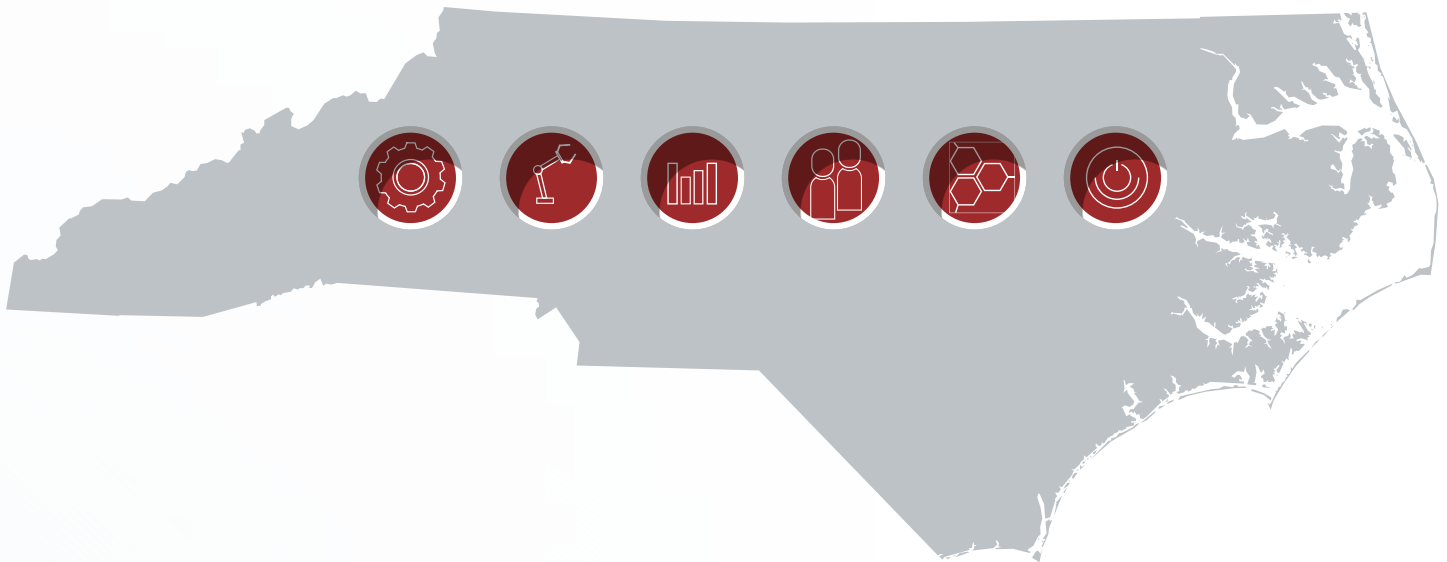


NORTH CAROLINA DEFENSE ASSET INVENTORY AND TARGET INDUSTRY CLUSTER ANALYSIS

**A STRATEGY FOR GROWING NORTH CAROLINA'S
DEFENSE AND HOMELAND SECURITY ECONOMY**



February 2020

Defense Alliance of North Carolina

with funding provided by
North Carolina Military Affairs Commission

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Executive Summary

North Carolina has a strong military presence with more than 145,000 personnel representing five branches of the military, equating to the 4th largest military footprint in the United States.¹ North Carolina also has an active network of companies, universities, government, and economic development organizations providing products and services to support the bases, personnel, and veterans. Despite the state's strong military presence and active innovation ecosystem, total dollars in defense contracts spent on North Carolina's businesses and research organizations rank the state as only 23rd in the country.²

The Defense Alliance of North Carolina (DANC) has a mission to grow North Carolina's defense economy in a way that creates new long-term investments and job opportunities. According to the 2019 North Carolina Defense Supply Chain Analysis by the North Carolina Defense Industry Diversification Initiative, the top 3 North Carolina industry sectors in 2017 supplying goods or services to the military were (1) professional/technical/scientific services, (2) manufacturing (including food, textiles, chemicals, pharmaceuticals, fabricated metals, and electronics), and (3) construction.³ DANC is committed to enhancing the strength of North Carolina's existing defense supply chains. To consider how North Carolina might grow its defense economy, DANC led a study to identify where North Carolina's capabilities intersect with six future technology area priorities of the US Department of Defense (DoD) that could be the basis of forming technology cluster areas for NC.

¹ Defense Manpower Data Center. (n.d.). DoD Personnel, Workforce Reports & Publications. Retrieved from https://www.dmdc.osd.mil/appj/dwp/dwp_reports.jsp

² Department of Defense, Office of Economic Adjustment. (March 2019). *Defense Spending by State, Fiscal Year 2017*. Retrieved from http://www.oea.gov/sites/default/files/fy2017-r2/FY2017_Defense_Spending_by_State_Report_Web_Version_20190315.pdf

³ North Carolina Defense Industry Diversification Initiative, NC State Industry Expansion Solutions, and North Carolina Department of Military and Veterans Affairs. (2019). *NC Defense Supply Chain Analysis*. Retrieved from https://f20f550a-f76b-4e46-949f-093f2dccabd1.filesusr.com/ugd/df24ba_bb1ae112a15643ad8e648561084578ef.pdf

This report contains the results of the study, which was funded by the North Carolina Military Affairs Commission with research and analysis conducted by RTI International and the North Carolina Department of Commerce. Informing this study was a core team representing 11 organizations from across North Carolina, with input from more than 30 industry, government, military, nonprofit, and academic organizations that continue to work together to support and build North Carolina’s defense economy. The team identified six technology areas, then analyzed North Carolina economic data, identified innovation assets and capabilities, and interviewed companies to identify barriers to obtaining defense contracts. The six technology areas are as follows:

- advanced manufacturing
- autonomous systems
- data and knowledge management
- human performance
- materials
- power

Findings

Economic data analysis shows that while North Carolina is a small overall market for defense business in each technology area, it is among the fastest growing states in the nation for jobs in the target areas. Over the past 5 years, the state ranked 1st in economic growth in data and knowledge management and human performance, 2nd in power and advanced manufacturing, and 6th in autonomous systems. Materials was the only sector to experience a decline, mirroring national trends. Additionally, North Carolina has a high concentration of jobs in research and services related to the six technology areas compared with the national average.

The study team targeted nondefense companies in North Carolina within each technology cluster area and interviewed them to understand why these companies are not pursuing defense as a market. The team also spoke with a few defense contractors to gain their perspectives on the opportunities and challenges with conducting defense business in North Carolina. Feedback included an unawareness of opportunities specific to their capabilities; difficulties in navigating defense proposal, contracting, and accounting processes; expense and time required to meet DoD quality, cyber security, and other requirements; and perceived less lucrative business opportunities in defense than in their current commercial markets.

The study uncovered innovation assets and capabilities in research centers, talent, and industry that can support growing the six technology areas. A sampling of notable assets includes the following by area:



- **Advanced manufacturing**—Assets in this area include major additive manufacturing (AM) production facilities at Oerlikon’s \$55 million Innovation Hub & Advanced Component Production facility in Huntersville and at large North Carolina contract manufacturer Protolabs; research facilities at North Carolina State University’s (NCSU’s) Center for Additive Manufacturing and Logistics; North Carolina companies and organizations are active in at least eight of the Manufacturing USA institutes, including biomanufacturing and advanced textiles, two existing industry strengths for the state.



- **Autonomous systems**—Assets in this area include testing platforms for autonomous vehicles at North Carolina Agricultural and Technical State University’s TECHLAV and the National Science Foundation–funded 5G drone Aerial Experimentation and Research Platform for Advanced Wireless (AERPAW) at North Carolina State University; Duke University’s Humans and Autonomy Lab, which focuses on human and computer decision-making in complex systems with embedded autonomy; and ABB’s Corporate Research Center that includes work in robot intelligence.



- **Data and knowledge management**—Assets in this area include IBM’s first North American Q Hub at NCSU to advance quantum computing; data analytics and computing powerhouses SAS, IBM, and Red Hat; and Renaissance Computing Institute, a high- performance computing data and networking research center.



- **Human performance**—Assets in this area include North Carolina’s biotechnology industry, with the entire innovation ecosystem of research and development (R&D), clinical testing, manufacturing, and hospital end users located within the state; the Armed Forces Institute of Regenerative Medicine led by Wake Forest University; the North Carolina Research Campus in Kannapolis that focuses on human health through nutrition; and gaming and virtual reality training companies such as Epic Games and Virtual Heroes.



- **Materials**—Assets in this area include companies making high-tech engineered and functional fabrics facilitated by the Nonwovens Institute and connected to the Advanced Functional Fabrics of America manufacturing innovation center and the Research Triangle Nanotechnology Network, a National Science Foundation–funded organization at Research Triangle Park–area universities that includes nanofabrication and characterization capabilities.



- **Power**—Assets in this area include leaders in next-generation power electronics, including wide bandgap semiconductors, that enable lightweight high-power systems for portable power, electric vehicles, and alternative power generation with companies Cree Wolfspeed, Qorvo, and Kyma Technologies; North Carolina State’s FREEDM Systems Center; and Power America, the \$140 million power electronics manufacturing innovation center; the headquarters of Duke Energy, one of the largest energy utilities in the United States with its headquarters and new innovation center located in Charlotte; the Electric Power Research Institute and its International Electrification 2020 Conference; and power storage systems manufacturers such as Clarios and Celgard.

Approximately 12% of North Carolina companies within these technology areas have defense contracts. To understand why more North Carolina companies were not in the defense market, the research team included interviews with companies in each technology area. The main reasons companies cited were (1) lack of awareness of opportunities relevant to their businesses; (2) difficulties in navigating government proposals, contracting, accounting, and quality requirements; and (3) for some, greater financial opportunities in commercial markets.

Concentrating growth activities on six technology areas important to the future of the DoD will help North Carolina focus and leverage resources for an intentional, strategic approach with a better likelihood for success.

Recommendations

To grow the defense industry in North Carolina, the state can consider two strategies: one that helps industry benefit from local opportunities and one that helps industry access defense and national security opportunities nationwide. For a local strategy, North Carolina can assist as requested to grow the military footprint; attain new commands or acquisition offices; increase the number of personnel; connect commands with research needs to local universities and research centers; and ensure that as many supplies and equipment, service, and construction contracts let by the installations go to local businesses. North Carolina can build on its success in this area because of the ongoing efforts of many people in state government such as the North Carolina Department of Military and Veterans Affairs; the Department of Commerce; and organizations like DANC, the Economic Development Partnership of North Carolina, the North Carolina Economic Development Association, the North Carolina Military Business Center, the North Carolina Defense Technology Transition Office, and the North Carolina Defense Industry Diversification Initiative. Deeper and sustained relationships with both uniformed and civilian leaders at the North Carolina installations are critical to this strategy.

Looking at the broader needs of the DoD beyond supporting local installations opens up a world of opportunity for North Carolina. The DoD has current and future needs for innovative solutions to enable the United States to continue to dominate in worldwide defense. These needs translate to contracts for research, products, and services that can be sourced from anywhere, and North Carolina businesses, organizations, and talent are well positioned to compete for and win these contracts. Concentrating growth activities on six technology areas important to the future of the DoD will help North Carolina focus and leverage resources for an intentional, strategic approach with a better likelihood for success.

The following recommendations were developed through conversations with companies and organizations in the state, analysis of North Carolina's innovation assets and capabilities within six DoD technology areas slated for growth, and insight from contributors listed in the Acknowledgements who have domain experience within the DoD and regularly engage with national security programs. While many of the following suggested activities exist today in areas of North Carolina's DoD strengths (e.g., military construction, textiles) or in areas of installation needs (e.g., the Hacking for Defense program), these recommendations are a response to needs articulated from nondefense companies interested in pursuing defense contracts.

To implement the recommendations of this report, DANC intends to create action plans and facilitate teams of economic development organizations, military support organizations, industry members, and academic partners. One team will address overarching recommendations that can support the six technology areas as well as existing North Carolina DoD sector areas of strength, and six teams will focus on building each technology area by implementing their specific recommendations.

I. Networking and Collaboration

- a. Provide opportunities and venues for the local innovation ecosystem in each of the technology areas to engage with the DoD and national security customers to identify opportunities to transition research out of academic labs to the government and commercial sectors.
- b. Host “innovation days” to showcase North Carolina’s nontraditional and entrepreneurial companies to both the DoD and venture capital funders.
- c. Proactively connect teams of researchers, startups, and companies to DoD end users within each technology cluster area using human-centered design to spur new innovation and provide opportunities for North Carolina organizations to better understand defense customer operating cultures and needs.
- d. Provide mentoring and peer-to-peer interactions and functional integration between the varied practitioners and stakeholders, both within and across the cluster areas, giving nondefense companies the opportunity to learn from and partner with prime contractors.

II. Contracting Assistance

- a. Raise companies’ awareness of existing resources and training to help them navigate proposal writing, accounting, and contracting requirements.
- b. Build a directory of service providers with DoD contracting experience.
- c. Partner primes with DoD experience with companies new to DoD contracts as part of the DoD Mentor Protégé program.

III. Removal of Barriers to Entry

- a. Promote certifications in ISO 9001, AS 9100, International Traffic in Arms Regulations (ITAR), Cybersecurity Maturity Model Certification (CMMC), and NIST 800-171 to strengthen companies’ ability to conduct DoD business.
- b. Assign one coordinating organization to manage third-party service providers in certifications and training to make it easier for companies to navigate the complexities of DoD contracting.
- c. Incentivize companies to consider entering the DoD market by educating them about revenue opportunities and access to Small Business Innovation Research nondilutive capital and to consider creative tax incentives for capital equipment or revenue from defense contracts.

IV. Agency Outreach

- a. Develop marketing materials for North Carolina’s value proposition in the six technology areas and communicate that information to DoD funders and prime contractors.

- b. Recruit a major DoD acquisition, rapid innovation office, or best practices work cells to the region to increase visibility of North Carolina’s innovation capability and attract high-tech and high-performing companies to North Carolina.
- c. Position North Carolina to be home of a new national technology center in one of the six technology areas, such as quantum for data and knowledge management, emerging biotechnology for national security for human performance, or a ground vehicles center of excellence for advanced manufacturing.

V. Specific Technology Areas



- a. **Advanced manufacturing**—Create an additive manufacturing (AM) materials characterization database and membership organization, identify or attract pre-and post-processing services, develop a catalog of AM providers, and build awareness for rural tool/die and contract manufacturing companies on AM opportunities. Consider establishment of a ground vehicles center of excellence using the AM expertise of North Carolina’s motorsports industry.



- b. **Autonomous systems**—Leverage AERPAW and other testing platforms to attract teams proposing to the DoD, use the Drone Summit to attract funders and relevant companies to network, match artificial intelligence companies with transportation companies and with decision-support software companies in the state to pursue autonomous systems opportunities.



- c. **Data and knowledge management**—Provide broadband infrastructure to enable companies working in the digital space to connect with customers, make available specialized infrastructure (e.g., Sensitive Compartmented Information Facility) to work in secure spaces, and develop cybersecurity resources and service providers to assist companies working in defense.



- d. **Human performance**—Leverage the North Carolina Biotechnology Center as the hub of human performance activities and broaden from there, embrace North Carolina’s human health innovation ecosystem to address warfighter performance needs, and work with virtual reality labs and interested gaming companies to develop warfighter training applications.



- e. **Materials**—Focus on functional fabrics and nanomaterials and identify DoD needs and funding for applications such as heating/cooling, communications, and color-changing clothing and materials.



- f. **Power**—Partner power electronics companies with those developing applications for the DoD to take advantage of the lightweight and increased power capacity for the military; provide access to high-voltage R&D facilities for these companies; and leverage the industry and research connections of Power America, the North Carolina Cleantech Cluster, and the University of North Carolina–Charlotte’s Energy Production and Infrastructure Center.

Introduction

North Carolina plays an important role in the defense infrastructure of the United States: it is the 4th largest state in terms of total Department of Defense (DoD) personnel with over 146,000 people stationed in the state at the end of 2018.⁴ However, it is a small market for defense business relative to its size: it ranks 23rd in DoD contracting at \$3.3 billion, with only 3% of that contracting going to research and development (R&D).⁵ Most defense business in the state, in dollar value, is contracting for services, supplies, and construction at large installations in the state. As part of its mission to grow North Carolina's defense economy in a way that creates new long-term investments and job opportunities, the Defense Alliance of North Carolina (DANC) is working to position businesses in the state to be more competitive in the defense market space in general and, via this study, in six emerging sectors of defense business, particularly in high-tech and high value-add sectors with potential for future defense applications.

Capabilities and innovation assets reside in the organizations in the state—the businesses new and existing, large and small; the universities and research organizations; the community colleges and educational institutions; and the economic development organizations and state and local governments. Assets include physical and programmatic infrastructure, intellectual property (IP), and talent. Infrastructure includes labs to create new discoveries, broadband to connect businesses to customers, airports/highways/ports to move goods and people, research programs that provide the framework for researchers to create new discoveries, and entrepreneurship programs that connect innovators to service personnel. IP is embedded in business and people, including trade secrets in how businesses create value by making products or providing services, and patents that protect new inventions. Talent

⁴ Defense Manpower Data Center. (n.d.). DoD Personnel, Workforce Reports & Publications. Retrieved from https://www.dmdc.osd.mil/appj/dwp/dwp_reports.jsp

⁵ Department of Defense, Office of Economic Adjustment. (March 2019). *Defense Spending by State, Fiscal Year 2017*. Retrieved from http://www.oea.gov/sites/default/files/fy2017-r2/FY2017_Defense_Spending_by_State_Report_Web_Version_20190315.pdf

resides in North Carolina's people, those who are working in businesses and organizations who possess the know-how to create solutions, make products, and provide services; those with new ideas who possess the drive to create new businesses; those being trained and graduating from schools to bring new insights to businesses and organizations; and those coming out of the many military installations in our state who have the domain knowledge and desire to make things better so the warfighter can complete his/her mission.

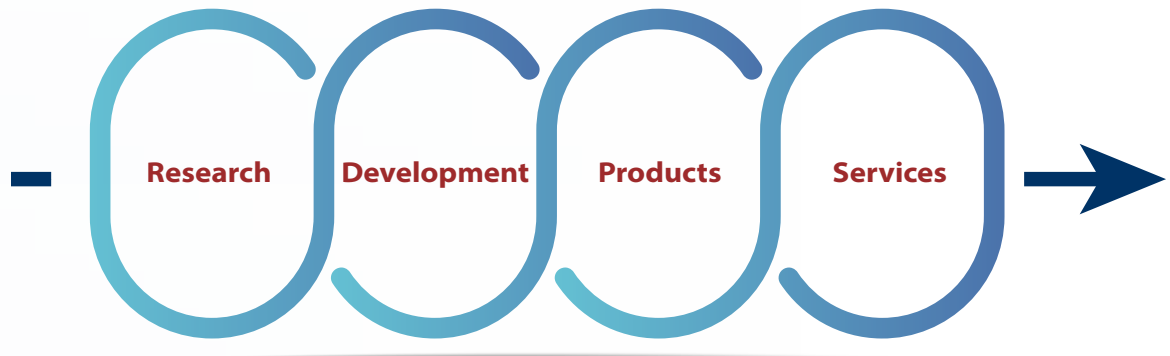
DANC, along with RTI International, the North Carolina Department of Commerce Labor and Economic Analysis Division (LEAD), and key partners and advisors from across the state, sought to examine future target cluster areas for growth, map the state's assets in each of the target cluster areas, identify strengths and gaps, and map a strategy to strengthen the defense business sector in North Carolina. This report and subsequent action plans are the result of that effort. It is hoped that the implementation strategies that emerge from this study can serve as a model to improve opportunities for North Carolina companies and academia across all of our market areas.

The purpose of this report is to provide actionable information that can help North Carolina's businesses, economic developers, academic organizations, and defense business support ecosystem partners increase the amount of DoD contracts for North Carolina, particularly for products, services, and research that can support any area of the DoD including and beyond North Carolina's local installations. The goal is to build North Carolina's clusters in areas that can support future areas of growth for the DoD, drawing on the state's capabilities and innovation assets to capture those future investments.

Target Cluster Areas and Definitions

The team defined the six target cluster areas based on a review of DoD strategic, forward looking documents and needs descriptions with input by military and state military business experts. They are based on a combination of North Carolina's strengths as a state and future strategy documents and announcements for DoD funding in the future. The cluster areas are meant to reflect how North Carolina can contribute to transformative trends in technologies for the warfighter and create high-value businesses in the future, beyond routine services such as construction or food service for bases.

The goal is to identify North Carolina's capabilities throughout the entire innovation life cycle. For each cluster area, the research team identified industry sectors, organizations, and companies that support the entire innovation life cycle from R&D to products and services.



Each of the target cluster areas, outlined in **Table 1**, cuts across various sectors, and many have overlapping assets and capabilities. Certain companies or industries may be involved in multiple target cluster areas.

Table 1: Target Cluster Areas

Target Cluster Area	Definition
Advanced Manufacturing 	Includes newer manufacturing methods that can support the warfighter in the field, such as additive manufacturing (AM), methods for lightweighting equipment, and quality/reliability testing methods to ensure part performance.
Autonomous Systems 	A cross-cutting sector that includes smart, self-directed systems, including unmanned air, ground, and water vehicles. Includes robotics, self-healing networks, human-machine interaction, and artificial intelligence (AI)/machine learning.
Data and Knowledge Management 	Combination of processing, storing, analyzing, protecting, and creating knowledge from data; includes cybersecurity—protection from cyber attack, system resilience, assurance, and cyber forensics. Future technologies include quantum computing.
Human Performance 	Includes augmenting, assisting, and protecting humans to optimize performance. This can include pharmacogenetics, microbiome, AI-powered diagnostics, regenerative medicine, wearable health monitors, and prosthetics integrated with the nervous system. Also includes human psychology, social behavior, and human factors and systems.
Materials 	Includes new materials to enable warfighter advantage, such as nanomaterials, ceramics, lightweight metal alloys, composites, flexible electronics, and functional fabrics.
Power 	A mix of traditional and nontraditional energy and power technologies that reduce size and weight and enhance electronic equipment performance, including energy production, harvest, storage, and distribution; batteries; microgrids; power electronics; and waste-to-energy systems.

In reviewing the target cluster areas and their potential for forming the next generation of defense business work in North Carolina, the research team reviewed the following data to benchmark and position the state:

- Jobs, job growth, and location quotient (LQ)
- Size of the supply chain and percentage of purchases made in state
- Number of companies directly involved in defense business and those with the potential to enter the defense business market
- Number of higher education programs and numbers of associate's, bachelor's, and advanced degrees granted

Together, the data presented show the size and potential of the assets in the state related to the target cluster areas: not all the companies, supply chains, jobs, or degrees reported are directly involved in defense business, and in many cases, defense business makes up a small percentage of the overall economic activity created by the sectors. [Appendix A](#) provides a full overview of the data and methodology.

Overall Findings

North Carolina is a relatively small market for defense business when measured by DoD contracting: despite being the 4th largest state in military personnel and 9th largest in population, the state ranks 23rd in value of DoD contracts awarded to companies in the state, which are mainly awards for base construction, services, and maintenance. Only 3% of the contracting dollars in the state are in R&D.

Similarly, the size of the existing market in the cluster areas in North Carolina is relatively small compared with its competitors. **Table 2** shows the number of jobs in North Carolina within each cluster area. When viewing relative concentration by LQ,⁶ all the sectors were at or below the national average.

■ **Table 2: Size and Specialization of Target Cluster Areas in North Carolina: 2018**

Cluster Area	Jobs in North Carolina	North Carolina LQ*	North Carolina National Rank
Advanced Manufacturing	47,017	0.92	13th
Autonomous Systems	103,223	0.78	16th
Data and Knowledge Management	130,337	0.97	14th
Human Performance	52,646	0.92	13th
Materials	32,164	0.92	13th
Power	54,278	1.03	11th
North Carolina, total	4.4 million	N/A	9th

Sources: Bureau of Labor Statistics. (2018). Quarterly Census of Employment and Wages (QCEW). Retrieved from <https://www.bls.gov/cew/>. Target cluster area industry code definitions are in the appendix.

Despite being a smaller market in the target cluster areas, North Carolina is among the fastest growing states in the nation: from 2013 to 2018 the state ranked 1st in growth in data and knowledge management and human performance and 2nd in power and advanced manufacturing, as shown in **Table 3**. Job growth in the state outpaced national growth across all areas; the fastest growth occurred in data and knowledge management with 37% job growth over a 5-year period. Materials was the only sector to experience a decline, mirroring national trends in textile and basic manufacturing jobs.

⁶ LQ is a relative measure of the proportion of jobs in the economy. Greater than 1 indicates a higher concentration than the national average; lower than 1 indicates a lower concentration.

■ **Table 3: Job Growth in Target Cluster Areas in North Carolina: 2013–2018**

Cluster Area	Job Growth: 2013–2018		National Rank for Job Growth
	North Carolina	United States	
Advanced Manufacturing	30%	4%	2nd
Autonomous Systems	32%	12%	6th
Data and Knowledge Management	37%	16%	1st
Human Performance	36%	14%	1st
Materials	–24%	–30%	35th
Power	30%	6%	2nd

Sources: Bureau of Labor Statistics. (2018). Quarterly Census of Employment and Wages (QCEW). Retrieved from <https://www.bls.gov/cew/>

Although North Carolina is not in the top 10 states for size, it ranks 3rd nationally in job growth, with 34% growth across the target areas. As shown in **Table 4**, this growth outpaced every state except for South Carolina and Tennessee, which each saw 43% growth over the same time period. The rapid growth of these industries in the South represents an opportunity for DoD contracting to expand beyond traditional markets and at the same time could be direct regional competition for North Carolina–based companies.

■ **Table 4: National Ranking of Jobs and Growth Across Target Cluster Areas: North Carolina, National Leaders, and Competitors**

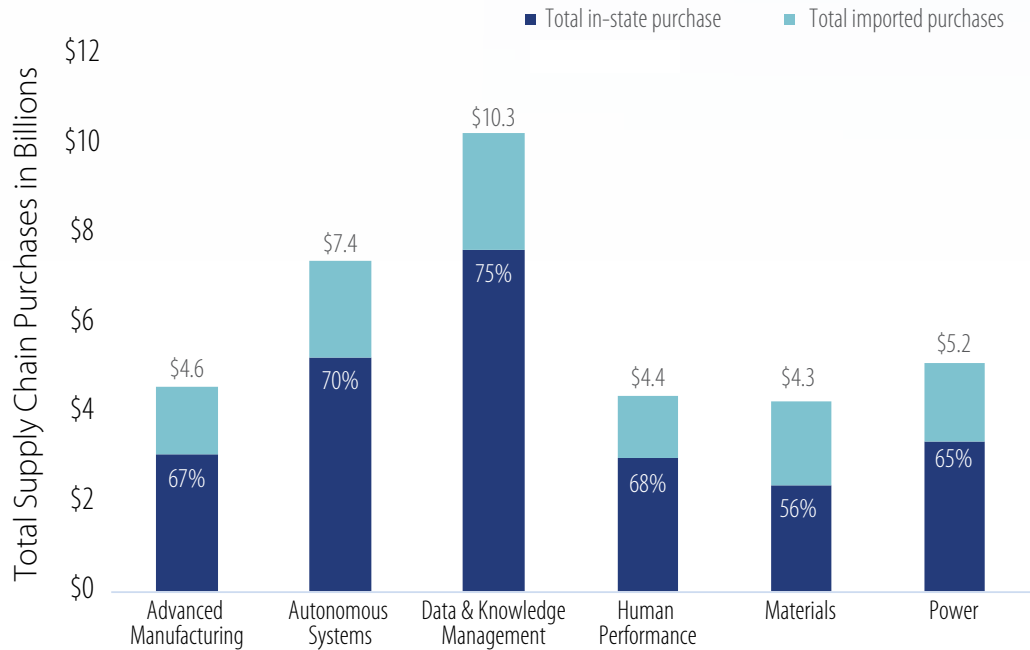
State	Total Jobs in Cluster Areas (2018)	National Rank in Total Jobs (2018)	Job Growth 2013–2018	National Rank in Growth
California	1,021,757	1st	24%	11th
Texas	554,760	2nd	12%	27th
Virginia	317,456	4th	7%	36th
North Carolina	190,245	11th	34%	3rd
Tennessee	100,045	21st	43%	1st
South Carolina	76,857	25th	43%	1st

Sources: Bureau of Labor Statistics. (2018). Quarterly Census of Employment and Wages (QCEW). Retrieved from <https://www.bls.gov/cew/>

Nationally California, Texas, and Virginia remain three of the most prominent states for defense contracting, and they are three of the four largest markets in the target cluster areas. California and Texas are two of the largest economies in the country, while Virginia benefits because it includes major national defense resources in Northern Virginia and Norfolk.

The size, growth, and relative strength of the state’s assets in the target cluster areas are reflected in the size of the in-state supply chain and in-state purchasing. Of the target cluster areas, data and knowledge management has the largest in-state supply chain, as shown in **Figure 1**. Companies in the state purchased over \$10 billion in the supply chain in 2017, of which 75% occurred in state.

Figure 1: Value of Supply Chain Purchasing for Target Cluster Areas in North Carolina



Source: Emsi. (2019). Input-Output Model, Industry Purchases, 2018. Retrieved from economicmodeling.com

When considering the size of the state’s supply chain, specific nuances of an industry influence how companies choose to purchase goods and services. For example, materials relies heavily on the petroleum and petrochemical industries, which have a minimal presence in North Carolina.

Assets by Target Cluster Area

The following sector characterizations are based on high-level statistics, assets, and interview findings by target cluster area. They are listed in alphabetical order. The data capture all the potential assets in the state, not just those that are directly or indirectly engaged in defense business in that area.



Advanced Manufacturing

In a defense context, advanced manufacturing includes methods of manufacturing that can support the warfighter in the field, such as AM (also known as 3D printing), methods for lightweighting equipment, and quality/reliability testing methods to ensure part performance.

Overall, North Carolina is the 2nd fastest growing state in the United States in the industry sectors that make up advanced manufacturing: Over 5 years, the state saw 30% growth in jobs compared with 4% nationally. There is a large in-state supply chain and pipeline of graduates.

The state's advanced manufacturing assets are most concentrated around Charlotte, the I-85 corridor between Charlotte and Greensboro, and in the Research Triangle Region, a product of the state's historic strengths in manufacturing.

Example assets in the state include Oerlikon's new \$55 million Innovation Hub & Advanced Component Production facility in Huntersville that was established to lead the industrial use of AM; North Carolina contract manufacturer Protolabs, one of the largest AM operations in the world; the motor sports industry with its precision manufacturing capabilities and early adopter of AM technology; NSCU's Center for Additive Manufacturing and Logistics, a pioneer in the use of titanium for electron beam AM; and North Carolina companies and organizations that are active in at least eight of the Manufacturing USA institutes, including biomanufacturing and advanced textiles, two existing industry strengths for the state.

Advanced Manufacturing Overview

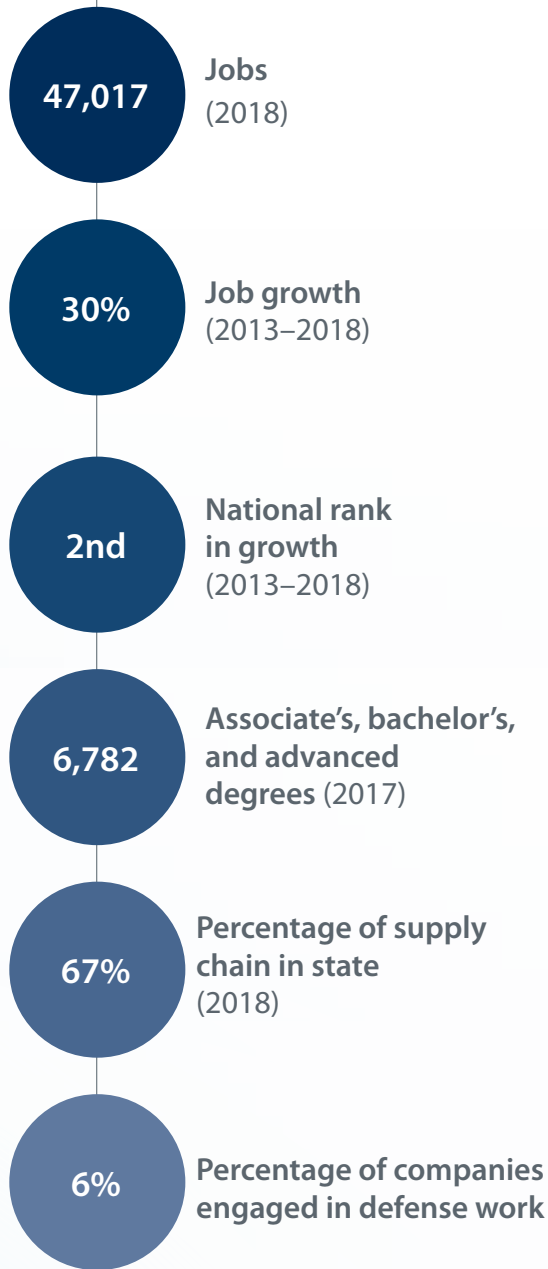
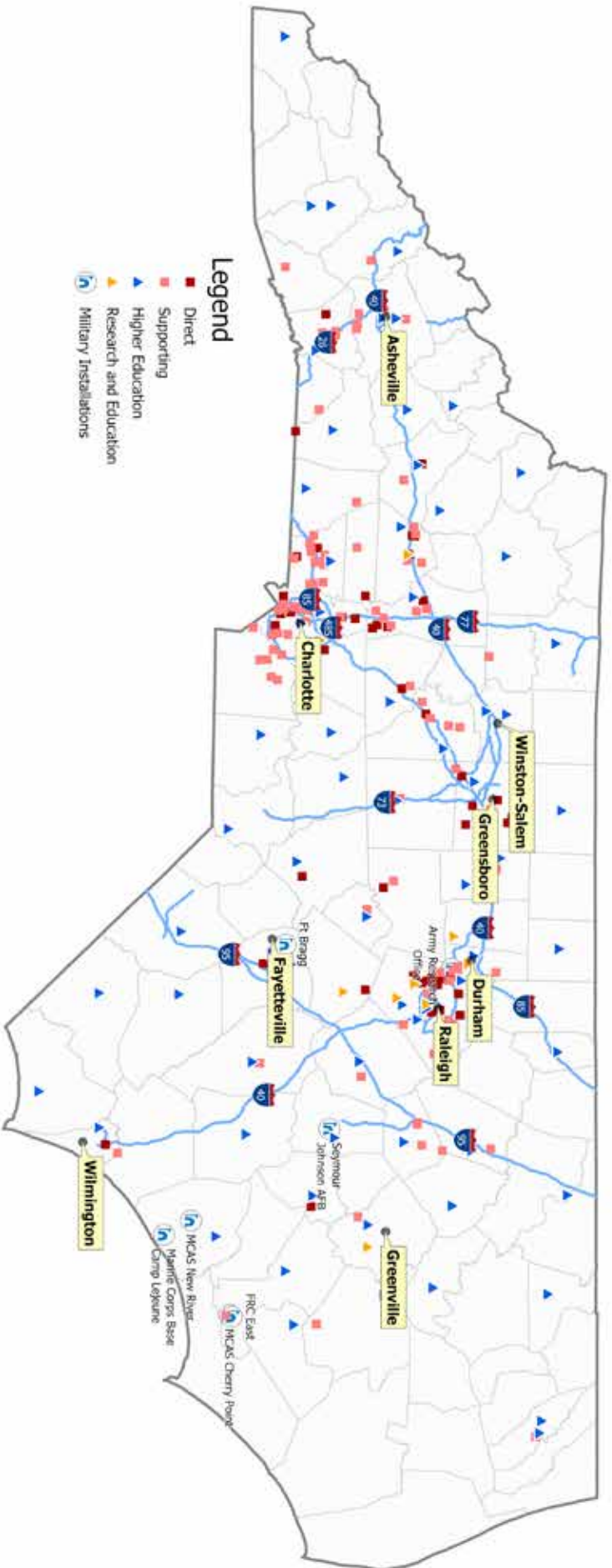


Figure 2: Location of Advanced Manufacturing Assets in North Carolina

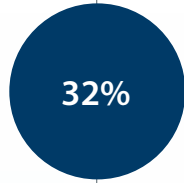
Advanced Manufacturing



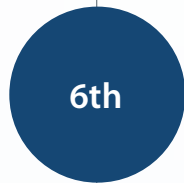
Autonomous Systems Overview



Jobs
(2018)



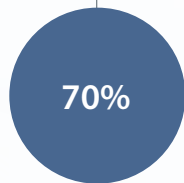
Job growth
(2013–2018)



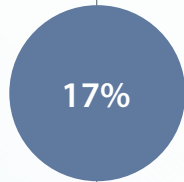
National rank
in growth
(2013–2018)



Associate's, bachelor's,
and advanced
degrees (2017)



Percentage of supply
chain in state
(2018)



Percentage of companies
engaged in defense work



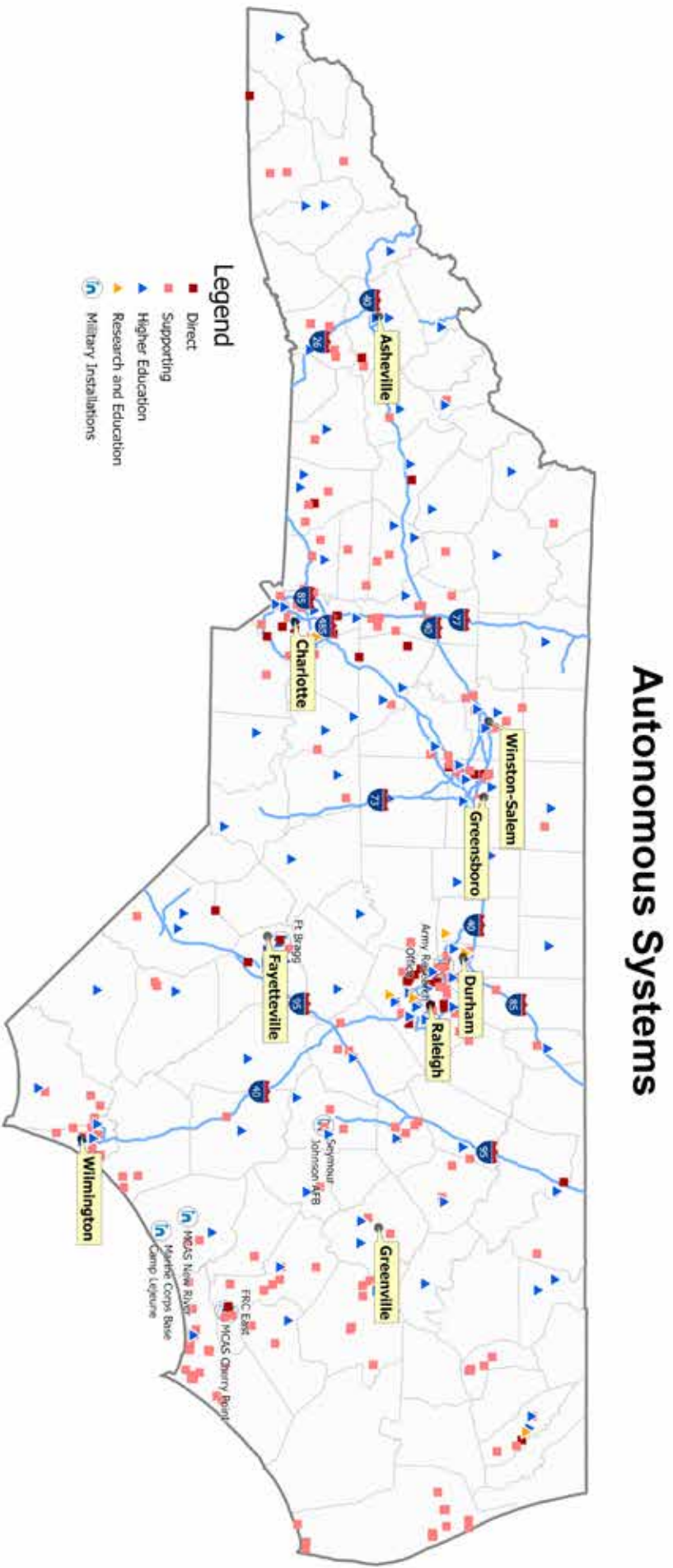
Autonomous Systems

Autonomous systems is a cross-cutting sector with the potential to affect various industries. It includes smart, self-directed systems that reduce manpower load and extend capability, including unmanned air, ground, and water vehicles; robotics; self-healing networks; human-machine interaction; and AI. AI is applied to systems for increased speed and agility; better decision-making; fewer maintenance failures; and improved accuracy using pattern recognition, prediction, and machine learning.

North Carolina has a select set of companies with direct capabilities that can support autonomous systems, which tend to be located in Charlotte and the major urban centers. However, supporting firms are located throughout the state. Shipbuilding in the eastern part of the state and components manufacturers across the state represent important supporting industries with the potential to support an autonomous systems cluster in North Carolina.

North Carolina's Department of Transportation has received several awards, including the National Association of State Aviation Officials' 2019 Most Innovative State Program for its use of drones for post-hurricane road and flood monitoring and for delivering food and medical supplies. Assets include testing platforms for autonomous vehicles such as North Carolina Agricultural and Technical State University's (NC A&T's) TECHLAV and the National Science Foundation (NSF)-funded Aerial Experimentation and Research Platform for Advanced Wireless (AERPAW), a testbed that allows 5G-powered drones and autonomous vehicles to be effectively integrated into smart city operations; Duke University's Humans and Autonomy Lab, which focuses on the multifaceted interactions of human and computer decision-making in complex systems with embedded autonomy; and ABB's Corporate Research Center that includes work in robot intelligence.

Figure 3: Location of Autonomous Systems Assets in North Carolina





Data and Knowledge Management

Data and knowledge management includes processing, storing, fusing, analyzing, and protecting data and creating knowledge from that data. It involves analytics, data collection, sensors, cybersecurity, and the next generation of quantum data processing.

Data and knowledge management is the largest and fastest growing sector among the target cluster areas in the state, and North Carolina is the fastest growing state in the country in jobs in this area. It has the largest in-state supply chain and largest percentage of purchases in state in this area.

Data and knowledge management is a human capital-intensive industry, and despite the state's wealth of higher education assets, the number of graduates with relevant degrees is low: fewer than 5,500 graduates in 2017 feeding into an industry with over 130,000 jobs. This signals a potential gap area that can be further investigated for strengthening to support this industry area. Assets in data and knowledge management are concentrated in the knowledge-intensive urban areas of North Carolina around Charlotte and the Research Triangle.

Assets include IBM's Q Hub at NCSU, the first university in North America of the global IBM Q Network to advance quantum computing; data analytics and computing powerhouses SAS, IBM, and Red Hat; and the Renaissance Computing Institute, a high-performance computing data and networking research center leading a \$20 million NSF-funded program to build a platform to test next-generation internet architectures.

Data and Knowledge Management Overview

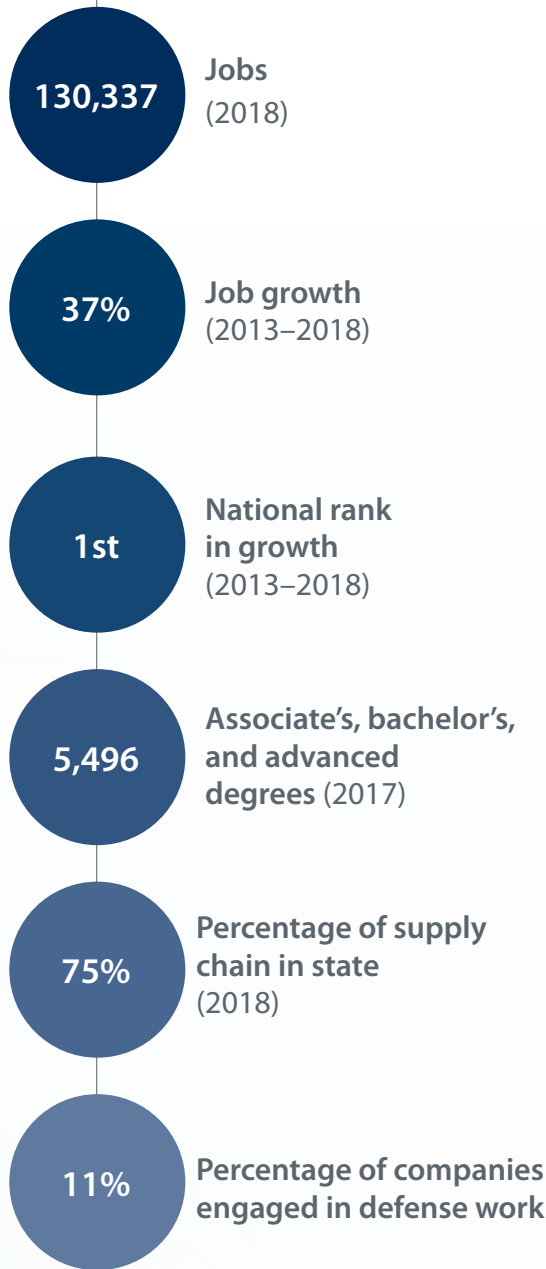
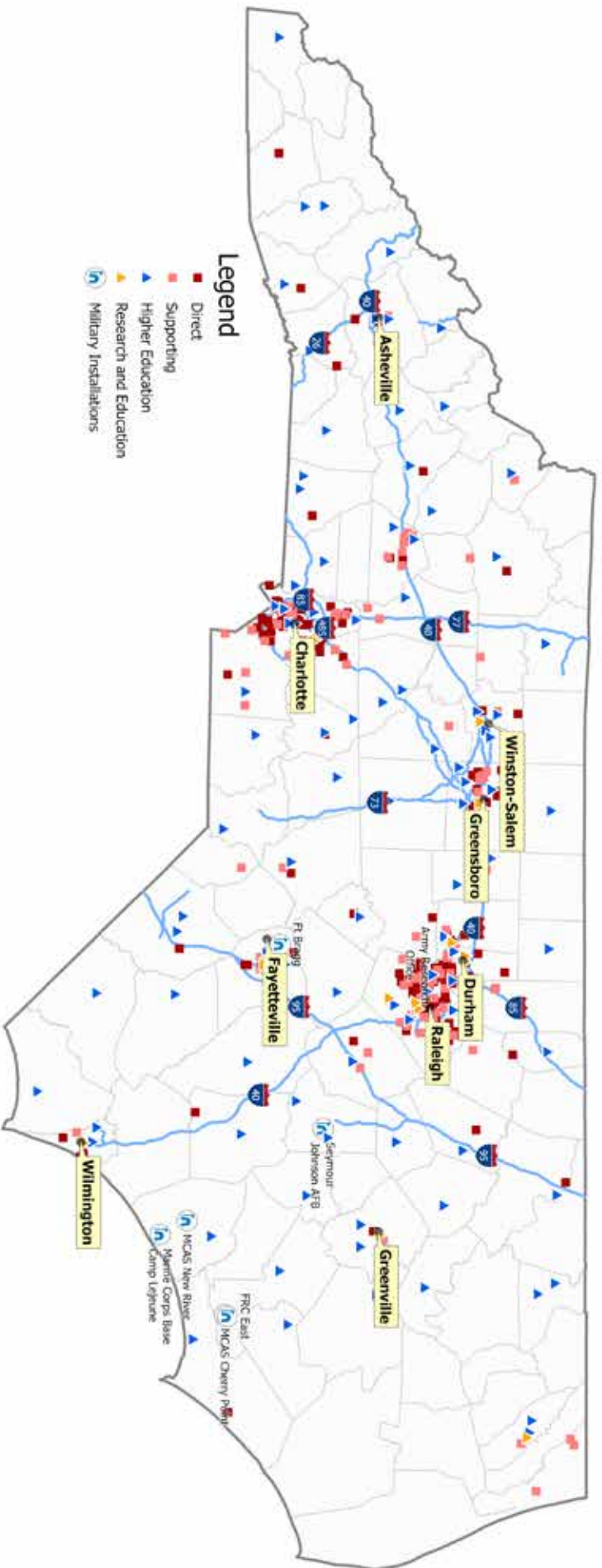
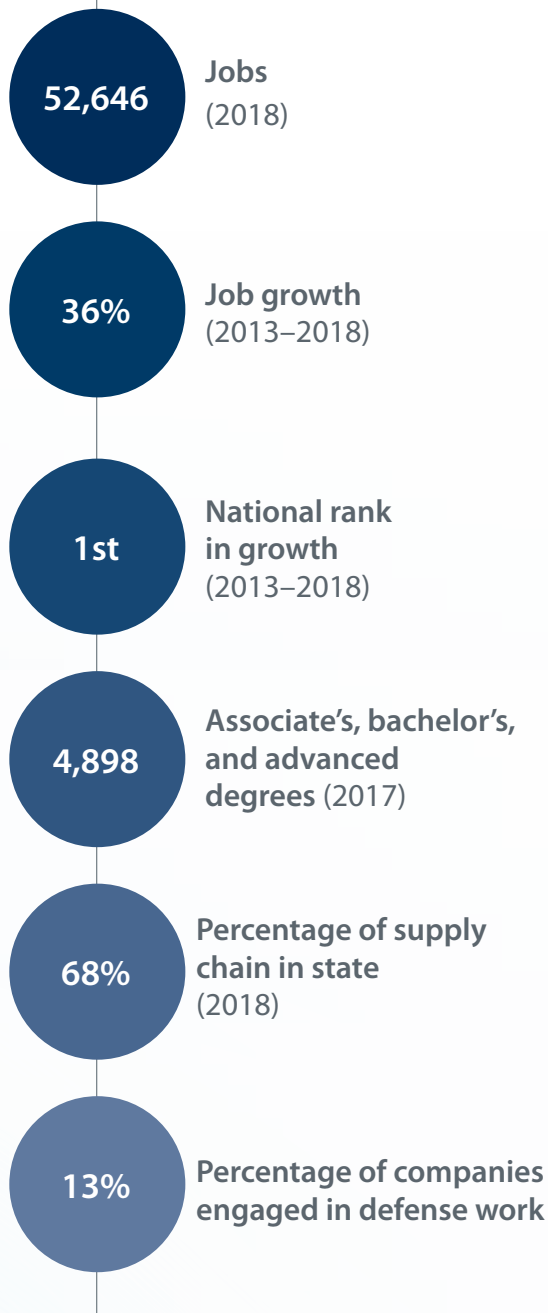


Figure 4: Location of Data and Knowledge Management Assets in North Carolina

Data & Knowledge Management



Human Performance Overview



Human Performance

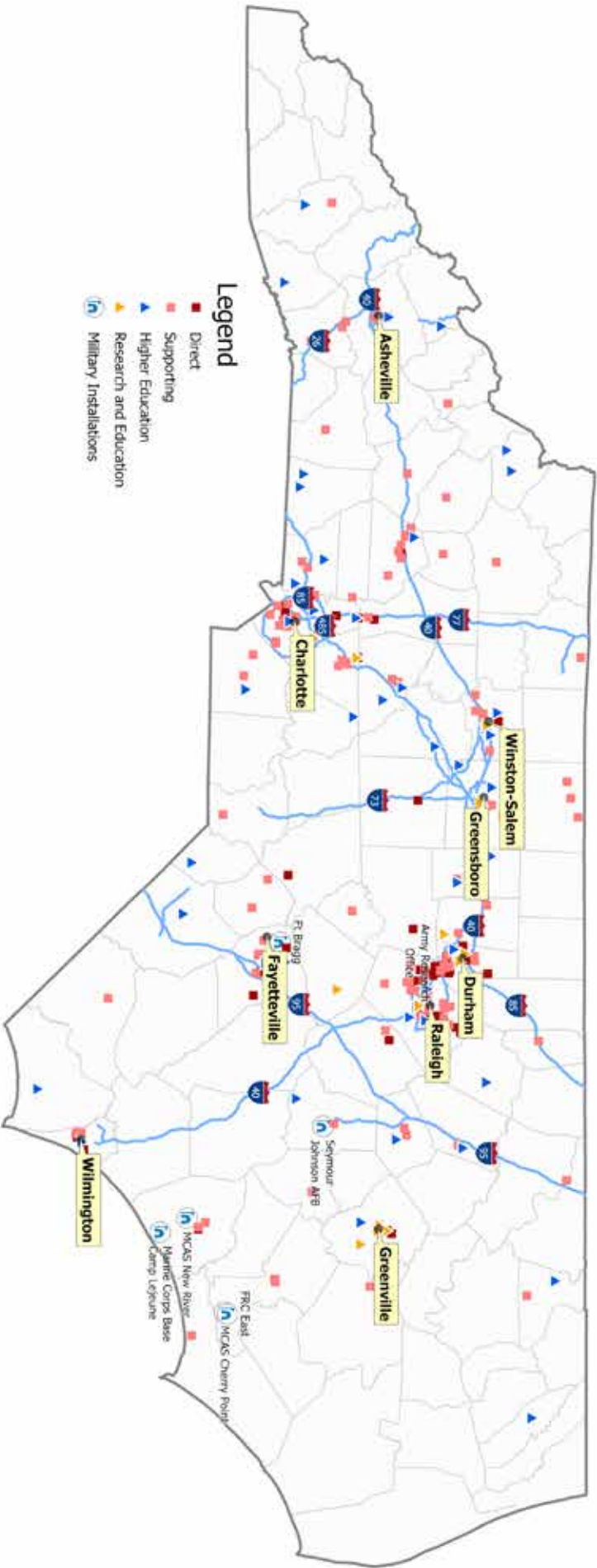
Human performance combines biological factors with technology and behavior that improve the performance of the warfighter. They include augmenting, assisting, and protecting humans to optimize performance through pharmacogenetics, microbiome, AI-powered diagnostics, regenerative medicine, wearable health monitors, and prosthetics integrated with the nervous system. This area also includes human psychology, social behavior, and human factors and systems.

Based on the industry classifications, North Carolina is the fastest growing state in the United States for jobs in human performance. A robust human capital pipeline of research-focused advanced degrees in biosciences is one of the state's strengths. Assets in human performance are concentrated around Charlotte and the Research Triangle.

Assets include North Carolina's strength in multiple types of biotechnology R&D, clinical testing, and manufacturing companies including the area of pharmaceuticals, regenerative medicine, and nutrition; the Armed Forces Institute of Regenerative Medicine led by Wake Forest University; the North Carolina Research Campus in Kannapolis, a 350-acre research center that collaboratively works to empower human health through nutrition; RTI International's work in military behavioral health; and gaming and virtual reality training companies such as Epic Games and Virtual Heroes.

Figure 5: Location of Human Performance Assets in North Carolina

Human Performance





Materials

Materials includes new materials to enable warfighter advantage, such as nanomaterials, ceramics, lightweight metal alloys, composites, flexible electronics, and functional fabrics.

National industry trends saw a 30% decline in materials jobs from 2013 to 2018, and North Carolina's sector declined at a slightly lower rate of 24%. The state saw a 24% decline in jobs from 2013 to 2018 compared with a 30% decline nationally. North Carolina saw the steepest decline in jobs in basic manufacturing including textiles. Despite materials being a historically large sector in the state, in 2018 there was a small in-state supply chain and a small percentage of firms engaged in defense work.

The state's assets in materials are concentrated around Charlotte and in the western half of the state where there is a legacy of manufacturing.

North Carolina's assets in textile R&D and manufacturing lay the groundwork for the future high-tech performance materials and engineered functional fabrics industry, facilitated by the Nonwovens Institute and connected to the Advanced Functional Fabrics of America manufacturing innovation center. The Research Triangle Nanotechnology Network is 1 of 16 sites created in 2015 by the NSF and includes nanofabrication and characterization capabilities.

Materials Overview

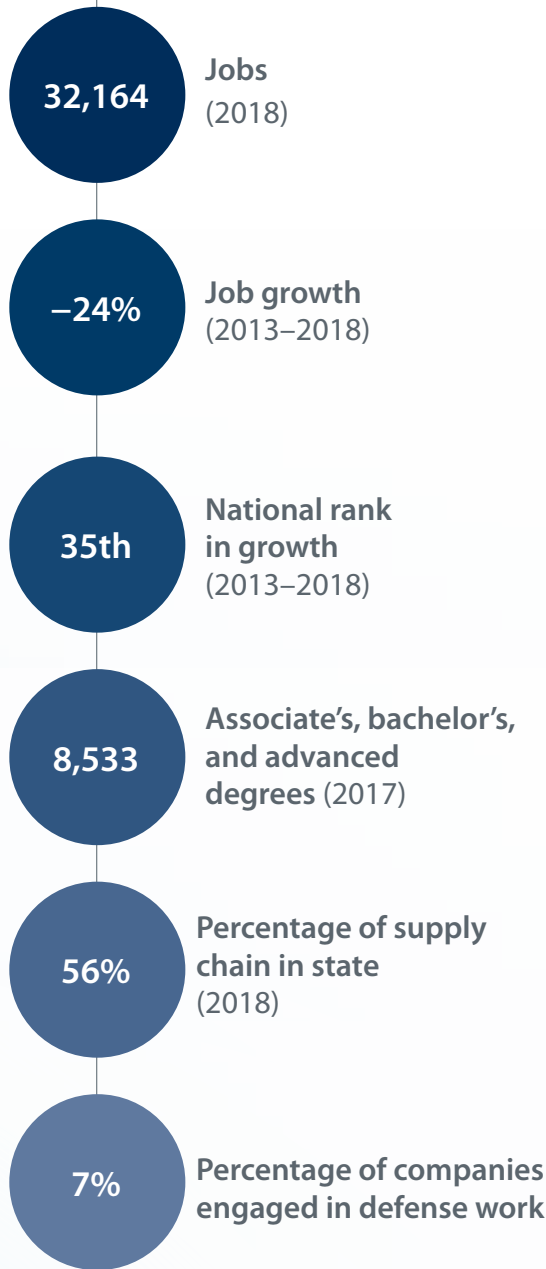
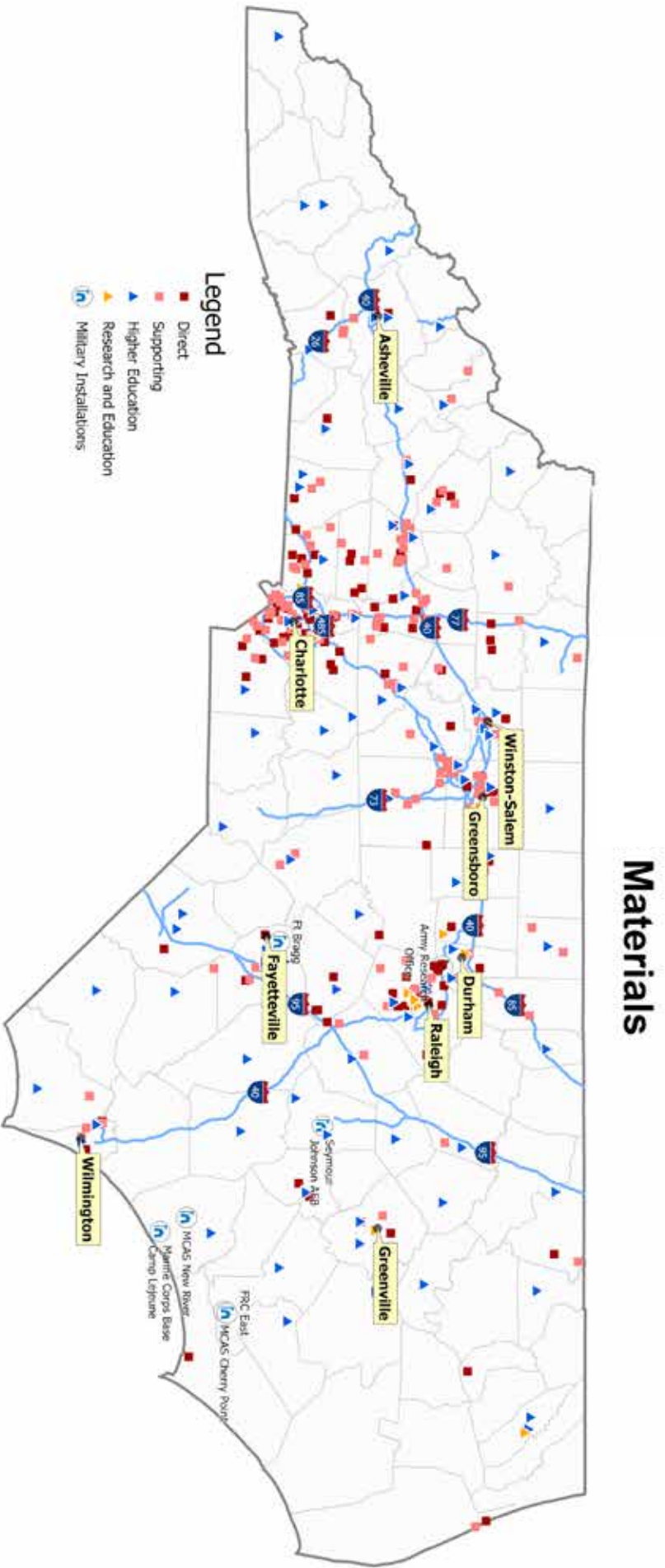


Figure 6: Location of Materials Assets in North Carolina



Map created by NC Commerce, LEAD, 12/2019



Power

The power target cluster area includes a mix of traditional and nontraditional energy and power technologies that reduce size and weight and enhance electronic equipment performance, including energy production, harvest, storage, and distribution; batteries; microgrids; power electronics; and waste-to-energy systems.

North Carolina is a national leader in job growth in power, ranking 2nd in growth from 2013 to 2018. There is a large in-state supply chain and human capital pipeline. The presence of a major utility headquarters (Duke Energy in Charlotte) is an important asset for the growth of the power sector, and the state is a leader in growth technologies, including power electronics, cleantech, and internet of things.

Assets in the target cluster are concentrated in the Research Triangle Region and Charlotte metropolitan area and include leaders in wide-bandgap semiconductors that enable lightweight, portable power and power management, including companies Cree Wolfspeed, Qorvo, and Kyma Technologies; the \$140 million manufacturing innovation center Power America; the FREEDM Systems Center that focuses on power electronics applications and building engineering talent; the headquarters of Duke Energy, one of the largest energy utilities in the United States is located in Charlotte and location of its new innovation center; the Electric Power Research Institute and its Electrification 2020 International Conference hosted in Charlotte; and power storage systems manufacturers such as Clarios and Celgard.

Power Overview

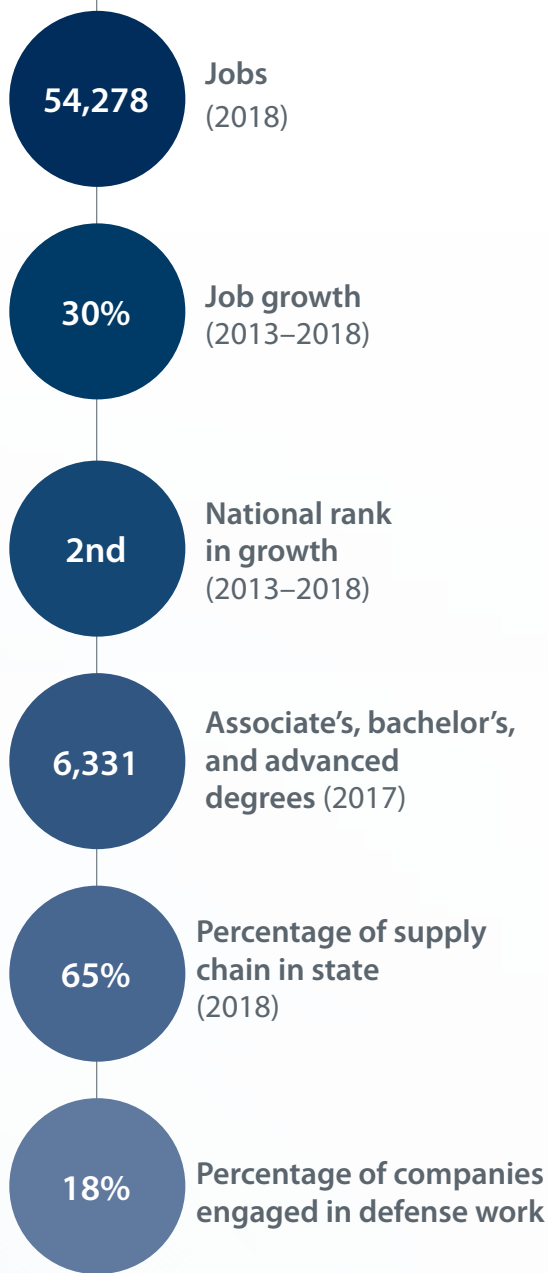
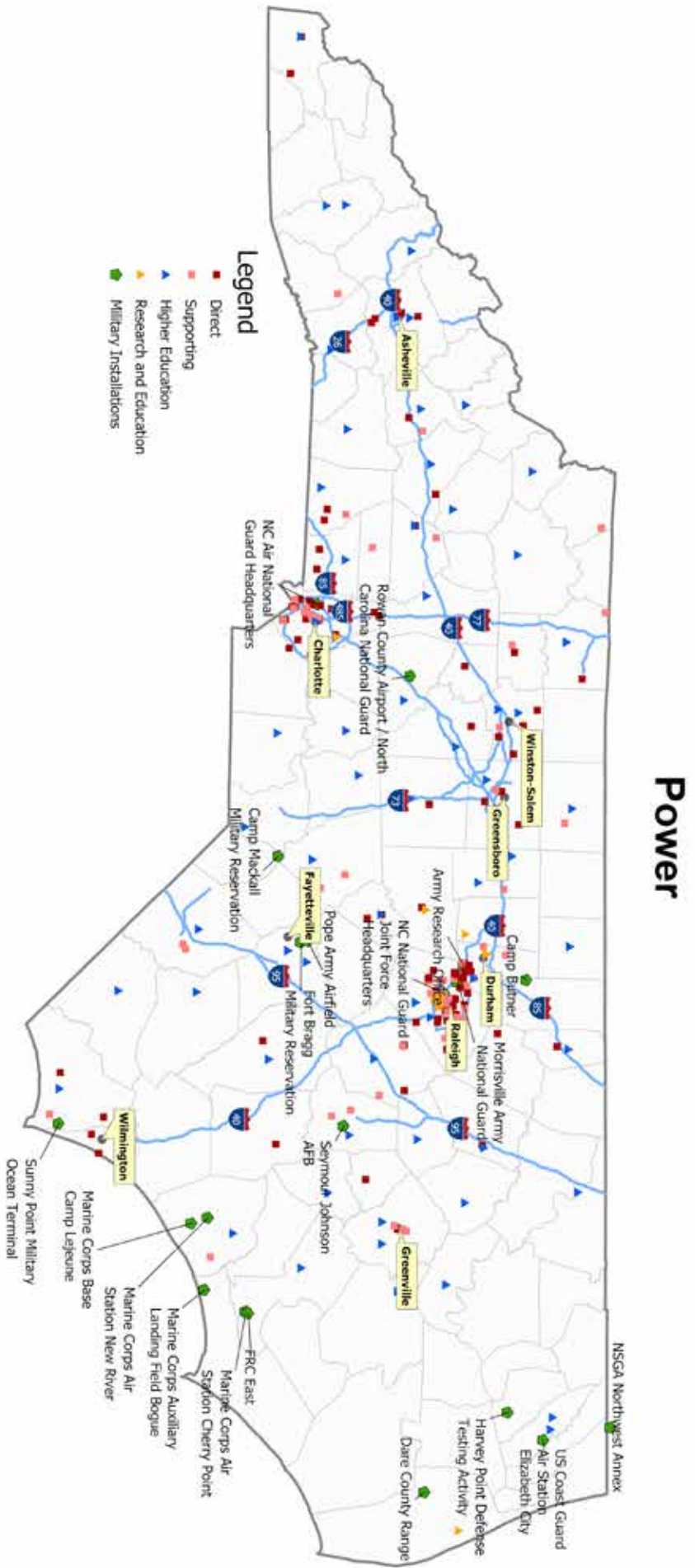


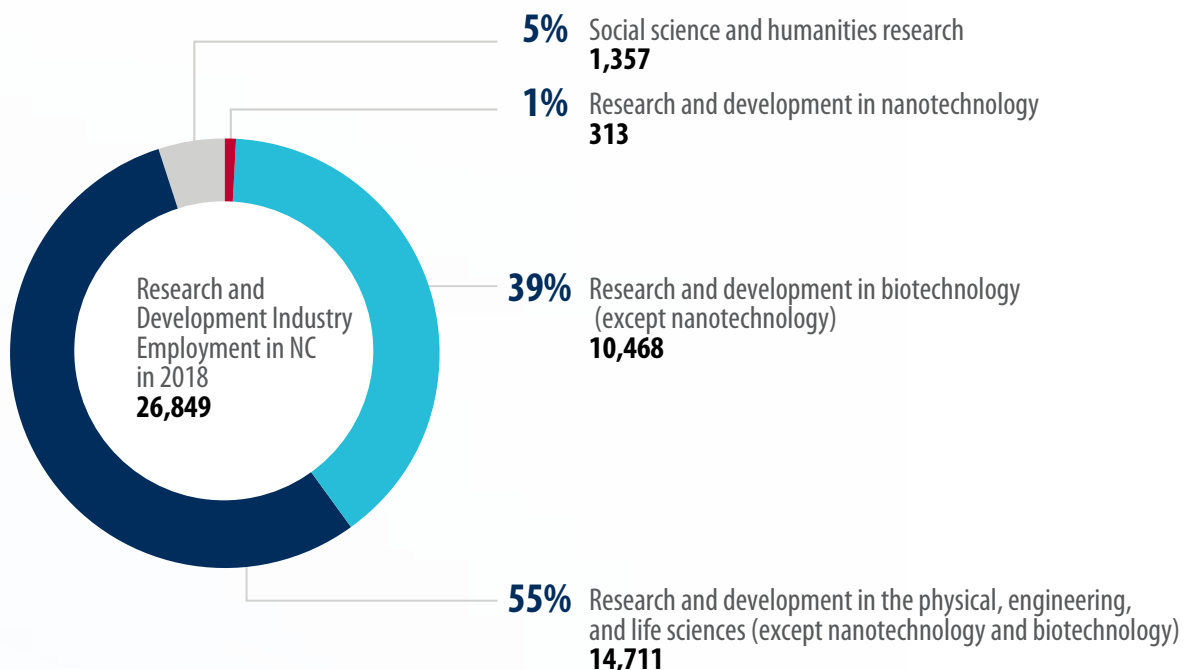
Figure 7: Location of Power Assets in North Carolina



Map created by NC Commerce, LEAD, 12/30/2019

Research, Development, and Education Assets

In the innovation life cycle, North Carolina's defense industry has the largest concentration of assets and jobs in research and services (when compared with development and products) in the country. Research in the state is not limited to biotechnology: 61% of the jobs in research firms in the state are in other types of research, including physical science, engineering, life sciences, nanotechnology, and social science.



Source: Bureau of Labor Statistics. (2018). Quarterly Census of Employment and Wages (QCEW). Retrieved from <https://www.bls.gov/cew/>

In 2018, North Carolina-based universities reported over \$141 million in research spending funded by the DoD, maintaining R&D spending totals from 2017. Duke University, NCSU, and Wake Forest University received the largest amounts of DoD research funding, with the largest amounts going to life sciences at Duke and Wake Forest and engineering at NCSU. Duke was the top North Carolina-based institution, ranking 17th with over \$63 million in spending.

For comparison, national leaders in DoD-funded research include Johns Hopkins University and its associated Applied Physics Laboratory (\$1.1 billion) and Georgia Institute of Technology (\$443 million) with the majority going to engineering research.

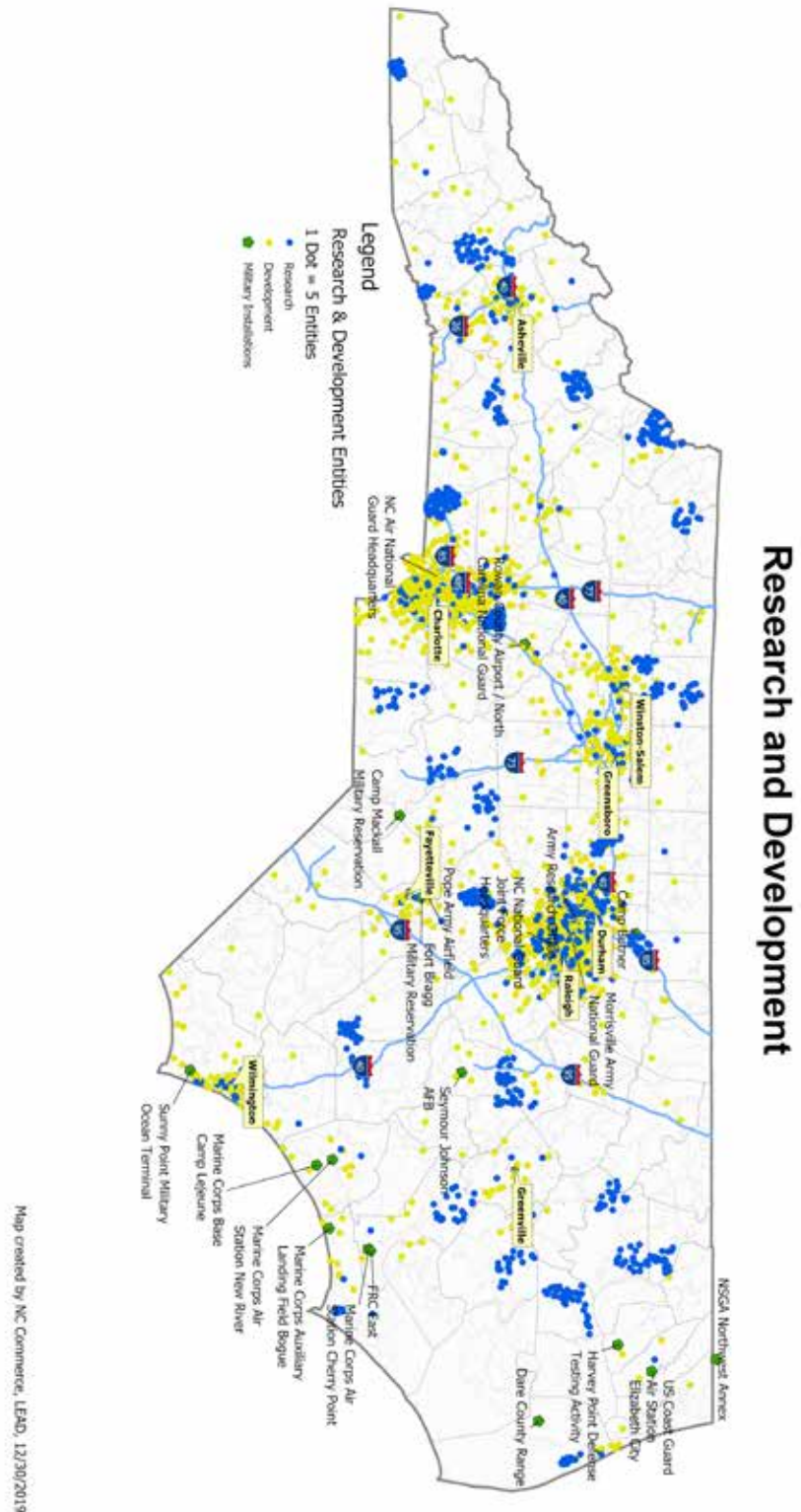
■ **Table 5:** Research Expenditures by Higher Education Institutions in North Carolina, Funded by the Department of Defense: FY 2018

Institutions	DoD-Funded Research Spending (FY 2017)
Public Universities	
North Carolina State University	\$32,831,000
University of North Carolina–Chapel Hill	\$13,820,000
North Carolina Agricultural and Technical State University	\$5,227,000
University of North Carolina–Charlotte	\$3,756,000
Fayetteville State University	\$532,000
University of North Carolina–Wilmington	\$470,000
East Carolina University	\$295,000
North Carolina Central University	\$235,000
University of North Carolina–Greensboro	\$214,000
Winston-Salem State University	\$150,000
University of North Carolina, general administration	\$98,000
Elizabeth City State University	\$69,000
Appalachian State University	\$67,000
University of North Carolina–Asheville	\$4,000
Private Universities	
Duke University	\$63,161,000
Wake Forest University	\$24,015,000
Davidson College	\$19,000

Source: National Science Foundation Higher Education Research and Development Survey, Fiscal Year 2018. Retrieved from <https://ncesdata.nsf.gov/herd/2018/>

As seen in **Figure 8**, assets in R&D are spread across the state. These range from specialized research firms in and around major metropolitan areas to smaller professional services firms that serve to bring research into the commercial sector.

Figure 8: R&D Assets in North Carolina



Recommendations

The defense industry in North Carolina is at a critical turning point: while the state has historically been a small market for defense-related business, data shown in **Table 6** indicate it is well positioned to be a national leader in emerging defense areas such as data and knowledge management, autonomous systems, and human performance in which it ranks among the fastest growing in the country. There is a large, untapped market for companies in the state to engage in more defense-related work in these emerging technology areas that are priorities for the DoD moving forward. The recommendations that will be implemented for these growth sectors will also serve as a model to better assist existing companies and industries across the state.

Table 6: Summary Statistics of Target Cluster Areas for Growth

Cluster Area	Growth Rate	Growth Rate Rank	Size of Total Supply Chain	Percentage of Supply Chain in State	Number of Graduates	Existing Defense Work	Companies (Direct/ Total Relevant)
Advanced Manufacturing	30%	2 nd	\$4.6B	67%	10,422	6%	54/156
Autonomous Systems	32%	6 th	\$7.4B	70%	10,564	17%	46/331
Data and Knowledge Management	37%	1 st	\$10.3B	75%	5,496	11%	210/315
Human Performance	36%	1 st	\$4.4B	68%	4,933	13%	57/184
Materials	-24%	35 th	\$4.3B	56%	12,173	7%	134/290
Power	30%	2 nd	\$5.2B	65%	7,981	18%	98/168

Sources: Bureau of Labor Statistics. (2018). Quarterly census of employment and wages (QCEW). Retrieved from <https://www.bls.gov/cew/>; Emsi. (2019). Input-Output Model, Industry Purchases, 2018. Retrieved from economicmodeling.com; US Department of Education, National Center for Education Statistics. (2017). Integrated Postsecondary Education Data System. Retrieved from <https://nces.ed.gov/ipeds/use-the-data>; North Carolina Defense Industry Diversification Initiative; RTI.

Considering North Carolina’s strengths and needs, the following recommendations can provide direction for activities that will address issues and serve to build North Carolina’s defense economy. Key to the successful implementation of these recommendations is the involvement of key partners in the state with a mission or desire to support and grow defense business. DANC intends to create annual detailed action plans with the support and leveraged and coordinated actions of these partners.

Recommendations:

I. Networking and Collaboration

North Carolina has a strong research infrastructure, programs like Hacking 4 Defense, access to warfighter needs, companies that have experience priming defense contracts, and engineering and product development companies that can apply research to create real solutions. These teams can create winning proposals for DoD contracts. North Carolina also has an infrastructure of existing innovation accelerators, NSF Industry/University Cooperative Research Centers Programs, and NSF Engineering Research Centers that can be used as hubs for these collective lab-to-market activities. The following recommendations address the needs expressed by companies to better learn of defense-related opportunities and identify collaboration partners:

- a. Provide opportunities and venues for the local innovation ecosystem in each of the technology cluster areas, including university technology commercialization offices, startups, and established companies, to engage with the DoD and national security customers to identify opportunities to transition research out of academic labs to the government and commercial sectors.
- b. Host “innovation days” to showcase North Carolina’s nontraditional and entrepreneurial companies to both the DoD and venture capital funders.
- c. Proactively connect teams of researchers, startups, and companies to DoD end users within each technology area, using human-centered design to spur new innovation and provide opportunities for North Carolina organizations to better understand defense customer operating cultures and needs.
- d. Provide mentoring and peer-to-peer interactions and functional integration between the varied practitioners and stakeholders, both within and across the cluster sectors, giving nondefense companies the opportunity to learn from and partner with prime contractors.

II. Contracting Assistance

Companies not working in the defense industry expressed reservations about the complicated nature of proposal writing, government contracting, and accounting practices to acquire defense contracts. A key factor to receiving DoD funding is a highly targeted proposal that fits a precise format and addresses critical elements like military impact and relevance. North Carolina small businesses and academic researchers have tremendous experience in writing successful National Institutes of Health proposals because of the region’s medical and life sciences capacity, but they have far less experience with DoD proposals. North Carolina has existing resources and training that can help companies navigate these areas. Organizations like the North Carolina Military Business Center, North Carolina Defense Technology Transition Office, and the Small Business and Technology Development Center, which has offices at each of the 16 UNC system universities, have experience and knowledge in government and DoD contracting.

- a. Raise companies' awareness of existing resources and training to help them navigate proposal writing, accounting, and contracting requirements.
- b. Build a directory of service providers with DoD contracting experience.
- c. Partner primes with DoD experience with companies new to DoD contracts as part of the DoD Mentor Protégé program.

III. Removal of Barriers to Entry

DoD business requires strong quality processes and risk understanding. Companies demonstrate these capabilities through qualify certifications in ISO 9001 and AS 9001 and through following the rules of International Traffic in Arms Regulations (ITAR). A major initiative in the DoD is the requirement for the defense industrial base to implement cybersecurity maturity model certification (CMMC) and to be compliant with the National Institute of Standards and Technology (NIST) publication 800-171 on Protecting Controlled Unclassified Information in Nonfederal Information Systems and Organizations. North Carolina can develop a strong defense industrial base by educating companies and providing easy access and connections to certification programs and service providers. Companies also mentioned that other states provide tax incentives for large capital equipment purchases, such as for AM equipment, which made locating in those states more desirable. Other companies were very successful in their commercial markets and considered entering the defense market as an opportunity cost.

- a. Promote certifications in ISO 9001, AS 9100, ITAR, CMMC, and NIST 800-171 to strengthen companies' ability to conduct DoD business.
- b. Assign one coordinating organization, such as the North Carolina Manufacturing Extension Partnership, to manage third-party service providers in certifications and training to make it easier for companies to navigate.
- c. Incentivize companies to consider entering the DoD market by educating them about revenue opportunities and access to Small Business Innovation Research nondilutive capital, expanding grant opportunities to obtain certifications, and considering creative tax incentives for capital equipment or revenue from defense contracts.

IV. Agency Outreach

North Carolina has unique capabilities to offer the DoD and needs to build a brand that will showcase the assets of these technology areas. North Carolina lacks a major DoD acquisition office, such as PEO-Soldier, which has significant influence and decision-making authority for DoD R&D spending. An acquisition office would complement the presence of major North Carolina commands and units like Army Forces Command, XVIII Airborne Corps, both the Army and the Joint Special Operations Commands, 4th Fighter Wing, and II Marine Expeditionary Force. Alternatively, establishing an outpost for a DoD rapid innovation office, such as the Defense Innovation Unit, DoD Rapid Reaction Technology Office, Army Rapid Capabilities and Critical Technologies Office, or an innovation entity similar to SOFWERX, AFWERX, or NAVALX would help attract and support high-tech innovation companies to the region.

- a. Develop marketing materials for North Carolina's value proposition in the six technology areas and communicate to DoD funders and prime contractors.
- b. Recruit a major DoD acquisition, rapid innovation office, or best practices work cells to the region to increase visibility of North Carolina's innovation capability and attract high-tech and high-performing companies to North Carolina.
- c. Position North Carolina to be the home of a new national technology center in one of the six technology areas, such as Quantum or Emerging Biotechnology for National Security. The FY2020 National Defense Authorization Act conference report released in December 2019 authorizes \$8 million for the establishment of a Quantum Information Science Innovation Center and commissions a Defense Science Board study on emerging biotechnologies pertinent to national security.

V. Specific Technology Areas

a. Advanced Manufacturing



- i. Assign a lead organization, such as NCSU and NC A&T, to find funding for and implement an AM materials characterization database. This resource can be the basis for a membership organization that pulls in AM equipment developers, equipment users, and DoD laboratories that need this information.
- ii. Create or attract pre- and post-processing services needed in AM, such as heat treatment and X-ray scanning/testing facilities.
- iii. Develop a catalog of AM providers in the state and deliver to relevant DoD users.
- iv. Build awareness for companies in rural areas of opportunities to provide AM services for the DoD.
- v. Consider establishing a ground vehicles center of excellence using the AM expertise of North Carolina's motorsports industry.

b. Autonomous Systems



- i. Leverage test platforms such as the AERPAW, a first-of-its-kind aerial wireless experimentation platform with the goal to accelerate the integration of unmanned air systems (UAS) into the national airspace. This test site can enable new advanced wireless features for UAS platforms, such as flying base stations for hot spot wireless connectivity, to attract teams of companies to propose solutions to DoD needs.
- ii. Actively use the Drone Summit to attract funders and gather companies with capabilities together and build network.
- iii. Match AI companies with transportation companies in the state (drone, truck, boat, construction equipment) to develop autonomous applications for the DoD.

- iv. Match AI companies with software providers to develop autonomous decision-support applications for DoD needs.

- c. Data and Knowledge Management



- i. Provide broadband infrastructure to enable companies working in the digital space to quickly access and provide digital products to their customers.
- ii. Make available specialized infrastructure, such as Sensitive Compartmented Information Facilities, for companies working in secure spaces.
- iii. Develop cybersecurity resources and service providers to assist companies working in defense.

- d. Human Performance



- i. Leverage the North Carolina Biotechnology Center as the hub of human performance activities and broaden from there, extending service areas to map to DoD human performance needs.
- ii. Embrace and coordinate North Carolina's strong human health innovation ecosystem (from research to clinical trials to device and pharma product manufacturing to medical market/Womack Army Medical Center and the Navy hospital at Camp Lejeune) to address warfighter performance needs related to health.
- iii. Use access to base installations and domain experience of exiting military combined with the gaming industry and emerging virtual reality labs to develop warfighter training applications and other applications using human-centered design.

- e. Materials



- i. Focus on functional fabrics and nanomaterials based on North Carolina's research strength in textiles; strength in textile manufacturing and equipment; textile and materials engineering talent from NCSU; affiliation with Advanced Functional Fabrics of America, a DoD-funded manufacturing innovation research center; and the Research Triangle Nanotechnology Network. Identify DoD funding and needs for applications such as electronic clothing for heating/cooling, color-changing camouflage, and other textile innovations.

- f. Power



- i. Build on the strength of North Carolina's capabilities in power electronics to partner semiconductor manufacturers; device, module, and system manufacturers; companies with power electronics applications; Duke Energy; NCSU's FREEDM Center; Power America; and the North Carolina Cleantech Cluster to develop applied systems for the DoD. Provide access to high-voltage R&D facilities for companies interested in developing higher-voltage wide-bandgap power electronics.
- ii. Leverage expertise, infrastructure, and industrial affiliates of Power America, North Carolina Cleantech Cluster, and UNC-Charlotte's Energy Production and Infrastructure Center.

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Appendix A: Data Resources and Methodology

RTI and the North Carolina Department of Commerce LEAD compiled data from the following sources and using the following methods. Detailed lists of companies and research assets by technology area are available from DANC to economic developers upon request.

Job Growth

To capture the size of existing industries, job growth, and state comparisons, the team used data from the Bureau of Labor Statistics QCEW. The QCEW program publishes a quarterly count of employment and wages reported by employers covering more than 95% of US jobs, available at the county, metropolitan statistical area, and state and national levels by industry. Industry types are defined by the North American Industry Classification System (NAICS).

The research team recognized the limitations in using NAICS to identify the specific capabilities desired within each technology area. However, NAICS data are the most established to benchmark growth and comparisons to the nation and other states. With input from internal and external stakeholders, RTI defined the six-digit NAICS codes for analysis in Table A-1.

■ **Table A-1: Framework for NAICS Code Classification by Target Cluster Area and Stage of the Value Chain**

Value Chain	Advanced Manufacturing	Autonomous Systems	Data and Knowledge Management	Human Performance	Materials	Power
Research	541715	541715	541715	541720 541714	541713	541715
Development	541330	541330 541511 541512	541330 541511 541512	541330	541330	541330
Products	332999 333244 333249 333999 333517	336411 336111 336611 336612 334413 334511	334111 334112 334210 334220 334290 511210	334510 339113 315990	335991 313230 325211 331410 327999 325510	335312 335911 335999
Services		541519	518210 541519	611420 621340		221118 237130

R&D NAICS codes cut across multiple target cluster areas and include the following:

- **541713** *Research and Development in Nanotechnology*
- **541714** *Research and Development in Biotechnology (except Nanobiotechnology)*
- **541715** *Research and Development in the Physical, Engineering, and Life Sciences (except Nanotechnology and Biotechnology)*
- **541720** *Research and Development in the Social Sciences and Humanities*
- **541330** *Engineering Services*
- **541511** *Custom Computer Programming Services*
- **541512** *Computer Systems Design Services*
- **541513** *Computer Facilities Management Services*

Additionally, specific NAICS codes applied uniquely to the six target cluster areas are the following:

Advanced Manufacturing

- **332999** *All Other Miscellaneous Fabricated Metal Product Manufacturing*
- **333244** *Printing Machinery and Equipment Manufacturing*
- **333249** *Other Industrial Machinery Manufacturing*
- **333999** *All Other Miscellaneous General Purpose Machinery Manufacturing*
- **333517** *Machine Tool Manufacturing*

Autonomous Systems

- **336411** *Aircraft Manufacturing (includes Drones, Helicopters)*
- **336111** *Transportation Equipment Manufacturing -- Automobile Manufacturing*
- **336611** *Transportation Equipment Manufacturing -- Ship Building and Repairing*
- **336612** *Boat Building*
- **334413** *Semiconductor and Related Device Manufacturing (Sensors)*
- **334511** *Search, Detection, Navigation, Guidance, Aeronautical, and Nautical System and Instrument Manufacturing*
- **541519** *Other Computer Related Service*

Data and Knowledge Management

- **334111** *Electronic Computer Manufacturing*
- **334112** *Computer Storage Device Manufacturing*
- **334210** *Telephone Apparatus Manufacturing*
- **334220** *Radio and Television Broadcasting and Wireless Communications Equipment Manufacturing*
- **334290** *Other Communications Equipment Manufacturing*
- **511210** *Software Publishers*
- **518210** *Data Processing, Hosting, and Related Services*
- **541519** *Other Computer Related Services*

Human Performance

- **334510** *Electromedical and Electrotherapeutic Apparatus Manufacturing*
- **339113** *Surgical Appliance and Supplies Manufacturing*
- **315990** *Apparel Accessories and Other Apparel Manufacturing*
- **611420** *Computer Training*
- **621340** *Offices of Physical, Occupational and Speech Therapists, and Audiologists*

Materials

- **335991** *Carbon and Graphite Product Manufacturing*
- **313230** *Nonwoven Fabric Mills*
- **325211** *Plastics Material and Resin Manufacturing*
- **325510** *Paint and Coating Manufacturing*
- **331410** *Nonferrous Metal (except Aluminum) Smelting and Refining*

Power

- **335312** *Motor and Generator Manufacturing*
- **335911** *Storage Battery Manufacturing*
- **335999** *All Other Miscellaneous Electrical Equipment and Component Manufacturing*
- **221118** *Other Electric Power Generation*
- **237130** *Power and Communication Line and Related Structures Construction*

LEAD and RTI compiled the data at the state level for all 50 states in the United States and benchmarked total jobs, job growth, and LQ, which is a relative measure of job concentration in a region.

Data are available at <https://www.bls.gov/cew/>.

Supply Chain Purchasing

To capture the upstream and downstream industries associated with the industries analyzed with the QCEW data, LEAD used an input-output (I-O) model from EMSI (<https://www.economicmodeling.com/>) to estimate in-state and out-of-state purchasing in the supply chain. Using the totals identified in the QCEW analysis, LEAD and RTI input the totals into the I-O model to estimate spending based on state assets and national I-O accounts such as those available from the US Bureau of Economic Analysis (<https://www.bea.gov/industry/input-output-accounts-data>).

More information is available at <https://www.economicmodeling.com/2009/04/02/io-guidebook-sec-v-using-input-output-for-economic-dev-analysis/>.

Educational Assets and Graduates

To identify higher education assets in North Carolina, RTI used the Integrated Postsecondary Education Data System from the US Department of Education, which captures graduates of all higher education institutions, including community colleges, by degree and program type. RTI used the programs listed in Table A-2 for analysis:

■ **Table A-2: Educational Program Classification of Instructional Programs (CIP) Codes and Target Industry Cluster Areas**

Data were limited to the following degrees conferred in 2017: associate's, bachelor's, master's degrees, and doctoral degrees in research and scholarship. The table does not include doctoral degrees in professional practice such as medical doctors, veterinarians, or dentists.

CIP Code	Advanced Manufacturing	Autonomous Systems	Data and Knowledge Management	Human Performance	Materials	Power
Biological and Biomedical Sciences				●		
Communications Technologies/ Technicians and Support Services		●	●			
Computer and Information Sciences and Support Services		●	●			
Engineering	●				●	●
Engineering Technologies and Engineering-Related Fields	●	●			●	●
Health Professions and Related Programs				●		

Data are available at <https://nces.ed.gov/ipeds/>.

RTI complemented these data with data from the NSF HERD, which collects data on research spending at US universities, broken down by R&D field and funding source. This includes DoD-funded research.

Data are available at https://ncesdata.nsf.gov/herd/2017/html/herd2017_dst_59.html.

CIP Code	Advanced Manufacturing	Autonomous Systems	Data and Knowledge Management	Human Performance	Materials	Power
Mathematics and Statistics			●			
Physical Sciences					●	
Precision Production	●				●	
Science Technologies/ Technicians	●				●	

Data are available at <https://nces.ed.gov/ipeds/>.

RTI complemented these data with data from the NSF HERD, which collects data on research spending at US universities, broken down by R&D field and funding source. This includes DoD-funded research.

Data are available at https://ncesdata.nsf.gov/herd/2017/html/herd2017_dst_59.html.

Company Lists and Existing Defense Work

Using the NAICS codes defined in the target cluster areas, RTI compiled a list of companies using D&B Hoover's (<https://www.dnb.com/>) and added to the list relevant companies and organizations identified via a survey sent to 40 individuals at 33 North Carolina research organizations, companies, and support organizations with knowledge of North Carolina's capabilities. RTI then narrowed that list through interviews and desktop research to those that provided a product or service that could potentially serve the defense industry within each technology area. RTI combined the Hoover's list with the companies identified by the North Carolina Defense Industry Diversification Initiative to estimate the percentage of those companies currently engaged in defense work.

