



# TARGET SECTOR ANALYSIS

## NORMAN, OKLAHOMA

Submitted by Market Street Services, Inc.  
[www.marketstreetservices.com](http://www.marketstreetservices.com)

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# PROJECT OVERVIEW

The five-phase research and strategic planning process will last approximately nine months, concluding in May 2018. A diverse Steering Committee comprised of representatives from the public, private, and non-profit sectors will guide the process and ensure that it lays the foundation that will allow people and businesses to thrive and wealth to accumulate in the community.

## PHASE ONE: STAKEHOLDER ENGAGEMENT

The Economic Development Strategic Plan must be adequately informed by the wants and needs of Norman's residents, workers, and employers. A series of one-on-one interviews and focus groups were conducted in October 2017. This input is complemented by feedback received from an online survey open to all residents and business in the Norman area that solicited more than 1,600 responses.

## PHASE TWO: COMMUNITY ASSESSMENT

The Community Assessment will provide a detailed examination of Norman's competitiveness as a place to live, work, and do business, weaving qualitative feedback from phase one with quantitative analysis to produce a set of "stories" that examine Norman's past, present, and future with respect to economic competitiveness. This narrative Assessment will be complemented by a set of scorecards that illustrate how the area compares to nine other communities that it competes with for jobs and workers.

## PHASE THREE: TARGET SECTOR ANALYSIS

The Target Sector Analysis will build upon the Community Assessment by providing a deeper examination of the community's economic composition. It will specifically identify those sectors of economic activity for which Norman is most competitive and which are most likely to support future job and wealth creation in the years ahead.

## PHASE FOUR: ECONOMIC DEVELOPMENT STRATEGIC PLAN

Informed by the input and research findings gleaned from phases one through three, the Economic Development Strategic Plan will detail a series of objectives related to the community's identified challenges and opportunities, and a corresponding set of actions, investments, and initiatives. That can help achieve those objectives and advance economic development in Norman over the next five to ten years. The Plan will be holistic, actionable, measurable, and considerate of relevant best-practice programs, policies, and initiatives from communities around the country.

## PHASE FIVE: IMPLEMENTATION PLAN

Timely and effective implementation is critical to the ultimate success of the Economic Development Strategic Plan. If the Strategic Plan represents *what* Norman and its community leadership need to do in order to realize the community's full economic potential, the Implementation Plan helps define *how* the community's leadership can collaboratively, effectively, and efficiently advance implementation. Specifically, the Implementation Plan will prioritize initiatives, formalize timelines for implementation, identify roles and responsibilities for lead and supporting organizations, evaluate financial and staff capacity to support implementation, and define performance metrics to track implementation progress and return on investment.

# STEERING COMMITTEE

The following individuals have generously volunteered their time to serve the community and this process by providing strategic guidance, input, and oversight throughout the process, attending seven meetings from October 2017 through May 2018.

## INDIVIDUAL

Andy Paden (Committee Chair)  
 Councilmember Kyle Allison  
 Jane Bowen  
 Joyce Burch  
 Councilmember Breea Clark  
 Shelley Coleman Cox  
 Dr. Michael Detamore  
 Mike Fowler  
 Anil Gollahalli  
 Patrick Grace, PE  
 Shane Hampton  
 Steve Ketchum  
 Chris Kuwitzky  
 Steve Lewis  
 Scott Martin  
 Curtis McCarty  
 Nick Migliorino  
 Mayor Lynne Miller  
 Daniel Pullin  
 Dan Quinn  
 Andy Sherrer  
 Jason Smith  
 Richie Splitt  
 Commissioner Darryl Stacy  
 Chuck Thompson  
 Casey Vinyard  
 Daren Wilson

## REPRESENTING ORGANIZATION

Moore Norman Technology Center  
 City of Norman  
 Moore Norman Technology Center Superintendent  
 University of Oklahoma  
 City of Norman  
 Norman Chamber of Commerce  
 University of Oklahoma  
 NEDC Board Member  
 NEDC Board Member  
 NEDC Board Member  
 University of Oklahoma  
 Moore Norman Technology Center  
 University of Oklahoma  
 NEDC Board Member, City Manager  
 Norman Chamber of Commerce President  
 Norman Chamber of Commerce Chair  
 Norman Public School System Superintendent  
 City of Norman  
 NEDC Board Member  
 NEDC Board Chair  
 Moore Norman Technology Center Board President  
 NEDC President  
 Norman Regional Health System CEO  
 Cleveland County  
 Sooner Centurion Chair  
 NEDC Board Member  
 United Way of Norman

# INTRODUCTION

The report – the Target Sector Analysis – represents the second phase of research supporting the development of a new Strategic Plan for Economic Development in Norman, Oklahoma. The previous phase, the Community Assessment, identified six key “stories” that cover the broad range of opportunities and challenges in Norman. **This report focuses more narrowly on a specific issue: Norman’s potential to create new jobs and wealth for its residents through “targeting.”**

For individuals and households, standards of living are closely linked with economic opportunities. If more people at a variety of skill levels are able to find jobs and earn wages, levels of prosperity will rise. To that end, communities around the country are directing finite resources toward the development of “targeted” business sectors that have the greatest potential to grow jobs and attract investment. This report identifies and profiles the sectors that possess such potential in Norman. It is divided into two sections:

- ∟ **Key Trends:** This section analyzes the existing economic composition and workforce dynamics in the Norman area. High level findings that were presented in the Community Assessment are discussed within the context of targeted growth potential and ability to increase wealth and prosperity. This section introduces the process for identifying the target sectors.
- ∟ **Recommended Target Sectors:** This section presents a set of recommended target sectors for Norman. It was developed from an extensive analysis of the community’s economic composition and competitive position for a variety of business activities. This process included evaluating relevant findings from the Community Assessment and the public input process, conducting an extensive analysis of business sector and workforce data, reviewing previously conducted research, and considering targeted activities at the regional and state level. A “ground up” approach – which focuses on the region’s workforce attributes and other assets that support specific types of economic activity – reveals opportunities and challenges and forms the basis for determining where Norman should be directing its economic development resources. The section includes a brief profile for each target sector, complete with a set of key strategic considerations that can inform the development of the upcoming Economic Development Strategy.

Before moving on, however, it is first necessary to define Market Street’s approach to targeting and establish how this practice differs from other strategic aims that might also lead to economic growth. Communities across the country are pursuing differentiated economic development strategies that seek to support the development of “targeted” business sectors which may benefit from specific competitive advantages afforded by the community, its location, and its asset base. The practice of “targeting” has grown as communities have witnessed the advantages that are afforded to the companies by such agglomerations or “clusters.” The remainder of this introductory section provides this additional context in addition to defining specific terms and outlining various strategic considerations that underpin the included analysis.

## KEY CONCEPTS RELATED TO TARGET SECTOR DEVELOPMENT

**CLUSTERS:** Agglomerations – or “clusters” – represent groups of interrelated businesses that choose to co-locate. The historical growth of clustered economic activity in areas such as the Silicon Valley, Route 128 in Massachusetts, and the Research Triangle Park in North Carolina are well-developed case studies of cluster development efforts that span decades, efforts which many other regions across the nation seek to mimic. There are countless other examples of smaller, more specialized clusters around the country and the world. Clustering can occur among competing or cooperative firms for a variety of different reasons. A group of suppliers may choose to locate in proximity to a major manufacturer for research and development efficiencies and reduced transportation costs; such is the case with an aerospace cluster anchored by Boeing Defense, Space & Security in St. Louis, Missouri. Other firms may co-locate in a specific area in order to take advantage of a specialized labor pool or to be in close proximity to specific infrastructure.

While the factors that have led to clustering vary tremendously by region and sector, such agglomerations occur over time because a location has an asset base that affords the sector and the companies that operate within them some form of competitive advantage. As the cluster grows, so too do the benefits afforded to the companies within the cluster: the available workforce grows, the potential for collaboration expands, competition may drive down costs, and buyer and supplier networks expand, among other potential impacts.

**TARGETS:** A targeted sector – or simply a “target” – is any type of business activity that is strategically pursued by an economic development organization and its partners for quality growth and development. That is to say, a “target” is an area where financial and staff resources, and the programs and policies they support, are specifically focused. “Targets” are often those segments of an economy where competitive advantages exist, prospects for future growth are greatest, and return on investment is likely highest. A “target” can be a single business sector with high growth potential or a “cluster” of businesses in related sectors. Many communities choose to target business sectors that are not presently concentrated in their community or characterized by existing competitive advantages. This may be because such activities are rapidly expanding, exhibit potential to become clusters in the years and decades to come, or align with other strategic objectives of the community. The aim of “targeting” is not necessarily to create new clusters of business activity – communities with multiple clusters are rare and tend to be among the nation’s largest and most dynamic economies.

## STRATEGIC CONSIDERATIONS FOR TARGET SECTOR DEVELOPMENT

**UNDERSTANDING YOUR ASSET BASE:** Strategic targeting is predicated upon a solid understanding of a community’s strengths and weaknesses, specifically as they relate to the needs of specific business sectors and the companies that operate within them. The factors that medium to large companies consider when evaluating a community as a potential location for a new facility are often referred to as site location factors, site selection factors, or site considerations. These factors vary tremendously by sector. Accordingly, communities that are able to offer such characteristics are better positioned to attract these kinds of operations. Understanding the community’s asset base – inclusive of a wide variety of these potential site location factors – is critical to understanding the community’s competitiveness for various business sectors. Likewise, an understanding of its deficiencies in terms of such site location factors will help the community identify areas that need further investment if the community wishes to transform such deficiencies into future assets.

**A HOLISTIC APPROACH:** Target business sectors reflect existing agglomerations of establishments with similar business activities that have likely flourished in a community because of an asset base that aligns with that sector's primary site location considerations. Other sectors that share similar site location factors may not currently be concentrated in the community, but the aforementioned asset base could make the community an attractive location for these new activities. Accordingly, such sectors represent opportunities where the community may have a particularly high chance for success in marketing and recruitment efforts that seek to attract new corporate investments or relocations that would benefit from the community's existing asset base.

For decades many communities and their economic development organizations have exclusively associated "economic development" with "business recruitment." While the recruitment of new companies is an important component of any targeted economic development program, it is only "one leg of the stool." Any effort to develop target sectors and nurture employment growth within them must focus upon the needs of existing businesses as well as entrepreneurs. Holistic economic development must also address the community or region's asset base that supports the competitiveness of target business sectors and the companies that operate within them.

## TARGET SECTOR ANALYSIS: APPROACH AND METHODS

Market Street's approach to target identification is rooted in a complete examination of the region's strengths and opportunities, including talent (the occupations and types of knowledge that support the region's business activities). This comprehensive, interrelated approach stands in contrast to the traditional "top down" approach long utilized in cluster identification and analysis. It recognizes the importance of talent and workforce sustainability to the business community. It is complemented by an evaluation of the region's business climate, networks, infrastructure, research assets, educational programs, and many other factors that influence site location decisions.

**CLASSIFICATION:** Our approach defines targets by their North American Industry Classification System (NAICS) codes. Though these codes are used to help quantify important employment trends and activity within each target, they should not be interpreted as rigid definitions of the composition of economic activity within a given target. Classification systems do not adequately capture certain niche technologies and opportunities that may deserve strategic attention in certain communities. We utilize the federal government's Standard Occupational Classification (SOC) system to classify occupations. SOC codes differ from NAICS in that they quantify worker's skill categories rather than the employment sector reported by their companies.

**TARGET DEFINITIONS AND DATA SOURCES:** The selection of NAICS subsectors and SOC occupations used to "define" the employment and skill sets of each target sector is made based on assessments of industrial categories published by the U.S. Bureau of Labor Statistics, U.S. Bureau of Economic Analysis, Economic Modeling Specialists International (EMSI), the U.S. Cluster Mapping Project, the U.S. Employment and Training Administration's Occupational Information Network (O\*NET), the National Center for Education Statistics, CareerBuilder, and other resources. Due to data-reporting protocols and limitations in specificity of industrial classifications, definitions are intended to be approximations of targeted activity.

**GEOGRAPHY:** Business and workforce composition information contained within this report is based on an analysis of trends at the zip code level for an area that most closely approximates the City of Norman. This encompasses the following zip codes: 73019, 73026, 73069, 73070, 73071, 73072, and 73068. Additionally, data for the Oklahoma City MSA is also included throughout the report to provide additional context to regional trends. The Oklahoma City MSA encompasses Canadian, Cleveland, Grady, Lincoln, Logan, McClain, and Oklahoma counties.

**LOCATION QUOTIENTS:** Location quotients (LQs) are used to measure the relative concentration of local employment in a given business sector or occupation. When applied to business sector employment, they measure the ratio of a business sector's share of total local employment to that business sector's share of total national employment. A business sector with LQ of 1.0 is exactly the same share of total local employment as that business sector's share of national employment. When a local business sector has a location quotient greater than 1.0, it signals that the sector is more heavily concentrated locally than it is nationwide. Those sectors with high LQs are often assumed to benefit from one or more sources of local competitive advantage. Location quotients can also be applied to occupational employment in the same manner that they are applied to business sector employment, helping to determine which occupations and corresponding skill sets are highly concentrated in the local workforce.

## KEY TRENDS: ECONOMIC COMPOSITION AND WORKFORCE DYNAMICS

This portion of the Target Sector Analysis focuses on key trends related to the business sector composition and workforce in Norman over the course of the previous decade. It integrates key findings from the Community Assessment, input from stakeholders around the community, and other relevant information, with an extensive quantitative analysis of two types of data: business sector data that is useful in identifying existing and potential clustered activities, and occupational data that highlights talent strengths and deficiencies. Market Street examined hundreds of indicators from each category, evaluated trends over time, and compared the region's economic composition to that of the regional and national economy. **What follows is a succinct summary of the most relevant and important themes and observations that emerged from this research.**

### *An evolving economy with less dependency on the public sector*

The following table displays a high-level overview of business sector composition in Norman and how it has changed over the past decade relative to the Oklahoma City metro and the national average.

**FIGURE 1: ECONOMIC PERFORMANCE BY BUSINESS SECTOR, NORMAN (2006-16)**

NAICS	Business Sector	Jobs (2016)	Change in Jobs (2006-2016)				Location Quotient (2016)	
		Norman	# Change, Norman	% Change, Norman	% Change, OKC MSA	% Change, U.S.	Norman	OKC MSA
90	Government	17,043	(3,442)	-16.8%	-0.6%	1.5%	1.77	1.28
44	Retail Trade	8,631	2,616	43.5%	8.3%	1.8%	1.33	1.02
72	Accommodation & Food Svcs.	7,721	1,835	31.2%	22.7%	19.1%	1.44	1.08
62	Health Care & Social Assistance	5,799	1,506	35.1%	15.6%	25.4%	0.74	0.92
54	Professional, Scientific, & Technical Svcs.	4,063	1,068	35.7%	20.2%	17.6%	1.01	0.88
56	Admin./Sup. & Waste Mgmt./Remed. Svcs.	3,143	(1,114)	-26.2%	-5.7%	7.3%	0.80	1.00
81	Other Svcs. (except Public Administration)	3,124	187	6.4%	5.8%	3.1%	1.04	1.04
23	Construction	2,796	(12)	-0.4%	4.3%	-14.9%	0.83	1.08
31	Manufacturing	2,748	(150)	-5.2%	-10.2%	-12.9%	0.55	0.67
52	Finance & Insurance	1,640	(41)	-2.5%	6.1%	-3.8%	0.67	0.96
53	Real Estate & Rental & Leasing	1,214	(26)	-2.1%	-22.3%	-5.7%	1.18	0.98
71	Arts, Entertainment, & Recreation	940	478	103.7%	25.2%	16.5%	0.88	0.90
42	Wholesale Trade	933	242	35.0%	4.7%	-1.3%	0.39	0.98
51	Information	715	43	6.4%	-39.8%	-7.7%	0.61	0.69
61	Educational Svcs.	538	4	0.8%	48.4%	25.9%	0.33	0.64
48	Transportation & Warehousing	527	63	13.5%	29.0%	12.1%	0.24	0.84
21	Mining, Quarrying, & Oil & Gas Extraction	411	192	87.3%	24.8%	-0.6%	1.65	6.25
55	Management of Companies & Enterprises	298	117	64.8%	92.2%	24.9%	0.34	1.00
22	Utilities	230	(25)	-9.8%	-1.9%	2.3%	1.04	1.15
11	Crop & Animal Production	210	25	13.7%	-27.3%	0.7%	0.27	0.27
Total Jobs		62,725	3,540	6.0%	6.4%	5.0%		

Source: Economic Modeling Specialists Intl. (EMSI)

Location quotients: Location quotients (LQs) measure the relative concentration of regional employment in a given business sector. Specifically, they are calculated by dividing a sector's share of regional employment by that sector's share of national employment. A location quotient above 1.0 would indicate that the sector is more heavily concentrated in the region than it is nationally. Color-coding: Employment growth is color-coded such that growing sectors are presented in green text and declining sectors in red text. Those with location quotients greater than or equal to 1.1 are presented with a green triangle. LQs lower than 0.9 are presented with a red triangle, and LQs between 0.9 and 1.1 have a yellow dash.

As was discussed in the Community Assessment, Norman's economy has historically been highly dependent on government employment. Norman's three largest employers are all government entities – the University of Oklahoma, Norman Regional Hospital, and Norman Public Schools. In 2016, roughly 27 percent of all jobs were in the public sector, down from 34.6 percent in 2006. Norman's major employers are all pivotal pieces to the economy. As such, government employment will continue to be an important source for jobs and economic activity in Norman moving forward. However, budget constraints in recent years at the state level has resulted in the loss of thousands of jobs within the public sector; between 2006 and 2016, total government employment fell by 16.8 percent.

**Despite such losses in the public sector, the Norman economy grew at a faster pace than the national average over the past ten years. Total employment increased by six percent compared to the national growth rate of five percent. Job growth was fueled by the private sector which posted strong employment growth across a variety of industries. Norman's private sector employment increased by 18 percent and job growth impressively outpaced its peer university communities in Ann Arbor, MI; Boulder, CO; and Lawrence, KS. Consequently, Norman's overall economy has evolved into one that is less dependent on the public sector and into one where the private sector has been driving employment growth.**

The second column from the right displays the "location quotient" for Norman in each of the broad business sectors as of 2016. A location quotient measures the concentration of a given sector within a local economy relative to the concentration of that same sector in the national economy. A sector with a location quotient above 1.0 is more heavily concentrated in the local economy than it is in the United States as a whole. Typically, a high location quotient indicates that the region has some level of competitive advantage to justify a higher-than-average concentration of jobs. The location quotient for the Oklahoma City MSA is also provided for additional context regarding the overall region's economic composition.

Beyond government, Norman has a high concentration of jobs in retail trade, accommodation and food services, real estate and rental and leasing, and mining. The first three sectors are tied to the fact that Norman is home to one of the state's major universities, the University of Oklahoma. Retail trade and accommodation and food services are a testament to the community's quality of life offerings while real estate activities are tied to the high share of students that are renters. Roughly half of the real estate jobs are for lessors of real estate. Oil and gas, on the other hand, is a major driver of the state's economy. It has a large economic impact on the region, but its output and associated employment can be highly cyclical.

While Norman has had success in growing its private sector and decreasing its dependency on the public sector, the economy is still relatively concentrated in just a handful of sectors, many of which are vulnerable to state budgets and consumer discretionary spending. As the Community Assessment highlighted, the lack of quality employment opportunities in Norman was cited as a challenge by a variety of input participants, namely higher skilled jobs that require postsecondary education. A 2016 survey of 300 OU students as part of the "Brand Dig" study found that out of the students that stated that did not want to live in Norman after graduation, 66 percent of them said a good or better job opportunity locally would help convince them to stay in Norman after graduation. **While job growth is a positive and important piece to a healthy economy, the composition and quality of jobs is just as important. Moving forward, a stronger, diverse economy would provide new, higher-quality employment opportunities for both existing and potential residents in Norman.**

***Health care and retail trade: critical for quality of life but limited in wealth creation potential***

As can be seen in Figure 1, private sector job growth was largely fueled by retail trade and accommodation and food services. Although these two sectors indicate that there have been improvements to quality of life offerings in Norman, they are primarily locally serving and their growth is largely tied to population growth. In other words, the retail and food service sectors principally recycle or recirculate local wealth, and bring little new wealth into the community except for that which is expended by visitors and non-residents. Additionally, they offer relatively lower paying and lower skilled employment opportunities. The biggest bright spot in the private sector job growth was in health care and professional, scientific, and technical services. Combined, the two sectors added more than 2,500 jobs over the past ten years.

Although the location quotient of Norman's health care sector suggests that it is less concentrated than the national average, total economic activity in Norman's health care sector is in fact much greater but is hidden in government employment. Norman Regional Health System (NRHS) is operated by Norman Regional Hospital Authority, a public trust, and therefore falls under the government classification system. NRHS employs roughly 3,000 individuals that are not reflected in the private sector data covering health care.

Even so, like retail trade and accommodation and food services, the health care sector is primarily locally serving. Although Norman Regional has attracted patients from all across the state and has some strong specializations, it is not a magnet for destination health care services. In fact, Norman has a high concentration of key occupations that operate in health care services such as family and general practitioners and surgeons, among others. This high concentration of key occupations is indicative of its position as a health care provider for the region and its strength in health care services. However, few regions are truly able to claim status as a destination medical center. Communities such as Rochester, Minnesota (home of the renowned Mayo Clinic) and Cleveland, Ohio (home to the Cleveland Clinic) are two such examples of communities and health care sectors that consistently and intentionally attract patients from all over the world. With a consumer base that extends well beyond the nearby community, they are able to bring in a significant amount of outside money into the community. In this regard and in the most extreme cases, some destination medical services are considered "medical tourism." Employment growth in health care jobs in Norman, however, is more closely tied to population growth within the region and therefore has a limit to the amount of additional economic activity it can attract. Its growth is most likely to be fueled by the community's overall growth; that is to say, efforts that expand jobs in primary, export-oriented sectors will benefit the health care sector and others that are predominantly local-serving.

**If Norman is to improve wealth and prosperity in the community, it will need to focus on advancing sectors that are export-oriented and have greater growth potential.** Those that are export-oriented are able to bring outside dollars into the community through exported goods and services, and they typically provide higher paying and higher skilled employment opportunities. Export-oriented sectors therefore lead to a greater return on investment when it comes to spending economic development dollars.

With that said, it should be noted that when referring to health care in Norman, it is in regards to health care services. As will be mentioned later, there is a tremendous amount of activity related to life sciences and biotechnology that offer more promising prospects for future quality growth and where return on any kind of targeted economic development investment would be greater. Additionally, all three of the previously mentioned sectors – retail trade, accommodation and food services, and health care services – will continue

to play an important role in Norman's economy in helping to strengthen the quality of life offerings for residents and potential residents in the area. However, **strategies to strengthen the retail trade and health care sectors will differ significantly when compared to those that are used for targeted economic growth, where dollars are often spent on recruitment and marketing in pursuit of growth. As previously suggested, the local-serving retail, health care, and food service sectors can benefit most appropriately from strategies that increase the *demand* for services and products in these sectors, as opposed to strategies that seek to increase the *supply* (i.e. retail recruitment).**

### ***Challenges attracting and retaining well-educated young professionals***

As the Community Assessment highlighted, Norman's educational attainment rate is above the state and national averages, however, it trails its peer benchmark set – Ann Arbor, MI; Boulder, CO; and Lawrence, KS. These three comparison communities, which are also home to research universities, have populations where 57 to 77 percent of adults have a four-year degree or higher. In Norman, 43 percent of adult residents have a bachelor's degree or higher compared to roughly 31 percent at the national level. The differences in the educational attainment rates between Norman and its competitive set is reflective of its current economic composition and has implications on the potential opportunities in the near-term.

In addition to current educational attainment rates trailing competitor communities, there are emerging threats related to Norman's future workforce competitiveness. These troubling trends were related to net out-migration from Cleveland County to other counties in the metro area, a declining population between the ages of 25 and 44, declining educational attainment levels, and an in-migrant population that is less well-educated than existing residents. These four key takeaways that emerged from the data and were discussed in the Community Assessment have important implications on the community's workforce sustainability and on the types of economic activity that the community can support moving forward.

**The city's previously discussed economic composition is partially a reflection of its lower educational attainment rates and these emerging trends. Norman has a low concentration in many traditional "white collar" industries such as finance and insurance, information, and management of companies where a four-year degree of higher is usually required of its workers. Instead, there is a high concentration of jobs in industries that require lower skilled jobs and offer lower wages such as retail trade and accommodation and food services. Given the positive relationship between educational attainment rates and earnings, these factors ultimately influence residents' standards of living. As observed in the Community Assessment, median household income in Norman lies below the national average and that of its benchmark communities, and income growth has significantly trailed the rest of the Oklahoma City metro in the last five years.**

**Long-term strategies can certainly seek to address these workforce challenges and reverse these trends. For example, some of these emerging threats are influenced by quality of life aspects and generational preferences for the types of communities that young, well-educated workers are seeking. Yet, in the near-term, educational attainment rates and other high-level statistics may put Norman at a disadvantage when compared to other university towns by a site selector at the national level. As a result, this may make attracting companies that demand a higher skilled workforce to Norman more difficult. In today's economy where skilled and talented workers are top site location considerations, companies increasingly follow the talent. As it stands currently, Norman is facing greater competition from the Oklahoma City metro area for well-educated residents and is showing signs that it is losing its young, well-educated residents.**

### ***High rates of self-employment within a developing entrepreneurial ecosystem***

While Norman may face some challenges attracting certain companies to the community when competing against Oklahoma City and other communities that are magnets for well-educated young professionals, it has great potential to create and expand jobs locally. To begin with, it has a very strong talent pipeline. From pre-K-12 in Norman Public Schools to the Moore Norman Technology Center to the University of Oklahoma, Norman has tremendous training capacity at every level. The overall variety of offerings can meet the diverse needs of companies that operate in various industries.

Norman has historically had great success in creating locally owned small businesses. In 2016, 11.4 percent of private sector jobs were held by self-employed individuals. This high share of self-employment was nearly four percentage points higher than the national average and almost two percentage points higher than its closest comparison community, Boulder (9.6 percent). Roughly 37 percent of private sector jobs in Cleveland County are at firms with fewer than 50 employees while 28.7 percent of private sector jobs in the Oklahoma City MSA are at similarly sized firms. Additionally, 14.4 percent of jobs were at firms that were less than 5 years; the Oklahoma City metro average was 11.7 percent. These indicators, coupled with others, suggest that Norman has an environment that allows small businesses to grow and thrive.

The data indicates that Norman has a healthy supply of small businesses, a strong training pipeline, and the human capital required to create homegrown businesses. However, input participants reported that more support is needed to foster growth in the startup community. Input participants stated that more resources and access to capital were needed to help start and scale companies in Norman. These reported weaknesses in the community's ecosystem make retaining both talent and companies in their early stages difficult. Startup 405 seeks to help provide the necessary support for startups and entrepreneurs, but it only recently opened in 2017. Ultimately, its goal is the help foster job growth in businesses with exportable products and services and to better connect the start-up community.

There are numerous assets at the University, many of which are anchored at the Research Campus. This includes the Innovation Hub, a resource for students that is home to the Fabrication Lab, the Center for Entrepreneurship, and the Ronnie K. Irani Center for the Creation of Economic Wealth (I-CCEW). The Princeton Review and the magazine, *Entrepreneur*, ranked OU's undergrad program for Entrepreneurs as the 12<sup>th</sup> best in the nation and its graduate program as the 14<sup>th</sup> best in the nation in 2018. Over the last five years, graduates from the graduate program have started 16 companies and collectively raised \$412 million in funding. From entrepreneurship education to fabrication labs to commercialization and technology transfer offices, the resources supporting potential entrepreneurship by students and faculty at OU are too numerous to exhaustively review herein.

At the state level, the mission of i2E is to invest in entrepreneurs to build successful high growth companies in Oklahoma. It was created in response to an Oklahoma Center for the Advancement of Science and Technology (OCAST) initiative to help entrepreneurs, researchers, and companies commercialize technologies and launch and grow new businesses. They have invested more than \$42 million in 180 companies over past 20 years and assisted more than 70 small businesses in Oklahoma. Additionally, SeedStep Angels was founded in 2009 and is a formalized group of Angel Investors that is managed by i2E. It was created to help narrow the capital gap in Oklahoma by making the investment process between early stage companies and member angel investors more efficient.

These are just a few examples of the capacity that exists today to support successful entrepreneurship in the Norman area. While there are a number of state and regional organization in place to assist entrepreneurs, additional collaboration and assistance in Norman could help to leverage the opportunities available through OU and the research activity occurring there. As discussed in the Community Assessment, R&D expenditures at OU currently trail those at its benchmark communities in Ann Arbor, Boulder, and Lawrence. The University of Oklahoma also trailed the research universities in its competitive set in the areas of patents issued, licensing income received, licenses and options executed, startups, and running royalties, among others. When discussing their desired economic future for the Norman area, the majority of input participants described a more diverse economy that was more heavily connected to the core competencies of students and faculty, and more heavily derived from their research activities. **If Norman is to secure its desired future to have a diverse, thriving, and innovation-driven economy, a healthy entrepreneurial ecosystem will be a critical component. This encompasses a wide variety of considerations from the types of supportive services and programming described above to the built environment and place-based amenities that certain startups and small enterprises seek today.**

### *Opportunities to leverage OU in weather and radar technologies*

Norman's job growth in professional, scientific, and technical services is a positive sign of the recent increase in the amount of economic activity occurring in sectors that are typically near universities. The location quotients in the benchmark communities, which are also home to research universities, are above average – Ann Arbor (LQ=1.30), Boulder (2.91), and Lawrence (1.22) – and illustrate the high concentration of these quality jobs. Although Norman's location quotient is roughly equivalent to that of the national average, its growth indicates that the sector is strengthening locally. Employment within this sector can often times stem from university research activities or companies that choose to locate near universities in order to capture their highly educated and skilled workers. Over the past ten years, employment growth within this sector primarily occurred in engineering services, computer systems design and related services, and other professional, scientific, and technical services.

As was discussed in the Community Assessment, research activity and commercialization of technology through the University trails that of other communities home to research universities. Yet, there is tremendous opportunity to foster growth, collaboration, and economic activity around OU's research activities. For example, while OU touts a number of top programs and accolades, its nationally ranked meteorology program stands out among the rest. The University of Oklahoma's School of Meteorology is among the largest program in atmospheric sciences in the country and is internationally renowned for its state-of-the-art education, research, and facilities. The school's programs are co-located with the National Oceanic and Atmospheric Administration (NOAA), Department of Interior, Department of Energy, and several university of strategic organizations which add to the breadth of quality education, training, and experience that it affords its students. The school itself is located on campus on the 5<sup>th</sup> floor of the National Weather Center. **Without a doubt, the University's strength in meteorology and atmospheric sciences is an exceptional asset that distinguishes it from other communities and universities.**

Additionally, OU is home to the Advanced Radar Research Center (ARRC) which resides in the state-of-the-art Radar Innovations Laboratory (RIL) that recently opened in 2015. The laboratory is dedicated to innovations in radar technology and science and is equipped with major test equipment and fabrication equipment to support the research, prototyping, and testing of radar and RF devices. Areas of research

include everything from the conceptual and system design to the EM fields and antennas to the signal processing and applications. The development of radar technologies in the ARRC can be applied to various fields, and growth prospects for radar technologies are tremendous. Private sector meteorologists provide one-on-one consultation and more detailed and accurate forecasting for clients such as airlines, event planners, utility companies, and businesses involved in logistics, fleet planning, and just-in-time delivery of goods. Radar technologies have extensive aeronautical, meteorological, and geological applications, with a variety of more specialized uses in fields as diverse as law enforcement and health care.

### ***Regional opportunities to grow life sciences and biotechnology***

According to the National Science Foundation, the majority of OU's R&D expenditures are in the field of life sciences. In 2016, OU had more than \$140 million in life science-related R&D expenditures, accounting for 54 percent to the University's total R&D expenditures. Roughly \$92 million were in health sciences while \$38.7 million were in biological and biomedical sciences. Although much of OU's health care activities are centered in downtown Oklahoma City at the OU Health Sciences Center, there are opportunities to leverage existing efforts and attract certain biotechnology operations to Norman. Additionally, OU's Institute for Biomedical Engineering, Science, and Technology (IBEST) is located in Norman at OU's Research Campus in the new Peggy and Charles Stephenson Research and Technology Center. The Stephenson Research complex is a state-of-the-art facility that houses cutting-edge research in the areas of robotics, genomics, and bioengineering. New opportunities to spur economic activity within this area could be explored.

**The city's claim to biotechnology activities is strengthened by the regional and state level efforts to bolster economic activity in bioscience.** Both the state and region have committed to strengthen the biosciences sector by directing economic development dollars towards fostering growth and attracting outside investment and companies. The state has also created a number of policies and incentivizes to help increase investment and spur additional job growth. With so many communities vying for biotechnology companies and research activities, Norman will get a greater return on its efforts to attract new investments and jobs if it is to "piggy back" on these state and regional economic development efforts. Rather than competing with Oklahoma City, Norman would be better suited to work with local and state officials and professionals to help identify which projects would be best fit in Norman. For example, this could include projects where the research and discoveries are occurring in Oklahoma City at the Health Sciences, but a company needs additional space and workers to scale its operations with an eye towards future production facilities. In this regard, Norman may be better positioned for more mature life sciences establishments as opposed to new startups, with its efforts to nurture entrepreneurship and innovation more heavily targeted towards other sectors such as weather and radar.

### ***Manufacturing strengths can be applied to a broader set of operations***

Although the manufacturing sector is not as heavily concentrated in Norman as the average American community, its exports are a major source for new money and wealth creation in Norman. Exports from the manufacturing sector includes a variety of subsectors, but a significant amount stems from machinery manufacturing, chemical manufacturing (which includes pharmaceutical preparation manufacturing), and computer and electronic product manufacturing. Combined, the three subsectors account for 64.4 percent of all manufacturing exports. Major employers such as Johnson Controls and Hitachi, as well as expanding homegrown successes such as IMMY, are certainly major economic drivers in the community.

When it comes to opportunities in the near-term for future manufacturing operations, **Norman's asset base lends itself to smaller, precision production operations that can be supported by the city's occupational strengths and training institutions in place.** Norman lacks the necessary industrial land and associated infrastructure to support a large relocation project demanding greater than 50 acres and/or rail service. Secondly, it simply does not have the workforce to absorb a large scale operation at the moment. Norman's unemployment rate is very low at 3.1 percent in October 2017, the most recent month for which data was available. This is a sign of a tight labor market with little available labor to support a major new facility.

**FIGURE 2: TOP 20 OCCUPATIONS IN MANUFACTURING\***

SOC	Description	Location Quotient		Jobs 2016	Median Hourly Earnings	Typical Entry Level Education
		Norman	OKC			
47-2211	Sheet Metal Workers	3.01	3.96	173	\$25.64	HS diploma or equiv.
51-2023	Electromechanical Equipment Assemblers	1.93	0.91	36	\$16.49	HS diploma or equiv.
51-4081	Multiple Machine Tool Setters/Operators/Tenders**	1.27	1.57	59	\$16.00	HS diploma or equiv.
51-2022	Electrical & Electronic Equipment Assemblers	1.19	0.84	102	\$14.12	HS diploma or equiv.
51-9011	Chemical Equipment Operators & Tenders	1.18	0.66	34	\$17.59	HS diploma or equiv.
15-1133	Software Developers, Systems Software	1.05	0.89	176	\$32.06	Bachelor's degree
41-4011	Sales Reps, Wholesale & Man., Tech./Sci. Products	1.01	1.82	138	\$25.37	Bachelor's degree
49-9071	Maintenance & Repair Workers, General	0.96	0.84	560	\$15.36	HS diploma or equiv.
51-4031	Cutting/Punching/Press Machine Setters...**	0.93	1.22	71	\$15.55	HS diploma or equiv.
51-6031	Sewing Machine Operators	0.86	0.60	53	\$11.80	No formal education
51-4121	Welders, Cutters, Solderers, & Brazers	0.81	1.31	130	\$19.18	HS diploma or equiv.
51-4011	Computer-Controlled Machine Tool Operators**	0.74	1.09	42	\$17.21	HS diploma or equiv.
51-1011	First-Line Supervisors of Prod. & Oper. Workers	0.63	0.86	154	\$24.54	HS diploma or equiv.
53-7062	Laborers & Freight, Stock, & Mat. Movers, Hand	0.52	0.89	549	\$12.56	No formal education
51-4041	Machinists	0.51	0.91	80	\$22.24	HS diploma or equiv.
51-9061	Inspectors, Testers, Sorters, Samplers, & Weighers	0.49	0.66	103	\$20.06	HS diploma or equiv.
51-9198	Helpers--Production Workers	0.46	0.71	78	\$12.70	No formal education
51-9111	Packaging & Filling Machine Operators & Tenders	0.43	0.56	66	\$12.09	HS diploma or equiv.
51-2092	Team Assemblers	0.43	0.55	188	\$14.52	HS diploma or equiv.
41-4012	Sales Reps, Whole. & Man., Exc. Tech./Sci. Products	0.35	0.68	202	\$22.55	HS diploma or equiv.

Source: Economic Modeling Specialists International (EMSI)

\*Not including management, office, and administration occupations, \*\*Metal & Plastic

Location quotients: Location quotients (LQs) measure the relative concentration of regional employment in a given business sector. Specifically, they are calculated by dividing a sector's share of regional employment by that sector's share of national employment. A location quotient above 1.0 would indicate that the sector is more heavily concentrated in the region than it is nationally. Color-coding: Employment growth is color-coded such that growing sectors are presented in green text and declining sectors in red text. Those with location quotients greater than or equal to 1.1 are presented in green font. LQs lower than 0.9 are presented with red font and LQs between 0.9 and 1.1 in orange font.

A look at the top 20 production and other-related occupations in the manufacturing sector offers further insight to the manufacturing activities and opportunities in Norman. The occupations are sorted by location quotient, indicating their concentration from highest to lowest. At the bottom of the list are key occupations that are associated with large-scale assembly operations. This includes, team assemblers, packaging and filling machine operators, helpers -- production workers, and laborers. **These assembly-oriented workers are not prevalent in the Norman labor force.**

**On the other hand, Norman has a high concentration of occupations with more specialized skills. This lends its support for more customized and precision manufacturing operations.** Norman has an above average share of workers with skills to fill occupations such as electromechanical equipment assemblers, multiple machine tool setters, electrical and electronic equipment assemblers, and chemical equipment operators and tenders, among others. The Oklahoma City metro area also has strengths in a number of occupations that require workers to have higher, more specialized abilities. These occupations have transferable skills that can be applied to a broader range of manufacturing operations, ones that require a workforce with higher skilled workers. For example, Norman has a particularly high share of workers with competencies in electronics.

Given the location and workforce considerations, **Norman has a strong case to attract and grow precision production-related jobs.** Additionally, the Moore Norman Technology Center is a local asset that can support many of the training needs for key occupations. Rather than targeting large scale operations, the region's occupational strengths can be applied to strengthening key industries such as aerospace, weather and radar technologies, energy, and other sectors that are naturally attracted to a larger regional asset base. Economic development activities can use the community's workforce strengths as a selling point for attracting additional economic activity and specialized manufacturing operations in diverse sectors. **Norman's recruitment and marketing efforts would ultimately have a greater return on investment by focusing on smaller, custom- or precision production facilities within existing regional and state target sectors (i.e. aerospace, energy, etc.) as opposed to simply targeting all manufacturing operations regardless of size, sector, or production process.**

#### ***Product limitations and the built environment: impact on white collar opportunities***

Norman's economic opportunities will also be influenced by perceived and real challenges related to its business environment. As previously mentioned, Norman lacks large, rail-served industrial sites, which would limit the size and type of a manufacturing or distribution project for which Norman could successfully compete. **Norman's product limitations also include a lack of abundant, high quality office product. These factors combined, further support efforts to attract and grow small to mid-size operations. As companies in certain "white collar" sectors increasingly seek mixed-use, walkable environments that are attractive to the next generation of workers, Norman will need to intentionally nurture compelling centers of activity that provide an environment conducive to new class A office development.** As national trends show, quality of life enhancements will attract growth in the form of new investments, new residents, new jobs, new companies, and new opportunities to increase wealth and raise standards of living.

## RECOMMENDED TARGET SECTORS

In addition to a review of the economic and workforce conditions in Norman, Market Street reviewed the key sectors that are being targeted for economic growth at the regional (by Greater Oklahoma City Economic Development) and state (by the Oklahoma Department of Commerce). This is motivated by the reality that communities, especially those located in a metropolitan region such as Oklahoma City, do not operate in a bubble. Companies that are located in the region benefit from a labor shed that crosses city limits and county lines. Likewise, residents and workers with the appropriate transportation means are also not limited to employment opportunities only in their city. Further, regions and states have other assets and advantages – from infrastructure to incentives – that make larger regions particularly competitive for certain types of activities. Given these facts and the reality that there are finite resources available to put towards targeting economic growth, it is sensible to leverage the resources expended at the regional and state level while giving appropriate consideration to Norman’s niche opportunities and specializations.

The following “key industries” are targeted by the State of Oklahoma:

1. Aerospace & Defense
2. Agriculture & Bioscience
3. Energy
4. Transportation & Distribution
5. Information & Financial Services
6. Manufacturing

The following “key industries” are targeted by Greater Oklahoma City Economic Development:

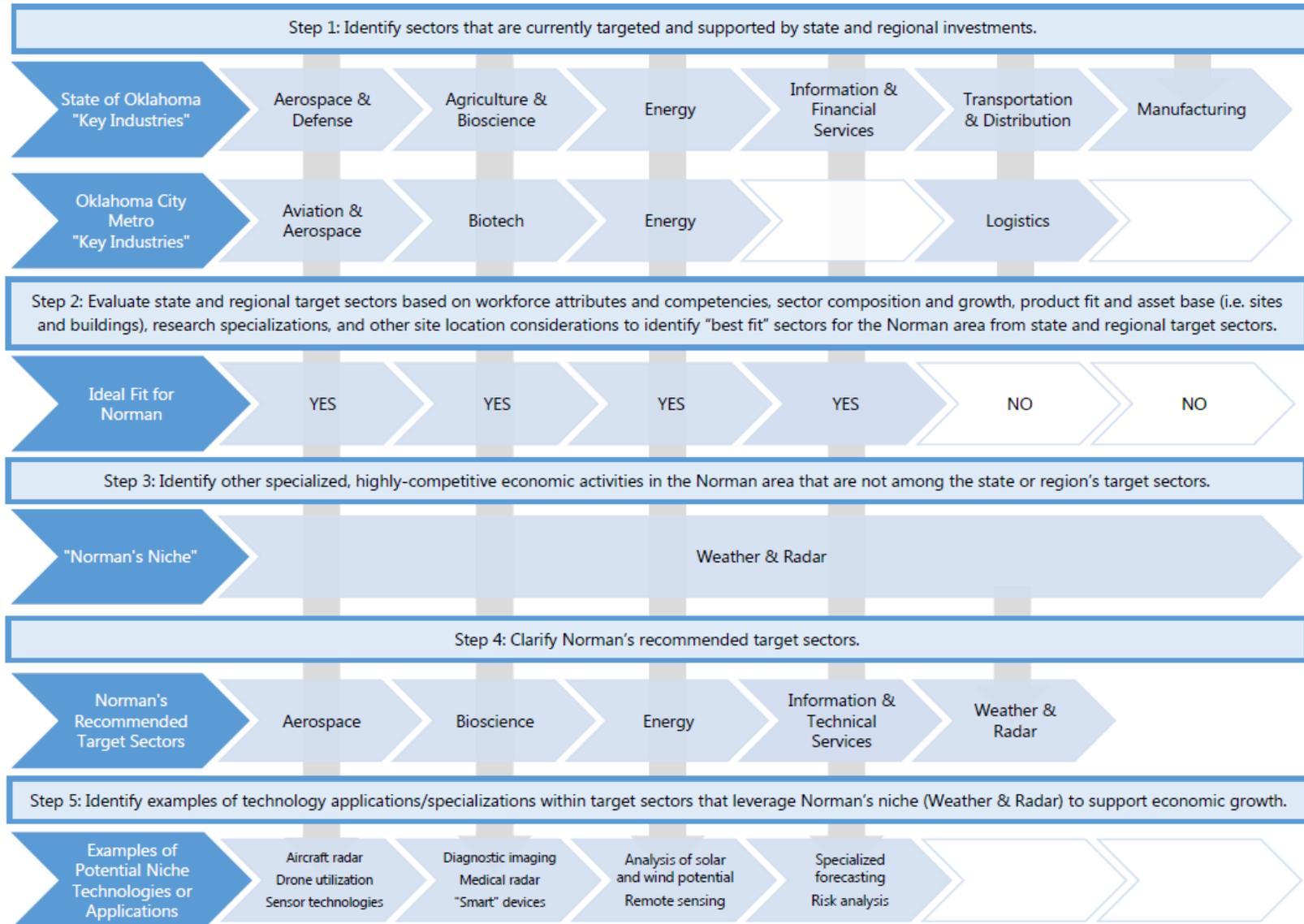
1. Aviation & Aerospace
2. Biotech
3. Energy
4. Logistics

Clearly and appropriately, there is a great deal of crossover between the two sets of target sectors. The graphic on the following page provides an overview of the process used to identify the target sectors with the greatest potential to support job creation, wealth creation, and realization of Norman’s economic vision for a more diverse and innovative economy. The recommended target sectors for Norman are:

1. Aerospace
2. Bioscience
3. Energy
4. Information & Technical Services
5. Weather & Radar

These recommendations are supported by the observations contained within the Community Assessment, the preceding discussion of economic and workforce trends, and the profiles of sector activity that follow. Within each profile there is an emphasis on the assets and attributes which distinguish Norman and its value proposition within that sector. Each profile concludes with examples of how Norman’s niche – Weather & Radar – can be leveraged in catalyzing innovative activity in the target sector.

**FIGURE 3: IDENTIFICATION OF RECOMMENDED TARGET SECTORS FOR NORMAN, OKLAHOMA**





## Aerospace

**DEFINITION:** The aerospace sector covers production operations and aviation-related services, including manufacturing, maintenance, research and development, training, and other activities that are related to air and space travel. This includes everything from the testing and manufacturing of aircraft parts to the maintenance, repair, and overhaul (MRO) operations for aircrafts.

**FIGURE 4: NORMAN AEROSPACE-RELATED SECTOR ACTIVITY, 2006-16**

NAICS	Business Sector	Jobs (2016) Norman	Change in Jobs (2006-2016)				Location Quotient (2016)	
			# Change, Norman	% Change, Norman	% Change, OKC MSA	% Change, U.S.	Norman	OKC MSA
3336	Engine, Turbine, & Power Trans. Equip. Man.	46	(5)	-10.5%	-15.2%	-2.4%	1.19	0.20
4881	Support Activities for Air Transportation	37	(4)	-10.5%	62.3%	24.9%	0.47	2.15
3333	Comm. & Service Industry Machinery Man.	21	N/A	N/A	726.2%	-18.2%	0.60	0.25
4812	Nonscheduled Air Transportation	15	N/A	N/A	510.8%	-3.5%	0.84	1.44
3342	Communications Equipment Man.	13	N/A	N/A	-34.1%	-38.1%	0.38	0.95
3369	Other Transportation Equipment Mfg.	0	0	N/A	N/A	-15.7%	0.00	0.01
3329	Other Fabricated Metal Product Man.	<10	N/A	N/A	-9.5%	-5.2%	0.04	1.73
3364	Aerospace Product & Parts Man.	<10	N/A	N/A	228.9%	3.3%	0.01	1.24
Total, Subsector		133	8	6.2%	49.8%	-3.1%	0.26	1.29
Total, All Jobs		62,725	3,540	6.0%	6.4%	5.0%		

Source: Economic Modeling Specialists International (EMSI)

Location quotients: Location quotients (LQs) measure the relative concentration of regional employment in a given business sector. Specifically, they are calculated by dividing a sector's share of regional employment by that sector's share of national employment. A location quotient above 1.0 would indicate that the sector is more heavily concentrated in the region than it is nationally. Color-coding: Employment growth is color-coded such that growing sectors are presented in green text and declining sectors in red text. Those with location quotients greater than or equal to 1.1 are presented in green font. LQs lower than 0.9 are presented in red font and LQs between 0.9 and 1.1 in orange font.

**REGIONAL OVERVIEW AND NATIONAL TRENDS:** The Greater Oklahoma City metro is home to a number of aerospace establishments that operate in a variety of activities. In the public sector, Tinker Air Force Base and the Federal Aviation Administration's (FAA) Mike Monroney Aeronautical Center are two of the largest government employers located in the greater region. Establishments involved in maintenance, repair, and overall (MRO) include Boeing, AAR Aircraft Service, Field Aerospace, General Dynamics, Pratt and Whitney, and Tetra Tech EMC. MRO activity is primarily located near Tinker AFB and Wiley Post Airport. Aircraft manufacturing, engineering, and consulting companies employ roughly 650 workers and produce \$113 million in total output throughout the region. Air transportation and other aerospace activities such as flight training schools and aerial photography account for the remaining aerospace-related goods and services operating in the greater region.

Nationally, aerospace employment suffered heavy losses during the recessionary years, but job growth has picked up in recent years. Between 2006 and 2016, jobs in aerospace product and parts manufacturing increased by 3.3 percent. Historically, the aerospace industry has been concentrated in just a few larger centers, such as Seattle and Wichita, but in recent years, the industry has been decentralizing with job growth occurring in many other communities. Employment in aerospace product and parts manufacturing has grown significantly in places like Cincinnati, Waco, and Oklahoma City. Total U.S. exports of aircraft parts reached \$56.2 billion, a record amount in 2014. It represented a 10.6 percent increase from 2013. In comparison, total exports from the U.S. increased by 2.6 percent.<sup>i</sup> According to Southern Business and Development magazine, aerospace projects of at least 200 employees or \$30 million in investment reached an all-time high in 2016 the South, a region that encompasses Oklahoma. Growth prospects for the sector along the supply chain are strong; site selectors anticipate more supplier announcements and more international investment in the years to come.

Constant research and development and new technological advancements that improve safety, efficiency, and the quality of components and parts have helped to drive growth within the sector. The 2017 Global aerospace and defense outlook produced by Deloitte expects growth within the sector will continue to be strong.<sup>ii</sup> Defense budgets in several nations have increased in recent years as demand for defense and military products has grown. This has primarily been driven by increased national security threats and rising global tensions. The commercial aerospace subsector is also expected to have above-average growth rates, driven by increased passenger travel demand, lower commodity prices, and an accelerated equipment replacement cycle. Additional economic activity is also expected to be driven by the growing Unmanned Aerial Systems (UAS) sector.

## KEY FINDINGS AND STRATEGIC CONSIDERATIONS

- ✓ Although Norman's aerospace sector is less robust than state and regional economic activity, there is great potential and many valuable opportunities to grow jobs within this sector locally. The majority of the aerospace activity in the Oklahoma City metro area is currently clustered in Oklahoma County; Norman's proximity to these activities is an important site location consideration. This includes activities such as those at Tinker AFB and Will Rogers Airport. Given the economic impact that the aerospace industry has on the state and regional economy, **targeted activities will need to focus on where Norman can differentiate itself in a pool of communities vying for a limited number of projects.** As previously mentioned, Norman has a number of workforce attributes that would be attractive to certain aerospace companies. Its asset base and occupational strengths make Norman most competitive for smaller operations, potentially suppliers that produce customized parts, as well as radar technology companies that can leverage the asset base supporting the community's Weather & Radar Technologies cluster.
- ✓ **Economic opportunities will need to leverage the community's workforce strengths.** For example, while it lacks aircraft mechanics and service technicians, its share of software developers for systems software is slightly above average and has grown by 45.6 percent over the past ten years. Software developers are the third most common occupation in the aerospace product and parts manufacturing sector in the Oklahoma City metro area. Likewise, Norman lacks avionics technicians but has a high concentration of electronics engineers.

- ✓ Norman also boasts a strong talent pipeline that can be leveraged to help support local aerospace economic activity. The University of Oklahoma offers a bachelor's of science in aerospace engineering which provides graduates with a strong technical background in both theory and applications of solid mechanics, aerodynamics, controls, propulsion, robotics, space science, design and integration. **Over the past ten years, there were nearly 300 completions in Aerospace, Aeronautical and Astronautical Engineering programs in Norman.** MNTC offers a two part electronics program and provides the education and training for students to earn the Associate Certified Electronics Technician Certificate. Overall, there was a total of roughly 840 completions in degrees and certificates related to electrical and electronics engineering over the past ten years. This bodes well for the community's competitiveness for production, particularly in the aerospace sector; production processes in a wide variety of manufacturing subsectors are increasingly reliant on electrical skill sets.
- ✓ Norman's low unemployment rate and worker competencies coupled with its industrial site limitations suggest it is unlikely to attract large projects such as an aircraft assembly plant or other large scale project. Instead, **Norman would likely have greater success and a greater return on its economic development investment dollar if it were to focus resources on attracting and growing small to medium-size enterprises.** For example, Norman would be more competitive to grow jobs in aircraft engine and engine parts manufacturing and other aircraft parts and auxiliary equipment manufacturing. Roughly 40 percent of the greater Oklahoma City's aerospace product and parts manufacturing inputs are met in-region, suggesting that there could be opportunities to capture some of the supply chain leakage. Likewise, only 7.8 percent of the region's demand for other aircraft parts and auxiliary equipment products are met in-region.
- ✓ Max Westheimer Airport is a general aviation airport and one of two reliever airports to Will Rogers World Airport in Oklahoma City. Its activities center on air transportation and support activities in addition to flight training such as through the Sooner Flight Academy. It's estimated that **Max Westheimer Airport's total annual statewide economic impact exceeds \$37 million and it supports a total of nearly 400 jobs, directly and indirectly.** There are currently large tracts of developable land surrounding Westheimer available to support future growth in aviation-related activities. Although the airport could viably compete for some MRO facilities for smaller aircraft, there are many other general aviation airports that provide longer runways and other assets that make them more attractive to aviation-related activities.
- ✓ As previously mentioned, this target aligns with the state and regional key industry sectors that are currently being targeted. According to a recent study released by the Oklahoma Aeronautics Commission, **Oklahoma's aerospace and aviation industry has an annual economic impact of around \$43.8 billion and employs more than 200,000 people throughout the state.** The Greater Oklahoma City Chamber also recently released an industry survey and economic impact assessment of the aerospace industry for the ten-county region. According to the report, there are approximately 230 public and private sector establishments operating in the aerospace industry within the Oklahoma City metro area. Combined, those establishments employ more than 36,600 workers, have a payroll of around \$2.7 billion, and produce an estimated \$4.9 billion in goods and services. In fiscal year 2015, the Oklahoma City metro area received \$1.19 billion in federal contracts directly related to aerospace.

Additionally, the aerospace industry indirectly supports another 31,000 workers that have a labor income of \$1.4 billion, while they produce roughly \$3.3 billion in total goods and services.

- ✓ Overall, the aerospace industry is a major driver of the regional and state economy and a tremendous source for wealth creation. As such, both the state and the Greater Oklahoma City region have committed to strengthening the aerospace industry. **State and local economic development officials have prioritized expansion efforts within the existing aerospace cluster and the state offers a variety of incentives to support its growth**, including the Aerospace Engineer Workforce Tax Credit and the 21st Century Quality Jobs Program. Likewise, many local economic development officials in the Oklahoma City metro area are also currently targeting economic growth in aerospace activities.
  - Aerospace Engineer Workforce Tax Credit: Aerospace companies hiring engineers in a variety of fields will receive a tax credit equal to five percent of the compensation paid to an engineer until January 1, 2026, or ten percent if the engineer graduated from an Oklahoma college or university (up to \$12,500 per employee per year). Additionally, another credit of up to fifty (50) percent of the tuition reimbursed to an employee until January 1, 2026. The engineer hired also receives a tax credit of \$5,000 per year until January 1, 2026.
  - 21st Century Quality Jobs Program: This program offers incentives to businesses with a highly skilled, knowledge-based workforce. For qualifying companies, this unique incentive would pay businesses cash back, up to 10 percent of payroll, for up to ten years for the creation of at least 10 jobs with an average wage of \$97,341 annually or higher, depending on county.

**NORMAN'S NICHE****EXAMPLES OF WEATHER & RADAR TECHNOLOGY APPLICATIONS WITHIN THE AEROSPACE SECTOR**

Aerospace is one sector with clear crossover to the Weather & Radar Technology target. The various applications of radar technology within aerospace, and the various applications of weather forecasting and modeling to aviation are immense.

OU was recently awarded a \$161 million, nine-year grant by NASA to advance understand of Earth's natural exchanges of carbon. According to OU's press release, the NASA Contract is for "a first-of-its-kind Earth science mission that will extend our nation's lead in measuring key carbon-based greenhouse gases and vegetation health from space to advance understanding of Earth's natural exchanges of carbon between land, atmosphere and ocean." The mission will launch on a commercial communications satellite with the OU's Geostationary Carbon Cycle Observatory (GeoCarb) in charge of monitoring plant health and vegetation stress and examining the sources and processes that control carbon dioxide, carbon monoxide, and methane in the atmosphere. This work lies at the intersection of the Aerospace, Energy, and Weather & Radar Targets.

Additional research has been conducted or is currently underway that involves the areas of aviation and radar technologies. Researchers from the College of Engineering at OU have worked on projects with the FAA and the OU Department of Aviation to implement differential-GPS based aircraft landing systems and distance measuring equipment.

In addition to the Advanced Radar Research Center, the Intelligent Aerospace Radar Team (IART) is a research and educational group that focuses on innovative system solutions and advanced processing algorithms for multi-functional radars, especially radar technologies used in comprehensive radar sense and avoid for UAS operations. Technologies and applications of radar in aerospace include radar for next generation air-traffic management and monitoring, sense and avoid radar concepts and development, low-cost airborne weather radar sensors for detection and monitoring of different types of hazards in airspace, and new technologies that support radar-sensing improvements, among others.

Advancements in technology for sensors also have applicability to the manufacturing sector. Researchers the OU School of Aerospace & Mechanical Engineering are working with Honeywell Federal Manufacturing and Technologies to do just that. Research and development of smart nanocomposites with autonomous sensing capability aim to provide highly flexible sensors for accurate real-time measurement of mechanical load and structural health condition monitoring.



## Bioscience

**DEFINITION:** Bioscience generally encompasses firms that are engaged in some level of activity related to the research, development, and manufacturing in the fields of biotechnology, pharmaceuticals, biofuels, medical implants, and plant and animal science, among others.

**FIGURE 5: NORMAN BIOSCIENCE-RELATED SECTOR ACTIVITY, 2006-16**

NAICS	Business Sector	Jobs (2016) Norman	Change in Jobs (2006-2016)				Location Quotient (2016)	
			# Change, Norman	% Change, Norman	% Change, OKC MSA	% Change, U.S.	Norman	OKC MSA
<b>Agricultural Feedstock and Chemicals</b>								
3251	Basic Chemical Man.	44	44	N/A	46.9%	1.6%	0.75	0.14
3112	Grain & Oilseed Milling	0	0	N/A	-81.6%	-0.3%	0.00	0.09
3252	Resin, Synthetic Rubber, & Artificial...Man.	0	(19)	-100.0%	-69.0%	-10.6%	0.00	0.08
3253	Pesticide, Fertilizer, & Other Ag. Chem. Man.	0	0	N/A	N/A	-8.3%	0.00	0.05
<b>Drugs and Pharmaceuticals</b>								
325411	Medicinal & Botanical Man.	<10	N/A	N/A	N/A	21.6%	0.05	0.08
325412	Pharmaceutical Preparation Man.	139	139	N/A	1258.6%	-10.5%	1.73	0.44
325413	In-Vitro Diagnostic Substance Man.	40	40	N/A	N/A	59.1%	4.00	0.62
325414	Biological Product (except Diagnostic) Man.	0	0	N/A	220.4%	22.0%	0.00	0.95
<b>Medical Devices and Equipment</b>								
334510	Electromed. & Electrother. Apparatus Man.	<10	N/A	N/A	N/A	7.8%	0.04	0.45
334517	Irradiation Apparatus Man.	<10	N/A	N/A	N/A	13.3%	0.32	0.03
339116	Dental Laboratories	<10	N/A	N/A	-46.3%	-12.0%	0.50	0.37
339113	Surgical Appliance & Supplies Man.	19	19	N/A	1.1%	2.5%	0.46	0.19
334516	Analytical Laboratory Instrument Man.	0	0	N/A	N/A	9.8%	0.00	0.00
339112	Surgical & Medical Instrument Man.	0	0	N/A	4.2%	11.2%	0.00	0.59
339114	Dental Equipment & Supplies Man.	0	0	N/A	-61.1%	-0.6%	0.00	0.25
339115	Ophthalmic Goods Man.	0	0	N/A	-84.3%	-15.5%	0.00	0.13
<b>Research, Testing, &amp; Medical Laboratories</b>								
541380	Testing Laboratories	<10	N/A	N/A	-37.2%	14.0%	0.11	0.40
5417	Scientific Research & Development Services	27	(16)	-37.3%	-36.1%	12.9%	0.10	0.28
<b>Bioscience-Related Distribution</b>								
424210	Drugs & Druggists' Merch. Wholesalers	<10	N/A	N/A	-2.1%	-4.5%	0.03	0.67
424910	Farm Supplies Merchant Wholesalers	<10	N/A	N/A	13.5%	5.8%	0.02	0.36
423450	Med., Dental, & Hosp. Equip...Wholesalers	0	0	N/A	-16.1%	8.7%	0.00	0.77
Total, Subsector		269	112	71.3%	-11.8%	4.7%	0.28	0.37
Total, All Jobs		62,725	3,540	6.0%	6.4%	5.0%		

Source: Economic Modeling Specialists International (EMSI)

Location quotients: Location quotients (LQs) measure the relative concentration of regional employment in a given business sector. Specifically, they are calculated by dividing a sector's share of regional employment by that sector's share of national employment. A location quotient above 1.0 would indicate that the sector is more heavily concentrated in the region than it is nationally. Color-coding: Employment growth is color-coded such that growing sectors are presented in green text and declining sectors in red text. Those with location quotients greater than or equal to 1.1 are presented in green font. LQs lower than 0.9 are presented in red font and LQs between 0.9 and 1.1 in orange font.

**REGIONAL OVERVIEW AND NATIONAL TRENDS:** The Oklahoma City region has a number of resources, programs, and organizations in place to help foster growth within the life sciences and biosciences field. For example, Oklahoma BioScience Association (OKBio) was created in 2008 with the mission of promoting the growth of biosciences in Oklahoma through partnership building, education and outreach, networking, policy development and publicity. Larger organizations such as OKBio are able to send delegations to conferences such as the BIO International Convention to promote biotechnology and life sciences on behalf of the state and region. The greater Oklahoma City area and state ultimately make a bigger impact through such collective efforts marketing the region.

The tremendous amount of growth in biotechnology and medical research is unlikely to stall any time in the near future. It encompasses such a wide range of economic activity from medical device manufacturing to research and development to DNA sequencing to agricultural chemicals and feedstock. The vast array of economic activity and research, development, and applications are in high demand and growing. Demand for health care services will continue to grow as the United States and global population ages. An aging population will help to further drive medical innovation and new and improved technological and medicinal services and products.

There are a number of bioscience companies currently located in Norman. A sampling of local companies and various bioscience-related activities is provided below.

- ✓ Avara, previously operating as Astellas, manufactures pharmaceutical products such as oral solid dosage forms. It has over 300,000 square feet of building space in Norman and serves dosage form development, commercial manufacturing, formulation, analytical laboratories, and warehousing. The site has the capacity to manufacture over two billion tablets a year.
- ✓ Health Engineering Services specializes in the distribution and servicing of the Unguator and the Unguator accessory line. The Unguator and its accessory line are distributed to compounding pharmacies and laboratories throughout the US and Canada.
- ✓ IMMY, a company that develops and makes diagnostic kits that are sold to hospitals and clinics around the globe. It operates out of 45,000-square-foot facility near the Max Westheimer Airport in Norman and employs 70 people.
- ✓ Linear Health Sciences, a medical device company and developer of the Orchid Safety Release Valve. Its proprietary, breakaway safety-valve technology can be attached to a variety of products and types of medical tubing. In December 2017, it announced additional investment funding of \$1.5 million, bringing the company's total financing to nearly \$3million.
- ✓ Simergent, a Norman-based medical device startup company, has developed an easy to use, affordable, home dialysis device for emerging market countries. It recently received \$1.2 million investment, include \$500,000 from the Oklahoma Seed Capital Fund and around \$120,000 from the SeedStep Angels, an Oklahoma investment group managed by i2E.

## KEY FINDINGS AND STRATEGIC CONSIDERATIONS

- ✓ **Norman's competitive advantage in the fields of biological and biomedical science fields have facilitated growth in bioscience in the greater Oklahoma City region.** Research taking place at OU has helped to launch a number of research and manufacturing firms in the area. Norman's workforce competencies and regional assets lend themselves to support economic activity across the whole spectrum of life science companies, from research and development to advancing new products through the production and scaling stage.
- ✓ However, while much of the bioscience activity is in Oklahoma City, **Norman has a strong case to assist companies in scaling their operations, especially when it comes to manufacturing new products and technologies.** The proximity to the research being conducted in Oklahoma City is an important factor, but so too is the availability of smaller industrial sites that could provide attractive locations for startups to scale within the metro area. IMMY is great example of a homegrown bioscience company that has successfully scaled its operations in Norman.
- ✓ Likewise, Norman's occupational strengths in computer and information research scientists (LQ=2.45) supports competitiveness for **bioinformatics or bioinformation projects.** Additional occupational support could be provided by systems software developers; jobs in this occupation have grown from 121 jobs to 176 over the past ten years in Norman.
- ✓ Additionally, Norman has an extremely high concentration of jobs in many health care services occupations. This is primarily due to Norman Regional Hospital and the University. This includes occupations such as respiratory therapy technicians (LQ=4.61), psychiatric technicians (3.67), biological technicians (2.86), ophthalmic medical technicians (2.38), medical records and health information technicians (2.12) and dietetic technicians (1.81), among others. **Although the majority of these individuals are engaged in the delivery of health care services, these specialized skill sets and technical positions are often needed in product development and testing environments for pharmaceuticals, medical devices, and a wide variety of other bioscience products.**
- ✓ The University of Oklahoma Health Sciences Center is comprised of seven medical schools and is a major driver of the state's biosciences industry. The 30 institutions on its campus bring in more than \$53 million in NIH funding. Overall, **life sciences accounted for more than half of the University of Oklahoma's R&D expenditures in 2016**, while another 10.8 percent was in the field of engineering. OUHSC has multiple areas of research expertise including in areas such as geriatric medicine, ovarian cancer, and immunology.
- ✓ **The Stephenson Life Sciences Research Center recently opened in 2010 in Norman.** It provides the Department of Chemistry and Biochemistry with 160,000 square feet of state-of-the-art, highly-flexible research laboratories and office space. The \$75 million facility also aids in the further development of the University's research strengths in genomics and integrative life sciences. It includes space for joint projects with industry, core research support facilities to serve the entire campus, and the infrastructure to foster more collaboration with the OU Health Sciences Center.

- ✓ University Research Park, a part of the University of Oklahoma Health Sciences Center, is located in Oklahoma City and consists of more than 700,000 square feet of biomedical research lab and office space and state-of-the-art communications and infrastructure systems. It sits on a 23-acre, \$100 million site that is home to around 40 science-based companies. **Its mission is to grow biomedical research in Oklahoma. The OU Health Sciences Center's 2015-2020 research strategic plan includes prioritizing efforts to commercialize its research. It includes an action item to support a sooner-to-market pipeline for assisting faculty with intellectual property development and commercialization.**
- ✓ The Oklahoma Medical Research Foundation (OMRF), an independent medical research institute, recently celebrated its 70<sup>th</sup> anniversary. Its staff of more than 300 scientists conduct biomedical research and explores human diseases such as Alzheimer's, brain diseases, cancers, diabetes, and lupus, among others.
- ✓ The state offers the Small Employer Quality Program incentive which would likely cover some bioscience companies. The program provides quarterly incentive payments to a qualifying small employer (90 employees or less). Quarterly payments may be as much as 5% of new taxable payroll for up to 7 years. Qualifying payroll must be attributable to annual salaries that are at least 110% of the average wage of the county in which the jobs are located. Qualifying companies must also attain 75% out of state sales. For Cleveland County, a salary of 110% would be \$37,167. It has an out-of-state sales requirement where 75 percent or more of the company's sales must be out-of-state, but research and development companies and testing labs are excused from the requirement.

#### NORMAN'S NICHE

##### EXAMPLES OF WEATHER & RADAR TECHNOLOGY APPLICATIONS WITHIN THE BIOSCIENCE SECTOR

The Biomedical Engineering Lab is located in Norman at the Stephenson Research and Technology Center. Its facilities include laser Doppler interferometer, material testing systems (MTS), microscopes, signal analyzers, data acquisition system, sound delivery and monitor system, surgical suite with surgical microscopes, drilling system and irrigation/suction apparatus for human temporal bone and animal studies, microtome for histology study, tympanometer, freezers, computers, various engineering software packages, among other equipment. Relevant research activities in the OU School of Aerospace and Mechanical Engineering (AME) include biomechanics and 3D printing of human and animal ears with materials mimicking bone and soft tissue. The Doppler interferometer and its applications to medical imaging are a good example of the crossover between the community's strengths in Weather and Radar Technologies and other targeted economic activities like bioscience.

Radar technology can be used in a variety of specialized ways in bioscience and health care applications, from diagnostics related to the auditory system and circulatory system to the integration of radar technology in medical devices and sensors, including "smart" devices that measure patient health conditions. Radar technology has recently been used by NASA and other partners to aid in search and rescue efforts by detecting human heartbeats beneath rubble in the wake of an earthquake or other natural disaster.



## Energy

**DEFINITION:** Oklahoma's economy has a long history of economic success in energy and its energy sector has diversified from traditional energy sources to those in clean and unconventional sources energy. The region's strengths in energy range from oil and gas extraction to manufacturing of oil and gas equipment and machinery to surveying and mapping services.

**FIGURE 6: NORMAN ENERGY-RELATED SECTOR ACTIVITY, 2006-16**

NAICS	Business Sector	Jobs (2016) Norman	Change in Jobs (2006-2016)				Location Quotient (2016)	
			# Change, Norman	% Change, Norman	% Change, OKC MSA	% Change, U.S.	Norman	OKC MSA
213112	Support Activities for Oil & Gas Operations	282	154	120.0%	-3.5%	18.5%	3.36	6.68
2211	Electric Power Generation, Trans. & Dist.	182	(22)	-10.6%	-13.7%	0.1%	1.16	1.02
237130	Power/Comm. Line & Related Structures Con:	145	37	34.3%	46.9%	26.5%	2.02	1.03
2111	Oil & Gas Extraction	113	39	51.8%	93.0%	27.6%	1.61	11.60
237120	Oil & Gas Pipeline & Related Struct. Const.	62	12	23.3%	298.8%	53.7%	1.16	1.52
541370	Surveying & Mapping (exc. Geophys.) Serv.	54	(13)	-19.2%	-3.7%	-29.7%	2.77	1.53
2212	Natural Gas Distribution	48	8	20.6%	33.6%	5.5%	1.08	1.95
541360	Geophysical Surveying & Mapping Services	25	11	87.2%	65.7%	-17.0%	3.88	4.53
333132	Oil & Gas Field Machinery & Equip. Man.	22	N/A	N/A	75.2%	5.6%	1.00	8.28
213111	Drilling Oil & Gas Wells	11	N/A	N/A	-22.7%	-42.1%	0.56	9.05
Total, Subsector		943	259	37.8%	28.9%	8.4%	1.73	4.00
Total, All Jobs		62,725	3,540	6.0%	6.4%	5.0%		

Source: Economic Modeling Specialists International (EMS)

Location quotients: Location quotients (LQs) measure the relative concentration of regional employment in a given business sector. Specifically, they are calculated by dividing a sector's share of regional employment by that sector's share of national employment. A location quotient above 1.0 would indicate that the sector is more heavily concentrated in the region than it is nationally. Color-coding: Employment growth is color-coded such that growing sectors are presented in green text and declining sectors in red text. Those with location quotients greater than or equal to 1.1 are presented in green font. LQs lower than 0.9 are presented in red font and LQs between 0.9 and 1.1 in orange font.

**REGIONAL OVERVIEW AND NATIONAL TRENDS:** Oklahoma City is home to the headquarter operations for a number of companies in the oil and gas sector such as Devon, Chesapeake Energy, Continental Resources, and SandRidge Energy, to name a few. There are hundreds of energy companies within the greater area including large and small independents, midstream companies, service businesses, startups and spinoffs. According to a recent Economic Study of the industry in Oklahoma, the oil and gas industry produced on average 37.1 billion in output of goods and services annually between 2010 and 2015. <sup>iii</sup>

While there is a tremendous amount of economic benefit associated with the oil and gas sector, the industry is also very volatile. In recent years, the overall energy sector suffered heavy losses as result of falling crude oil prices in 2014, and the state of Oklahoma was hit hard by the decline in the energy sector. The national rig count fell to its lowest number in seven decades and drilling activity in Oklahoma fell by 59 percent.

However, the energy sector is continuing to recover and the outlook is positive. During the first week in January, crude oil prices reached their highest level in more than three years and U.S. crude oil refinery inputs reach a record high in December. Growth in manufacturing activity is helping to drive crude oil and petroleum product demand.<sup>iv</sup> The U.S. Energy Information Administration expects U.S. crude oil production to surpass 10 million barrels per day in February 2018. The oil and gas industry is also undergoing transformative changes, driven by consumer demand, changing political environments, new technological advancements and a new focus on more long-term growth opportunities which should strengthen the industry and open up new opportunities for economic growth. Meanwhile, continued innovation in alternative energy conversion, transmission, and storage is creating new markets for consumers and producers.

## KEY FINDINGS AND STRATEGIC CONSIDERATIONS

- ✓ Energy is a major source for new money in a community given that it is so heavily export-oriented. Oil and gas extraction accounted for the second-largest share of Norman's exports in 2016, following just state government in total exported goods and services. In 2016, **Norman exports in oil and gas extraction totaled nearly \$570 million, a major source of new wealth for the community.**
- ✓ **Norman's proximity to hundreds of energy companies and operations make it an attractive place for companies in the energy field.** Oklahoma has five petroleum refineries with a combined capacity of more than 500,000 barrels per day, or roughly three percent of the total US capacity. The state is also home to the new GE Oil & Gas Technology Center. The Center opened in 2016 and is the first GE global research center to focus on only one industry. Future advancements in applied technology look to make the oil and gas industry more efficient. The Center will provide the ability for commercialization of new technology and new approaches at a faster pace.
- ✓ The GE Oil & Gas Technology center is likely to attract other technology-focused industry and research companies. For example, GE recently unveiled a prototype drone that is engineered to detect emissions precisely and cost-effectively. It aims to help customers reduce environmental impact and improve operational efficiency in the oil and gas industry. The cross sector applications in such innovations lend themselves to spur additional economic activity in the areas of aerospace, transportation, and others. **Norman's proximity to this growing cluster can be leveraged to capture opportunities in smaller, precision manufacturing operations and potential collaborations in other industry strengths.**
- ✓ Local employers include Bergey WindPower Co and Cimarron Energy, among others. Bergey WindPower Co is the nation's oldest manufacturer of small wind turbines. The company designs and manufactures residential-sized wind turbines. Its product line includes grid tied turbines, off grid turbines and tower options. Cimarron Energy designs and manufactures natural gas production and processing equipment. Its equipment provides separation, flowback, and environmental products to oilfield exploration and production companies.
- ✓ **Norman's talent pipeline produces a high number of quality petroleum engineers each year.** The University of Oklahoma's petroleum engineering program is consistently ranked as one of the best in the country. Its undergraduate program ranked third best in the country according to a recent US

News and World Report ranking and its graduate petroleum engineering program tied for 6<sup>th</sup>. Between 2006 and 2016, there were roughly 1,200 degree completions in petroleum engineering. Petroleum engineering is another example of a skill set with potentially cross-sector applications as engineers engaged in the discovery and efficient extraction of energy resources are increasingly utilizing information technologies for big data analysis (Norman's Information and Technical Services target) and radar technologies that improve remote sensing (Norman's Weather & Radar Technologies target).

**FIGURE 7: TOP OCCUPATIONS IN ENERGY-RELATED SECTORS, NORMAN**

SOC	Occupation	Jobs (2016)	Location Quotient (2016)		Median Hourly Earnings	Typical Entry Level Education
		Norman	Norman	OKC MSA		
47-1011	First-Line Supervisors of Const. Trades & Extr. Workers	270	1.07	1.57	\$24.77	HS diploma or equiv.
17-3031	Surveying & Mapping Technicians	56	2.42	2.16	\$15.58	HS diploma or equiv.
47-5071	Roustabouts, Oil & Gas	34	1.71	5.02	\$18.40	No formal education
17-1022	Surveyors	32	1.77	1.34	\$19.98	Bachelor's degree
49-9012	Control & Valve Instal. & Repairers, Exc. Mech. Door	28	1.52	2.49	\$23.61	HS diploma or equiv.
17-2171	Petroleum Engineers	24	1.77	7.42	\$44.55	Bachelor's degree
19-4041	Geological & Petroleum Technicians	22	3.67	8.20	\$21.12	Associate's degree
47-5012	Rotary Drill Operators, Oil & Gas	16	2.55	8.69	\$26.67	No formal education
47-5011	Derrick Operators, Oil & Gas	14	3.19	10.33	\$21.67	No formal education
17-2151	Mining & Geolog. Eng., Incl. Mining Safety Engineers	<10	2.94	6.36	\$41.38	Bachelor's degree
51-8093	Petro. Pump System Oper., Refinery Oper., & Gaugers	<10	0.22	1.45	\$26.28	HS diploma or equiv.
53-7071	Gas Compressor & Gas Pumping Station Operators	<10	1.42	5.48	\$29.53	HS diploma or equiv.
53-7072	Pump Operators, Except Wellhead Pumps	<10	0.89	1.36	\$22.53	HS diploma or equiv.
53-7073	Wellhead Pumps	<10	1.91	3.69	\$28.63	HS diploma or equiv.
47-5021	Earth Drillers, Except Oil & Gas	<10	0.84	1.48	\$15.98	HS diploma or equiv.

Source: Economic Modeling Specialists International (EMSI)

Note: data is for total occupations across all industries, not limited to those in the energy-related subsectors listed in the target. Location quotients: Location quotients (LQs) measure the relative concentration of regional employment in a given business sector. Specifically, they are calculated by dividing a sector's share of regional employment by that sector's share of national employment. A location quotient above 1.0 would indicate that the sector is more heavily concentrated in the region than it is nationally. Color-coding: Employment growth is color-coded such that growing sectors are presented in green text and declining sectors in red text. Those with location quotients greater than or equal to 1.1 are presented in green font. LQs lower than 0.9 are presented in red font and LQs between 0.9 and 1.1 in orange font.

- ✓ **The energy sector provides many high-wage employment opportunities.** Average wages range from \$41,415 in the surveying and mapping sector up to \$98,261 in the electric power generation, transmission and distribution sector. Additionally, it provides well-paying jobs for workers at every skill and educational attainment level. Median hourly earnings for a full-time worker in the top occupations in energy range from \$32,416 for a surveying and mapping technician where a high school diploma is typically sufficient to fill an entry level position, all the way up to \$92,669 for a petroleum engineer where a bachelor's degree is required.
- ✓ **Oklahoma is the third-largest producer of wind power in the country.** According to a recent report by the American Wind Energy Association, Oklahoma's current construction activity has put it on pace to overtake Iowa by the end of 2017 to become the second-ranked state in installed wind power

capacity.<sup>v</sup> In 2016, the wind industry supported between 8,000 and 9,000 direct and indirect jobs and total capital investment exceeded \$12 billion.<sup>vi</sup>

- ✓ AEP recently invested \$4.5 billion into the Wind Catch Energy Connection Project, a 2,000-megawatt wind farm in the panhandle and dedicated power line to deliver energy produce by the turbines. It will serve Public Service Company of Oklahoma and Southwestern Electric Power Company customers.
- ✓ Norman's proximity to the nation's "Wind Corridor" – which extends from southern Texas to the northern Minnesota – not only lends itself as a valuable attribute to the production and research side of economic activities related to wind power, but it can also provide opportunities for manufacturers. **Norman's location near the country's most favorable sites for wind power generation could enable manufactures to reduce transportation costs along the supply chain.** There are currently over 500 manufacturing facilities in the country producing products from the wind industry. Products include blade, tower, and turbine assembly facilities, in addition to raw component suppliers such as fiberglass and steel.
- ✓ Faculty at the University of Oklahoma are focused on researching novel materials and structures for applications in next generation solar cells. Additionally, OU faculty are active members in the Oklahoma Photovoltaics Research Institute, a statewide consortium focused upon education and research programs related to next generation solar cells. The primarily goal of the institutions is to **foster collaboration across the state in research, education, and outreach related to photovoltaics (PV).** The institutes comprises faculty members for physics, chemistry, materials science, and engineering at the state's three major research universities – OSU, OU, and UT.

### NORMAN'S NICHE

#### EXAMPLES OF WEATHER & RADAR TECHNOLOGY APPLICATIONS WITHIN THE ENERGY SECTOR

With technological advancements, wind and solar power are projected to grow which should lead to more demand for atmospheric scientists. Utility companies will depend more heavily on weather forecasting when it comes to buying and selling wind, solar, and other clean energy sources whose sources vary with the weather in order to know when to buy or sell power depending on the supply. Likewise, companies operating in the production of clean energy power will depend on analytics to determine optimal locations for solar and wind installations. Similarly, advancements in solar panels and photovoltaics research will likely create additional demand for atmospheric scientists to assist in site locations and optimal positioning for solar fields. Analysis of wind and solar power potential is an area at the intersection of the weather and radar, energy, and information and technical services targets.

Interestingly, the energy sector and the weather and radar technology sectors have intersected as wind farm proliferation has interfered with radar technologies used to predict weather and guide aircraft. The U.S. Department of Energy seeks to develop strategies that mitigate interference, increasing the need for effective siting of wind farms.

Radar technologies and interferometry are also used in the energy sector to support remote sensing needs from the identification of faults and fractures to the mitigation of oil spills.



## Information and Technical Services

**DEFINITION:** Information and Technical Services includes economic activities that leverage technology both in providing services and in the manufacturing of relevant equipment. Part of the growth within this sector is attributed to the increase in activities related to “shared services.” For example, in an effort to decrease costs by eliminating duplicate activities and creating new efficiencies, companies have been outsourcing certain functions (such as payroll) or consolidating them into a handful of vertically integrated business units for decades. Other applications include data analysis and software as a service (SaaS) such as cloud computing software services.

**FIGURE 8: NORMAN INFORMATION & TECHNICAL SERVICES-RELATED SECTOR ACTIVITY, 2006-16**

NAICS	Business Sector	Jobs (2016)	Change in Jobs (2006-2016)				Location Quotient (2016)	
		Norman	# Change, Norman	% Change, Norman	% Change, OKC MSA	% Change, U.S.	Norman	OKC MSA
5413	Architectural, Eng., & Related Services	930	429	85.4%	-7.5%	0.6%	1.57	0.84
5412	Accounting, Tax Prep., Bookkeeping...	576	(15)	-2.5%	52.5%	8.9%	1.26	1.54
3341	Computer and Peripheral Equipment Man.	374	114	43.7%	17.2%	-16.7%	5.75	1.13
541512	Computer Systems Design Services	309	89	40.7%	72.9%	62.7%	0.78	0.34
541511	Custom Computer Programming Services	289	173	148.1%	-0.6%	48.7%	0.79	0.53
54171	R&D in the Phys., Eng.g, & Life Sciences	24	(10)	-29.1%	-36.7%	15.2%	0.10	0.29
541519	Other Computer Related Services	24	N/A	N/A	203.6%	0.9%	0.49	2.05
541618	Other Management Consulting Services	21	(19)	-47.4%	-2.5%	10.5%	0.47	0.64
541513	Computer Facilities Management Services	10	(20)	-66.8%	80.6%	20.2%	0.35	0.76
Total, Subsector		2,557	765	42.7%	20.0%	18.0%	1.14	0.81
Total, All Jobs		62,725	3,540	6.0%	6.4%	5.0%		

Source: Economic Modeling Specialists International (EMSI)

Location quotients: Location quotients (LQs) measure the relative concentration of regional employment in a given business sector. Specifically, they are calculated by dividing a sector’s share of regional employment by that sector’s share of national employment. A location quotient above 1.0 would indicate that the sector is more heavily concentrated in the region than it is nationally. Color-coding: Employment growth is color-coded such that growing sectors are presented in green text and declining sectors in red text. Those with location quotients greater than or equal to 1.1 are presented in green font. LQs lower than 0.9 are presented in red font and LQs between 0.9 and 1.1 in orange font.

**REGIONAL OVERVIEW AND NATIONAL TRENDS:** Jobs within the information and technology field have been growing rapidly both in the metro area and nationwide. Employment in the sector grew by more than triple the rate of total job growth in the Oklahoma City MSA and across the country. Advancements in technology have been a driving force for economic activity in information and technical services. Technological advancements have enabled companies to more efficiently and effectively reach clients and customers across the country and globally and have opened up new growth opportunities for B2B companies and data processing firms. With digital information growing at an exponential rate, there is ever-increasing demand for innovations and new capacity with respect to data analytics, management, and storage.

The Internet of Things (IoT) is also an ever-increasing market whose growth prospects are immense; data is gathered and used for increased machine-to-machine communication, cloud computing software, and smart technologies. Its applications are vast and include items such as sensors which are used to measure, evaluate, and gather data. Manufacturing, transportation, logistics, and utilities are projected to lead IoT spending but there are a number of consumer applications as well. IoT has the potential to improve the accuracy, speed, and scale of supply chains and open up new opportunities for Business-to-Consumer (B2C) companies. Business-to-Business (B2B) opportunities will likely be driven by activities such as analytics, connectivity, cybersecurity, and cloud and platform services. According to one estimate, the IoT market is projected to grow from \$2.99 trillion in 2014 to \$8.9 trillion in 2020. <sup>vii</sup>

There are a number of companies that were founded in Norman that have operations in activities related to information and technical services. The following list is a sample of some local successes and various activities currently operating in the city.

- ✓ Agio Technology was founded in Norman and is leading provider of managed IT and cybersecurity services. It offers technology hosting, monitoring, management, helpdesk, disaster prevention and recovery, and cybersecurity management, programs, and consulting. Agio has roughly 200 employees at its three offices in New York, NY; Norman, OK; and Raleigh, NC.
- ✓ While Hitachi is a manufacturing company, its applications and inputs are tied to the information and technology services sector. Hitachi Computer Products is a full service custom electronic manufacturing service provider. The Norman facility is involved in both the production and distribution of its products.
- ✓ NextThought offers products and services that enhance online education through engaged learning communities. Products and services include building learning platforms, learning design, and video production services. It was founded in 2011 and got its start in NEDC's business incubator, eTec.
- ✓ StoneHouse Marketing Services is a full service marketing company. Its services include print management, packaging and distribution, card affixing, and card personalization. It manufactures, packages, and distributes items such as gift, loyalty, and healthcare laminated cards and key-tags. The company was started in 1995
- ✓ Xyant Technology Inc. is an information technology support company that provides on demand technology services support. Its services include technology consulting, global payroll services, innovation and technology platforms, and human capital management and program management.

## KEY FINDINGS AND STRATEGIC CONSIDERATIONS

- ✓ Professional, scientific, and technical services companies, which include many businesses that also have operations related to weather and radar, brought in roughly \$345 million to Norman in the form of exported services. Exports within the professional, scientific, and technical services were spread out among a variety of subsectors. (Note that "exports" in the regional context refer to any sales outside the local market – that includes other domestic markets as well as international buyers.) **Engineering services accounted for the largest share with \$48.9 million in exports, followed by all other professional, scientific, and technical services with \$46.6 million.**

- ✓ In Norman, **information and technology-related sectors nearly doubled in size over the past ten years.** For service-providing sectors, Norman has an especially high concentration of jobs in architectural, engineering, and related services and accounting, tax preparation, bookkeeping, and payroll services. For goods-producing jobs, those related to information and technology products are primarily found in computer and peripheral equipment manufacturing.
- ✓ Every year, OU produces hundreds of graduates each year in related fields as the increase in demand for these workers has led to an increase in talent production and more degree output. The number of **degree completions in computer science programs in 2016 was up 80 percent from 2006.** In total, there were nearly 600 completions in related programs over the past ten years. Combined, there were another 688 completions in other related programs, including computer engineering, computer/information technology administration and management, computer systems networking and telecommunications, computer software and media applications, and computer programming.
- ✓ The growth in IoT and the increase in big data platforms and applications has led to an increase in demand for data scientists. Nationally, employment increased by nearly 20 percent. Norman has a high concentration of jobs in computer and information research scientists. Although this likely covers some of the economic activity occurring in the weather industry, it is a positive sign of the workforce competencies. The concentration of jobs is roughly double that of the national average.
- ✓ Occupations in information and technical services are high paying jobs that provide quality employment for individuals. Median hourly earnings in Norman for computer and information research scientists are estimated to be \$44.15 an hour. Nationally, median hourly earnings are \$53.75 an hour. Norman's low cost of living is supportive of a lower wage and is an important site location consideration for companies comparing the labor costs between communities.
- ✓ **High paying, quality employment opportunities are important to increasing prosperity in the city.** Other common occupations within this sector include: accountants and auditors (median hourly earnings, \$28.99); software developers, applications (\$41.14); software developers, systems software (\$32.06); computer user support specialists (\$19.75); computer programmers (\$32.99); and computer systems analysis (\$31.85).
- ✓ The U.S. News & World Report recently named Price College as one of the best business schools of 2018, ranking the undergraduate program in the top 50 for public universities, and two specialty programs in the top 25 (International Business at #19 and Center for Entrepreneurship at #22).
- ✓ Although Oklahoma's technical workforce and relatively low utilities cost may make it an attractive place for some data centers in the state, Norman's location near tornado alley could make it difficult to attract certain data center operations that seek to avoid areas with natural disaster risk. These activities are therefore not included in the related sectors used to define this target. Data centers are capital intensive, often have limited job creation potential, and the competition is immense.

**NORMAN'S NICHE****EXAMPLES OF WEATHER & RADAR TECHNOLOGY APPLICATIONS WITHIN THE INFORMATION & TECHNICAL SERVICES SECTOR**

Information & Technical Services is certainly the target sector with the greatest similarity to and crossover with the Weather & Radar Technology target. The disciplines of meteorology, climatology, and atmospheric science in general are information and technical services at their core. The community's obvious strengths in these disciplines in terms of educational, research, and economic output provide it with a truly distinct specialization in the "Information" sector that few communities and regions, if any, can emulate. This specialized application of information management and data analysis as it relates to weather forecasting is comparable in principle to the specialization that so many communities and regions seek to develop with regards to healthcare information technology.

While countless areas can effectively compete for healthcare information technology jobs, few can demonstrate a value proposition associated with weather-related information technology akin to Norman. And in a world where the weather impacts so many types of economic activities and investments, there is immense brand and economic value associated with a specialization in such an important and growing field where continued improvements in the accuracy of weather forecasts – a key information service – can improve efficiency and profitability in countless other sectors, from insurance (risk modeling) to tourism (event planning and preparedness) and transportation (fleet coordination and planning) to agriculture (planning for sowing and irrigation). Opportunities likely exist in the growth of private-sector providers of specialized forecasting services to meet the unique needs of these differentiated markets.



## Weather and Radar Technologies

**DEFINITION:** Unlike previously defined target sectors, the Weather and Radar target is not easily defined using traditional industrial classification systems. The application of weather and radar technologies extends itself to a variety of sectors. The use of radar technologies can be applied to various fields of climate, weather, aviation, oil exploration, and other sectors where communication technologies are used. Meteorology and atmospheric sciences applications are being used to provide detailed and accurate forecasting for clients such as airlines, event planners, utility companies, and businesses involved in logistics and just-in-time delivery of goods. Accordingly, its applications to a wider variety of sectors – including other targeted activities in Norman – provide opportunities to strengthen Norman’s niche as a Weather & Radar cluster.

**FIGURE 9: NORMAN WEATHER AND RADAR-RELATED SECTOR ACTIVITY, 2006-16**

NAICS	Business Sector	Jobs (2016)	Change in Jobs (2006-2016)				Location Quotient (2016)	
		Norman	# Change, Norman	% Change, Norman	% Change, OKC MSA	% Change, U.S.	Norman	OKC MSA
541330	Engineering Services	661	397	149.9%	-12.5%	5.8%	1.72	0.73
541990	All Other Prof., Scientific, and Tech. Services	251	185	280.0%	70.9%	86.6%	2.66	0.80
541690	Other Scientific & Tech. Consulting Services	32	12	57.9%	470.8%	48.4%	0.34	1.31
541620	Environmental Consulting Services	23	(20)	-46.7%	18.1%	12.6%	0.59	0.71
423860	Trans. Equip. (exc. Motor Veh.)...Wholesalers	18	N/A	N/A	1.9%	-4.0%	1.40	1.66
5179	Other Telecommunications	16	(15)	-47.8%	-65.8%	-52.3%	0.50	1.13
334290	Other Communications Equip. Man.	13	N/A	N/A	742.3%	-25.6%	1.82	2.37
334514	Totalizing Fluid Meter & Counting Dev. Man.	<10	N/A	N/A	N/A	-21.4%	0.54	0.10
3359	Other Electrical Equip. & Component Man.	<10	N/A	N/A	-35.5%	-4.9%	0.04	0.07
423690	Other Elec. Parts & Equip...Wholesalers	<10	N/A	N/A	6.5%	-17.7%	0.01	0.82
5174	Satellite Telecommunications	<10	N/A	N/A	54.0%	-50.0%	1.50	1.03
541712	R&D in Phys., Eng., & Life Sci. (exc. Biotech.)	<10	N/A	N/A	-35.3%	11.8%	0.04	0.31
334513	Instrum. & Rel. Prod. Man. for Measuring...	<10	N/A	N/A	-15.1%	0.8%	0.02	0.81
334220	Broad. & Wireless Comms Equip. Man	0	0	N/A	N/A	-34.5%	0.00	0.04
334511	Search, Det., Nav., Aero...Instrum. Man.	0	0	N/A	N/A	-23.6%	0.00	0.03
334512	Automatic Environmental Control Man...	0	0	N/A	261.2%	-30.2%	0.00	0.62
334515	Instrument Man. for Meas. & Testing Elect...	0	N/A	N/A	N/A	-20.2%	0.00	0.01
334519	Other Meas. & Controlling Device Man.	0	N/A	N/A	N/A	3.1%	0.00	0.18
336419	Other...Space Veh. Parts & Aux. Equip. Man.	0	0	N/A	-100.0%	-32.0%	0.00	0.00
Total, Subsector		1,015	520	104.9%	1.0%	2.8%	0.93	0.66
Total, All Jobs		62,725	3,540	6.0%	6.4%	5.0%		

Source: Economic Modeling Specialists International (EMSI)

Location quotients: Location quotients (LQs) measure the relative concentration of regional employment in a given business sector. Specifically, they are calculated by dividing a sector’s share of regional employment by that sector’s share of national employment. A location quotient above 1.0 would indicate that the sector is more heavily concentrated in the region than it is nationally. Color-coding: Employment growth is color-coded such that growing sectors are presented in green text and declining sectors in red text. Those with location quotients greater than or equal to 1.1 are presented in green font. LQs lower than 0.9 are presented in red font and LQs between 0.9 and 1.1 in orange font.

**REGIONAL OVERVIEW AND NATIONAL TRENDS:** New types of computer models and technological advancements are enabling the weather community to apply their skills more readily in the private sector. Accurate, current, and customized weather forecasts enable companies to improve efficiency and effectiveness of operations in variety of ways from reduced transportation delays to optimized staffing levels to improved accuracy in estimating wind energy potential. In today's information age where data is expanding exponentially, meteorology is no exception. Our ability and capacity to extract, manage, and analyze weather-related information is constantly growing, and demand for increasingly customized or specialized weather forecasts is likely to grow as well.

With respect to radar technologies that help collect such information, according to one estimate, the global radar systems and technology market is projected to grow at a compound annual growth rate of more than four percent between 2017 and 2021.<sup>viii</sup> Radar technologies lend themselves to everything from aerospace and automotive to manufacturing and logistics. For example, the automotive radar market is expected to grow rapidly with technological advancements and innovations due to a growing focus on safety features and growth in autonomous vehicles. Radars detect objects in various safety systems such as pedestrian detection, blind spot detection, and automated emergency braking.

Examples of local employers in the Weather & Radar Technologies target include:

- ✓ Atmospheric Technology Services Company (ATSC) offers a reliable, high-quality small business alternative to in-house resources for government operated weather stations, instrumented sites, research support, consulting, technical and business management of government contracts. ATSC economically provides a high level of informed expertise, know-how, contacts, and confidentiality.
- ✓ Nanowave designs and manufacturer of advanced microwave, millimeter-wave and electro-optic components and sub-systems. The company specializes in radars for the aerospace industry. It has a research program at OU's ARRC.
- ✓ National Weather Center is located at the University of Oklahoma. It has played a key role in bolstering economic strengths and is an invaluable asset to the activities in Norman related to weather and atmospheric sciences. NWS provides weather, water, and climate data and delivers forecasts and weather warnings.
- ✓ The NOAA National Severe Storms Laboratory (NSSL) works to improve the lead time and accuracy of severe weather warnings and forecasts. Basic and applied research focuses on understand sever weather processes, development weather observation technology, and improving forecast tools, with emphasis on weather radar, hydrometeorology, and forecast and warning improvements.
- ✓ Weather Decision Technologies, Inc (WDT) provides organizations with weather decision support on a global scale. WDT offers specific expertise with Big Data as it applies to hazardous weather detection and prediction, forecast modeling, decision analytics, GIS, mobile apps and interactive mapping.
- ✓ Weathernews is a Japanese forecasting company that opened its U.S. operations center in 2004 in Norman for meteorological research and development in the world. It is located on the OU Research Campus, and as of 2014, its operations provided forecasting data to approximately 2,000 vessels each day.
- ✓ The Oklahoma Mesonet is a world-class network of environmental monitoring stations that was designed and implemented by scientists at the University of Oklahoma and Oklahoma State University. There are 121 automated stations across the state. It is operated and maintained by the Oklahoma Climatological Survey.

## KEY FINDINGS AND STRATEGIC CONSIDERATIONS

- ✓ The Bureau of Labor Statistics projects that jobs for Atmospheric Scientists, which includes meteorologists, are projected to grow faster than average. **Between 2016 and 2026, employment is project to grow by 12 percent.** This will partially be driven by technological advancements that will improve the accuracy of forecasts and enable atmospheric scientists to tailor forecasts to specific purposes. As such, demand for atmospheric scientists will likely increase as businesses in private sector seek more specialized weather forecasts and data.
- ✓ **Over the past ten years, there were an estimated 700 degree completions in the atmospheric sciences and meteorology programs in Norman.** Annual openings for related jobs indicate that Norman's degree completions exceed the estimated number of job openings available locally in related occupations. Given the specialization of the degree, it's not surprising that many graduates likely move elsewhere for work. However, it also indicates that the city has excess capacity for meteorologists and similar occupations. **This highly specialized talent pool is unquestionably among the community's most marketable advantages to Weather & Radar companies small and large.**
- ✓ Employment in weather and radar-related sectors are high skilled and high paying occupations. Nationally, atmospheric and space scientists have median hourly earnings of \$44.45/hr. For a full-time employee, that equates to an annual income of \$92,456. Similarly, geoscientists, except hydrologists and geographers, have median hourly earnings that equate to \$90,064 for a full time employee.
- ✓ Economic activity in the area of radar technologies requires workers with competencies in computer and electrical engineering. In Norman, the share of electrical engineering is roughly half that of the average community nationwide, however, the number of electrical engineers in Norman has been growing rapidly over the past ten years. Even so, Norman is not currently retaining its electrical and electronics engineering graduates. In 2016, there were an estimated 98 completions but just five openings for related jobs in the Norman area. This indicates that there is excess workforce capacity; that the employment opportunities are not there locally to retain many graduates. This sentiment was expressed by stakeholders from around the community – Norman is lacking quality job opportunities and losing many graduates.
- ✓ Much of the higher education research activities at the University of Oklahoma are in atmospheric science and meteorology. In FY2016, **OU's R&D expenditures in atmospheric sciences were the sixth highest in the country with more than \$35 million in expenditures.** Atmospheric science R&D expenditures accounted for the second highest field out of all R&D expenditures at OU. In total, 17.2 percent of the university's total expenditures went to geosciences, atmospheric sciences, and ocean sciences; life sciences led spending and accounted for over half (54 percent) of total R&D expenditures.
- ✓ **OU's Advanced Radar Research Center (ARRC) focuses on interdisciplinary education, leveraging a nationally ranked meteorology program and growing engineering departments.** The ARRC resides in the state-of-the-art Radar Innovations Laboratory – a 35,000-sqft working laboratory dedicated to innovations in radar technology and science. The RIL is dedicated to advancing OU's radar program. The laboratory includes a large microwave lab with seating for 70 students, 22 staff, and 18 faculty members, a high-bay garage for mobile radar platforms, prototype fabrication facilities, a fully stocked

machine shop, two precision anechoic chambers, an experimental observation deck, state-of-the-art classroom and seminar space, and an "Ideas Room" for fostering collaboration and innovation. Located just east of the National Weather Center, the RIL has been open since 2015 and has become an integral part of the OU South Research Campus.

- ✓ **The University of Oklahoma's School for Electrical and Computer Engineering has been growing significantly due in large part to the advancements made in radar and applied electromagnetics.** The cross-disciplinary radar curriculum provides students with a unique and comprehensive coverage of all aspects of radar engineering, from atmospheric science, remote sensing, and propagation to microwave/antenna engineering, signal processing, and systems engineering. Emphasis is placed on providing a hands-on experience for students in designing, analyzing, and prototyping radar components and systems. Additionally, students have the opportunity to analyze real data from several radars here in the Norman area, including the PX-1000, RaXpol, the Digital Array Radar testbed, and the NWRT Phased Array Radar/KOUN Polarimetric Doppler Radar, both operated by the National Severe Storms Laboratory.
- ✓ Advancements in the use of drones to improve weather forecasts offer new opportunities for cross-sector applications between the Aerospace and Weather & Radar targets. Interdisciplinary research collaboration is underway between the National Weather Center and the Advanced Radar Research Center of OU and is being funded by the NOAA. **Drones have the potential to collect valuable data on wind velocity, air pressure, and humidity in the presence of severe and rapidly changing atmospheric events.** Better data would allow researchers to provide more accurate weather forecasts and better anticipate severe weather warnings.
- ✓ **In June 2017, Japanese-based Weathernews and Canadian company Nanowave agreed to partner on the manufacture of portable weather radars.** The new device is called the Enthusiasm for Asia-Genesis Leading Edge (EAGLE) radar. It was developed by Weathernews in collaboration with OU researchers and students at the ARRC. The new partnership with Nanowave, a radio frequency electronics company will create 10 to 15 high-tech engineering jobs. The radars will be made out of Two Partners Place.

# ENDNOTES

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- <sup>v</sup> "U.S. Wind Industry Third Quarter 2017 Market Report." American Wind Energy Association. October 25, 2017.
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- <sup>viii</sup> "Radar Systems and Technology Market Size - Forecast and Assessment Until 2021 by Technavio." Business Wire. June 23, 2017.