons of cargo a year and 8,300 vessel stops.[62]

The Houston average annual unemployment rate (5.2%) in 2016 is above the state and national rates (4.6% and 4.9% respectively).[63] The region's unemployment rate consistently decreased from 2012 to 2015, down 2 percentage points, then experienced a moderate increase in 2016. By October 2017, the rate had fallen further to 4.1 percent (despite the temporary impacts of Hurricane Harvey), slightly above the national rate for all metropolitan areas.[64] The average

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[58] U.S. Energy Information Administration. 2017. "Texas: State Profile and Energy Estimates." *U.S. Department of Energy*. https://www.eia.gov/state/analysis.php?sid=TX

[59] Yu, Roger. Houston port reopens cargo terminals while waterways access remains limited. USA Today. Accessed at: https://www.usatoday.com/story/money/2017/09/01/houston-port-reopens-cargo-terminals-business/625479001/

[60] Port of Houston Authority. 2016. "The Port of Houston: A Major Economic Engine at Work." https://www.houstontx.gov/controller/investorrelations/2016invconf/Port_Of_Houston.pdf

[61] Port Houston. nd. "Economic Impact." http://porthouston.com/portweb/about-us/economic-impact/

[62] Collier, Kiah. 2013. "Houston has the busiest seaport in the U.S." *Houston Chronicle*. http://www.chron.com/discoverhouston/article/Houston-has-the-busiest-seaport-in-the-US-4486844.php

[63] U.S. Bureau of Labor Statistics, 2016 annual averages

[64] U.S. Bureau of Labor Statistics, Unemployment Rates for Metropolitan Areas, Not Seasonally Adjusted, https://www.bls.gov/web/metro/laummtrk.htm

Figure 31: Houston Region Industries with High Specializations

NAICS	Industry	2016 Jobs	LQ
211	Oil and Gas Extraction	51,035	14.0
486	Pipeline Transportation	10,980	10.9
213	Support Activities for Mining	36,830	6.6
324	**Petroleum and Coal Products Manufacturing***	**9,953**	**4.4**
483	Water Transportation	4,317	3.2
491	Postal Service	370	2.7
237	**Heavy and Civil Engineering Construction***	**48,546**	**2.5**
325	**Chemical Manufacturing***	**38,110**	**2.3**
481	Air Transportation	21,359	2.2
488	Support Activities for Transportation	29,041	2.2
333	**Machinery Manufacturing***	**45,114**	**2.0**
236	**Construction of Buildings***	**56,214**	**1.9**
332	**Fabricated Metal Product Manufacturing***	**49,319**	**1.7**
532	Rental and Leasing Services	17,245	1.5
423	**Merchant Wholesalers, Durable Goods***	**92,011**	**1.5**
221	**Utilities***	**15,916**	**1.4**
562	Waste Management and Remediation Services	11,329	1.4
814	Private Households	7,907	1.4
238	Specialty Trade Contractors	108,969	1.3
811	**Repair and Maintenance***	**32,795**	**1.2**

SOURCE: EMSI, 2016 DATA

wage for workers across all industries in the region is $ $77,667, which exceeds the national average of $66,205.[65]

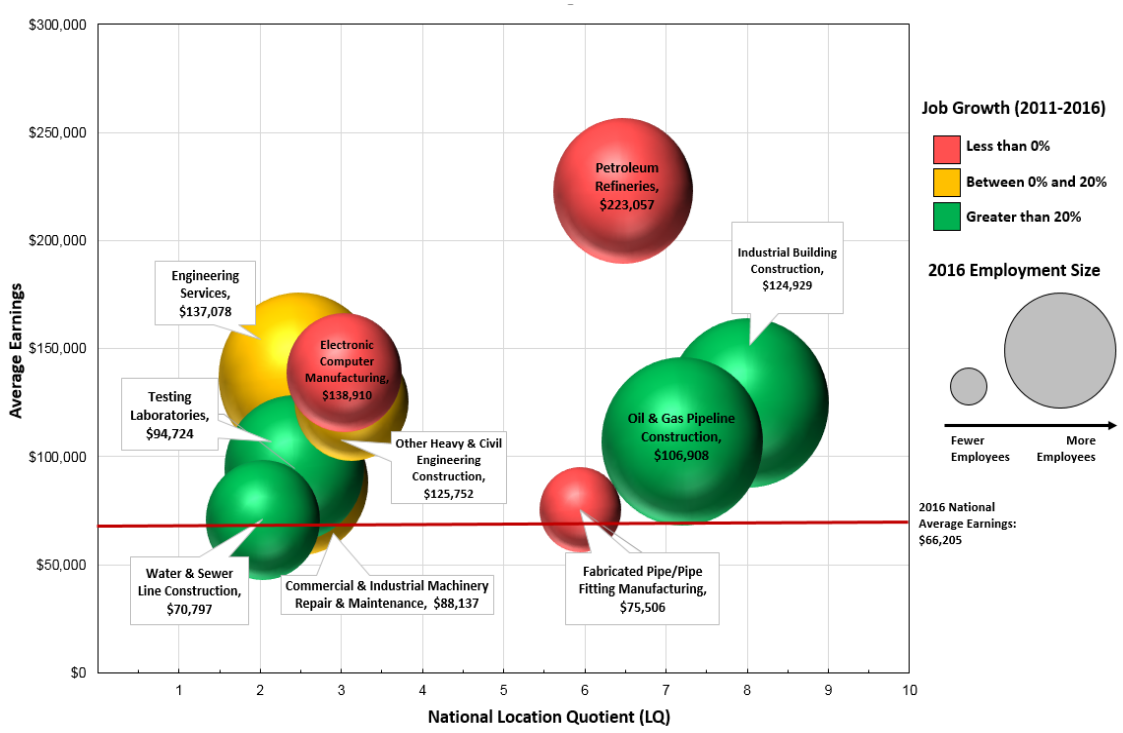
Houston Defense Economy

Houston has 20 3-digit NAICS industries with high concentrations of employment relative to (i.e., greater than 20 percent above) the industry's share nationally (Figure 31). These high rates are measured as location quotients, and an LQ of 1.2 means that the region has about 20 percent more employment than would be otherwise expected – indicating a local concentration due to unique economic characteristics. These 20 highly concentrated industries account for more than 687,000 jobs or 24 percent of all jobs in Houston. Nine industries, and presumably

[65] EMSI, 2016 average earnings

many of the businesses in these sectors, are either performing defense-related contract work or can be considered to be part of a broader defense value chain. The industries are Petroleum and Coal Products Manufacturing (NAICS 324), Heavy and Civil Engineering Construction (NAICS 237), Chemical Manufacturing (NAICS 325), Machinery Manufacturing (NAICS 333), Construction of Buildings (NAICS 236), Fabricated Metal Product Manufacturing (NAICS 332), Merchant Wholesalers, Durable Goods (NAICS 423), Utilities (NAICS 221), and Repair and Maintenance (NAICS 811). Together these "Defense Cluster" industries employ more than 388,000 jobs (or 13 percent) of all Houston area workers in 2016.

Figure 32: Houston Region Employment of Defense-Related Industries



SOURCE: CREC, USING EMSI DATA

Figure 32 highlights key characteristics about the Houston area's 10 most highly specialized defense-related industries. The chart provides data on employment size, growth, earnings, and employment concentration. These industries all had average earnings greater than the national average ($66, 205) and regional job concentrations that exceeded job concentrations of the industry at the national level. Additionally, 7 of the 10 industries shown added employment between 2011 and 2016 with industrial and pipeline construction industries leading the way.

Four industries were more than five times as concentrated in the Houston metro as in the nation—Petroleum Refineries, Oil & Gas Pipeline Construction, Industrial Building Construction, and Fabricated Pipe/Pipe Fitting Manufacturing Industries. These industries, given their relevance as upstream or downstream components of the oil and gas value chain, are essential to buttressing Houston's national leadership in oil and gas related industry. Industrial Building Construction demonstrated the greatest strength among the region's defense-related industries, with average earnings for that industry almost twice the national average. While Petroleum Refineries experienced job losses in recent years, it persists as a significant regional economic driver and paid workers at levels that were more than three times the national average.

Figure 33: Defense Contracts in Houston Region (2013-2016)

NAICS	Industry	DOD Contracts
324110	Petroleum Refineries	$ 4,243,868,617
483111	Deep Sea Freight Transportation	$ 391,459,825
524114	Direct Health and Medical Insurance Carriers	$ 194,388,000
561210	Facilities Support Services	$ 175,458,587
621491	HMO Medical Centers	$ 139,716,161
236210	Industrial Building Construction	$ 59,795,517
324191	Petroleum Lubricating Oil and Grease Manufacturing	$ 58,574,061
221122	Electric Power Distribution	$ 52,016,905
541712	Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)	$ 49,863,468
336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing	$ 47,054,690
332510	Hardware Manufacturing	$ 34,476,098
325120	Industrial Gas Manufacturing	$ 30,849,718
334515	Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	$ 30,142,575
541330	Engineering Services	$ 29,048,188
333611	**Turbine and Turbine Generator Set Units Manufacturing**	**$ 26,640,169**
562910	Remediation Services	$ 24,333,469
211111	Crude Petroleum and Natural Gas Extraction	$ 23,875,547
424480	Fresh Fruit and Vegetable Merchant Wholesalers	$ 18,504,235
237990	Other Heavy and Civil Engineering Construction	$ 18,038,985
236220	Commercial and Institutional Building Construction	$ 16,349,228
	Top 20 Total	**$ 5,664,454,044**
	Top 20 as % of Total Houston DOD Contracts	***94%***
	Houston Contracts Total	**$ 6,000,856,459**

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

Petroleum Refineries are also critical to the Department of Defense footprint in the region. Businesses in Houston received more than $6 billion in DoD contract awards between 2013 and 2016 (See Figure 33).[66] More than 70 percent of the awards in the region were to Petroleum Refineries, with the overall amount being about 11 times more than Deep-Sea Freight Transportation, the regional industry receiving the next greatest dollar volume of DoD contracts between 2013 and 2016. Further, Petroleum Refineries in Houston fielded more than half the total contract dollars awarded to the industry for the entire state.

Houston is a hub for petroleum in the state of Texas, and given its proximity to the Gulf, also plays an integral role in facilitating deep sea freight transportation from its port. Overall, the Top 20 industries in Houston receiving DOD contract awards account for 94% of all contracts awards between 2013 and 2016.

Houston's leadership, particularly as the engine of the U.S. petroleum industry, might also figure integral to the matrix of communities supporting DoD's ongoing energy needs. The DoD is the largest consumer of energy in the United States, with 70 percent used by the Defense department for operation energy. [67] Operational energy is "energy required for training, moving, and sustaining military forces and weapons platforms for military operations" and includes energy used by ships, aircraft, combat vehicles and tactical power generators."[68] While there are efforts to decrease petroleum consumption, seeking to explore and implement the use of alternative fuels to increase energy efficiency, petroleum persists as a staple of fuel harnessed to sustain DoD operations—in FY 2014, DoD consumed 84.7 million barrels of fuel.[69]

Fuel support for the DoD is often sourced from Defense Fuel Support Points (DFSP), strategically positioned in regions, both domestic and international, conducive to best

[66] www.USAspending.gov, based on DOD contracts "place of performance".

[67] Office of the Assistant Secretary of Defense.2016. "Department of Defense Annual Energy Management Report." https://www.acq.osd.mil/eie/Downloads/IE/FY%202015%20AEMR.pdf

[68] Office of the Assistant Secretary of Defense for Energy, installations, and Environment. Nd. "Operational Energy." https://www.acq.osd.mil/eie/OE/OE_index.html

[69] Department of Defense. 2016. 2016 "Operational Energy Strategy." https://www.acq.osd.mil/eie/Downloads/OE/2016%20DoD%20Operational%20Energy%20Strategy%20WEBc.pdf

leveraging military assets. Domestically, Houston is the site of Texas' only Defense Fuel Support Point (DFSP) and one of two sub-regional offices for the Defense Logistics Agency (DLA) Energy Americas.[70] This DLA program support the Department of Defense and other government agencies through the procurement and delivery of fuel for federal and military purposes.[71] While the only military installation in Houston is the Coast Guard Air Station Houston, the DLA Energy America at Houston serves a broader expanse of military operations across the nation. The DLA Energy Americas East at Houston is responsible for the transport of fuel to support national DoD operations, helping 300 military bases across the nation meet their jet fuel and natural gas needs. [72]

Given its economic significance, petroleum refining in the Houston region is the focal point for much of the region's defense-related investment in energy-related sectors. Industries proximate to petroleum refining, such as those part and parcel to upstream operations like oil and gas extraction, as well as downstream operations like distribution of petroleum products and the broader generation, transport and transmission, of energy, benefit from the industry's prominence in the Houston region. Importantly, several industries pivotal to the refining and transport of fuel are not only invaluable to the Houston MSA's economic well-being, but also foundational to DoD operations. An example of an industry that is elemental to the value chain of energy generation, yet is less prominently positioned compared to other industries in the value chain, is the turbine and turbine generator set units manufacturing industry.

The importance of the turbine and turbine generator set units manufacturing industry from a DoD perspective is in part quantified by the $26.6 million contract dollars awarded to establishments in this industry from FY 13-16. The value of the industry communicated via DoD contract dollars captures a portion of the economic impact realized as a function of the products and services provided by manufacturers in this industry. Turbine and turbine generator set units manufacturers are responsible for the versatile technology foundational to supporting power systems across the spectrum of energy production. Turbines and turbine

[70] Defense Logistics Agency. Nd. "Americas." *DLA Energy*. http://www.dla.mil/Energy/Locations/Regions/Americas.aspx

[71] Defense Logistics Agency. Nd. "What DLA Energy Offers." *DLA Energy*. http://www.dla.mil/Energy/Offers.aspx

[72] Ibid.

generators are incorporated in the extraction and refining of crude oil, the systems that propel tanks, jets, and helicopters, as well as the generation of electrical energy at power plants.

Houston Value Chain Analysis: Turbine & Turbine Generator Manufacturing

The turbine and turbine generator set units manufacturing industry is integral to the production of commercial, electrical energy. Within this industry, companies produce and repair turbines and turbine components, fundamental mechanisms for transforming into electricity, resources such as coal, crude oil, natural gas, wind, and nuclear power. The state of Texas generates electricity across a variety of energy sources, both traditional and sustainable, generating and consuming more electricity than any state in the nation.[73]

In some ways, this leadership might be attributed to Houston's turbine and generator set units manufacturing industry, which is responsible for 564 jobs – more than half of the industry's job presence in the state of Texas. As a result, many aspects of the energy production process, from industries that produce the inputs necessary for turbine manufacturing (i.e. metal valve manufacturing) to the industries that utilize turbines and turbine generator sets (i.e. electric power generation, transmission, and distribution) are co-located in the Houston region and exist at more concentrated levels than in other regions of the state.

Original Equipment Manufacturers (OEMs) at the forefront of innovation with respect to efficient power plant systems and turbine and generator technology such as General Electric (GE) and Siemens, while not headquartered in Houston, play an integral role in supporting the regional turbine and turbine and turbine generator set units manufacturing industry via their Houston-based operations. Other companies driving impact in the region include small-to-medium manufacturers such as Ethosenergy Light Turbines LLC, Allied Power Group, and RWG (Repair and Overhauls).

As Texas sustains its lead in energy production and continues exploring ways to harness its renewable energy potential across wind, solar, and biomass resources,[74] the turbine and turbine generator manufacturing is, importantly, expected to remain a competitively

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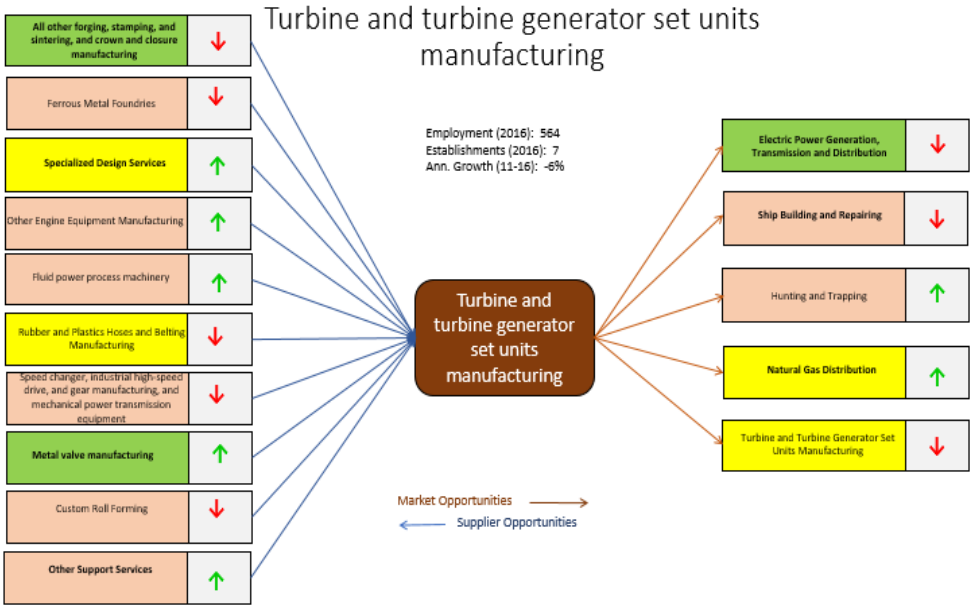
[73] U.S. Energy Information Administration. 2017. "Texas: State Profile and Energy Estimates." *U.S. Department of Energy*. https://www.eia.gov/state/analysis.php?sid=TX

[74] Office of the Governor, Economic Development and Tourism Division. 2016. "Energy." https://businessintexas.com/sites/default/files/08/08/16/energy-2016.pdf

Figure 34: Houston MSA Turbine and Turbine Generator Industry Linkages



SOURCE: CREC, USING EMSI DATA

concentrated industry in the Houston region. Figure 34 provides a summary of the relationships between the turbine generator industry and industries that both supply to and purchase from the sector, demonstrating potential sources for Houston to deepen local supply chain linkages.

Supplier opportunities

Within the region, of the several industries identified as primary suppliers to the turbine and turbine generator set units manufacturing industry, two industries have especially strong job concentrations relative to the nation and the state of Texas: (1) metal valve manufacturing and (2) all other forging, stamping and sintering, and crown and closure manufacturing. Metal valve manufacturing experienced a moderate increase in jobs from 2011 to 2016, maintaining the largest number of jobs of suppliers in the region (6,877 jobs). However, the all other forging manufacturing industry experienced a decrease in jobs (6 percent). Across both industries, companies manufacture components essential to manufacturing, operation, and maintenance of turbines and turbine generators. Metal valve manufacturers in the region include companies with Houston headquarters such as CIRCOR Energy as well as multi-national operations with Houston establishments, such as Bray Controls USA and Cameron Valves & Measurement.

Companies providing forging manufacturing industry in the region include Ellwood Texas Forge Company and Wyman-Gordon.

Additional supplier opportunities included industries that demonstrated growth despite relatively low job concentration. Other support services had the second largest number of jobs for supplier industries (4,409 jobs), and the largest absolute increase in jobs. However, like most supplier industries, other support services had a relatively low job concentration. Additional industries that experienced growth but had low job concentrations relative to the nation included other engine equipment manufacturing, specialized design services, and fluid power process machinery. Of supplier industries, the region's fluid power process machinery industry experienced the largest job gains by percentage in the region (7 percent), demonstrated a high job concentration relative to the nation, and outpaced state and national growth rates.

While the custom roll forming and rubber and plastics hoses and belting manufacturing industries both experienced low to moderate job concentrations and job losses from 2011-2016, these industries might also be considered supplier opportunities given their competitive regional concentration compared to statewide. The custom roll-forming and rubber and plastics hoses and belting manufacturing industries proved to represent a significant share of state employment in the industry, with 45 percent and 60 percent respectively of the state's employment found in the region.

Other industries, such as ferrous metal foundries, and speed changer; industrial high-speed drive; and gear manufacturing; and mechanical power transmission equipment, supply the turbine and turbine generator set units manufacturing industry, but may not continue to be viable supplier opportunities for Houston based manufacturers as they lose local market share. Their decreasing presence and low relative competitiveness of these industries to the state and nation suggests that Houston turbine manufacturers are now sourcing materials provided by these industries from suppliers outside the region.

Market opportunities

This analysis of the turbine and turbine generator supply chain (as illustrated in Figure 34) suggests that the strongest market opportunity for turbine and turbine generator set units manufacturing is the nation's electric power generation, transmission, and distribution industry. While that electric power industry has experienced recent job declines, the sector is still very large (with more than 11,000 jobs found locally). Furthermore, Houston represents a

substantial share of the state's activity in the industry, including more than 30 percent of industry jobs in the state. In addition, the industry is expected to grow through 2021. An example of a company representing the power generation, transmission, or distribution industry includes CenterPoint Energy, which specializes in both transmission and distribution of electricity, operating and maintaining the chain of physical infrastructure for delivering electricity from sites of power generation, or power plants, to customers. Alternative fuels are also expanding market opportunities. Companies like Calpine Corporation specialize in power generation and operating power plants focused on harnessing natural gas, geothermal, and other energy sources. In addition, Texas has been an innovator in developing competitive electricity distribution to customers. As such, new companies have emerged such as Champion Energy Services (distributing and delivering electricity to consumers from the transmission systems).

Other industries that are likely opportunity areas include the industries of shipbuilding and repairing as well as natural gas distribution. Shipbuilding and repair has seen declines in the past few years, but the competition for large ships and the region's role as a key oil exporter means that it offers opportunities for certain types of ship repair and servicing concentrated in the Houston Ship Channel area. Companies like Channel Shipyard Co and Baron's Marine Ways, Inc. represent this industry. They focus on repairing specific ship components such as wall-paper and insulation. Other companies in this space might also work to incorporate turbines in the power generation systems to assist with the propulsion of large ships, both commercial (cruise ships) and government (naval ships).

An additional market opportunity includes natural gas distribution, which in 2016, was only moderately concentrated in the Houston area relative to the rest of the nation, but showed signs of rapid job growth in recent years. Given Texas' leadership as a natural gas producer,[75] and natural gas' increasing affordability due to technology advancements in exploration and production,[76] natural gas distribution as an industry is expected to continue playing a pivotal role in electricity generation for the state and the Houston region. Natural gas distribution jobs

[75] U.S. Energy Information Administration. 2017. "Texas: State Profile and Energy Estimates." *U.S. Department of Energy*. https://www.eia.gov/state/analysis.php?sid=TX

[76] U.S. Department of Energy. 2015. "Advancing Systems and Technologies to Produce Cleaner Fuels: Technology Assessments." *Quadrennial Technology Review*. https://energy.gov/sites/prod/files/2016/04/f30/QTR2015-7E-Natural-Gas-Delivery-Infrastructure.pdf.

in the Houston region were responsible for almost 40% of the state's employment in the industry (2,675 jobs). Local distribution companies in the region include, Anadarko Energy Services Co, Cheneire Energy Inc, and CDM Resource Management.

Energy, Space Tech, and the Houston Innovation Ecosystem

This section examines the network of economic and workforce development intermediaries promoting the Houston region's innovation efforts. A quick review of the region's ecosystem finds a rich network of nearly 100 intermediary organizations, so it is important to focus attention on those that serve the key sectors that are most important to DoD's interests in the Gulf Coast region. To that end, the region has long been known as a national center for two key industries: oil and gas as well as space exploration.

CREC's assessment of the network is that the defense sector is not highly visible in the region according to local leaders. This may be because defense contracting is so highly concentrated on petroleum refining activities, masking the importance of DoD procurement to that already large sector. For instance, the Houston region annually averaged about $1.5 billion in defense contracts between 2013 and 2016, 70 percent of which went to oil and gas purchases. So, even the region's defense activities are highly connected to its refineries. Yet, a closer look at traditional DoD contractors finds that many have a significant presence as NASA contractors and rely on a larger NASA procurement budget in the region.

Figure 35: Artist's rendering of the proposed Houston Spaceport at Ellington Field in Texas.

Credit: Houston Airport System

In September 2013, Houston Spaceport unveiled its initial plans (Figure 35), and in 2015, NASA entered into an agreement with the Houston Airport System to allow the Houston Spaceport to tap into the federal space agency's assets and expertise. Meanwhile, NASA reduced its footprint in Houston when the space shuttle program was retired in 2011. However, NASA designated the Johnson Space Center (JSC) to lead NASA's

International Space Station operations as well as the development of the Orion crew vehicle, designed to take astronauts to deep space. In 2014, Johnson Space Center's annual budget of $4.4 billion included nearly $3 billion in contracts to Texas-based businesses.[77] This Federal investment in the region has spawned the spin-off of a commercial space industry created to serve the International Space Station. The United Space Alliance – a joint venture of Boeing and Lockheed Martin – as well as other traditional defense contractors like Jacobs Engineering, and UTC Aerospace as well as Boeing and Lockheed Martin can be found in the region.

A key trend influencing the greater Houston economic development eco-system in the past few years has been sharp declines as illustrated in Figure 36 in local energy revenues from all sectors (including defense) because of greater demand for lower cost natural gas as well as alternative fuels.

Figure 36: Houston's Reliance on the Energy Sector

CREDIT: ACCENTURE, "INNOVATION IN HOUSTON: A STUDY OF THE BAYOU CITY'S STARTUP ECOSYSTEM," MARCH 2017

A shorter-term threat to the region in 2017 was the impact of Hurricane Harvey, but most economists believe the short-term impact on commercial and industrial activities is not expected to last. With no major damage occurred to electrical or control systems, the hurricane did not impact overall capacity. [78] More subtle damage to consumer attitudes about oil and gas may have resulted from the production disruptions that will spur further demand to diversify energy consumption through alternative fuels.

Much of Houston's oil production and services is "upstream" – meaning that the employee base tends to be office-based engineers with some refinery and drilling support manufacturing activities along the coast. Since the global industry is competing with other plentiful and inexpensive fuels like natural gas fracking), depressed consumption has resulted in excess global capacity. Global demand is important in this context because of Houston's role as a

[77] Texas Office of the Governor, 2017 Texas Aerospace, Aviation and Defense, July 2017.

[78] Robert W. Gilmer, Ph.D., "Slow Growth Returns to Houston in 2017: Can We Bring Back the Oil Jobs in 2018?" presentation, C.T. Bauer College of Business, November 6, 2017.

global center for the industry. Worldwide energy challenges call for action to diversify Houston's economic base.

Even as the oil industry bounces back from the local energy recession, Greater Houston leaders are increasingly focused on supporting a next generation of businesses to fuel the regional economy. Defense contracting does not rate highly among area leaders' priorities currently, but the aerospace industry more broadly (including NASA-related contracting) is vital to the region's future. The creation of a commercial space industry and the recent hints from Washington about a renewed interested in space exploration suggest new opportunities for area defense-related firms that could also be used to advance technology and innovation for the DoD warfighter.

Innovation and new technologies are viewed as a foundation for the development of key sectors including energy, life sciences, manufacturing, logistics and aerospace. According to Accenture's innovation framework, talent, capital, markets, and technology opportunities drive the future and Houston's ecosystem must be ready to act. To build the capacity of local firms to

Figure 37: Innovation Ecosystem Partners in Greater Houston

Issue Area	Types of Support Services	Area Service Providers/Resources
Workforce Talent	Workforce Training, Classes, HR services	Workforce Solutions Gulf Coast, Greater Houston Partnership, Greater Houston Manufacturers Association
Capital	Loans, Equity Investments, Working Capital, Coaching	Houston Galveston Area Local Development Corporation, Houston Business Development Inc., Greater Houston Partnership (GHP), Houston Angel Network, University of Houston Technology Gap Fund
Physical Assets		Houston Technology Center, Station Houston, TMCx, TMC Innovation Institute, University of Houston (UH) RED Labs, Rice OwlSpark, JLabs at Texas Medical Center
Business Development and Know-How	Peer Networks, Professional Development, Training Programs	UH Small Business Development Center, SCORE – Houston Chapter, Office of Business Opportunity Solutions Center
Technical/Engineering Support	Access to equipment, engineering support, technology development and commercialization	Texas Manufacturing Assistance Center / Gulf Coast, Beehive Fund, Bay Area Houston Advanced Technology Consortium (BayTech), Space Alliance Technology Outreach Program (SATOP)
Market Development	Export promotion, procurement assistance, supply chain connections	UH Procurement Technical Assistance Center, UH International Trade Center, GHP International Services, Houston International Trade Development Center, Economic Alliance Houston Port Region

remain resilient and compete for future opportunities, area leaders are expanding the region's innovation ecosystem, building on the ecosystem assets identified in Figure 37.

Following is a discussion of how these key partners are addressing the challenges and how they relate to the Houston area's efforts to support the defense sector.

Workforce Talent

The Houston workforce is highly educated, young, and diverse – with more than 300,000 educated millennials and 240,000 science, technology, engineering, and math (STEM) workers, many of them graduates of one of the five local nationally-ranked universities and graduate schools. Job growth in STEM in Houston is highest in the country according to the U.S. News STEM Index.[79] This is important for both the petrochemical industry as well as the space technology sector. NASA-related activities and the energy industry both demand engineering talent that far exceeds what might be expected in most regions.

Focusing on NASA, the Johnson Space Center (JSC) in Houston serves as the region's center piece for employment opportunities as well as a key source for NASA-related contracting. Roughly 3,000 employees, predominantly engineers and scientists work at JSC. An additional 50 contractors employ roughly 7,400 workers at the space center. Federal budget cuts during the Obama Administration eliminated thousands of NASA jobs locally, but private companies picked up many of those employees. While NASA was growing from the Space Shuttle program, Houston also grew from corporate relocations of major energy companies. This migration began with Shell Oil moving from New York in 1971.[80] Other major energy companies followed, including Phillips 66, ConocoPhillips, and Russell Morgan Oil and Gas.

Houston has a variety of workforce development organizations that seek to address the region's skilled talent needs. The Greater Houston Partnership features two major workforce development efforts: UpSkill Houston and City with No Limits. UpSkill Houston is an industry-led collaboration working to develop local talent through marketing, training, and job

[79] U.S. News & World Report, "Houston and Austin, Texas, Best Metro Areas for STEM Workers", January 2015. https://www.usnews.com/news/blogs/data-mine/2015/01/14/houston-and-austin-texas-best-metro-areas-for-stem-workers

[80] Greater Houston Partnership, "Why Houston?". https://www.dropbox.com/sh/07gi7dentkrsxbq/AACJYee0YnQ9JpwiTtVoSmz0a/Energy.pdf?dl=0

placement services, while City with No Limits is a talent attraction strategy targeted to millennials. In addition, the Gulf Coast Workforce Board and its operating affiliate, Workforce Solutions, serves as the public workforce system in the Houston MSA, providing job search, financial aid, training, and other services at career offices across the region.

Community colleges in Houston also provide employers with a pipeline of potential employees. For example, San Jacinto College has developed non-credit curriculum for an assortment of businesses and subjects in Pasadena. While higher education institutions, such as the Rice University Brown School of Engineering has full departments dedicated to Mechanical and Aerospace Engineering while and the University of Houston Cullen College of Engineering has highly rated civil, mechanical, computer, electrical, and chemical engineering programs.

Another key component of greater Houston's workforce strategy revolves around attracting the talent necessary to support large businesses in the oil and aerospace industries. For example, City with No Limits at the Greater Houston Partnership offers a recruiter toolkit including marketing graphics, videos, infographics, media assets, and other resources. This approach seeks to find skilled workers trained elsewhere who are willing to move to Houston for job opportunities.

For technical workers that do not require a baccalaureate degree, the Gulf Coast Workforce Board provides workforce training by encouraging local businesses to enroll employees in Registered Apprenticeship Programs. In addition, Gulf Coast Workforce Solutions provides a system designed to match job seekers or current employees with training in a variety of subjects. Workforce Solutions also provides financial aid to the region's targeted high-growth occupations including Aerospace Engineers, Chemical Plant and System Operators, and Petroleum Engineers. Workforce Solution's Community College Petrochemical Initiative, funded by a $500,000 grant from ExxonMobil, seeks to help pay for two-year degrees in related fields to grow the pool of skilled workers in the Gulf Coast Region.

In addition, the Greater Houston Manufacturer's Association is collaborating with the Houston Independent School District to support an "Adopt a School" mentoring program that supports the HISD Plan Your Path program. Member manufacturers work with schools to help local students become more aware of manufacturing careers and the educational foundations required to enter those careers.

Houston features a robust workforce that has proven that it can adapt to the loss of major employers and the hardships from natural disasters. In addition to the JSC reductions, other

examples demonstrate this resiliency. For example, in 2013, BAE systems closed their Houston-area facility in Sealy, affecting 325 workers – and this follows reductions in the location's workforce of roughly 1,000 workers in the previous two years.[81] Still, the Houston job market absorbed those workers quickly. After the devastating effects of Hurricane Harvey in late summer 2017, the Texas Workforce Commission (TWC) partnered with the National Labor Exchange to facilitate job postings for employers seeking employees because of the hurricane.[82] TWC also partnered with Workforce Solutions to create the Shared Work Program to provide companies with an alternative to layoffs while assisting with employee recruiting and hiring.

The ongoing growth of the tech industry in Houston has significant implications for the energy and aerospace industries so important to DoD. For energy, this would include the development of digital oilfields and smart grids, deep water and remote operations, and plant asset security systems. In the aerospace industry, asset tracking and intelligent cabins, robotic manufacturing, and blockchain maintenance are quickly growing. These technology developments will continue to drive the high demand for efforts to enhance area STEM workers in the short- and mid-term.

Capital

The region has many assets that provide debt capital for small businesses. For 2017, SBA lending totaled $929 million through 1,616 loans made to businesses in the greater Houston area. Top private lenders include BBVA Compass Bank, Wells Fargo, JPMorgan Chase, Spirit of Texas, and Wallis State Bank.[83] The area's largest SBA licenses Certified Development Company is the Houston-Galveston Area Local Development Corporation. In addition, the City of Houston created Houston Business Development, Inc. (HBDi) in 1986 as a non-profit, non-bank community lending organization to provide small businesses and entrepreneurs in the greater Houston area with debt capital. HBDi has leveraged about $82 million in small business loans, creating 2500 jobs for low-moderate income citizens.[84]

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[81] Houston Business Journal, "BAE Systems to close Houston-area facility, affecting 325 employees", October 2013. https://www.bizjournals.com/houston/news/2013/10/15/bae-systems-to-close-houston-area.html

[82] Texas Workforce Commission, "Hurricane Harvey Resources", November 2017. http://www.twc.state.tx.us/hurricane-harvey-resources

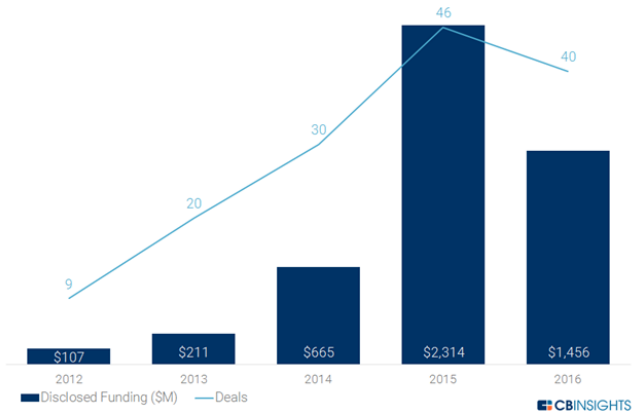
[83] Source: SBA, SBA Houston Continues Upward Lending Trends in FY17, press release, November 9, 2017.

[84] Source: Houston Business Development, Inc., http://www.hbdi.org/mission-statement-background/

While financing for contractors in the greater Houston area largely occurs through traditional debt financing, equity capital gaps have been identified as a challenge by Accenture and the Greater Houston Partnership in 2017.[85] While larger defense contractors may have the ability to self-generate investment or attract traditional debt capital to finance growth or transitions, smaller firms need access to equity capital. This lack of experience with equity financing creates a significant challenge for small area firms seeking to develop new technologies. Research found that the nation's 4th largest city was ranked 20th in the number of venture capital deals and 19th in the average size of those deals. Capital also tends to follow regional specialties. Most local start-up activity occurred in the energy and life sciences sectors, and Accenture's research for the Greater Houston Partnership found that about 75 percent of venture investment in the greater Houston area focuses on the capital-intensive energy sector.

However, that leaves limited resources for other advanced technology areas. Nationally, the aerospace sector represents an important investment opportunity – an industry in which Houston is at the center. Houston has retained its competitive strength as NASA created the Commercial Crew and Cargo Program Office (C3PO) to facilitating private transportation systems to ferry cargo and human crews to the International Space Station. C3PO replaces the space shuttle as the center of space exploration activities. NASA's mission with the program is to achieve deep space travel. To take humans to Mars will require testing new technologies, advancing human health and performance, validating our ability to explore in deep space. NASA is leveraging the capabilities and innovation in the private sector to do so more cost efficiently. The result is the development of a nascent commercial space industry that may be an important contributor to US military advantage.

Figure 38: Space Tech Annual Global Financing History, 2012-2016



SOURCE: CB INSIGHTS, APRIL 2017

Investment in space technologies grew rapidly during the first half of the 2010s,

[85] Accenture, "Innovation in Houston: A Study of the Bayou City's Startup Ecosystem," Accenture and the Greater Houston Partnership, March 2017.

but dropped off to about $1.5 billion in private equity financing as illustrated in Figure 38. NASA has embraced the private sector as a key partner in space flights and high-profile investors (such as Elon Musk and Jeff Bezos) have helped to attract nearly $5 billion in private capital since 2012.[86] Before that point, private investment in this segment was almost non-existent. The companies attracting investment are making satellites and rockets for outer space as well as developing big-data operations to monitor the design and launch of space systems. Commercial space firms have been the beneficiaries of these investments, including traditional defense contractors diversifying into space production in addition to well-funded startups. Some key competitors, including Boeing, SpaceX, Blue Origin, ULA, and XCOR, are providing space transport for cargo, satellites, and tourists.

In the 2017 Innovation Houston plan for expanding the region's innovation ecosystem, the kinds of activity that are being recommended is exemplified by the Houston Angel Network (HAN). HAN touts itself as the oldest and most active network in Texas. In 2015, the network investment $12 million in 43 deals and $73 million in 235 deals since its inception in 2001. The Houston Angel Network (HAN) touts itself as the oldest angel network in Texas and the most active angel network in the USA. An angel network provides opportunities for accredited investors to provide capital and coaching to early stage companies. Examples of HAN investments include CS Identity (a consumer services identity company later acquired by Experian) and nMetric (a scheduling software). Overall, however, investment through private funding sources appear to be episodic, and in a market as large as Houston, these capital infusions should be a bit less noteworthy. In fact, several examples of equity investment successes featured companies raising funds from East Coast investors who then moved the company out of Houston. Area leaders believe that more frequent equity investments by area investors would result if these high net worth individuals were more oriented toward technology start-ups.

In addition to private capital efforts, other funding gaps exist as well. Smaller initiatives seek to provide gap financing to encourage technology innovation. For instance, the University of Houston created its Technology Gap Fund to help UH inventors move technologies closer to commercial readiness. This is essentially pre-seed funding to allow inventors to decrease

[86] CB Insights Research Reports, "Space Tech Funding Drops Back to Earth While Deals Push Up," April 11, 2017, https://www.cbinsights.com/research/space-tech-startup-funding.

technical risks associated with a technology that may ultimately be licensed to an existing company or used to catalyze a startup.

One of the key recommendations from the Houston Technology and Innovation Task Force Recommendations is to shift the attitudes among the region's high net worth individuals and institutions to consider investments in emerging technology companies and early stage ventures by promoting angel investing and venture philanthropy.[87] Implementing this strategy would involve significant education among potential investors about these opportunities, given the region's inexperience in technology investing.

Two ideas put forth by the Innovation Houston Technology and Innovation Task Force include the creation of a Fund-of-funds to absorb non-market capital and to activate an ultra-high net worth individuals (UHNW) to educate and "social proof" start-up investing as a viable financial investment approach. In both ideas, strategists recognize that financial capital is available but that the Houston culture has never been focused on investing in technology related businesses. The Greater Houston Partnership has committed to helping establish a fund of funds that would attract more venture capital activity and encourage local corporations and foundations to finance local venture capital funds. This strategy is viewed as a viable way to improve the region's performance in advancing future defense-related technologies that might benefit aerospace through (1) new technologies that track assets and manage intelligent aerospace cabins, (2) enhanced robotics, and (3) expertise in blockchain maintenance to secure aerospace computing systems. In addition, these strategies would also benefit energy sector assets by investing in technologies that help to digitize oilfields, deploy smart grids, allow the remote operation of deep water drilling facilities, and manage the security of physical plants (especially high value energy facility assets).

Physical Place

As one venture capitalist noted, "Density is …the No. 1 element of what makes an ecosystem work."[88] An important part of the Houston strategy to promote innovation in the region is to concentrate emerging new activities in a special geographic area designated to create critical

[87] Greater Houston Partnership, "Houston Technology & Innovation Task Force Recommendations," June 2017, (https://www.houston.org/innovation/).

[88] Lydia DePillis, "Where should Houston's innovation district be?" Houston Chronicle, July 10, 2017.

mass of activity and foster human interaction. While the proposed Houston Innovation District has not yet been sited, the area ultimately selected is expected to represent a highly visible symbol of leadership's commitment to technology startup activity.

This approach builds on the work of the Houston Technology Center (HTC), a business and technology incubator and accelerator that has operated since 1999. HTC specializes in helping startup companies in the energy, information technology, life sciences, transportation & logistics, and commercial space industries. HTC client and graduate companies have raised more than $3.5 billion of capital and created more than 6,000 jobs.[89] Other innovation intermediaries have also launched co-working spaces and accelerators such as Station Houston, TMCx, UH's RED Labs, Rice's OwlSpark and JLabs. These spaces provide entrepreneurs with a physical focus for their efforts that create and build a critical mass of activity so that startups can mitigate risk and build momentum. In a large, sprawling region like Houston, the identity of focusing on a small area is vital to enhancing the visibility and building the brand for technology assets in the region.

Business Development and Know-How

Small firms that face business development, marketing, and operational challenges may need help to build their skills or access best-practice ideas. The University of Houston Small Business Development Center (UH SBDC) at Bauer College represents one of the largest SBDC networks in the nation. UH SBDC provides affordable training seminars to small and medium-sized business owners and managers. UH SBDC serves 32 counties in Southeast Texas through 14 physical locations affiliated with the University of Houston, Galveston County, San Jacinto College, Brazosport College, Lee College, Lone Star College System, Sam Houston State, Coastal Plains, Fort Bend County, and Prairie View.

The training offered through the UH SBDC focuses on start-up and pre-venture entrepreneurial skills as well as marketing finance, management, and executive management. The SBDC network also helps entrepreneurs in assessing their ideas and creating a business plan. The SBDC can also help existing companies develop strategies, attract customers, increase sales, and improve productivity. In addition, UH SBDC also offers specialty assistance for entrepreneurs wanting to sell to the government, do business internationally, or commercialize their technology.

[89] Source: Houston Technology Center, https://www.houstontech.org/about-htc/

Another key intermediary is the region is SCORE Houston, which also provides entrepreneurial education and counseling to small businesses. SCORE is a nonprofit group that engages volunteer professionals to donate time to help small businesses succeed. Counselors are experts in such areas as accounting, finance, marketing, management and business plan preparation. SCORE is a national network with more than 130 volunteers serving the 9-county Greater Houston Area.

Also, the City of Houston maintains its Office of Business Opportunity Solutions Center (OBOSC) as a resource companies about city, county, state and federal regulations. In addition to supporting the UH SBDC and SCORE, OBOSC also supports programs managed through the U.S. Small Business Administration programs, the Harris County Clerk, the Texas State Comptroller, and the Minority Business Enterprise Center. Through these contacts, OBOSC maintains a referral network of area organizations, incubators, and educational institutions that can help businesses. The Office's staff primarily offer direct help with permits and licenses while turning to SCORE business advisors to provide counseling, and helping eligible companies to gain certification as a minority or woman-owned small business.

Technical/Engineering Support

To maintain its competitive edge, area companies must access the latest ideas and technologies as well as process capabilities. One of the most important partners in support of the region's A&D industry has been the Texas Manufacturing Assistance Center (TMAC Gulf Coast), a partner with the statewide TMAC system and the national Manufacturing Extension Partnership that has served nearly 600 manufacturers since 1995. TMAC Gulf Coast operates from the TEEX Training Center in Houston and partners with the Beehive Fund, a global network of technical experts providing help with developing turnaround strategies, system or process improvements, product development and market expansion efforts for companies in manufacturing, oil & gas, food processing, warehousing & distribution, aerospace, automotive, and other sectors.

To supplement the process assistance available through TMAC, Houston has developed an unusual array of technology resources to support its technology entrepreneurs. Rice University, NASA, and the Bay Area Houston Economic Partnership have been at the forefront in creating opportunities for new firms to start-up and existing firms to expand through the deployment of new technologies in the aerospace and petrochemical industries.

The Rice Alliance for Technology and Entrepreneurship (Rice Alliance) provides help to companies and entrepreneurs on how to commercialize new technologies. Working collaboratively with Rice University's George R. Brown School of Engineering, Wiess School of Natural Sciences and Jesse H. Jones Graduate School of Business, the Rice Alliance has helped to create more than 1,800 new companies since 2000 and raise more than $3.6 billion in early-stage capital.[90] Rice Alliance also coordinates the Rice University Business Plan Competition, the "World's Richest and Largest." Competitors have received more than $8.4 million in prizes since 2001, and more than 200 are operating businesses today.

The Bay Area Houston Economic Partnership has been at the forefront of supporting new product development and technology translation efforts in the region. It sponsors the Bay Area Houston Advanced Technology Consortium (BayTech) and the Space Alliance Technology Outreach Program (SATOP). To ensure that Houston retained its critical advantage in space technologies after NASA cancelled the Space Shuttle and Constellation Programs, BayTech formed as a nonprofit to bring together academia, industry, NASA Johnson Space Center, and the State of Texas. BayTech support technology development and actively pursues research and technology development funding opportunities for the region.

Funded by the state of Texas, SATOP provides technical assistance to facilitate space technology transfer to commercial applications. One way that SATOP accomplishes this is by offering small businesses up to 40 hours of free technology assistance. SATOP seeks to help small businesses apply the technical expertise derived from the US space program to machine design, process engineering, material selection, and similar engineering or technical challenges. SATOP Houston is one of four locations, and it represents more than 45 space companies, universities, colleges, and NASA centers (Johnson Space Center – Texas, Kennedy Space Center – Florida, and White Sands Test Facility – New Mexico), SATOP finds professionals within these companies who volunteer their time and expertise in solving the challenges brought forth by the inquiring businesses.

[90] About the Rice Alliance https://alliance.rice.edu/about

Market Development

Fortunately for Houston, DoD energy procurements in the region represent less than 2 percent of the region's total oil-related GDP. So, military cuts have not been felt as much as the larger global challenges that face the energy sector. Meanwhile, Houston's aerospace industry has successfully transitioned after the elimination of the Space Shuttle and the Constellation programs as the International Space Station and the Journey to Mars programs were implemented, engaging the commercial sector in new ways.

Key to maintaining the success of the firms impacted by transitions in A&D sector is the help that intermediaries can provide in accessing new government and global markets. To that end, the University of Houston SBDC also manages a Procurement Technical Assistance Center (UH PTAC). Funded in part by the DoD Defense Logistics Agency (DLA), the UH PTAC helps companies interested in selling to Federal, State, and Local Government agencies learn about the government contracting process. The UH SBDC also manages the International Trade Center (ITC). Created in 1988, the ITC helps small and medium-sized companies explore export market opportunities through seminars, networking events, and assistance with accessing pre- and post-export financing from SBA and EX-IM Bank.

In addition, the Greater Houston Partnership's international services division supports both foreign direct investment recruitment as well as trade development for area firms. Its FDI efforts focus on supporting international firms seeking area locations while its trade development activities center on connecting companies to area markets and events as well as coordinating missions to foreign markets.

Another intermediary, the Houston International Trade Development Council, Inc. (HITDC), was established in 2008 to help area firms access markets in new and emerging markets such as the developing countries of Africa, Asia, the Caribbean, Central and South America. HITDC works with local business intermediary organizations and other area international support organizations to help businesses by organizing trade missions and conferences as well as expanding visibility for Houston in international markets.

In addition, The Economic Alliance Houston Port Region addresses the economic development needs of the 12 cities and the Port of Houston Authority that are centered around the Houston Ship Channel, home to one of the world's most influential energy and trade coordinators. The Economic Alliance focuses on facilitating business activities that support direct foreign investment that builds from the region's trade and distribution assets.

Houston Innovation Ecosystem Summary

No analysis of the greater Houston area can do justice the rich network of organizations that serve the area's economic development efforts. The Greater Houston Partnership has organized an informal network – the Houston Region Economic Development Alliance (HREDA) – to help maintain lines of communication across the multitude of organizations in the region. This network is one key point of access into the array of more than 100 local economic development groups. Historically, much of the focus of the HREDA partners has been on attracting development – or more precisely, the effort has focused on how to manage the rapid growth in Houston, despite the turbulence in both the energy and space tech sectors.

Only recently have Houston leaders come together with the mission of making the region a top-10 startup ecosystem by 2022. "Houston Exponential" is an initiative created to integrate of Houston Mayor Sylvester Turner's Innovation and Technology Task Force, the Houston Technology Center and the Greater Houston Partnership's Innovation Roundtable. Houston Exponential seeks to accelerate the development of Houston's innovation economy by fostering a supportive ecosystem for high-growth, high-impact startups.

The role of Houston Exponential will be to convene ecosystem partners, facilitate development of an innovation district in Houston, and attracting the talent needed to thrive. Houston Exponential plans to use committees and working groups of universities, incubators, entrepreneurs, technologists, corporations, investors, accelerators and other experts to accomplish its work. In addition, with staff support from the Greater Houston Partnership, Houston Exponential plans to launch a Fund of Funds (HX Venture Funds) as an equity investment vehicle for local investors and as a resource to develop regional expertise in managing risk capital. Houston's plans also include developing a more integrated startup ecosystem aimed at creating a crucial mass of activities in several key areas including industrial internet-of-things (IIOT), robotics, and cybersecurity.

An Assessment of the Defense Sector in the San Antonio-Austin Region

With defense contractors in the region receiving $8 billion, the San Antonio-Austin region is an important location for A&D companies and significant to much of the state's defense economy. This section provides a profile of the structure of the San Antonio-Austin defense sector and the key economic segments that make up the defense-related supply chain in the region. Besides providing an overview of the region's economy and its specific strengths related to the defense economy, the profile also includes a value chain analysis that examines an emerging defense cluster industry. Both cities are known for IT related innovation, and the value chain analysis focuses on cybersecurity as the defense economy strength emerging within the megaregion. The regional profile ends with a discussion of current innovation assets and potential areas of both strengths and weaknesses related to cybersecurity.

San Antonio-Austin Economic Overview

Roughly 80 miles apart from downtown to downtown, San Antonio and Austin are two mid-sized metro areas that are coalescing into a larger "mega-region." The two cities are quite different culturally today, but continued economic growth is likely to increase interaction and help to expand the national profile of both cities. San Antonio has an economy steeped in the military and tourism while Austin is a national computer technology center. Combined, these assets make the region formidable. As one commentator put it:

> *From a national and global perspective, a [San Antonio-Austin] region comprising five or six million people in the next decade or so would attract more attention and opportunities than two separate regions of two or three million each. In one case, we're in the same league as Seattle or Atlanta; in the other case we stack up against Indianapolis or Cincinnati.*[91]

The Census Bureau is not yet ready to recognize the area as a 'consolidated statistical area' (like Dallas-Fort Worth, for instance) because there is not yet enough employment interaction between the two metro areas, but the economic assets claimed by the two cities could be critical as foundations that help create a central Texas identity that is as well-known as North Texas or the Texas Gulf Coast.

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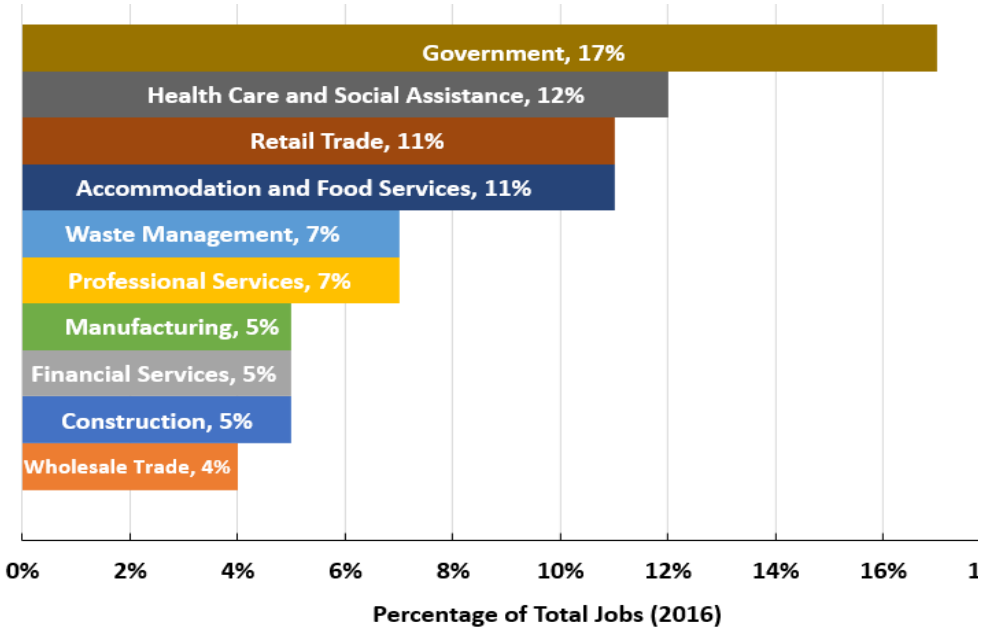
[91] Karl Baker, "Commentary: San Antonio-Austin Megaregion Isn't Just Down the Road," The Rivard Report, September 2, 2016.

When examined together, the San Antonio and Austin regional economies have experienced significant growth over recent years, highlighting the economic competitiveness of the two cities within the state and nation. With 4.5 million people, San Antonio is slightly larger with 2.4 million people and Austin with 2.1 million. The region grew by 2.45 percent per year between 2011 and 2016, significantly faster than the rest of Texas, which added about 1.7 percent per year during the same time or the U.S. which grew at 0.7 percent per year.

However, with nearly 2.8 million workers in 2016, the two metro areas each contribute about half of the mega-region's total employment. The US Bureau of Economic Analysis reports that San Antonio and Austin grew very rapidly between 2011 and 2016 at one of the fastest rates in the nation. The combined metro GDPs grew at an annual rate of 6.5 percent, led by Austin at 7.0 percent growth and San Antonio at 5.9 percent.[92] While Austin has boasted a slightly larger GDP than San Antonio for more than a decade, its employment base has historically been

Figure 39: Distribution of San Antonio-Austin Region Employment by Industry Sector (2016)



SOURCE: EMSI

[92] U.S. Bureau of Economic Analysis, accessed at: https://www.bea.gov/newsreleases/regional/gdp_metro/2017/pdf/gdp_metro0917.pdf

smaller. However, at the current pace of growth, the Austin metro area is set to pass the San Antonio metro as the larger employment center and the larger source of total personal income when BEA releases its 2017 figures. Major employers including government, health care providers, food services, and retail trade, which together employ more than one million Texans in the region. These industries represent slightly more than half the regional employment base (see Figure 39). Professional, scientific, and technical services and finance and insurance together employ over 240,000 people and provide very high wages – over $80,000 on average. Manufacturing accounts for just 5 percent of employment in the region, well below the national average, but it tends to be in higher end products.

The region's largest public company is San Antonio-based Valero Energy with revenues totaling $137.7 billion. Tesoro, USAA, Whole Foods Market, CST Brands, and CC Media Holdings are other major public companies in the region. Dell of Round Rock is the mega-region's largest privately held company with revenue of $56.9 billion, while H.E.B Grocery Company is another significant private business.[93]

San Antonio-Austin Defense Economy

Defense-related industries and facilities are also major economic drivers for the mega-region. Firms in the San Antonio-Austin region received more than $8 billion in Department of Defense contract funding between 2013 and 2016. More than 13,000 businesses, with more than 220,000 jobs, operate in defense cluster related industries in the San Antonio-Austin region. San Antonio is more highly focused on defense, and the city has been dubbed "Military City USA" due to its large population of active military personnel, and major military facilities including Joint Base San Antonio (JBSA), Randolph Air Force Base, Fort Sam Houston, Lackland Air Force Base, and Camp Bullis. Together these facilities create an estimated $48.7 billion in economic impact and 282,995 direct and indirect jobs in the region. [94]

While Austin may be a center for computer hardware development, the region's strong military presence is supported by a growing and diverse cybersecurity sector, especially in San Antonio. San Antonio's workforce of over 60,000 science and technology professionals includes more

[93] Texas Office of the Governor, The Largest Companies Headquartered in Texas

[94] The San Antonio Economic Development Foundation, accessed at: http://www.sanantonioedf.com/industry-sectors/military-defense1/

than 80 information security firms and a consortium of eight area institutions that represent a growing ecosystem supporting defense related cyber technology investment. In 2009, Lackland Air Force Base was selected as the headquarters for the Airforce Cyber Command (24th Air Force). The U.S. Department of Defense has located an additional 11 federal cybersecurity operations in San Antonio.[95]

San Antonio's development as a hub for cybersecurity is part of the broader region's growth as an economic leader in information technology. In addition, Austin's technology sector has been recognized by the U.S. Department of Defense as an asset for defense related technology innovation. In 2016, the DOD announced the establishment of a Defense Innovation Unit Experimental (DIUx) in Austin to provide technological solutions to national security issues.[96]

Figure 40: San Antonio-Austin Region Industries with High Specializations

NAICS	Industry	2016 Jobs	LQ
518	Data Processing, Hosting, and Related Services	11,354	2.79
486	Pipeline Transportation	1,728	2.59
334	**Computer and Electronic Product Manufacturing***	**28,833**	**2.03**
524	Insurance Carriers and Related Activities	45,275	1.47
211	Oil and Gas Extraction	3,269	1.35
517	**Telecommunications***	**14,478**	**1.33**
902	State Government	81,575	1.32
237	**Heavy and Civil Engineering Construction***	**16,818**	**1.32**
532	Rental and Leasing Services	9,719	1.31
213	Support Activities for Mining	4,831	1.30
236	**Construction of Buildings***	**25,815**	**1.29**
423	**Merchant Wholesalers, Durable Goods***	**50,585**	**1.27**
522	Credit Intermediation and Related Activities	44,720	1.27
901	Federal Government	47,218	1.25
722	Food Services and Drinking Places	191,661	1.25
443	Electronics and Appliance Stores	8,514	1.21

SOURCE: EMSI, 2016 DATA

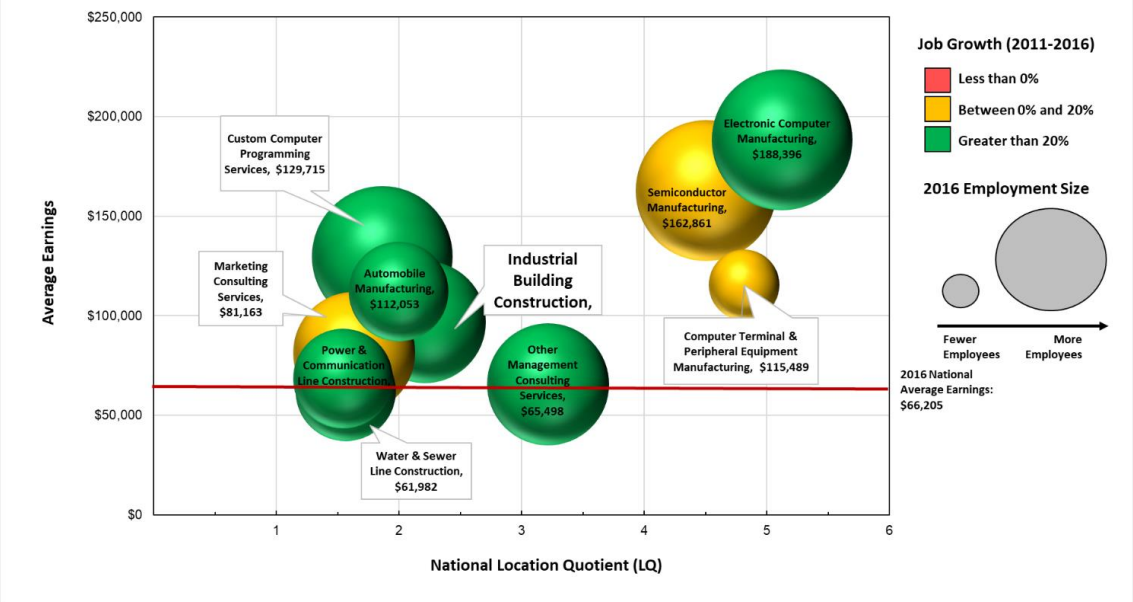
[95] The San Antonio Economic Development Foundation, accessed at: http://www.sanantonioedf.com/images/uploads/CybersecurityFactSheet.pdf

[96] U.S. Department of Defense, accessed at: https://www.defense.gov/News/News-Releases/News-Release-View/Article/944255/secretary-carter-announces-diux-presence-in-austin-texas/

The San Antonio-Austin mega-region has strengths in sixteen 3-digit NAICS industries (Figure 40) that have an employment concentration at least 20 percent above the national rate (e.g., location quotients of 1.2 or higher). Five of the industries have a substantial amount of business with the defense sector or are part of the broader defense industry value chain: Computer and Electronic Product Manufacturing (NAICS 334), Telecommunications (NAICS 517), Heavy and Civil Engineering Construction (NAICS 237), Construction of Buildings (NAICS 236), and Merchant Wholesalers, Durable Goods (NAICS 423).

As of 2016, over 13,000 businesses, with more than 220,000 jobs, operate in defense cluster related industries in the San Antonio-Austin region. This represents 14 percent of the region's employment. While these businesses do not all serve the Department of Defense directly, they work within industries vital to the national defense industrial base.

Figure 41: San Antonio-Austin Regional Employment in Defense-Related Industries, 2011-2016



SOURCE: CREC, USING EMSI DATA

The San Antonio-Austin region is highly specialized in several defense cluster industries as measured by location quotients. Figure 41 demonstrates that the region's highest area of specialization is in the Electronic Computer Manufacturing industry, with more than 5 times the national concentration in jobs. The importance of IT as an economic driver in the region is further evidenced by the high concentration of jobs in Semiconductor Manufacturing,

Computer Terminal and Peripheral Equipment Manufacturing, as well as Custom Computer Programming Services. Electronic Computer Manufacturing offers the highest average earnings at $188,396 and has been growing jobs at a rapid pace, better than 20 percent in recent years. Semiconductor Manufacturing employs the most people with 11,138 jobs. Automobile Manufacturing, Construction, and Consulting Services are also key defense related industries. None of the top 10 defense-related industries in the San Antonio-Austin region have seen decreases in jobs in recent years. This indicates a highly robust set of defense cluster driver industries.

Firms in the San Antonio-Austin region received more than $8 billion in Department of Defense Contract funding between 2013 and 2016. The region's petroleum refineries received the largest share of Department of Defense contract dollars with roughly $2.5 billion between 2013 and 2016. The region's Department of Defense contracting activities also align with the state of Texas, as the second largest share of 2013 to 2016 defense contract dollars obligated came from the Aircraft Engine and Engine Parts Manufacturing Industry.

Figure 42: Defense Contracts in San Antonio-Austin Region (2013-2016)

NAICS	Industry	DOD Contracts
324110	Petroleum Refineries	$ 2,437,951,849
336412	Aircraft Engine and Engine Parts Manufacturing	$ 746,228,216
236220	Commercial and Institutional Building Construction	$ 482,831,921
541712	Research and development in the physical, engineering, and life sciences (except biotechnology)	$ 396,938,343
561720	Janitorial Services	$ 299,476,831
336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing	$ 256,620,004
722310	Food Service Contractors	$ 245,267,552
621399	Offices of All Other Miscellaneous Health Practitioners	$ 232,792,471
334111	Electronic Computer Manufacturing	$ 219,741,384
541810	Advertising Agencies	$ 193,716,400
541512	Computer Systems Design Services	$ 172,425,412
488190	Other Support Activities for Air Transportation	$ 127,403,356
311812	Commercial Bakeries	$ 97,775,708
561110	Office Administrative Services	$ 92,374,012
541330	Engineering Services	$ 92,139,629
541990	All Other Professional, Scientific, and Technical Services	$ 82,904,356
561210	Facilities Support Services	$ 76,701,504
541519	Other Computer Related Services	$ 69,545,616
621111	Offices of Physicians (except Mental Health Specialists)	$ 63,616,718
541511	Custom Computer Programming Services	$ 62,744,954
	Top 20 Total	**$ 6,449,196,236**
	Top 20 as % of Total Texas DOD Contracts	***81%***
	San Antonio-Austin DOD Contracts Total	**$ 8,000,623,515**

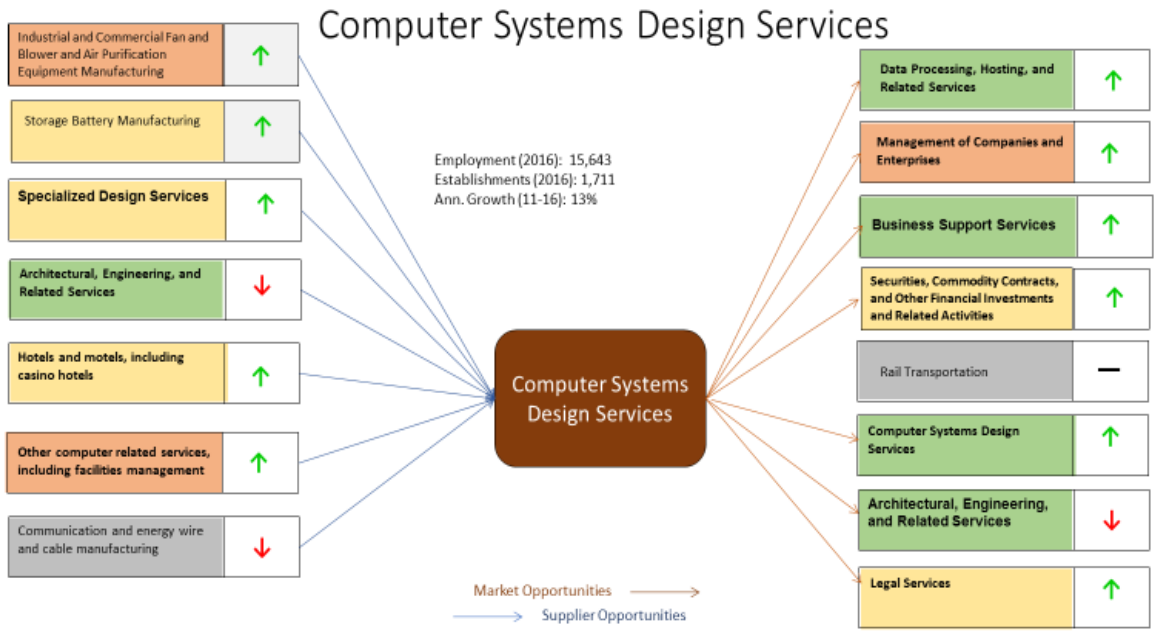
SOURCE: USASPENDING.GOV, BASED ON DOD CONTRACTS "PLACE OF PERFORMANCE"

Within the San Antonio-Austin's top 20 Defense Department contracting industries by contract dollars awarded were Electronic Computer Manufacturing; Computer Systems Design Services; Professional Scientific, and Technical Services; and Computer Related Services; and Custom Computer Programming Services. San Antonio-Austin based firms in these five industries combined for over $600 million in defense contracts between 2013 and 2016, further emphasizing the region's specialization in information technology and reinforcing the importance of cybersecurity as an area of emerging opportunity.

San Antonio-Austin Value Chain Analysis: Computer Systems Design Services

The Computer Systems Design Services industry is an important part of the well-established and growing information technology (IT) sector in the San Antonio-Austin region.[97] Computer Systems Design Service providers develop solutions for the integration of computer hardware,

Figure 43: San Antonio-Austin Region Computer Systems Design Industry Linkages



SOURCE: CREC, USING EMSI DATA

[97] Office of the Governor Economic Development & Tourism, "Texas IT Services Industry," July 2017, Accessible at: https://businessintexas.com/sites/default/files/07/14/17/it_report.pdf

software, and communication technologies. Firms in this industry provide services that include consultation, management, and design for technology system integration.[98] As illustrated in Figure 43, Computer Systems Design Services was chosen as a critical San Antonio-Austin defense cluster industry for several reasons. Among defense cluster industries in San Antonio-Austin, the industry employs the second-greatest number of people with 15,643 employees, while the largest industry by employment is related: Custom Computer Programming Services, with 21,538 employees. Professional, Scientific, and Technical Services (which includes many cybersecurity firms) is the fifth largest industry by employment in San Antonio-Austin with 140,411 employees, representing 7 percent of total employment in the region. Computer Systems Design Services features on the list of regional industry specialties, with an LQ locally of 1.25 (or 25 percent above the share of employment in this industry nationally) that reflects 15,643 industry jobs in 2016. Furthermore, regional employment grew by more than 7,000 jobs since 2011, a 13 percent annual growth rate. The region is projected to add another 5,300 computer systems design services jobs between 2016 and 2021.[99] The Department of Defense awarded nearly $175 million in contracts during the 2013-2016 period to area businesses. These figures illustrate the growing competitiveness of the San Antonio-Austin mega-region as an IT center and its great potential to become a cybersecurity hub.

The region's major local employers in this industry include Forcepoint, an Austin based firm and subsidiary of Raytheon focused on internet security software, and Asure Software, an intellectual property management software company based in West Lake Hills. The region also houses corporate offices for Actian, AT&T, and Cisco Systems among many other local, national, and multinational corporations in the computer systems design services sector. San Antonio-Austin's concentration of these firms, provides a complement to the region's IT powerhouse, Dell, and supports a broader regional IT ecosystem.[100]

Supplier opportunities

The left side of Figure 43 demonstrates the supplier opportunities for the computer systems design services industry. The San Antonio-Austin region has a strong concentration of

[98] See North American Industry Classification System definition at: https://www.census.gov/cgi-bin/sssd/naics

[99] EMSI

[100] Reference USA

businesses in Architectural, Engineering, and Related Services, but this industry saw an employment decline between 2011 and 2016.

The two supplying industries experiencing the greatest growth in the region are Industrial and Commercial Fan and Blower and Air Purification Equipment Manufacturing and Storage Battery Manufacturing, with growth rates of 11 percent and 44 percent, respectively, building from a small employment base of less than 200 employees. These industries reflect the importance of data processing centers as suppliers to the Computer Systems Design Service industry. This sector provides great potential for further growth. Specialized design services are another of the most closely connected industries to the core industry and grew at a 7 percent rate to reach over 1,900 employees. The industry is also buying services from Architectural, Engineering, and Related Services and Hotels and Motels. Engineering services are integrated with computer system design, and the lodging industry suggests that buyers are traveling to the area to meet with computer systems designers. One important national supplier to the industry that is not present locally is the Communication and Energy Wire and Cable Manufacturing sector. Local employment in this industry has declined to a negligible level following the departure of 85 employees from 2011 to 2016.

Market opportunities

The Computer Systems Design Services industry has a strong concentration that links to several industries for potential market opportunities. Four industries (including Data Processing, Hosting, and Related Services; Business Support Services; Computer Systems Design Services; and Architectural, Engineering, and Related Services) are relatively large in size (with more than 1,000 employees each). Since they are more highly concentrated in the San Antonio-Austin region relative to what they might be elsewhere, there may be a competitive advantage for area customers seeking computer system design services.

Missing from the typical market linkages to the region's Computer Systems Design Services value chain are potential customers in several industries, including the Management of Companies and Enterprises (i.e., business holding companies); Securities, Commodity Contracts, and Other Financial Investments; and Legal Services. All three of these industries have been growing but still have lower than average industry location quotients, suggesting that local firms might be able to continue growing at a relatively rapid pace, thereby creating opportunities for local Computer Systems Design firms.

A significant industry in the local Computer Systems Design Services industry's customer base is the Architectural, Engineering, and Related Services Industry, with over 22,000 employees in the region. However, the industry recently experienced a small decline in employment, which is especially concerning considering that the industry is highly integrated as both a supplier and customer to the Computer Systems Design industry.

Cybersecurity and the San Antonio-Austin Innovation Ecosystem

Cybersecurity has received tremendous attention in recent years, but it remains an industry still very much in its infancy. Cybersecurity is an important component of the broader Computer Systems Design Services industry value chain. It is also a national policy priority for defense, government, and commercial enterprises. Given the strength of existing IT-related industries in the region and its priority focus nationally, cybersecurity has been targeted as a growth industry for the San Antonio-Austin region. The National Security Agency (NSA) defines cybersecurity as "measures that protect and defend information and information systems by ensuring their availability, integrity, authentication, confidentiality and non-repudiation." At its core, cybersecurity is the protection of intellectual property and digital information. As the cybersecurity market evolves, so does its definition, classifications and functions.

In 2013, President Obama signed an executive order (EO) directing federal agencies to pen suggested cybersecurity standards for the private sector, providing a framework for cybersecurity by seeking defined activities, outcomes and references common across sectors. In May 2017, President Trump signed a new cybersecurity executive order that triggers a cyber policy review across a variety of sectors (communications, defense, financial, information technology, transportation, health care, manufacturing, among others), and focuses on the federal government securing its own systems. This most recent EO creates new opportunities and risks for cybersecurity firms and additional guidelines for categorization, procurement, processes and more. As the information threat landscape continues to change so do government rules and regulations for operating in this fluid environment.

The threat to security infrastructure is expected to increase in sophistication, scale and targeting. Consequently, expenditures are expected to grow accordingly to protect critical infrastructure and related digital systems. This will create significant revenue opportunities for security technology and service providers.

Large-scale, military cybersecurity decisions are being made. Because of this, cybersecurity is today a federal budget growth area. But, for years, sequestration was the norm. To counter

the previous slowdown in defense and other government spending, contractors split their attention to include commercial security service practices and made organizational changes to pursue the private sector customer. Considerable vendor efforts went into serving energy/power utilities, telecommunications, manufacturing, the financial sector, and health care. These were, and still are, among the dominant purchasers of private cybersecurity services. It remains unclear the extent to which the Trump Administration's return to military expansion will prompt cybersecurity firms (especially smaller companies) to refocus on this space.

Cybersecurity in San Antonio-Austin

The San Antonio-Austin cybersecurity business base is comprised of hundreds of firms. Some of these firms are military-focused, some are commercially-focused, and many serve both or are transitioning from military to commercial operations. The following section focuses on the cybersecurity context within San Antonio primarily, as the city has undertaken a concerted effort to boost this target industry. Austin is a powerhouse in Computer Systems Design Services as well, with a host of companies and budding entrepreneurs that stand to support, drive and potentially benefit from the region's advancing position in cybersecurity, both on the defense and commercial sides.

San Antonio, in particular, is one of the founding members of the nation's cybersecurity elite. The community has long appreciated cybersecurity and knows it is already in rarified air in terms of military cybersecurity presence, ongoing commitment of the Department of Defense, cyber-acclaimed universities, and a growing business base of service providers. The 24th Air Force, 25th Air Force and NSA Texas, all based in San Antonio, are considered the envy of other communities. The military and other government operations in San Antonio are charged mainly with: intelligence, surveillance and reconnaissance; and information operations and network defense.

San Antonio's history would suggest that cybersecurity here is all or at least overwhelmingly military. To the untrained eye, cybersecurity in San Antonio may look like a defense-centric industry, but it is not. The San Antonio Chamber of Commerce recently surveyed the local cybersecurity industry. The results showed that over half the community's cybersecurity firms are both commercial and defense in nature, and a number are overwhelmingly and increasingly skewed toward the commercial marketplace. This is especially the case with firms that were birthed in San Antonio, as opposed to those that set up satellite operations here.

Many of the CEOs of San Antonio's enterprises may have developed their cybersecurity skills in the military, but the military is not the primary source of their revenue growth. To be sure, San Antonio's has a base of dedicated military contractors represented by large national firms, but most San Antonio cybersecurity firms are small businesses.

Whereas other cities have evolved their cybersecurity industries via contractors headquartered elsewhere, most of San Antonio's operations are homegrown. This is especially the case with its more prominent cybersecurity stars. Cybersecurity here is mostly a grassroots industry, with the preponderance of firms growing out of the entrepreneurial spirit of one or two local individuals during the past decade.

Regional Cybersecurity Ecosystem

The San Antonio-Austin region has an array of service providers and resources to help support area businesses grow, innovate, and bring new technologies to market. These types of support services are critical to the development of key industry sectors including computer systems design services and cybersecurity. According to Accenture's innovation framework, talent,

Figure 44: Innovation Ecosystem Partners in San-Antonio-Austin

Issue Area	Types of Support Services	Area Service Providers/Resources
Workforce Talent	Workforce Training, Classes, HR services	Workforce Solutions Alamo, Workforce Solutions Capital Area, San Antonio Economic Development Foundation, Austin Chamber of Commerce, CyberSecurity San Antonio
Capital	Loans, Equity Investments, Working Capital, Coaching	MassChallenge Texas, Rackspace, San Antonio Angel Network, Capital Factory, CyberTexas Foundation
Physical Assets		Build Sec Foundry, Center for Infrastructure Assurance and Security (CIAS) at the University of Texas at San Antonio (UTSA), Southwest Research Institute, DIUx Austin, Port San Antonio
Business Development and Know-How	Peer Networks, Professional Development, Training Programs	Texas State Small Business Development Center (SBDC), University of Texas at San Antonio SBDC, SCORE – Austin Chapter, CyberSecurity San Antonio
Technical/Engineering Support	Access to equipment, engineering support, technology development and commercialization	Texas Manufacturing Assistance Center / South Central, Institute for Cyber Security at UTSA, Austin Chamber of Commerce, Cybersecurity Council – San Antonio Chamber of Commerce
Market Development	Export promotion, procurement assistance, supply chain connections	UTSA Procurement Technical Assistance Center, Office of the Texas Governor Business Assistance, UTSA International Trade Center, CyberTexas Foundation

capital, markets, and technology opportunities drive the future and a strong innovation ecosystem in the mega-region will be needed to build the capacity of local firms to remain resilient and compete for future opportunities. Some of the prominent innovation ecosystem resources in the San Antonio-Austin region are identified in Figure 44.

This section is an attempt to characterize the region's ecosystem for cybersecurity operations. This effort mostly examines cybersecurity in the San Antonio-Austin region holistically. However, it is worth noting that characteristics and needs of military-oriented cybersecurity firms can differ from those of their commercially-oriented counterparts.

The cybersecurity industry in the mega-region as well as around the globe is in a constant state of change in response to the morphing threat landscape. As such, findings from this high-level initiative should be viewed as a window in time into an exceedingly complicated, rapidly evolving industry. Observations regarding San Antonio-Austin's cybersecurity ecosystem have been categorized into six areas important to the region's cybersecurity business base:

- Workforce Talent
- Capital
- Community Know-How
- Education
- Property
- Procurement

These categories are addressed more fully below. The observations are based on the results of the cybersecurity focus group, conversations with cybersecurity economic development leadership and supplemental knowledge. [101]

[101] The CREC Research Team, working with Prager Company, facilitated a focus group with leaders of the region's cybersecurity small business community in July 2017 to identify needs and challenges of the cybersecurity industry in San Antonio. Arranged by CyberSecurity San Antonio (a division of the San Antonio Chamber of Commerce) in partnership with the San Antonio Area Economic Development Foundation, the focus group discussions provided insights on unmet local needs for the cybersecurity industry. We wish to thank and acknowledge the businesses participating in our regional cybersecurity focus group: CNF Technologies, Coherent Cyber, Cyber Checkmate Consultants, Def-Logix, Delta Risk, Digital Defense, Infocyte, Innove, IPSecure, Jungle Disk, Webhead.

Workforce Talent

A robust, sufficiently trained workforce is critical to addressing the rapid increase in demand for cybersecurity support services and technology. The San Antonio-Austin region's cybersecurity firms struggle to attract the right talent for their businesses. There is a shortage of job-ready candidates, especially those with proper security clearance. This is believed to be exacerbated by the fact that cybersecurity internships are insufficient, up-training and retraining is deficient, and providing on-the-job training can be difficult in a secure and secretive work environment.

Wage premiums paid by cybersecurity firms to attract and retain highly desirable employees (versus that paid by other industries in the region) reinforce the fact that properly skilled individuals are in short supply here. The region has a justifiable reputation for lower workforce costs on average versus competing U.S. markets. But this advantage is less relevant when it comes to attracting highly skilled, mobile individuals, such as those needed in cybersecurity.

Although technologically sophisticated employees are most sought after, there is a tendency to think that the cybersecurity workforce consists only of highly technical professionals. According to focus group attendees, this is not the case. While computer network professionals, programmers and IT professionals are exceedingly desirable, a sizable percentage of jobs can be filled by sufficiently experienced medium or lower-tech professionals. Finding those with sufficient experience can, however, be a challenge. The region's large population of hard working blue collar labor provide a potential source to ease the cybersecurity industry's shortage, but only if proper transitional training is made available to these jobseekers.

Employers state a preference for those with a bachelor's degree, but a premium is placed on direct experience over a college degree. This should not be surprising given that cybersecurity is an outgrowth of the information technology field, where self-taught, experienced and skilled professionals and technicians have always been highly valued. Although the region has a substantial cybersecurity industry footprint from a national perspective, its information technology talent market is smaller than other major cybersecurity locations.

Unlike many industries where on-the-job training and internships are commonplace tactics for addressing skill shortages, this is not so easy with cybersecurity. Many operations require some level of security clearance. Even those that don't, work with clients reluctant to expose their information to novices. The San Antonio-Austin region is fortunate to have an advanced network of schools that teach cybersecurity and help individuals secure sought-after industry certifications. But this does not take the place of in-the-field know-how and demonstrated

competency. Some efforts are underway to begin addressing this skill gap, such as certification support and related training of military veterans with active clearances. But shifting and sometimes unpredictable military contracting requirements can present problems when it comes to determining exactly what training and which certifications are most essential.

The San Antonio-Austin region is considered to have a high quality of life and very low cost of living, both of which bode well for recruiting from the outside. But while its cybersecurity industry is growing rapidly, some candidates fear the local industry environment is not yet mature enough if something happens to the job they are hired to fill. If forced to look elsewhere, the IT market may not be large enough to accommodate their unique skill set. For this reason, some companies set up satellite offices in other cities known as major IT and cybersecurity markets for the primary purpose of hiring high skilled individuals who, while employed by an area firm, telework from their current place of residence.

Capital

Focus group attendees state that the San Antonio-Austin region has neither the level of capital investment nor the number of private investors supporting cybersecurity (or other rapid growth sectors) found in other leading cybersecurity communities, especially in major metro markets. The issue is twofold. First, it is a need for dollars to help existing firms grow. Second, it is a shortage of locally-based financial influencers who can help businesses get to the next revenue-generation level and, perhaps, position themselves for acquisition (an important growth path for cybersecurity entrepreneurs).

Venture capitalists and angel investors tend to follow investment opportunities and may aggregate in a particular place if large enough. According to attendees, this cluster does not exist in the region, nor do the sorts of well-networked forums found in other major cybersecurity markets for innovators and entrepreneurs to meet venture capitalists, bankers, angel investors and other potential investors. However, thanks to the entrepreneurial development commitment of Rackspace (one of the nation's largest managed cloud and tech support providers), and even more so to the individuals who became wealthy by virtue of Rackspace, venture capital is starting to emerge in the region. The prevailing issue today is characterized as one of scalability for firms that have reached a certain threshold more so than initial financing to get operations off the ground.

Texas is one of the nation's most aggressive and best-funded providers of incentives to business. However, it has limited incentives specifically for the cybersecurity industry. As

voiced by attendees, the majority of Texas's most beneficial financial programs were designed for large, job-generating operations and most cybersecurity firms do not fit that description.

Community Know-How

San Antonio, especially, is viewed a dominant player in the nation's rapidly emerging cybersecurity industry. Few can match San Antonio's concentration of military, education infrastructure, university scientific research and training, and large network of cybersecurity businesses. San Antonio is growing into its self-proclaimed moniker as "Cyber City USA."

The presence and growth of military operations is a foundation upon which San Antonio's cybersecurity industry has been built and is a continued source of stability and national prominence. In 2009, the cybersecurity and defense contracting clusters benefited greatly when the Air Force Space Command chose San Antonio's 24th Air Force at Lackland Air Force Base as headquarters for its cyber command. San Antonio received another major cybersecurity military endorsement when, in 2014, a decision was made to expand the 688th Cyberspace Wing (at Joint Base San Antonio).

The region, building from San Antonio as a hotbed of cybersecurity corporate and small business operations, stands to benefit from these continuing operations. The region claims more than 250 cybersecurity firms, including the presence of virtually all the nation's top corporate players. Cybersecurity firms like to cluster close to other cybersecurity firms. This is the case in the region. Based on focus group comments, some the San Antonio-Austin region's cybersecurity providers would risk possible cannibalization of their workers in exchange for a cybersecurity concentration that brings with it the ability to learn from one another and advocate as one loud voice. This is precisely what is happening here now. Firms are beginning to cannibalize each other's highly skilled workers due to labor shortages, but the collegial atmosphere of cybersecurity start-ups is beginning to make for a mutually beneficial support network.

A distinguishing characteristic of the region's cybersecurity ecosystem is its concentration of educational institutions focused on the industry. The University of Texas in San Antonio (UTSA) is home to both the Center for Infrastructure Assurance and Security (CIAS) and the Institute for Cyber Security (ICS). The former works to improve the overall security of state and community technology infrastructures, while the latter conducts basic and applied research in cybersecurity and pursues development of viable commercial technologies and services.

In Austin, the Department of Defense expanded its technology outreach and investment efforts by establishing the Defense Innovation Unit Experimental (DIUx) at the startup incubator Capital Factory.[102] DoD created DIUx to rebuild the bridge between the Pentagon and the innovative American technology community. Through DIUx, DoD is seeking to contract with companies offering solutions in a variety of areas – from autonomy and AI to human systems, IT, and space – to solve a host of defense problems.[103] The Austin hub is the third established hub across the country, joining Silicon Valley and Boston. More recently, MassChallenge Texas, a global network of startup accelerators, launched its newest program in the Austin/San Antonio region. MassChallenge Texas will accelerate up to 100 high impact, high potential companies, which compete for up to $500,000 in equity-free cash awards. MassChallenge Texas is supported by a public-private partnership that includes founding corporate partners Southwest Airlines, USAA, and Upstream. MassChallenge Texas supports the region's ecosystem through its deep experience in key industries, help for early-stage startups and entrepreneurs through community-building activities, tailored programming, and ecosystem development. The not-for-profit is also focused on fostering collaboration by connecting large corporations with the startup community.

Founded on its cybersecurity expertise and driven by hyper industry growth, several years ago the San Antonio Chamber of Commerce formed CyberSecurity San Antonio. This entity helps cybersecurity firms evolve and new firms emerge. CyberSecurity San Antonio works with educators, workforce development providers, small business consultants, and cybersecurity business executives to impart knowledge and advance the industry.

The region has many cybersecurity experts in the government space. It also has a growing number of support providers for cybersecurity commercial operations. What is not clear is whether there are sufficient service providers able to help military-oriented cybersecurity firms expand or shift into the commercial space should they choose to do so. Many choose just that because of the regulatory and procurement challenges of securing and maintaining large federal contracts.

Companies that attempt to pivot from military to commercial cybersecurity quickly learn that, while the revenue potential is significant and growing, the business model can be very

[102] http://statescoop.com/diux-expands-to-austin-texas

[103] https://www.diux.mil/portfolio

challenging and the necessary procedures for request for proposals (RFP) response and customer interaction somewhat foreign. Trying to maintain cybersecurity clientele in both the military sector as well as commercial can be too much to handle for many small cybersecurity businesses. As with the military, large corporations may have pre-established cybersecurity providers. When open to hiring new support providers, they will often gravitate toward those with a discernable reputation, brand and customer service orientation. Learning differing protocols and how to go from a military clientele to a corporate clientele requires effort. For many firms, the path of least resistance is a larger number of small to mid-sized commercial clients, but this is a revenue generation model unfamiliar to many.

According to focus group attendees, Series C companies in the region today are better supported than in the past. But at the Series A level there is a shortage of mentoring and service sector expertise to help these companies along in such areas as accounting and reporting, legal and transactional, and so on.

Education

In the San Antonio-Austin region, cybersecurity job growth is outpacing labor availability. This is a constant challenge for local businesses. Nonetheless, the region is praised for its array of educational institutions serving the cybersecurity industry. From a higher education and research standpoint, the region has acclaimed cybersecurity institutions and programs. Among its dominant players are the: UTSA Institute for Cyber Security and Center for Infrastructure Assurance, St Mary's University Center for Terrorism Law (with emphasis on cyberspace and information assurance technologies), Our Lady of the Lake University Center for Information Assurance Management and Leadership, and the Southwest Research Institute (awarded the nation's first cybersecurity R&D program by the Department of Homeland Security). When it comes to hiring local graduates, emphasis appears to be on those with a Bachelor's Degree in Cybersecurity and specialties such as Security Informatics and Information Assurance.

Focus group attendees express satisfaction with the quality of local educational institutions. They also express general satisfaction with the extent to which higher educational institutions and the cybersecurity business community are working together. This connection includes development of curriculum and instruction with business experts and other talent development initiatives. However, many attendees state that they recruit most heavily from higher educational institutions outside the region.

In the cybersecurity industry, many young individuals hired have no college degree. For them, formal cybersecurity training offered in high school can be an advantage. The region is credited for its attempts to build its cybersecurity talent pipeline through courses that begin in high school and continue through college, but more coding and other fundamental orientation is said to be needed and at an earlier age.

Overall, the San Antonio-Austin region's higher educational institutions are sophisticated providers of cybersecurity education and the high schools are considered to offer a solid grounding in the industry. But cybersecurity employers prefer those with industry experience over new college graduates with any specific degree or those straight out of high school. So, while the region is producing students schooled and credentialed in cybersecurity this does not come close to satisfying local industry demand.

Property

Some cybersecurity companies can be accommodated in traditional office settings of which the San Antonio-Austin region has a reasonable supply. Other companies require more secure space or even advanced Sensitive Compartmented Information Facility (SCIF) space that allows them to perform their operations protected from outside access or interference. Based on focus group comments, classified government conferences and other highly sensitive meetings often must be performed on the military base because other suitable property options are limited.

Unlike some other major technology markets, relevant property inventory is dispersed throughout the region rather than clustered in any particular location. There is an effort underway, particularly by San Antonio, to shift the center of gravity to have more commercially-oriented technology firms in the downtown, but this may be years off as appropriate building space is limited and downtown parking is problematic.

On the federal contractor side – where specialized, secure office space may be more essential – cybersecurity companies are also scattered around the region. However, this is in the process of being addressed. For example, San Antonio is evolving a 1,900-acre campus and large office building at Port San Antonio that will benefit San Antonio's defense companies, ranging from 4,000 square foot users to more established 30,000 square foot companies. Several focus group attendees already have committed to this development. Because this space is open to any users, full building occupancy is expected.

The movement to create a critical mass of commercial technology companies downtown as well as the evolving Port San Antonio will benefit San Antonio's cybersecurity industry. This will also be helpful to the region's overall growth and opportunities in cybersecurity. Albeit helpful to the industry's evolution, the current decentralization of property does not appear to be a major problem for the industry's smaller firms. And it may not be a problem at all for the largest contractors who, upon being awarded big contracts, can and will build out SCIF and other customized space as needed.

Many of the San Antonio-Austin region's cybersecurity firms are small, newer enterprises requiring inexpensive, interactive space to accelerate innovation. These firms would benefit from one-stop, centralized support in areas including: feasibility and commercialization, prototype development and testing, R&D funding, capital formation and access, market development, and contract procurement. The region has a relatively small but increasing number of options in this arena.

Focus group attendees are particularly interested in more testing facilities to refine their cybersecurity innovations before taking them to market. They suggest that a cybersecurity test range for small innovators would be beneficial; less grandiose than that at Port San Antonio and more nimble and interactive for newer entrepreneurs on a tight budget. Focus group attendees also suggest that if the region is to promote itself as Cyber City USA (or Cyber Region USA), it should put in place a Cyber Demonstration Center for innovators to showcase their capabilities to major contracting entities and other prospective clients. A still-developing concept is being floated to develop such a facility where emerging product could be tested and validated (a huge need for early stage security innovations) and, when ready, would be demonstrated to the marketplace.

Procurement

Given the highly sensitive nature of cybersecurity, customers have a strong preference for trusted, well-established vendors with a proven track record. The issue of trust is more pronounced in cybersecurity than in many other industries where less may be at stake. This is a sizable hurdle for newer firms and those with less-known products and services. The issue among prospective clients is not merely the credibility of the firm, but whether it will be around for the long haul so as to continue serving the client and supporting its cybersecurity product(s).

Newer firms have a keen desire to demonstrate their capabilities. In order to do so, some attendees claim a willingness to initially provide their services and software for free to a large-

scale federal or corporate client. Often, the larger the organization being served (even if pro bono), the faster reputation is established, credibility is demonstrated, and references procured. The added benefit of these arrangements can be door opening to prospective clients in the same industry and real-world advice needed to refine services and customer interaction. The challenge in the San Antonio-Austin region is that scant few federal entities and corporations are willing to serve as demonstration environments for piloting software and new technology.

Contract procurement regulations and processes for federal contracts often favor big firms, as contractors and integrators tend to go with those they know. The same can be true with private sector companies, albeit to a somewhat lesser degree. This is particularly the case where selection guidelines give an edge to firms with a large body of work and a diverse menu of products and services. It also occurs when contracting officers insert certification requirements (sometimes when not essential) that are more commonly held by the larger organizations. It is, in part, for these reasons that federal cybersecurity contracting is dominated by six corporations, and small firms are challenged to win commercial contracts as well. Government agencies, in particular, are known to have a preferred short-list of firms from which to choose and repeatedly go to this same group for contracting. Many of these entities are then pre-approved for several years.

Small cybersecurity firms, especially new entrants, face an uphill battle with federal government procurement. As focus group attendees point out, even the interview process can be problematic. Cybersecurity is an industry founded on innovation, which is what differentiates many newcomers. However, during interviews, larger corporations may be in the same room and, thus, privy to these new concepts and other confidential information. Some have been known to use this intelligence for their own gain.

A dilemma for many smaller cybersecurity businesses is that they are, or are perceived to be, technology firms rather than service providers. Government clients are often predisposed to hiring cybersecurity service providers with big teams that can keep existing operations running and in good repair with minimal disruption. Unless mandated, they are less inclined to contract for technological innovation to their infrastructure, hardware and software that would improve and modernize their systems. While the smaller firms may be technology innovators, the perceived need is often for large-scale service providers.

Both the federal government and large corporations have ways of weeding out start-up companies and smaller firms through rigid evaluation criteria. For those small firms that make the first cut, procurement process timing can be a marathon effort. The process can last upwards of six months -- a major obstacle for smaller operations with limited staff and lean financial resources.

The Trump Administration's EO suggests a greater focus on IT modernization and shared services. Both will help smaller cybersecurity firms oriented toward technological innovation as well as multi-award contracts. This is especially the case if more is done to train firms and facilitate partnerships between entities within a given industry and between technology innovators and service providers. However, the Administration's desire to reduce the federal workforce while simultaneously increasing security speaks to a greater need for outsourcing cybersecurity functions to well-staffed, major contractors (i.e. service providers). It is too early to tell how this will play out.

San Antonio-Austin Innovation Ecosystem Summary

Both San Antonio and Austin are proven economic powerhouses. Together, the emerging mega-region holds the potential to be one of the global centers for the Innovation Economy. The defense economy is an important driver of this success and future prospects, especially in areas like cybersecurity. The San Antonio-Austin cybersecurity business base is comprised of hundreds of firms. Some of these firms are military-focused, some are commercially-focused, and many serve both or are transitioning from military to commercial operations within the region. The region's current asset base in IT, along with the national security priority attached to cybersecurity, bodes well for future business and job opportunities.

Despite having deep IT specialization, and many organizations and services in the region to help support businesses and workers, more can be done to promote the San Antonio-Austin innovation ecosystem and defense economy. This includes more opportunities to coordinate, expand, and promote services in the areas of workforce talent, capital, community know-how, education, property, and procurement related to cybersecurity. Cybersecurity has received tremendous attention in recent years, but it remains an industry still very much in its infancy. With an increased focus on developing the region's innovation ecosystem, San Antonio-Austin will be in even better position to capitalize on this growing industry and also to seize the pockets of opportunity that offer promising targets for enhanced defense diversification support efforts.

Report Findings & Recommendations

This research work is based on several independent "deep dive" research efforts that examine the Texas defense industrial base via different lenses, such as by region, by growth status, by industry focus, and by company size. The sheer scale and size of the Texas defense industry is the most obvious conclusion from this research. Texas-based defense firms operate in nearly all defense-focused sectors, and nearly every kind of A&D-related specialization can be found in the state. Firms vary greatly, from massive OEMs to small traditional manufacturing shops to fast-growing and nimble technology firms.

Texas' defense firms operate in many sectors, but the state is home to an especially strong concentration of expertise in aircraft manufacturing and the traditional energy sectors, which have a long history of close partnerships with DoD. In addition, an emerging cybersecurity sector is developing in San Antonio-Austin and in other parts of Texas as well. These focus areas account for the vast bulk of DoD spending. In fact, 80% of all current DoD procurement dollars in Texas are now expended in either aerospace or energy.[104]

Within this diverse group of companies, we find other interesting patterns as well. Among high growing firms, many of the best performing sectors, such as computer systems design and scientific R&D services, are inherently dual use and have great potential for growth in both military and commercial markets. In addition, many regional clusters, such as San Antonio's cybersecurity sector, Richardson's Telecom Corridor, or near Ellington Field in Houston also have promising growth opportunities in many technology-related lines of business. Finally, business survey data and other research indicate that a large share of Texas defense firms are accustomed to operating simultaneously at multiple points in the defense supply chain—as a prime contractor, major subcontractor or small parts/technology supplier. This pattern suggests that these firms have the internal management capacities to undertake more focused work to enter new markets, whether they be defense or commercial.

While aerospace and defense have long been big business in Texas, regional or local economic development organizations have not placed a heavy emphasis on supporting defense-related industry growth. Many factors were at play. State defense contracting activity was growing organically, so local leaders focused instead on other emerging industry clusters. At the same

[104] CREC analysis of Department of Defense procurement data for Texas, 2013-2016, www.usaspending.gov

time, many traditional sectors—such as energy and space in Houston—were also thriving and viewed DoD as one customer among many. However, as other energy and aviation markets stagnate and federal procurement spending levels decline, a renewed focus on the state's competitive advantage in capturing DoD procurement—and the defense sector more generally—as a core customer makes sense.

These pockets of opportunity offer promising targets for enhanced defense diversification support efforts. Working with these companies to assist them in entering new markets can offer benefits in the form of new revenues and jobs as well as help to strengthen A&D clusters across Texas. New market and product development further benefits Texas' economy as companies and communities become better partners to DoD. The result of this private investment is better technologies, deployed more efficiently, to pioneer new innovations for the future. Additionally, while fast-growing firms are job-creators, the fast-growing defense contractors may "fall through the cracks" in various regional ecosystems. Their importance to the local economy may not be fully understood, and existing business service providers—public and private—may not be tailoring their work to these important economic engines.

The state's A&D sector would also benefit from a few new policy directions. Texas' business climate is generally considered quite supportive, but a few problem areas do exist. With federal corporate tax policy at top of mind, it is notable that that Texas' current tax structure creates competitive disadvantages for defense firms and manufacturers. The Tax Foundation's annual assessment of state tax regimes consistently ranks Texas #49 in the US for its relatively high corporate tax rates. Texas also scores poorly on its property tax structure as well.[105] While some efforts have been made to reduce marginal tax rates, continued focus in this area will be needed to bring Texas more in line with other states.

Texas' defense sector would further benefit from better integration of economic and workforce development efforts in each of the regions. Texas is home to many Chambers of Commerce and economic development organizations (EDOs) that view the defense sector as a target industry or key economic driver. However, these efforts are small and fragmented. Few unified or coordinated regional efforts currently exist to promote the defense industry or to support its further expansion.

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[105] Jared Walczak, Scott Drenkard, and Joseph Henchman, 2017 State Business Tax Climate Index, Tax Foundation, 2017, p. 23 (https://files.taxfoundation.org/20170302120920/TF-SBTCI-2017-Final1.pdf)

As Texas seeks to further strengthen its already impressive A&D sector capacities, it should consider the following options:

- Develop strong defense sector innovation capabilities

Texas and its major metro areas are hotbeds of defense activity, but they are not yet viewed as hotbeds of defense industry innovation (beyond computer systems). This is starting to change, as new resources such as the Austin DIUx office, Dallas Innovate, and the Houston Exponential initiative gain local momentum.

State, regional, and local economic development initiatives can help spur this work in a number of ways. First, defense innovation should be part of the menu of programming and services offered by all of the state's entrepreneurship and innovation networks. These include groups like the Dallas Entrepreneur Center, Austin's Capital Factory, or Geekdom in San Antonio and links to regular events such as the Open Houston Conference or the forthcoming MASS Challenge Texas effort.

Defense sector entrepreneurs can enrich these conversations and benefit from linkages to other high growth entrepreneurs, especially in the areas of computer systems design (i.e., cybersecurity), energy, space tech, telecom, and advanced instrumentation. TMAC can be particularly important in connecting the Internet of Things to the state's cybersecurity movement and helping to advance key technologies to support state-of-the-art unmanned aerial vehicles as well as space vehicles.

Second, economic developers and community leaders should aggressively reach out to identify their region's high growing defense firms. Our surveys of high growers indicate that fast growing defense firms are prevalent in Texas, and offer large scale benefits in terms of generating new jobs and revenue. These firms would benefit from closer ties to various business support programs operating across Texas. As part of this research, the CREC team identified a group of fast-growing and sustained-growth defense companies that TMAC could begin communicating with to determine their technology and business challenges, then working with the rich ecosystem of service providers to ensure that all are connecting to defense firms as appropriate.

Finally, while the military has long been a priority of statewide organizations such as the Texas Economic Development Corporation and the Texas Military Preparedness Commission, TMAC and other partners need to help raise the visibility of defense innovation as a strategic economic development priority. Statewide groups currently promote and support the military

presence in Texas, but they could be vital in ensuring that the military commands in the state are more closely tied to the state's fast-growing defense technology firms.

- Create strategies that tap new defense market capabilities in emerging sectors, like cyber, UAVs, and space tech, to enter new markets, especially overseas

In a related strategy, state and local economic developers should invest in key sectors with the potential for growth in both commercial and military markets. Cybersecurity, UAV, and space technology development represent some of the most promising near-term opportunities. Some local cluster development efforts have emerged in the past.

For example, the San Antonio Economic Development Foundation has made a major push to position the region as CyberCityUSA.[106] Similarly, the Arlington Chamber of Commerce and other partners in the DFW region, have sought to develop industry consortia focused on UAV development.[107] Houston's Exponential is seeking to translate the region's ultra-high wealth individuals into a source for technology investment capital that could be vital not only to Houston but also to the rest of the state.

- Continue strong programming in workforce development

In most of Texas' major metro areas, workforce availability is the number one challenge facing growing defense firms. This talent gap has been widely recognized and is a top priority at the state, regional, and local level. Regional groups, such as the DFW Regional Aerospace Consortium and UpSkill Houston, have developed award winning programs to train workers and encourage youth and others to pursue training and careers in the field. This important work should continue and be expanded across Texas.

San Antonio and Houston have been leaders in identifying the specific needs of key sectors such as cybersecurity and energy. The San Antonio Chamber and the Greater Houston Partnership recently served as pilots for the US Chamber of Commerce Foundation's Talent Pipeline Management program. TMAC could potentially play a role in serving as a TPM intermediary in Texas to help fill the void (or help recruit intermediaries to develop similar programs in other Texas Triangle cities).

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[106] San Antonio Economic Development Foundation, "San Antonio, a Leading Center for Cybersecurity," 2013 http://www.sanantonioedf.com/images/uploads/CybersecurityFactSheet.pdf

[107] Arlington Chamber EDI effort

Local partners also understand that the immediate talent needs in the Texas Triangle go far beyond what their local talent solution providers (schools, colleges, universities, and private trainers) can deliver. They must develop talent attraction strategies that appeal to the world's best and brightest talent. These strategies need to be in place to highlight the opportunities in the defense cluster and to reduce barriers for workers to enter these occupations if Texas is to maintain its advantage in appealing to high skilled workers.

- Better understand and capitalize on regional supply chain opportunities

Texas is home to a set of the largest and most complex A&D supply chains in the world. It hosts large OEMs who operate in a diverse set of defense markets, along with a diverse set of suppliers as well. Texas-based defense firms already do a significant amount of business in the state of Texas. The research completed for this project indicates that Texas defense firms generate $25 to $30 billion annually in defense-related procurements. Not all of those funds stay in the state. A survey of defense contractors found that half of the supplies these firms purchase come from other Texas-based firms. This number is impressive, but could always be improved—especially since Texas is home to such a diverse array of A&D companies. State and local economic development leaders need to better understand current supply chain structures and develop new capacities that help link Texas based firms in new business relationships with each other.

The data and analysis presented in this report can provide numerous benefits to stakeholders in Texas and across the broader OEA network. Within Texas, we have identified a strong core of high growing defense firms that not only contribute to a stronger defense industrial base, but also serve as potential "target customers" for state and local economic development efforts. High growth defense firms are critical job creators. As they succeed, Texas communities will prosper, and the U.S. military will also benefit from a stronger and competitive base of suppliers.

The Texas innovation ecosystem, led by TMAC and others, could make a significant contribution to Texas economic development potential by focusing assistance to high-growth defense firms because they are lynchpins in complex defense supply chains affecting companies across the state and nation. The project's supply chain analysis highlights huge new opportunities within Texas based A&D supply chains. Previous OEA-sponsored grantee research sought to better understand supply chain dynamics, focusing on efforts to identify "at-risk" companies. This research flips that script to focus on "high potential" companies that could benefit DoD while

also spurring local economic development. The potential for deepening the defense supply chain relies on the strength of these high potential companies.

As this report began, when it comes to the aerospace and defense industries, it is hard to get bigger than Texas. Nearly ten percent of all US defense spending occurs in the state. Texas is home to some of the military's most important installations, and it hosts major operations for nearly all of the U.S.'s most important defense contractors. Yet, there is still ample room for the state to continue to grow its footprint in defense, and to aid existing DoD contractors diversify and grow in other markets. These new directions do not require major new investments or large-scale shifts in policies. However, they do call for the widespread recognition of the Texas aerospace and defense sector as not only an important guarantor of our national security, but also as an important driver of innovation, job creation and wealth creation for the state and its many diverse regions.

Appendix A: Texas Defense Cluster Data

Texas

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Geophysical Surveying and Mapping Services	5,928	(2,041)	-26%	4.7	418	$116,267
Industrial Building Construction	52,483	10,949	26%	3.9	641	$109,949
Oil and Gas Pipeline and Related Structures Construction	40,442	1,029	3%	3.7	586	$97,103
Petroleum Refineries	19,477	(2,027)	-9%	3.4	143	$207,499
Ammunition (except Small Arms) Manufacturing	3,467	(57)	-2%	3.3	5	$113,681
Footwear Manufacturing	2,891	161	6%	2.6	46	$44,270
Fabricated Pipe and Pipe Fitting Manufacturing	7,339	(2,004)	-21%	2.5	151	$73,765
Industrial Valve Manufacturing	4,937	(1,291)	-21%	2.3	110	$100,070
Other Management Consulting Services	17,401	(448)	-3%	2.2	2,925	$103,452
All Other Miscellaneous Chemical Product and Preparation Manufacturing	6,401	(111)	-2%	2.1	185	$118,318
Plastics Bag and Pouch Manufacturing	5,400	498	10%	2.0	41	$66,938
Electronic Computer Manufacturing	17,552	4,873	38%	2.0	54	$164,814
Prefabricated Metal Building and Component Manufacturing	4,858	810	20%	2.0	156	$69,270
All Other Basic Organic	6,146	469	8%	2.0	84	$161,097

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Chemical Manufacturing						
Flight Training	2,760	(209)	-7%	1.9	110	$83,693
Plate Work Manufacturing	7,268	(1,536)	-17%	1.9	242	$72,287
Surveying and Mapping (except Geophysical) Services	7,032	191	3%	1.8	703	$69,688
Consumer Electronics Repair and Maintenance	1,865	802	75%	1.8	157	$42,957
Other Heavy and Civil Engineering Construction	16,482	2,258	16%	1.8	516	$95,382
Ethyl Alcohol Manufacturing	1,681	196	13%	1.8	15	$163,881
Plastics Material and Resin Manufacturing	8,738	1,090	14%	1.8	122	$154,124
Totalizing Fluid Meter and Counting Device Manufacturing	1,513	184	14%	1.8	23	$89,010
Water and Sewer Line and Related Structures Construction	26,269	4,571	21%	1.8	1,175	$64,457
Communication Equipment Repair and Maintenance	2,173	(249)	-10%	1.8	191	$74,067
Transportation Equipment and Supplies (except Motor Vehicle) Merchant Wholesalers	4,785	(120)	-2%	1.8	352	$92,981
Semiconductor and Related Device Manufacturing	26,420	(2,742)	-9%	1.7	152	$171,603
Fabricated Structural Metal Manufacturing	12,716	208	2%	1.7	369	$69,455
Clay Building Material and Refractories Manufacturing	3,396	543	19%	1.7	48	$70,292
Air and Gas Compressor	2,803	2	0%	1.7	76	$116,814

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Manufacturing						
Plastics Pipe and Pipe Fitting Manufacturing	3,757	(488)	-12%	1.6	69	$75,778
Synthetic Rubber Manufacturing	1,384	(175)	-11%	1.6	22	$126,283
Metal Tank (Heavy Gauge) Manufacturing	4,770	(788)	-14%	1.6	141	$72,052
Aircraft Manufacturing	30,992	(1,527)	-5%	1.6	88	$139,412
Power Boiler and Heat Exchanger Manufacturing	2,917	(739)	-20%	1.6	60	$94,176
Mechanical Power Transmission Equipment Manufacturing	1,690	(110)	-6%	1.5	29	$65,101
Commercial and Industrial Machinery and Equipment (except Automotive and Electronic) Repair and Maintenance	25,377	202	1%	1.5	2,230	$78,162
Other Basic Inorganic Chemical Manufacturing	4,800	628	15%	1.5	93	$144,887
Explosives Manufacturing	858	2	0%	1.5	4	$122,500
Fluid Power Valve and Hose Fitting Manufacturing	4,389	414	10%	1.5	62	$95,979
Power and Communication Line and Related Structures Construction	21,115	3,977	23%	1.5	777	$72,708
Urethane and Other Foam Product (except Polystyrene) Manufacturing	4,162	766	23%	1.4	91	$56,472
Security Systems Services (except Locksmiths)	13,992	2,509	22%	1.4	756	$66,360
Switchgear and Switchboard	3,882	142	4%	1.4	63	$96,223

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Apparatus Manufacturing						
Computer and Office Machine Repair and Maintenance	4,866	(205)	-4%	1.4	548	$64,074
Apparel Accessories and Other Apparel Manufacturing	1,365	214	19%	1.3	44	$40,074
Uranium-Radium-Vanadium Ore Mining	60	(209)	-78%	1.3	6	$83,318
Fiber Optic Cable Manufacturing	1,111	436	65%	1.3	8	$97,395
Small Electrical Appliance Manufacturing	1,215	(262)	-18%	1.3	26	$109,874
Administrative Management and General Management Consulting Services	57,502	20,283	54%	1.3	8,258	$119,467
Other Warehousing and Storage	4,569	466	11%	1.3	232	$71,594
Tire and Tube Merchant Wholesalers	2,954	590	25%	1.3	224	$60,512
Testing Laboratories	17,243	2,269	15%	1.3	924	$84,470
Engineering Services	97,552	(1,879)	-2%	1.3	5,924	$122,713
Other Communications Equipment Manufacturing	1,877	135	8%	1.3	50	$129,333
Paint and Coating Manufacturing	4,159	56	1%	1.3	111	$100,731
Automobile and Other Motor Vehicle Merchant Wholesalers	11,951	1,620	16%	1.2	479	$77,169
Metal Heat Treating	1,965	(509)	-21%	1.2	52	$73,606
All Other Leather Good and Allied Product Manufacturing	1,046	111	12%	1.2	81	$41,553
Synthetic Dye and Pigment	1,358	198	17%	1.2	25	$146,323

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Manufacturing						
Alumina Refining and Primary Aluminum Production	857	(463)	-35%	1.2	8	$105,666
Ornamental and Architectural Metal Work Manufacturing	3,904	560	17%	1.2	177	$56,540
Motor Vehicle Electrical and Electronic Equipment Manufacturing	5,767	918	19%	1.2	57	$61,282
Sheet Metal Work Manufacturing	10,096	770	8%	1.2	357	$59,165
Other Industrial Machinery Manufacturing	5,245	717	16%	1.1	117	$104,602
Bottled Water Manufacturing	1,422	258	22%	1.1	39	$80,723
Ophthalmic Goods Manufacturing	2,500	192	8%	1.1	33	$65,367
Commercial and Institutional Building Construction	56,102	6,951	14%	1.1	3,738	$80,863
Locksmiths	1,529	363	31%	1.1	273	$50,433
Armored Car Services	2,765	(2)	0%	1.1	50	$56,219
Laminated Plastics Plate, Sheet (except Packaging), and Shape Manufacturing	1,720	70	4%	1.1	25	$71,216
Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers	5,188	(548)	-10%	1.1	242	$62,086
Nonferrous Metal (except Aluminum) Smelting and Refining	805	(29)	-3%	1.1	13	$96,105
Process, Physical Distribution, and Logistics Consulting Services	10,204	2,146	27%	1.1	1,060	$80,598

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Other Technical and Trade Schools	5,681	(2,278)	-29%	1.1	404	$54,858
Custom Computer Programming Services	75,533	20,246	37%	1.1	8,671	$124,445
Other Aluminum Rolling, Drawing, and Extruding	2,421	(256)	-10%	1.0	22	$66,076
Computer Systems Design Services	81,275	22,019	37%	1.0	9,946	$113,333
Other Electronic and Precision Equipment Repair and Maintenance	2,897	(11)	0%	1.0	378	$77,576
Flat Glass Manufacturing	893	92	11%	1.0	13	$65,119
Paperboard Mills	2,609	12	0%	1.0	16	$107,457
Copper Rolling, Drawing, Extruding, and Alloying	2,428	748	45%	1.0	28	$67,365
Instruments and Related Products Manufacturing for Measuring, Displaying, and Controlling Industrial Process Variables	5,204	(1,096)	-17%	1.0	177	$92,176
Cosmetology and Barber Schools	1,598	(119)	-7%	1.0	162	$43,474
Iron and Steel Forging	1,885	(1,065)	-36%	1.0	42	$92,817
Automobile Manufacturing	9,850	3,067	45%	1.0	20	$111,606
Other Communication and Energy Wire Manufacturing	1,064	201	23%	1.0	16	$99,986
Pump and Pumping Equipment Manufacturing	2,172	153	8%	1.0	80	$88,325
Security Guards and Patrol Services	57,583	6,618	13%	1.0	1,017	$30,068
Leather and Hide Tanning and	363	(38)	-9%	1.0	19	$59,826

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Finishing						
Marketing Consulting Services	18,534	4,757	35%	1.0	2,831	$87,922
Other Metal Valve and Pipe Fitting Manufacturing	1,270	(64)	-5%	1.0	45	$73,336
Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	4,078	(1,503)	-27%	1.0	81	$135,012
Polystyrene Foam Product Manufacturing	2,470	421	21%	1.0	43	$52,232
Truck Trailer Manufacturing	2,991	82	3%	1.0	63	$58,319
Other Fabricated Wire Product Manufacturing	2,059	(568)	-22%	1.0	72	$59,172
Human Resources Consulting Services	6,292	1,191	23%	1.0	580	$87,535
Motor and Generator Manufacturing	2,903	57	2%	1.0	51	$99,877
Printed Circuit Assembly (Electronic Assembly) Manufacturing	4,323	1,324	44%	0.9	75	$72,979
Other Scientific and Technical Consulting Services	15,172	3,070	25%	0.9	3,108	$125,645
Steel Wire Drawing	851	(199)	-19%	0.9	19	$56,156
Computer Terminal and Other Computer Peripheral Equipment Manufacturing	3,162	(159)	-5%	0.9	53	$111,270
Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing	1,893	702	59%	0.9	14	$73,678
Fluid Power Cylinder and Actuator Manufacturing	1,272	15	1%	0.9	33	$89,718

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Rolled Steel Shape Manufacturing	1,541	(143)	-8%	0.9	13	$86,739
Iron and Steel Pipe and Tube Manufacturing from Purchased Steel	1,852	346	23%	0.9	51	$74,855
Steel Foundries (except Investment)	1,107	(646)	-37%	0.9	27	$61,377
Adhesive Manufacturing	1,606	242	18%	0.9	54	$90,176
Metal Window and Door Manufacturing	4,479	79	2%	0.9	100	$57,337
General Warehousing and Storage	57,808	19,691	52%	0.9	971	$46,523
Measuring and Dispensing Pump Manufacturing	231	(147)	-39%	0.9	2	$60,170
Bare Printed Circuit Board Manufacturing	2,113	(2,237)	-51%	0.9	58	$107,425
Environmental Consulting Services	6,024	269	5%	0.9	701	$82,863
All Other Miscellaneous Textile Product Mills	2,356	249	12%	0.9	260	$34,411
Travel Trailer and Camper Manufacturing	2,820	768	37%	0.9	68	$60,723
Satellite Telecommunications	564	(128)	-18%	0.8	54	$132,120
Welding and Soldering Equipment Manufacturing	1,070	77	8%	0.8	29	$78,613
Other Aircraft Parts and Auxiliary Equipment Manufacturing	7,543	(1,425)	-16%	0.8	83	$115,309
Abrasive Product Manufacturing	725	11	2%	0.8	17	$58,269
Unlaminated Plastics Film and Sheet (except Packaging)	2,741	170	7%	0.8	45	$71,224

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Manufacturing						
Motor Vehicle Supplies and New Parts Merchant Wholesalers	11,552	168	1%	0.8	908	$62,790
Investigation Services	2,453	(32)	-1%	0.8	322	$53,677
Software and Other Prerecorded Compact Disc, Tape, and Record Reproducing	784	(179)	-19%	0.8	35	$140,223
Other Electronic Component Manufacturing	4,277	(627)	-13%	0.8	91	$121,925
Other Metal Container Manufacturing	1,033	73	8%	0.8	35	$66,240
Machine Shops	18,481	(5,883)	-24%	0.8	1,681	$65,366
Refrigerated Warehousing and Storage	3,795	178	5%	0.8	84	$52,047
All Other Miscellaneous General Purpose Machinery Manufacturing	2,556	(386)	-13%	0.8	107	$70,684
Other Pressed and Blown Glass and Glassware Manufacturing	996	98	11%	0.8	24	$69,477
Rope, Cordage, Twine, Tire Cord, and Tire Fabric Mills	413	19	5%	0.8	17	$58,226
Commercial Screen Printing	4,725	960	25%	0.8	452	$40,277
Motor Vehicle Seating and Interior Trim Manufacturing	4,555	609	15%	0.8	32	$71,415
Plastics Plumbing Fixture Manufacturing	883	106	14%	0.8	24	$44,212
Corrugated and Solid Fiber Box Manufacturing	5,753	(15)	0%	0.7	112	$69,769

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Other Personal and Household Goods Repair and Maintenance	2,012	(82)	-4%	0.7	580	$40,330
Motor Vehicle Parts (Used) Merchant Wholesalers	1,356	(157)	-10%	0.7	132	$48,921
Bolt, Nut, Screw, Rivet, and Washer Manufacturing	2,396	(12)	0%	0.7	49	$68,440
Iron and Steel Mills and Ferroalloy Manufacturing	4,911	49	1%	0.7	111	$74,947
Commercial Printing (except Screen and Books)	19,301	(1,517)	-7%	0.7	1,482	$61,525
Aircraft Engine and Engine Parts Manufacturing	4,592	(318)	-6%	0.7	45	$80,861
Other Measuring and Controlling Device Manufacturing	2,085	(290)	-12%	0.7	80	$68,432
Spring Manufacturing	945	28	3%	0.7	30	$68,270
Metal Can Manufacturing	1,109	112	11%	0.7	14	$91,531
Women's Handbag and Purse Manufacturing	72	26	56%	0.7	8	$43,158
Fabric Coating Mills	413	(218)	-34%	0.7	14	$59,329
Current-Carrying Wiring Device Manufacturing	1,836	(156)	-8%	0.7	32	$94,726
Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	2,022	(45)	-2%	0.7	77	$112,908
Software Publishers	18,873	1,409	8%	0.6	1,007	$151,060
Noncurrent-Carrying Wiring Device Manufacturing	563	(14)	-2%	0.6	19	$76,741
Electronic Connector	1,054	167	19%	0.6	16	$58,174

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Manufacturing						
Custom Compounding of Purchased Resins	907	106	13%	0.6	34	$76,416
Dental Laboratories	2,351	(72)	-3%	0.6	347	$54,645
Carbon and Graphite Product Manufacturing	396	(33)	-8%	0.6	10	$81,797
Overhead Traveling Crane, Hoist, and Monorail System Manufacturing	743	(38)	-5%	0.6	28	$83,714
Research and Development in the Social Sciences and Humanities	3,105	673	28%	0.6	229	$74,624
Other Paperboard Container Manufacturing	1,248	(48)	-4%	0.6	27	$82,942
Other Computer Related Services	5,503	171	3%	0.6	339	$133,619
Pharmaceutical Preparation Manufacturing	9,910	1,420	17%	0.6	108	$133,901
Electroplating, Plating, Polishing, Anodizing, and Coloring	2,961	(669)	-18%	0.6	158	$54,874
Plumbing Fixture Fitting and Trim Manufacturing	520	18	4%	0.6	12	$62,285
Textile Bag and Canvas Mills	1,158	(232)	-17%	0.6	89	$45,493
Tire Retreading	299	(229)	-43%	0.6	29	$52,260
Small Arms, Ordnance, and Ordnance Accessories Manufacturing	894	257	40%	0.5	48	$46,062
All Other Miscellaneous Fabricated Metal Product Manufacturing	3,519	461	15%	0.5	175	$63,358

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Men's and Boys' Cut and Sew Apparel Manufacturing	1,187	(68)	-5%	0.5	46	$47,706
Analytical Laboratory Instrument Manufacturing	1,532	(2)	0%	0.5	35	$107,887
Rubber Product Manufacturing for Mechanical Use	1,319	(535)	-29%	0.5	26	$80,515
Cyclic Crude, Intermediate, and Gum and Wood Chemical Manufacturing	136	(69)	-34%	0.5	10	$75,506
Computer Facilities Management Services	2,799	271	11%	0.5	248	$124,285
Glass Container Manufacturing	616	73	13%	0.5	10	$91,611
Industrial Process Furnace and Oven Manufacturing	420	(16)	-4%	0.5	18	$66,612
Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing	5,035	(2,371)	-32%	0.5	46	$147,275
Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing	211	(9)	-4%	0.5	2	$96,246
Apprenticeship Training	564	52	10%	0.5	82	$49,782
Cutting Tool and Machine Tool Accessory Manufacturing	1,003	50	5%	0.5	63	$78,502
Hardware Manufacturing	990	3	0%	0.5	37	$62,539
Conveyor and Conveying Equipment Manufacturing	1,193	(492)	-29%	0.5	41	$73,007
Rolling Mill and Other Metalworking Machinery Manufacturing	474	42	10%	0.5	18	$69,360

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Industrial Design Services	673	(13)	-2%	0.5	115	$95,418
Nonferrous Forging	283	(28)	-9%	0.5	10	$60,618
Motor Vehicle Body Manufacturing	2,218	(520)	-19%	0.5	55	$59,107
Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing	451	(681)	-60%	0.5	11	$75,401
Relay and Industrial Control Manufacturing	1,712	(232)	-12%	0.5	83	$100,131
Saw Blade and Handtool Manufacturing	1,035	(348)	-25%	0.4	62	$63,584
Turbine and Turbine Generator Set Units Manufacturing	1,036	(145)	-12%	0.4	22	$100,922
Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)	16,024	367	2%	0.4	869	$127,075
Other Electric Power Generation	38	33	657%	0.4	11	$131,442
Other Engine Equipment Manufacturing	1,604	686	75%	0.4	20	$78,581
Unlaminated Plastics Profile Shape Manufacturing	825	326	65%	0.4	24	$51,388
Iron Foundries	1,288	(724)	-36%	0.4	26	$68,572
All Other Rubber Product Manufacturing	890	(49)	-5%	0.4	35	$54,608
Secondary Smelting, Refining, and Alloying of Nonferrous Metal (except Copper and Aluminum)	345	(27)	-7%	0.4	18	$61,055
Cut and Sew Apparel	1,321	399	43%	0.4	81	$64,814

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Contractors						
All Other Miscellaneous Electrical Equipment and Component Manufacturing	977	(170)	-15%	0.4	59	$92,856
All Other Plastics Product Manufacturing	9,855	(1,231)	-11%	0.4	261	$57,938
Machine Tool Manufacturing	1,346	24	2%	0.4	74	$60,809
Electromedical and Electrotherapeutic Apparatus Manufacturing	2,068	30	1%	0.4	53	$127,655
Surgical Appliance and Supplies Manufacturing	3,317	(95)	-3%	0.4	192	$99,683
Elevator and Moving Stairway Manufacturing	297	122	70%	0.4	9	$106,151
Semiconductor Machinery Manufacturing	579	(65)	-10%	0.4	21	$127,696
Metal Crown, Closure, and Other Metal Stamping (except Automotive)	1,722	180	12%	0.4	50	$65,110
Support Activities for Printing	831	(374)	-31%	0.4	93	$55,747
Ship Building and Repairing	3,168	(2,367)	-43%	0.4	64	$83,680
Other Motor Vehicle Parts Manufacturing	4,900	362	8%	0.4	96	$66,754
Secondary Smelting and Alloying of Aluminum	176	(107)	-38%	0.4	9	$57,681
Capacitor, Resistor, Coil, Transformer, and Other Inductor Manufacturing	534	(591)	-53%	0.4	18	$50,713
Food Product Machinery Manufacturing	558	137	32%	0.4	23	$78,872
Perishable Prepared Food	1,437	323	29%	0.4	95	$36,646

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Manufacturing						
Rubber and Plastics Hoses and Belting Manufacturing	682	(583)	-46%	0.4	22	$65,967
Books Printing	556	22	4%	0.3	34	$63,390
Research and Development in Biotechnology	4,866	381	8%	0.3	414	$116,658
Folding Paperboard Box Manufacturing	823	43	6%	0.3	16	$58,489
Other Specialized Design Services	428	101	31%	0.3	156	$61,462
Aluminum Foundries (except Die-Casting)	492	(3)	-1%	0.3	20	$57,734
Surgical and Medical Instrument Manufacturing	3,304	289	10%	0.3	106	$83,673
Dental Equipment and Supplies Manufacturing	415	53	15%	0.3	31	$100,168
Industrial Mold Manufacturing	1,067	245	30%	0.3	59	$54,745
Fluid Power Pump and Motor Manufacturing	498	38	8%	0.3	14	$74,527
Optical Instrument and Lens Manufacturing	509	(17)	-3%	0.3	29	$91,928
Biological Product (except Diagnostic) Manufacturing	820	(20)	-2%	0.3	26	$105,453
Broadwoven Fabric Mills	704	(607)	-46%	0.3	25	$47,017
Steel Investment Foundries	303	(179)	-37%	0.3	8	$51,913
Motor Vehicle Gasoline Engine and Engine Parts Manufacturing	1,627	26	2%	0.3	62	$64,828
Metal Kitchen Cookware, Utensil, Cutlery, and Flatware	239	55	30%	0.3	10	$49,673

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
(except Precious) Manufacturing						
Scale and Balance Manufacturing	100	(6)	-5%	0.3	9	$79,979
Photographic Film, Paper, Plate, and Chemical Manufacturing	280	(37)	-12%	0.3	15	$83,140
Glass Product Manufacturing Made of Purchased Glass	1,074	238	28%	0.3	63	$57,414
Boat Building	870	123	16%	0.3	30	$52,826
Printing Machinery and Equipment Manufacturing	174	(53)	-23%	0.3	16	$73,013
Packaging Machinery Manufacturing	469	13	3%	0.3	24	$68,393
Narrow Fabric Mills and Schiffli Machine Embroidery	159	(182)	-53%	0.3	5	$45,188
Nonferrous Metal Die-Casting Foundries	577	81	16%	0.3	22	$42,578
Plastics Packaging Film and Sheet (including Laminated) Manufacturing	432	284	191%	0.3	18	$86,777
Medicinal and Botanical Manufacturing	579	188	48%	0.3	28	$107,922
Custom Roll Forming	136	(172)	-56%	0.3	9	$75,277
Power, Distribution, and Specialty Transformer Manufacturing	532	(23)	-4%	0.3	14	$68,003
Automatic Environmental Control Manufacturing for Residential, Commercial, and Appliance Use	379	(3)	-1%	0.3	28	$56,949
Precision Turned Product	823	50	6%	0.2	31	$54,076

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Manufacturing						
Other Nonferrous Metal Foundries (except Die-Casting)	243	(50)	-17%	0.2	15	$47,886
Nonwoven Fabric Mills	269	13	5%	0.2	12	$56,464
Guided Missile and Space Vehicle Manufacturing	1,095	(220)	-17%	0.2	3	$161,806
Nonferrous Metal (except Copper and Aluminum) Rolling, Drawing, and Extruding	249	(102)	-29%	0.2	17	$84,364
Special Die and Tool, Die Set, Jig, and Fixture Manufacturing	1,159	52	5%	0.2	84	$65,456
Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing	621	179	40%	0.2	9	$62,718
Motorcycle, Bicycle, and Parts Manufacturing	197	(79)	-29%	0.2	15	$45,418
Motor Vehicle Metal Stamping	1,251	593	90%	0.2	12	$57,860
Storage Battery Manufacturing	224	(35)	-13%	0.2	9	$93,407
Irradiation Apparatus Manufacturing	181	111	159%	0.2	11	$96,749
Blank Magnetic and Optical Recording Media Manufacturing	49	(16)	-25%	0.1	2	$43,168
Heavy Duty Truck Manufacturing	311	(238)	-43%	0.1	5	$81,372
All Other Transportation Equipment Manufacturing	163	7	5%	0.1	14	$51,145
Light Truck and Utility Vehicle	681	(788)	-54%	0.1	5	$83,759

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
Manufacturing						
Military Armored Vehicle, Tank, and Tank Component Manufacturing	61	(42)	-41%	0.1	5	$65,238
Motor Vehicle Transmission and Power Train Parts Manufacturing	754	(321)	-30%	0.1	24	$51,625
Aluminum Sheet, Plate, and Foil Manufacturing	153	74	93%	0.1	4	$79,294
Sawmill, Woodworking, and Paper Machinery Manufacturing	117	(99)	-46%	0.1	10	$78,001
Powder Metallurgy Part Manufacturing	74	19	36%	0.1	4	$75,582
In-Vitro Diagnostic Substance Manufacturing	193	(15)	-7%	0.1	16	$84,899
Textile and Fabric Finishing Mills	165	(31)	-16%	0.1	31	$51,480
Motor Home Manufacturing	115	21	22%	0.1	3	$35,880
Tire Manufacturing (except Retreading)	288	57	25%	0.1	7	$70,604
Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing	57	52	1046%	0.1	1	$74,592
Computer Storage Device Manufacturing	109	0	0%	0.1	11	$269,648
Paper (except Newsprint) Mills	327	(48)	-13%	0.1	13	$80,286
Primary Battery Manufacturing	63	40	181%	0.1	7	$85,828
Artificial and Synthetic Fibers	119	81	213%	0.1	6	$133,379

Industry	2016 Jobs	Job Change (2011-2016)	%Job Change (2011-2016)	LQ	2016 Establishments	Average earnings
and Filaments Manufacturing						
Ball and Roller Bearing Manufacturing	122	(129)	-51%	0.1	7	$87,878
Motor Vehicle Brake System Manufacturing	90	14	18%	0.0	7	$54,913
Power-Driven Handtool Manufacturing	28	(72)	-72%	0.0	7	$111,644
Fiber, Yarn, and Thread Mills	62	8	15%	0.0	9	$34,407
Knit Fabric Mills	13	(32)	-71%	0.0	2	$32,610
Small Arms Ammunition Manufacturing	18	13	254%	0.0	9	$60,212

SOURCE: EMSI

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 three countries 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 Center for Regional Economic Competitiveness' Statewide Supply Chain Mapping of Texas' Defense & Manufacturing Industries, the University of Northern Iowa's ResearchIQ conducted quantitative primary research to gather targeted information from defense-dependent and defense-related companies related to their supply chain relationships, operating environment, and market diversification opportunities/potential.

ResearchIQ conducted primary research among Texas companies engaged in defense-related activities (prime contractors and Tier 1, 2, and 3 suppliers) by employing an integrated approach of telephone recruiting and online survey administration. The primary lines of questioning included assessing organizations' current level of dependency on defense spending, evaluating their capacity to shift their core manufacturing or service capabilities into new markets, and understanding how their organizations process information.

Specific project activities performed included the following:

- Development of the screener and recruitment script

- Refinement and management of the recruitment list provided by CREC
- Placement of the telephone recruitment subcontract to a trusted and proven vendor
- Development of the content of the online survey instrument
- Translation of the content of the survey instruments to Qualtrics™ online software and designing/formatting the online instruments appropriately
- Pre-testing the online instruments for functionality and clarity
- Management of respondent recruitment (note: up to six calls to reach each contact was attempted)
- Sending of email invitations to recruited respondents with appropriate links to the online survey
- Collection of survey response data
- Sending of reminder emails and/or reminder telephone calls to tardy respondents
- Management of data cleaning and manipulation for subsequent analysis
- Analyzing of all response data
- Generation of an in-depth research & analysis report

CREC provided an initial Texas company call list of 2,326, however, this was paired down to list of 1,359 companies after cleaning out companies with no direct tie to manufacturing. A total of 218 respondents were recruited from this list with 106 survey starts and 57 completions. A minimum of 3 email reminders were sent, and a phone call reminder was made.

Next, a new call list was sourced from subscribers to the *Aerospace and Defense Technology Magazine*. The new purchased list contained an additional 2,746 companies of which 1,500 were provided to our call vendor and were targeted from study participation. Again, a minimum of 3 email reminders were sent and one phone call reminder was made. A total of 135 participants were recruited from this new list with 73 new survey completions. This provided a grand total of 130 survey completions across both list resources. However, after data cleaning procedures a sample of 123 companies was included for analysis. This produces a 95% confidence level with a +/- 8.65% margin of error from the combined target sample population of 2,859.

High Growth Firm Methodology

This project extensively utilized data from InfoGroup's 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 Texas,

within the Texas defense industry, and within targeted defense industry segments and target cities.

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 the Texas Foundation for Innovative Communities jointly determined the specific geographic areas and industry segments to be used for this study. They also decided to focus 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.

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.[108]

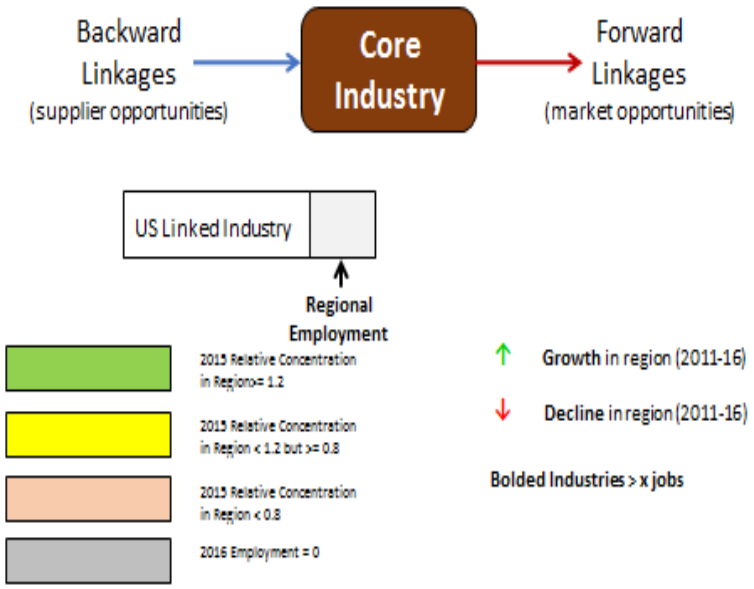
[108] The model is based upon the U.S. Census Bureau's Economic Census and Benchmark Input-Output data, developed by the U.S. Bureau of Economic Analysis. It therefore attempts to account for all the buying and selling between all industries in the U.S. economy. In an ideal world this model would be 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 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:

- *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

Figure 45: Explanation of Value Chain Graphs



linked industries within the state or region. 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 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.

Appendix C: Regional Defense Cluster Industries with High Specializations

Texas and the major metropolitan areas of Dallas-Fort Worth, Houston, and San Antonio-Austin are highly specialized in several defense cluster industries as measured by location quotients. The tables below indicate the defense cluster related industries with the highest specializations for each of these.

Dallas-Fort Worth Region

Industry	2016 Jobs	Job Change (2011-2016)	% Job Change (2011-2016)	LQ	2016 Establishments	Average Earnings
Consumer Electronics Repair and Maintenance	1,379	905	191%	4.8	50	$37,762
Explosives Manufacturing	735	57	8%	4.5	3	$86,466
Aircraft Manufacturing	22,825	(2,413)	-10%	4.2	34	$151,874
Flight Training	1,610	142	10%	4.0	41	$88,701
Transportation Equipment and Supplies (except Motor Vehicle) Merchant Wholesalers	2,976	214	8%	3.9	143	$95,975
Plastics Bag and Pouch Manufacturing	2,893	226	8%	3.9	16	$73,065
Communication Equipment Repair and Maintenance	1,284	(271)	-17%	3.7	64	$82,594
Fiber Optic Cable Manufacturing	877	322	58%	3.7	5	$99,261
Clay Building Material and Refractories Manufacturing	2,086	566	37%	3.7	17	$74,818
Ophthalmic Goods Manufacturing	2,098	271	15%	3.3	15	$68,103
Semiconductor and Related Device Manufacturing	14,290	(2,564)	-15%	3.3	71	$181,648
Mechanical Power Transmission Equipment Manufacturing	956	(96)	-9%	3.1	11	$75,375
Other Management Consulting Services	6,724	(1,913)	-22%	3.0	936	$109,051

Industry	2016 Jobs	Job Change (2011-2016)	% Job Change (2011-2016)	LQ	2016 Establishments	Average Earnings
Bottled Water Manufacturing	1,036	470	83%	2.9	16	$88,415
Other Communications Equipment Manufacturing	1,190	(50)	-4%	2.8	14	$144,244
Copper Rolling, Drawing, Extruding, and Alloying	1,708	846	98%	2.5	10	$64,914
Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing	2,950	(748)	-20%	2.5	43	$145,392
Other Aircraft Parts and Auxiliary Equipment Manufacturing	6,212	(1,536)	-20%	2.4	49	$125,959
Other Aluminum Rolling, Drawing, and Extruding	1,586	(481)	-23%	2.4	10	$66,271
Automobile Manufacturing	6,631	2,134	47%	2.4	4	$111,636

SOURCE: EMSI

Houston Region

Industry	2016 Jobs	Job Change (2011-2016)	% Job Change (2011-2016)	LQ	2016 Establishments	Average Earnings
Geophysical Surveying and Mapping Services	3,656	(1,704)	-32%	11.8	166	$147,843
Industrial Building Construction	26,699	5,334	25%	8.0	211	$124,929
Industrial Valve Manufacturing	4,209	(313)	-7%	8.0	75	$103,573
Oil and Gas Pipeline and Related Structures Construction	19,381	3,441	22%	7.2	195	$106,908
Petroleum Refineries	9,130	(2,406)	-21%	6.5	58	$223,057
Ethyl Alcohol Manufacturing	1,349	113	9%	6.0	4	$178,542
Fabricated Pipe and Pipe Fitting Manufacturing	4,237	(791)	-16%	5.9	89	$75,506
All Other Miscellaneous Chemical Product and Preparation Manufacturing	3,822	493	15%	5.1	77	$134,140
Prefabricated Metal Building and Component Manufacturing	2,639	625	31%	4.4	39	$77,143
Metal Heat Treating	1,553	(259)	-14%	4.0	32	$75,291
Plate Work Manufacturing	3,628	(692)	-16%	3.9	91	$76,229
Switchgear and Switchboard Apparatus Manufacturing	2,582	265	11%	3.8	27	$91,826
Synthetic Dye and Pigment Manufacturing	1,032	187	22%	3.8	12	$171,237
Power Boiler and Heat Exchanger Manufacturing	1,561	426	38%	3.5	22	$109,064
Other Basic Inorganic Chemical Manufacturing	2,660	331	14%	3.4	43	$154,609
Plastics Pipe and Pipe Fitting Manufacturing	1,841	(326)	-15%	3.3	28	$87,920
Plastics Material and Resin Manufacturing	3,698	476	15%	3.1	64	$164,232

Industry	2016 Jobs	Job Change (2011-2016)	% Job Change (2011-2016)	LQ	2016 Establishments	Average Earnings
Other Heavy and Civil Engineering Construction	6,894	721	12%	3.1	127	$125,752
All Other Basic Organic Chemical Manufacturing	2,372	(104)	-4%	3.1	37	$197,487
Electronic Computer Manufacturing	6,501	(1,353)	-17%	3.0	18	$138,910

SOURCE: EMSI

San Antonio-Austin Region

Industry	2016 Jobs	Job Change (2011-2016)	% Job Change (2011-2016)	LQ	2016 Establishments	Average Earnings
Electronic Computer Manufacturing	7,298	2,119	41%	5.1	16	$188,396
Computer Terminal and Other Computer Peripheral Equipment Manufacturing	2,678	362	16%	4.8	14	$115,489
Semiconductor and Related Device Manufacturing	11,138	888	9%	4.5	48	$162,861
Totalizing Fluid Meter and Counting Device Manufacturing	542	116	27%	3.9	2	$79,932
Other Management Consulting Services	4,135	2,035	97%	3.2	492	$65,498
Printed Circuit Assembly (Electronic Assembly) Manufacturing	2,229	1,721	339%	3.0	20	$69,771
Computer and Office Machine Repair and Maintenance	1,631	(65)	-4%	2.8	101	$49,404
Other Industrial Machinery Manufacturing	1,672	(23)	-1%	2.2	13	$140,398
Industrial Building Construction	4,890	2,471	102%	2.2	73	$96,773
Surveying and Mapping (except Geophysical) Services	1,331	309	30%	2.1	110	$72,791
Automobile Manufacturing	3,186	1,064	50%	2.0	5	$112,053
Motor Vehicle Electrical and Electronic Equipment Manufacturing	1,587	372	31%	2.0	7	$59,461
Custom Computer Programming Services	21,538	10,425	94%	1.9	1,899	$129,715
Electronic Connector Manufacturing	485	59	14%	1.8	3	$49,723
Human Resources Consulting	1,889	(193)	-9%	1.8	115	$49,138

Industry	2016 Jobs	Job Change (2011-2016)	% Job Change (2011-2016)	LQ	2016 Establishments	Average Earnings
Services						
Instrument Manufacturing for Measuring and Testing Electricity and Electrical Signals	849	67	9%	1.7	18	$107,472
Marketing Consulting Services	4,980	2,735	122%	1.6	567	$81,163
Water and Sewer Line and Related Structures Construction	3,733	894	32%	1.6	168	$61,982
Power and Communication Line and Related Structures Construction	3,621	1,881	108%	1.5	132	$68,483
Semiconductor Machinery Manufacturing	367	104	40%	1.5	10	$132,571

SOURCE: EMSI