STRATEGIC PLAN FOR THE GROWTH OF OKLAHOMA'S AEROSPACE INDUSTRY

September 2009

Prepared for the Oklahoma Aerospace Industry Partners by:

IronWolf Community Resources | simply strategy. more modern marketing solutions | RTI International | Scruggs & Associates, LLC

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Executive Summary

The aerospace industry has been a cornerstone of Oklahoma's economy for decades; Oklahoma's position as one of the major worldwide centers for maintenance, repair and overhaul of aircraft has provided well paying jobs for a variety of skill levels. The industry's position in Oklahoma is now challenged by global competition, changes in technology, national and worldwide economic conditions, and U. S. national policies affecting defense, civilian and commercial aviation. To maintain this important sector of Oklahoma's economy, the state's economic development leaders have taken on the challenge of increasing the industry's competitiveness.

According to the Oklahoma Department of Commerce, the industry accounts for over 72,000 jobs with an average wage well above the state's average wage. Unlike other industry sectors that are centered in just a few areas, Oklahoma's aerospace industry assets span the state. From Ardmore to Tulsa, Ponca City to Fort Sill, Oklahoma City to the Spaceport, there is an array of manufacturing, testing, maintenance, and research companies directly engaged in aerospace.

The purpose of this strategic plan is to connect the assets of the aerospace industry in Oklahoma with existing and emerging markets that will help existing companies expand, attract new companies, and build renowned expertise in specific areas of research, testing and operations.

Strategic Plan Goals

- To increase the markets and competitiveness of Oklahoma's existing aerospace companies.
- To attract new aerospace companies, suppliers and workers to the state.
- To enhance Oklahoma's reputation as a leader in identified areas of research, testing, and operations.

Desired Outcomes

By focusing on targeted strategies and coordinating resources, industry and economic partners intend to grow overall jobs and research funding as well as to achieve specific regional outcomes including the following:

- Maintain Tinker AFB as one of the primary centers for aerospace excellence and innovation, and expand the number and size of contractors and subcontractors that serve Tinker (utilizing facilities such as the MROTC and TAC).
- Expand MRO operations in Tulsa, maintaining a strong presence for American Airlines and expanding other opportunities.
- Increase aerospace opportunities around regional airports, including Oklahoma City, Tulsa, Lawton and Ardmore.
- Be a key player in UAS testing and development utilizing university research and testing centers/facilities throughout the state.
- Increase the amount of federal contracts and federal research dollars for aerospace awarded to state institutions and companies.
- Ramp-up university research and spin-outs in the areas of composite development, diagnostics and repair; sensor technology development and applications; unmanned systems development, testing and operations; and alternative fuels for aerospace applications, including biofuels.

- Expand awareness of Oklahoma's aerospace industry inside and outside the state and strengthen the state's global aerospace presence through focused and strategic marketing and communications.
- Increase the pipeline of Oklahoma students completing aerospace education and training, closing the gap between projected graduates and expected jobs.

Oklahoma Aerospace Assets, Opportunities & Gaps

Oklahoma has significant assets in the aerospace industry. Both government installations and private sector companies have developed an extended value chain of suppliers, producers and customers for aerospace sectors. Exciting new initiatives complement the already strong MRO and OEM activities in Oklahoma's aerospace landscape, including the University Multispectral Lab and the UAV/UAS test range. Highlights of assets include:

- Federal government installations such as Tinker Air Force Base, Federal Aviation Agency (FAA) Mike Monroney Aeronautical Center, Altus Air Force Base, and Vance Air Force Base.
- Major private sector aerospace companies including American Airlines, Nordam, Spirit, Boeing, Northrop Grumman and Pratt & Whitney.
- University research capabilities in aerospace design, composites and advanced materials, sensors, advanced controls, advanced processing and heat transfer, as well as newer applications related to vehicle dynamics, controls, robotics, and intelligent systems, the design of long-endurance UAVs, micro air vehicles (MAVs), and nano air vehicles (NAVs).
- Testing and training facilities in a variety of aerospace applications ranging from the Lawton UAV/UAS Testing Facility, utilizing Ft. Sill restricted air space; aerospace-related sensor testing and evaluation at OSU/UML in Ponca City; FAA Mike Monroney Center with training capability; and flight and air traffic control simulation including the U.S. Customs and Border Protection Air and Marine National Air Training Center.
- Progressive and widespread incentive packages that include assistance for manufacturing, workforce, financing and facilities and can be applied for both expansion and recruitment efforts.

A primary element of this plan is to identify key market opportunities to sustain and grow Oklahoma's aerospace industry. Three sectors comprise the majority of the state's current industry: maintenance, repair, and overhaul (MRO); original equipment manufacturing (OEM); and air transportation with related training services. In addition to expansion possibilities in existing sectors, the state is also poised to take advantage of emerging aerospace markets.

Maintenance, Repair & Operations (MRO): Opportunities in intelligent systems, remote condition monitoring, predictive maintenance, and more integration between routine and MRO services will become much more important with next-generation aircraft from Airbus and Boeing. Composite materials, especially in the examination and repair area, continue to need innovative research and development. One-stop MRO shops, especially those who are able to bring all components into one location, are attractive.

Original Equipment Manufacturing (OEM): Companies place high value on engineering and design expertise among their supplier base. As customers seek more design content from their suppliers, the level of experience and capability will become more important as discriminators in competition for contracts. Oklahoma should expand their manufacturing focus on OEM companies to include engineering and design divisions. Lean and green manufacturing are increasingly coupled, and businesses that operate in an

environmentally responsible way while demonstrating low-cost methods will continue to gain market share.

Fuel and Engine Technology: Aerospace applications for alternative fuels, synthetic fuels and biofuels represent a nexus of Oklahoma's three major industries: aerospace, energy, and agriculture. States like Oklahoma with fossil and biofuel resources have the opportunity to make major moves on the technology to commercialize a viable alternative fuel. The opportunity for Oklahoma is amplified by the presence of Tinker Air Force Base and its interest in alternative fuels for the DoD, by Oklahoma's natural gas and biofuel resources, and by innovative technologies developed and acquired by the Tulsa company, Syntroleum. DoD funding available to support research efforts with this focus are very significant.

Unmanned Aircraft Systems (UAS): A current focus of military aviation applications is UAS. Systems such as the Predator and the Global Hawk are important contributors to U.S. military operations globally. Civilian applications for UAS, while currently restricted in the U.S., are gaining acceptance in international markets. Oklahoma has opportunities and unique assets that could position the state in a leadership role in UAS technology development, testing and training that could lead to UAS production in the state.

NextGen: Oklahoma is well-positioned to be a center of NextGen-related testing and training for ground based operators/air traffic controllers. NextGen-related aerospace weather research for the "4D Weather Cube" creates a possible link with the National Weather Center: OU and NOAA (National Severe Storm Laboratory) to jointly develop tools in the areas of forecast, warning and radar.

While Oklahoma's aerospace assets provide a wide range of opportunities, the state also has challenges which may inhibit the pursuit of these markets. Aerospace increasingly relies on new technologies and materials, yet Oklahoma's overall rating in innovation ranks them in the state well below national averages (Sources: Kauffman Foundation and Milkin Institute). This is especially true for indicators of commercialization (industry R&D and patents), and science and engineering workforce. While the state has a long history of investing in science and technology, the scale of investment is lower than other states. Given the fact than more than two-thirds of innovation comes directly from industry (rather than government or universities), Oklahoma should put additional investments in industry R&D and commercialization efforts. Likewise, statewide efforts to increase science, technology, engineering and mathematics (STEM) education at both k-12 and post-secondary issues will drive not only the competitiveness of aerospace companies, but all industries in Oklahoma that rely on technical workers.

Recommended Course of Action

- Establish Oklahoma as a world-recognized center of excellence for the diagnostics, examination, and repair of new composites and strong metals.
- Gain recognition for leading edge fuel and related engine technology development and engine MRO.
- Become an acknowledged center for testing/training of aerospace-related products and processes.
- Increase the competitiveness of Oklahoma's aerospace industry through targeted operational practices.
- Enhance the pipeline and capabilities of Oklahoma's workforce.
- Improve Oklahoma aerospace industry organization and market positioning.

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Section 1 Introduction

1.1 The Importance of the Aerospace Industry in Oklahoma

The aerospace industry has been a cornerstone of Oklahoma's economy for decades, providing well paying jobs for a variety of skill levels. The industry's position in Oklahoma is now challenged by global competition, changes in technology, national and worldwide economic conditions, and U. S. national policies affecting defense and civilian/commercial aerospace. To maintain this important sector of Oklahoma's economy, the state's economic development leaders have taken on the challenge of increasing the industry's competitiveness.

> *"Statewide direct and indirect gross output from Oklahoma's commercial aviation industry was estimated to be $12.4 billion in 2004, accounting for just over 10% of Oklahoma's industry output. With wages within the industry typically above the state average wage of $15.13 an hour, the aerospace industry is a strong economic driver for the state's economy."*
>
> ***Oklahoma's Aerospace Industry Workforce: 2007 Report***

According to the Oklahoma Department of Commerce, the industry accounts for over 72,000 direct jobs with an average wage of $55,000; that is almost double the state average. Unlike other industry sectors that are centered in just a few areas, Oklahoma's aerospace industry assets span throughout the state. From Ardmore to Tulsa, Ponca City to Fort Sill, Oklahoma City to the Spaceport, there is an array of manufacturing, testing, maintenance, research companies, and public entities directly engaged in aerospace.

The purpose of this strategic plan is to connect the assets of the aerospace industry in Oklahoma with existing and emerging markets that will help existing companies expand, attract new companies, and build expertise in specific areas of research, testing and operations.

1.2 Project Methodology

The project objective was to produce a plan with broad support and immediate implementation, providing project sponsors and the State of Oklahoma with tools to sustain efforts related to the aerospace industry for years to come. A consulting team of professionals with strategic planning and local and state economic development experience, as well as technology development and market research expertise, was chosen to provide an action-oriented and measurable plan based on sound research and built on the preferences and strengths of the aerospace industry in Oklahoma.

Economic development and industry groups from across the state joined together to support this strategic planning effort. Their support included funding, as well as the contribution of their expertise, staff time, and contacts with local industry members. Project management functions were performed by the Oklahoma Aerospace Institute. The sponsors include:

- Oklahoma Aeronautics Commission
- Oklahoma Department of Commerce
- Greater Oklahoma City Chamber
- Tulsa Metro Chamber
- Ardmore Development Authority
- Ponca City Development Authority

The consulting team, comprised of four individual entities, was selected to identify the current assets in Oklahoma, evaluate strengths and weaknesses of the industry, and recommend potential directions for future industry growth and investment. This team included:

IronWolf Community Resources LLC

IronWolf Community Resources (www.ironwolfcr.com) has organizational expertise accumulated over 25 years in local and regional economic development program management. Larry Pederson of IronWolf served as the overall project manager.

RTI International

RTI (www.rti.org) is one of the world's leading technical consulting and research institutes. With a staff of over 2,600 and projects in more than 40 countries, RTI offers services to governments and businesses worldwide in the areas of economic and community development, research and advanced technology development, energy and the environment, education and training, and governance and social development. Specifically in the aerospace field, RTI has contributed technical research and services in support of NASA science programs and FAA regulatory and safety programs. In addition, RTI has provided market analysis and state of the art studies for NASA for over 20 years to support their various aeronautics, science, and space programs. Most recently, RTI completed a study of global emerging technologies for the American Institute of Aeronautics and Astronautics, and for wind tunnel business development for NASA Langley Research Center. Kirsten Rieth and C. Gary Hughes were RTI's principal project contributors.

Scruggs & Associates LLC

Founded in 1993, Scruggs & Associates LLC (www.scruggsassociates.com) is a strategic consulting firm specializing in economic development assessments, plans, and policies. Scruggs & Associates LLC is located in Davidson, North Carolina. Patricia Scruggs was the principal contributor from Scruggs & Associates.

Simply Strategy LLC

Based in Sarasota, Florida Simply Strategy LLC (www.simplystrategy.net) specializes in market strategies and communications to enhance community engagement. Dorothy Carlin was Simply Strategy's principal contributor to this project.

Methodology

The consultant team used a five-step process to develop a strategic plan for the state's Aerospace industry:

1. *Identify assets and challenges of Oklahoma's aerospace industry*
   In order to learn about the traits and facets of the Oklahoma aerospace industry, the team reviewed an array of industry information and reports, conducted 24 phone interviews, and facilitated four focus group sessions that included leaders from Oklahoma aerospace businesses, customers, and economic development organizations.

2. *Research market trends in worldwide aerospace*

The team conducted an analysis of national and global industry trends, opportunities, and challenges for key Oklahoma aerospace sectors, which included commercial and military maintenance, repair, and overhaul (MRO) services, aerospace original equipment manufacturing (OEM), and unmanned aerial systems (UAS). The team obtained information by doing secondary research using publicly available aerospace market reports, and tapping into expert knowledge of national and global aerospace industry trends and developments.

3. *Benchmark other states and regions*
   The team reviewed regions with a significant aerospace presence in order to determine against which competitors Oklahoma's performance should be benchmarked. Four primary criteria were established in order to focus on the most applicable regions:
   1. Comparable industry size, and the size of the region.
   2. Industry diversity, including government and private sector participants.
   3. Presence of innovation assets, such as federal laboratories, that would be difficult to duplicate.
   4. Strength, vitality, and growth of the industry over the past five years, including industry organizations.

   Based on those criteria, some competitor regions were dismissed due to size (California, Texas and Florida), lack of diversity of the industry present, similar scope of assets (Alabama has unique government assets), and the health of the industry (Ohio's industry is stagnant, and declining in some sectors). Ultimately, three comparable regions were selected as benchmarking targets: Georgia, Arizona, and the Province of Ontario. The success and vitality of the aerospace industry in these regions can provide valuable lessons for Oklahoma.

4. *Assess Oklahoma's competitive position and potential market opportunities*
   The team assessed the state's strengths, weaknesses, and business opportunities based on knowledge gathered through the first three steps. Through this process, specific opportunities with the following overlays were identified:
   1. Growth opportunities common among multiple segments of the industry clusters where statewide efforts would assist a wide array of companies.
   2. Growth opportunities specific to a certain industry sub-sector and its supply chain.
   3. Growth opportunities in specific geographic areas.

5. *Develop strategy and recommendations*
   The final step combined the results of all assessments and best practice research, and developed an implementation plan for the aerospace industry. The draft plan was reviewed by members of the steering committee that included representatives from economic development organizations and statewide institutions.

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Section 2 Aerospace Industry Analysis

The aerospace industry is continually being challenged. Lower-priced foreign competition, especially in the area of passenger craft maintenance, repair and overhaul (known as MRO), is a constant specter that American and other carriers must review and evaluate. Because a significant portion of Oklahoma's aerospace industry is related to MRO, this issue is very important to the state and its future in aerospace. The highly competitive nature of the industry, as well as the difficulty of obtaining new military and commercial contracts, are pinching margins for both primary industry members and their value chain of suppliers and service providers. New technologies in unmanned systems have significantly delayed contracting for next generation piloted aircraft, especially for military applications. Finally, the aging fleets of existing aircraft have presented new technical and facility challenges to the organizations that are tasked with maintenance and repair functions.

> *"The aerospace industry is one of the critical economic engines for the Oklahoma economy and has been for many years. A 1999 report prepared for the Aeronautics Commission by the University of Oklahoma concluded that the aerospace industry directly and indirectly employs over 143,000 Oklahomans, and accounts for $4.7 Billion in payroll, $11.7 Billion in industrial output, $77 Million in state income tax and $60.6 Million in state sales tax. The industry is concentrated in Tulsa and Oklahoma City, but significant intellectual and capital investments, industry suppliers, and a skilled workforce exist across the state."*
>
> ***2004 Report of the Governor's Aerospace Task Force***

The aerospace industry is a critical sector in Oklahoma's economy. Three sectors comprise the majority of the state's industry: maintenance, repair, and overhaul (MRO); original equipment manufacturing (OEM); and air transportation with related training services. Oklahoma has a rich heritage in commercial and military aerospace that is well documented; and more importantly, it has been able to build on that heritage by establishing a strong multifaceted industry. While the aerospace industry has a well-paid workforce, it is now under pressure from several fronts including foreign competition and national and global financial downturns. The technological and economic drivers are constantly changing the nature of the industry, and the competition from international players is increasing at a rapid pace. The military MRO requirements remain steady, but the out years are difficult to predict, as are the manufacturing trends, since the drivers for both are greatly influenced by political pressures. Changes coming to the national airspace in the form of the Next Generation Air Transportation System (NextGen) will affect not only the OEM and MRO markets by requiring changes in equipment avionics, but will also affect flight patterns and air traffic control processes, requiring new training. The OEM market is affected by the UAS sector which is growing rapidly and, depending on progress made in opening the national airspace to UAS usage, the commercial applications have potential for driving growth at an accelerated pace, especially beyond 2014.

2.1 Overview of Oklahoma's Aerospace Industry

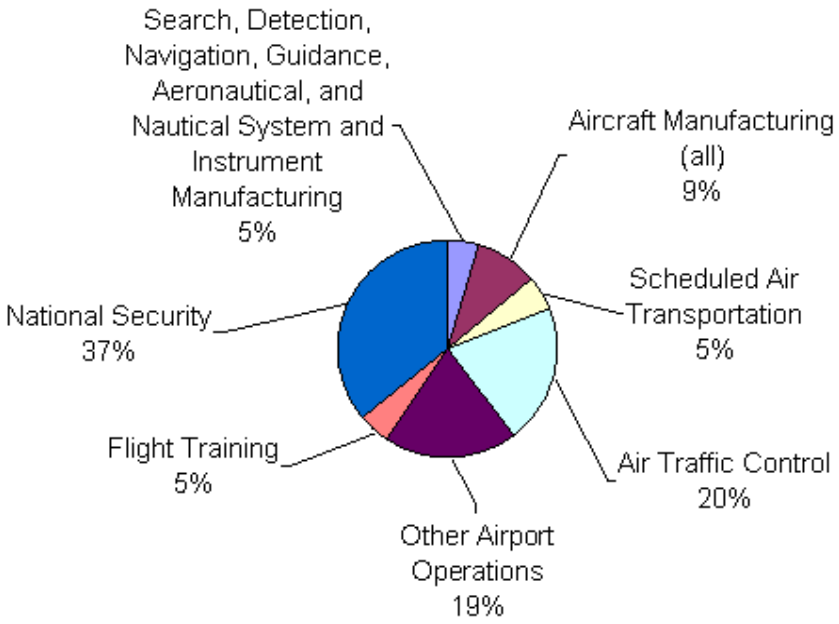
Oklahoma's aerospace industry assets support the three major markets of MRO, OEM, and air transportation with related training services. Major assets contributing substantially to Oklahoma's aerospace industry are federal installations, primarily Tinker Air Force Base and the Federal Aviation Agency (FAA) Mike Monroney Aeronautical Center. These provide aerospace industry jobs for approximately 26,000 and 6,500 workers, respectively.[1] Oklahoma Aerospace

[1] Tinker Air Force Base Fact Sheet, January 2009/Greater Oklahoma City Chamber of Commerce

Commission data shows that 52 of Oklahoma's 77 counties are represented in Tinker's workforce. Altus and Vance Air Force Bases are also located in Oklahoma and provide training operations for airlift and aerial refueling crews, and undergraduate pilot training. *Aviation Week's* World Aerospace Database lists 383 aerospace companies in Oklahoma. NAICS data from the Oklahoma Department of Commerce estimates that 498 organizations or establishments are located in the state.

Figure 1 below shows the breakdown by type of establishments. The high number of National Security establishments reflects the large presence of military in Oklahoma, anchored by Tinker AFB. The high percentage of Air Traffic Control establishments reflects the FAA's large compound with multiple addresses. The next highest percentage of establishments is Other Airport Operations at 19 percent, which is made up primarily of MRO service companies. Aircraft Manufacturing in Oklahoma is comprised of a combination of aircraft component and structure manufacturers, MRO companies, and support organizations such as precision machine shops.

Figure 1. Oklahoma's Aerospace Industry Breakdown by Sector



Source: Oklahoma Aerospace Institute, Oklahoma Department of Commerce

Examining a core set of aerospace sectors, including those in manufacturing, transportation, services and national security, employment in these sectors grew by 7 percent from 2003 to 2007 (Table 1). For that same time period, overall employment in Oklahoma grew by almost 9 percent. Aerospace manufacturing grew at more than 77 percent, while support services for air transportation grew by 42 percent. Compared to selected competitor states Arizona and Georgia, Oklahoma's aerospace industry grew at a slightly higher employment rate (Table 2).

Table 1. Employment of Selected Aerospace Sectors

	Oklahoma Employment		
Sector (NAICS)	2003	2007	Growth Rate
Navigation & Instrument Mfg (334511)	494	541	10%
Aerospace Manufacturing (3364)	2,954	5,226	77%
Air Transportation (481)	9,956	8,683	-13%
Support Services for Air Transp. (4881)	3,080	4,372	42%
Flight Schools (611512)	1,051	1,208	15%
National Security (982210)	19,609	19,838	1%
TOTAL	37,144	39,868	7%

Table 2. Employment of Selected Aerospace Sectors in Arizona and Georgia

	Arizona Employment			Georgia Employment		
Sector (NAICS)	2003	2007	Growth Rate	2003	2007	Growth Rate
Navigation & Instrument Mfg (334511)	8,143	8,416	3%	390	303	-22%
Aerospace Manufacturing (3364)	26,804	27,426	2%	16,376	19,012	16%
Air Transportation (481)	14,374	16,229	13%	38,670	38,656	0%
Support Services for Air Transp. (4881)	5,260	5,747	9%	3,543	4,583	29%
Flight Schools (611512)	898	1,164	30%	652	763	17%
National Security (982210)	8,332	8,504	2%	27,173	27,695	2%
TOTAL	63,811	67,486	6%	86,804	91,012	5%

Overall, Oklahoma aerospace sectors added about 24 establishments from 2003 to 2007, a six percent growth compared to the state's nine percent overall firm growth rate. Wages grew between 11 percent and 19 percent in most sectors, reflecting the overall growth rate of wages in the state.

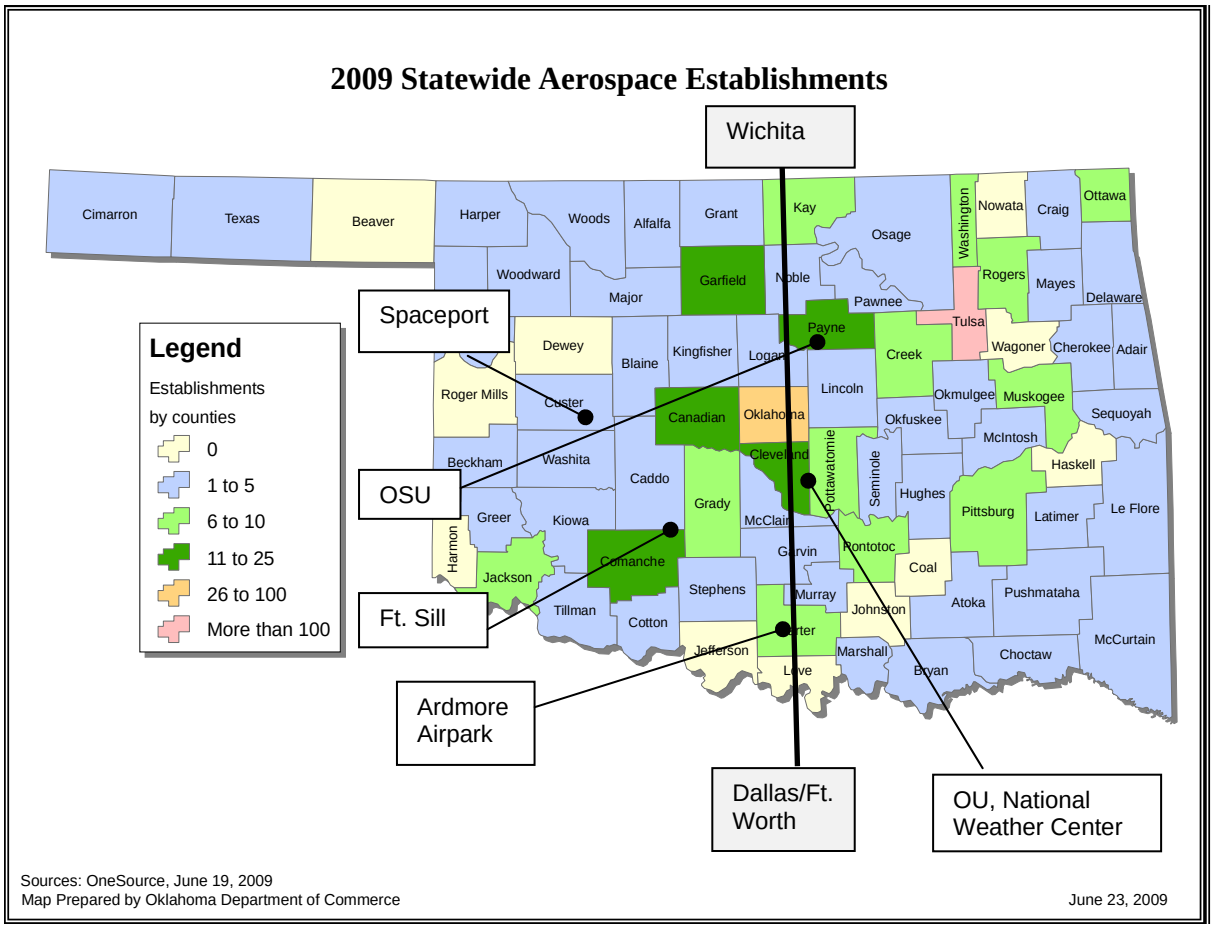
Table 3. Oklahoma Establishments and Wages in Selected Aerospace Sectors

	Oklahoma Establishments			Annual Wages		
Sector (NAICS)	2003	2007	Growth Rate	2003	2007	Growth Rate
Navigation & Instrument Mfg (334511)	7	5	-29%	$47,198	$52,325	11%
Aerospace Manufacturing (3364)	66	80	21%	$52,664	$59,037	12%
Air Transportation (481)	60	71	18%	$48,948	$56,711	16%
Support Services for Air Transp. (4881)	163	163	0%	$40,449	$48,095	19%
Flight Schools (611512)	28	33	18%	$47,654	$56,747	19%
National Security (982210)	57	51	-11%	$51,552	$61,439	19%
TOTAL	381	403	6%			

Source: Bureau of Labor Statistics

Figure 2 shows the location of aerospace establishments across the state, with Tulsa and Oklahoma shown as the two dominant counties. The next tier counties, for the most part, lie along the I-35 corridor which is anchored by two large aerospace metro areas: Wichita, KS and Dallas/Ft. Worth, TX.

Figure 2. 2009 Oklahoma Statewide Aerospace Establishments



Tulsa's aerospace industry is anchored by American Airlines MRO which employs approximately 7,000 and is deemed to be the largest commercial aircraft overhaul facility in the world. Lufthansa Technik is a significant global business jet MRO, and it has a modification/completion center located in Tulsa.

The military MRO industry is centered on Tinker AFB in Oklahoma City, with defense contractors such as Boeing, Northrop Grumman, and Pratt and Whitney supporting military MRO activities there. Engineering service provider ARINC and machine shops such as Profab provide supply chain support. Though primarily in the commercial MRO market, 3rd party MRO provider AAR is also located in Oklahoma City. The FAA's Monroney Center also provides depot level repair services for more than 28,000 National Airspace System facilities around the world.[2]
An additional significant asset is 8,000 acres of developable property adjoining Will Rogers World Airport.

[2] *The Journal Record*, April 4, 2007

Tulsa is also home to several large aerospace manufacturing OEMs. Spirit AeroSystems, providing structures, components, and propulsion products, employs approximately 2,200 individuals. Nordam employs approximately 2,000 and produces, among other things, nacelles and composite structures. Flight Safety Systems, a developer of flight simulation training systems as well as an operator of flight training centers, employs about 750 people in the state.[3] Tulsa Airport has developable land contiguous to its air facilities, which is a significant asset.

Oklahoma has vast capabilities in aerospace training, primarily because of the FAA Mike Monroney Aeronautical Center. One of its primary missions is to train air traffic controllers, and approximately 15,200 controllers pass through the facility every year. The Center also trains 4,600 management and executive level leadership students annually.[4] The Department of Transportation's Transportation Safety Institute is located in Oklahoma City and provides 16 aviation safety training courses in instrument flight procedures and accident investigation management.[5] The U.S. Customs and Border Protection Air and Marine National Air Training Center, also in Oklahoma City, provides tools and training for pilots and crew members. The FAA pilot school database shows Oklahoma to be tied for 17th in the nation, with nine flight training schools. For aircraft mechanic schools, Oklahoma is tied for 6th place with Arizona and Georgia, each state housing six schools.

An important asset supporting Oklahoma's aerospace research is the Ft. Sill testing facility associated with Oklahoma State University's University Multispectral Laboratory (UML). This facility has access to restricted airspace up to 40,000 ft and a 2200 ft long runway that will enable the flight of UAS without the need to go through the FAA's cumbersome Certificate of Authorization process. Other aerospace related assets include the Ardmore Airpark, an intermodal transportation facility located along the I-35 corridor across the Texas-Oklahoma border from the Dallas/Ft. Worth area, with a 9,000 ft. runway, rail service directly to the facility, and 1,000 acres available for development, as well as the Oklahoma Space Industry Development Authority (Spaceport), one of only 6 licensed spaceports in the U.S. The Spaceport has a 13,500 ft. long, 300 ft. wide runway, one of the longest runways in the U.S. The increased width of the runway provides an additional safety factor for take-off and landing tests of new aircraft.

2.2 Oklahoma Adjacent Industries: Energy and Agriculture

Oklahoma has a history of strength in fossil fuels. It is one of the top natural gas producing states in the US, touting approximately 10 percent of the nation's production and 12 percent of the country's largest natural gas fields.[6] Chesapeake Energy Corporation in Oklahoma City is the "number one independent producer of natural gas in the nation and the most active driller of new wells in the U.S."[7] Devon Energy Corporation, another leader in oil and gas exploration and the largest domestic production company, is also headquartered in Oklahoma City. Conoco-Phillips, a $143 billion energy company, has facilities in Ponca City and Bartlesville.

Petroleum strengths extend beyond resources and production; Oklahoma's technology, engineering and research are also valuable assets. The University of Oklahoma's petroleum engineering program (Master's in Natural Gas) and University of Tulsa's petroleum engineering department are two of only 26 programs in the US[8] with additional strong programs at Oklahoma State University.

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[3] Interview: Flight Safety, Inc.
[4] Interview: FAA
[5] Transportation Safety Institute, "About TSI"
[6] Energy Information Administration, State Energy Profiles
[7] Chesapeake Energy Corp. website
[8] Society of Petroleum Engineers

Related to the industry, Oklahoma has been involved with the testing of natural gas-derived synthetic jet fuel at Tinker AFB for the B-52 and KC-135 aircraft. The Air Force has implemented a certification program for its aircraft to use synthetic fuel derived from natural gas.[9][10] Tinker AFB began testing the synthetic fuel in 2006, starting with the B-52 and continuing with the KC-135.[11] Syntroleum, a Tulsa Fischer-Tropsch technology company, is one of the US leaders in synthetic fuel technology, including the gas-to-liquids (GTL) technology for natural gas-derived synthetics. It was the first company to supply synthetic fuel to the Air Force. Syntroleum is now building a bio-based synthetic fuel plant in Louisiana.[12]

In addition to traditional petroleum-based fuels, Oklahoma is also focusing on bioenergy. The Oklahoma Bioenergy Center is a research and economic development organization that partners with the University of Oklahoma, Oklahoma State University and the Noble Foundation to advance development of cellulosic ethanol and biodiesel from crops like switchgrass, sweet sorghum and milo, and from natural oils like sunflower seeds and canola.

Three scientists at The Samuel Roberts Noble Foundation in Ardmore, Oklahoma received a combined $1,225,152 from the National Science Foundation (NSF) and state research funds through the Oklahoma Experimental Program to Stimulate Competitive Research (EPSCoR) to begin new research and examine evolving aspects of switchgrass as a potential bioenergy crop. The Noble Foundation is a member of the Department of Energy's BioEnergy Science Center, led by Oak Ridge National Laboratory.

2.3 Aerospace Innovation Compared to Competitor Regions

A review of project awards for national Small Business Innovation Research and Small Business Technology Transfer programs showed that Oklahoma had 315 total awards for 1983-2008. By total dollars awarded, Oklahoma ranks 31st in the country. In aerospace related awards from NASA and the Air Force, Oklahoma climbs to 25th in the country at a total of $18,929,216. This compares with benchmark states Georgia at 22nd place at a total of $43,116,499, and Arizona in 17th place at a total of $57,655,736. Figure 3 below shows award trends for the last five years for these three states. Oklahoma, while awarded lower dollar amounts than the other two states, shows a slight upward trend.

A review of the Oklahoma aerospace related SBIR and STTR project technologies reveals that 25 percent of the aerospace related awards are for MRO-related technologies. Examples include "Reusable Internal Mandrels for Composites Repair or Fabrication," "Advanced MRO Multi-Echelon Planning and Scheduling," and "Low Cost Curing and Repair Process for Composites." Companies winning multiple awards include Nomadics (ICx Technologies), Anautics, Aeromet (now L-3 Communications), Zivko Aeronautics, Design Intelligence, and Precision Design. Veracity Technology Solutions, though not listed as winning SBIR or STTR awards, is earmarked to win $2 million in the Senate mark-up of the FY10 Defense Authorization Bill. This is for an advanced ultrasonic inspection system for aging helicopter rotor blades, another MRO supportive technology.[13]

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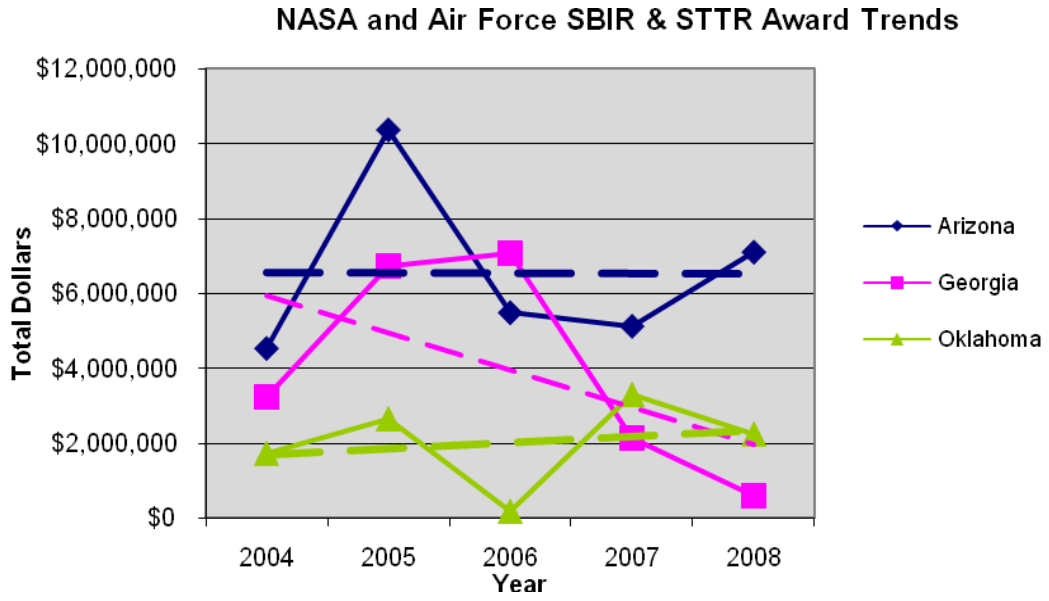
[9] Flight Global, US Air Force to use synthetic fuel across fleet by 2011, July 13, 2007
[10] U.S. Air Force, Sheppard officials test synthetic fuels, June 6, 2009
[11] Air Force officials test new constant-pressure fuel system, June 27, 2009
[12] Syntroleum Press Release, "Initial Construction Underway on Dynamic Fuels Plant," Jan. 13, 2009
[13] Capitol Hill Press Release, "Senate Committee Completes Defense Authorization Bill," June 26,2009

Figure 3: SBIR/STTR Awards



Source: U.S. Small Business Administration Tech-*Net* database.

In aerospace innovations (as measured by patents), Oklahoma does not rank highly. In a review of patents in classification code 244, Aeronautics and Astronautics, Oklahoma ranked 33rd with a total of three patents granted from 2004-2008. Arizona was ranked 3rd with 93 patents, and Georgia was ranked 21st with 13 patents. A review of both patent applications and patents with 244 listed as a primary or secondary classification code for the 1999-2009 timeframe shows that Nordam dominates this space, with 11 patents related to nacelles, thrust reversers, or engine components.

An analysis of patents assigned to the University of Oklahoma shows the top number of patents to be in the areas of chemistry, molecular biology, and drug compositions. No aerospace technologies are given, though there were some measurement and testing technologies. A review of Oklahoma State University's patents also showed a predominance of drug compositions and molecular biology as well, but optics and optical sensor related technologies were also high on the list.

In the UAS arena, Oklahoma State University student design teams have successfully competed in the American Institute of Aeronautics and Astronautics Student Design/Build/Fly Competition for the last five years, placing in the top four out of approximately fifty teams every year (including five teams from Arizona and one from Georgia). The University of Oklahoma won 6th place in the same competition last year. In other unmanned industry competitions, however, Oklahoma universities are not represented. The Association for Unmanned Vehicles International (AUVSI), the world's largest non-profit unmanned vehicle organization with industry, government, and university membership, sponsors several annual UAS competitions. Oklahoma universities are not shown as participants in any recent events. In other competitions that promote unmanned, robotic technologies (ground and water-based as well as aerial) such as the past DARPA Grand Challenges, Oklahoma has no presence. There are no AUVSI industry chapters in Oklahoma, but there are two in Georgia and one in Arizona. Oklahoma did make a presentation at the 2007 AUVSI Unmanned Systems North America Conference.

The University of Oklahoma has research capabilities in vehicle dynamics, controls, robotics, and intelligent systems, all of which are important when it comes to solving current UAS technical challenges. Likewise, Oklahoma State University has strong research capabilities in the design of long-endurance unmanned air vehicles (UAVs), micro air vehicles (MAVs), and nano air vehicles (NAVs). The institution also has research capabilities in plasma research for MAV and NAV applications, as well as a robotics laboratory and research program.

National and International Market Assessments

As a first step toward understanding the effects of the market forces on the Oklahoma aerospace industry sector, the team delved into the current and forecasted market characteristics for each of the sectors of interest. The MRO and OEM markets are currently contributing significant dividends to the state's economy. The third area, the UAS market, is more of an emerging opportunity for Oklahoma designated by client organizations as an interest area for exploration. The following sections provide brief overviews of market size data, market trends, and opportunities that have relevance to Oklahoma.

2.4 Maintenance, Repair, and Overhaul

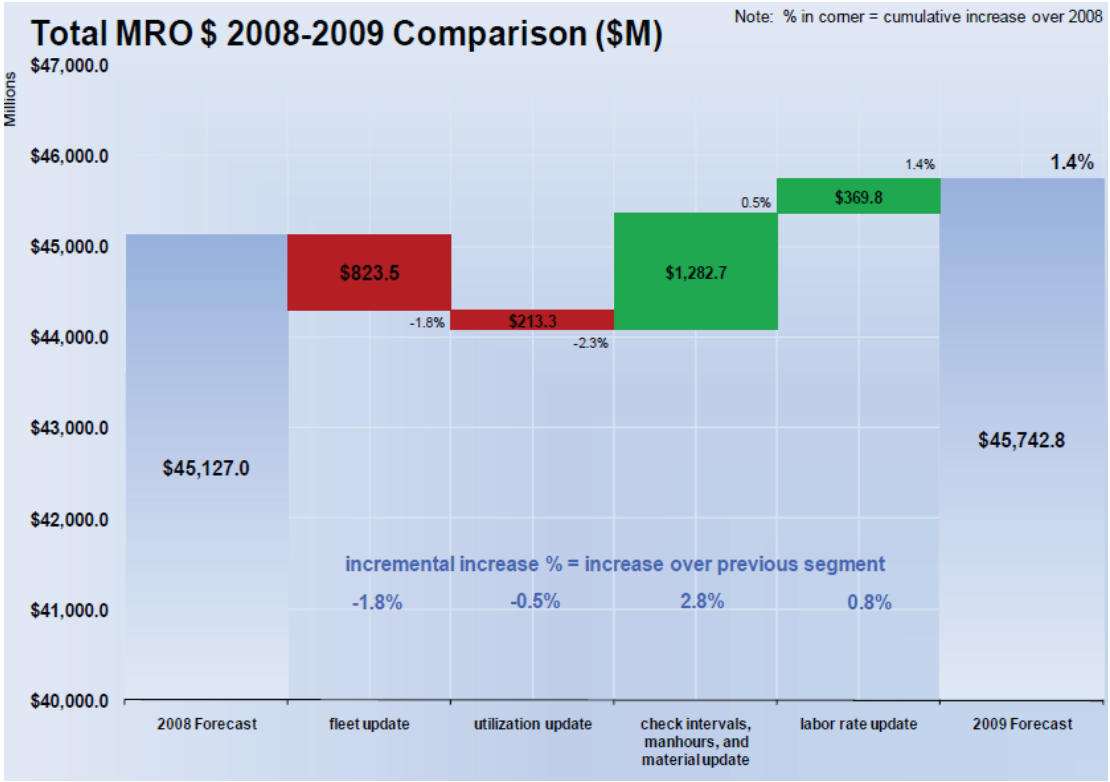
MRO markets are characterized by commercial and military segments serviced by OEMs, independent providers, and by the airline operators themselves. The market is dominated by engine servicing and repair, which represents about 40 percent of the market. Heavy maintenance and repair accounts for 22 percent, line work 20 percent, and components 18 percent. Line work is standard terminology referring to maintenance work done on the aircraft while it remains in service or on the line. Typically this is done overnight and includes cabin maintenance, routine engine maintenance, and clearing of log book notations of minor anomalies.

Military and commercial segments share equally in 92 percent of the MRO market with rotorcraft and general aviation/business jets representing the remainder.

Market Size and Growth of MRO

The April 2009 forecast by TeamSAI (shown below in Figure 4), describes the various factors affecting the MRO market as offsetting, resulting in nearly flat growth in 2009 compared to 2008 when the total market value was $45.1 billion. North America represents 35 percent of the global market with Europe claiming 29 percent and Asia/Pacific 17 percent. In the past year, material and labor costs, along with check intervals and materials upgrades, experienced market increases while fleet upgrades and aircraft utilization rates decreased from 2008 levels.

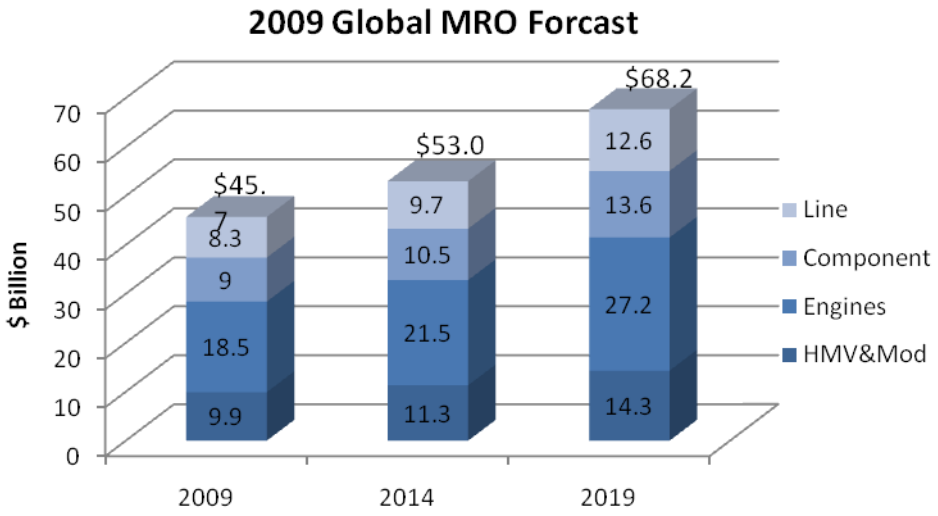
Figure 4. Global MRO Market, 2008 Compared to 2009 Forecast



Source: TeamSAI, Inc. The Global MRO Forecast; Searching for Direction in a Down Market; 2009–2019 (April 2009) http://tinyurl.com/muq96t

Looking forward to the next decade, the MRO market should resume its growth pattern, climbing at an average rate of 4.1 percent compound annual growth rate CAGR as shown in Figure 5.

Figure 5. Global MRO Market, Forecast through 2019



Source: TeamSAI, Inc. The Global MRO Forecast; Searching for Direction in a Down Market; 2009 – 2019 (April 2009)

The global MRO market figures mask the weakness in the North American market. Compared to the rest of the world, which enjoys positive growth, MRO business in North America is forecast to be relatively flat for the next five years. TeamSAI predicts that after 2014, all regions of the world will demonstrate decent growth rates, with Asia/Pacific leading at five percent growth and 15 percent market share.

Trends in MRO

Customers have many options: aircraft can be flown virtually anywhere for MRO services. Military aircraft, of course, are an exception for now. However, no one in the MRO business can be complacent with its position in the industry.

It is projected that the U.S. share of the MRO market will decrease. Team SAI, Teal, and others show that the U.S. MRO business, while growing, is dropping in share, dropping from 35 percent of the world market in 2009 to less than 28 percent in 2019.

MRO trends that were identified in interviews and market research include:

- Outsourcing of MRO services, including line maintenance, by airline operators: The operators find cost savings, improved flexibility, and a responsiveness that serves their immediate needs. Going forward, many analysts anticipate that this trend will continue. Benefactors include both OEMs, who continue to add MRO capacity, and independent operators. TeamSAI identifies technical support services, including engineering and logistical support, as an emerging and growing element in the outsourcing equation for operators.
- Pressure on cost and productivity: In both military and commercial MRO operations, the reality of the current economy is driving MRO strategies by measuring outcomes against financial metrics—so-called lean processes. Regulatory and safety requirements are foremost, but no other drivers come close to the financial issues faced by the operators and military decision makers.
- Increasing automation: Closely related to the cost issue is the trend toward automation. Demand for decreased labor costs and increased reliability and productivity will continue to push for more automation.
- Increasing amount of composites: In both military and commercial aircraft, use of composite materials is rapidly increasing. Nondestructive examination, diagnostics, and repair techniques are not yet fully mature, nor has a national leader emerged in the MRO field.
- Increasing complexity of engines: As engine complexity increases, so does the need for skilled labor, sophisticated engine health monitoring, diagnostics, and associated maintenance and repair facilities and procedures, which will drive up labor and parts costs for future maintenance cycles. On the other hand, current generation engines are being serviced at shorter cycle times with less labor, making the engine MRO market increasingly competitive as the new engines work their way through warranty periods. Exploration of development of an engine center of excellence would be worthwhile, including stakeholders such as the airline operators, OEMs, MRO suppliers and parts/subsystem suppliers. A value add to the center would be an advanced modeling and simulation capability with virtual training features.
- Increased need for electronics and avionics technicians: The downstream effects of National Air Space changes caused by the NextGen program will require replacement of flight control systems and communications equipment. Also, as in-flight entertainment

and communications systems' reliability, safety, and technology obsolescence issues prevail, repairing, replacing, or removing these systems will be required.

- Green trend: While not yet a determining driver, the trend toward incorporation of more environmentally friendly processes in greener facilities is becoming more prominent. From the design and construction of LEEDS Platinum hangars to the implementation of solvent-free cleaning processes, the supplier who has demonstrated strength in these areas will eventually have the upper hand, provided cost structures are equivalent. Green applies to aircraft design as well, with more efficient, low emission, low noise engines and lightweight materials and structures, primarily through the use of composites. Europe is leading the way in this trend through the European Commission's Clean Sky Joint Technology Initiative, and the green goals set by the Advisory Council for Aeronautics Research in Europe (ACARE). The U.S. military is under increasing pressure to make significant advances in this area, especially in fuel efficiency and lowered emissions.

Oklahoma Opportunities in MRO

Oklahoma seeks to grow from its strength and not merely maintain its position. Fortunately, the MRO industry is not static and driving toward the lowest common denominator, nor is it being transformed into a commodity market. Opportunities are apparent in several areas of the industry:

- The Oklahoma Aeronautics Commission estimates that Tinker annually outsources approximately $5 billion in contracts for MRO work; roughly only $500 million of that work is provided by Oklahoma companies. Capturing a larger share of those MRO contracts could provide for a growth opportunity for statewide companies.
- Independent MROs have the opportunity to bundle their offerings, making them more attractive to operators for getting more done in one spot—reducing costs, downtime, and administrative overhead. One-stop MRO shops, especially those who are able to bring all components into one location, are attractive. In addition, as aircraft manufacturers have continued to design for conformed cockpits and other systems, the opportunities for consolidation of MRO services have improved. "Conformed systems" refers to the commonality of systems from one model to another across the Airbus fleet or the Boeing suite of aircraft. The manufacturers do this to make it easier for maintenance: parts costs are lower, design is faster, and pilot training/recertification is much more efficient.
- Europe has the lead in this area at present. TeamSAI claims that this is a major need in North America. Oklahoma's commercial MRO industry has the opportunity to create the one-stop MRO experience for customers through company partnerships and a coordinated effort to integrate supply chain processes.
- Opportunities in intelligent systems, remote condition monitoring, predictive maintenance, and more integration between routine and MRO services are emerging and will become much more important with next-generation aircraft from Airbus and Boeing. Well-designed systems that become embedded in the operators' procedures will be an advantage for both the operator and the MRO provider in terms of increased reliability, lower maintenance costs, reduced downtime, and increased safety. This will advantage anyone that ties up an operator with an agreement to maintain their equipment and their intelligent systems.
- The UAS MRO market would likely be represented by refurbishment of only the large airframes, sensor packages, and propulsion units for larger, more expensive flight aircraft: Predator/Reaper (~$4.5 million per copy) and Global Hawk (~$35 million each).

The 2009 Predator fleet stands at 195 with an additional 28 Reapers (Predator B). Fewer than 20 Global Hawk production aircraft have been delivered. The Air Force plans to operate a fleet of 54 after the next-generation aircraft are delivered over the next several years. MRO requirements for UAS vehicles are not as comprehensive as for crewed vehicles; nevertheless, these complex and expensive articles require MRO service to achieve maximum useful life value. Whether small or medium-sized unmanned aerial vehicles (UAVs) will present a viable market in the current mix of UAS, or whether prospective commercial applications will offer MRO opportunities, deserves additional study. Opportunities for military UAS MRO are not strong at this time since the major systems are designated for MRO service in other locations.

- The MRO market is tightly wrapped around cost, service efficiencies, and turnaround time. Labor rates are not the only factor in the cost equation. Automated and efficient processing can overcome lower labor rates, but the combination of efficiency and low labor rates are emerging as the standard of comparison, especially in international competitors. Regulatory oversight, workforce training, and quality are sometimes questioned for those competitors, but it is only a matter of time before all of those issues are ironed out, especially when partnerships with U.S. based firms are becoming commonplace (e.g., Timco Aviation Services partnership with Coopesa in Costa Rica). Oklahoma must continue to implement process efficiency programs, such as Lean Manufacturing, to remain competitive.
- Green initiatives are becoming more attractive to operators as well. Service providers that offer lower carbon footprint, lower volatile organic compound (VOC) emissions (painting, cleaning), advanced engine washing techniques, and other environmentally friendly facilities and processes will have slight advantages now and more in the future as the norms shift.

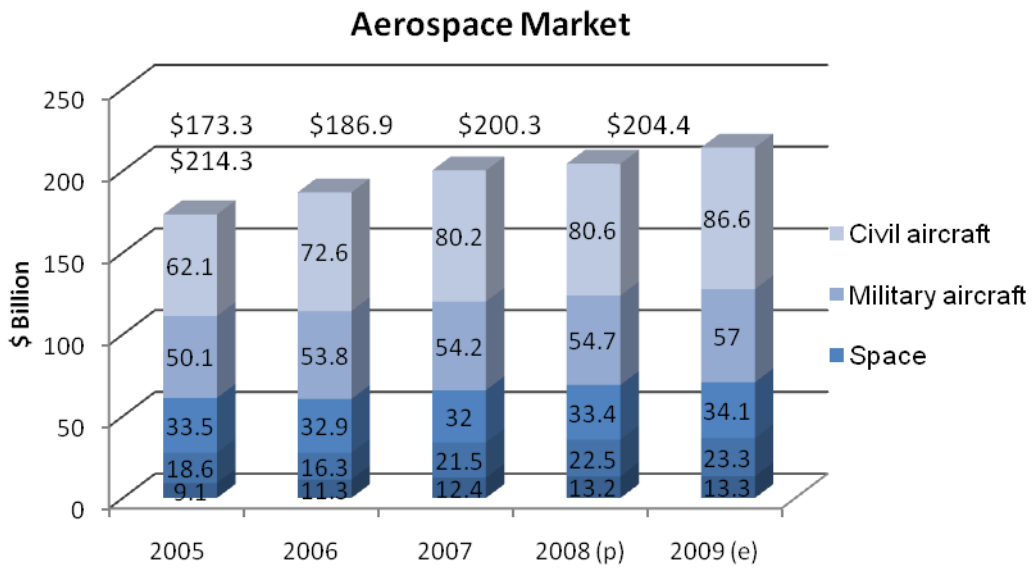
2.5 Aerospace Original Equipment Manufacturing

The U.S. aerospace OEM industry is comprised of missiles (6.5%), civil aircraft (39.4%) and military aircraft (26.8%), space launchers and vehicles (16.3%), and other related products (11.0%). Vertically sliced, these segments consist of component manufacturers, systems integrators, and airframe manufacturers, all of whom are served by various supply and distribution networks.

Market Size and Growth in OEM

Of the major global industries, the aerospace industry has weathered the global economic downturn as well as any. Global sales for 2008 were $674.6 million, with U.S. sales representing about 30 percent of the total, or $204.4 million. U.S. sales for 2008 showed a 2.2 percent year-over-year increase, and 2009 growth is forecast to be 4.4 percent (all figures cited by the Aerospace Industries Association [AIA] in their Year-End Review and Forecast). Figure 6 shows the industry breakdown for the past four years and the 2009 forecast by market sector. The major prime manufacturers are represented in Figure 7, along with their reported 2008 production.

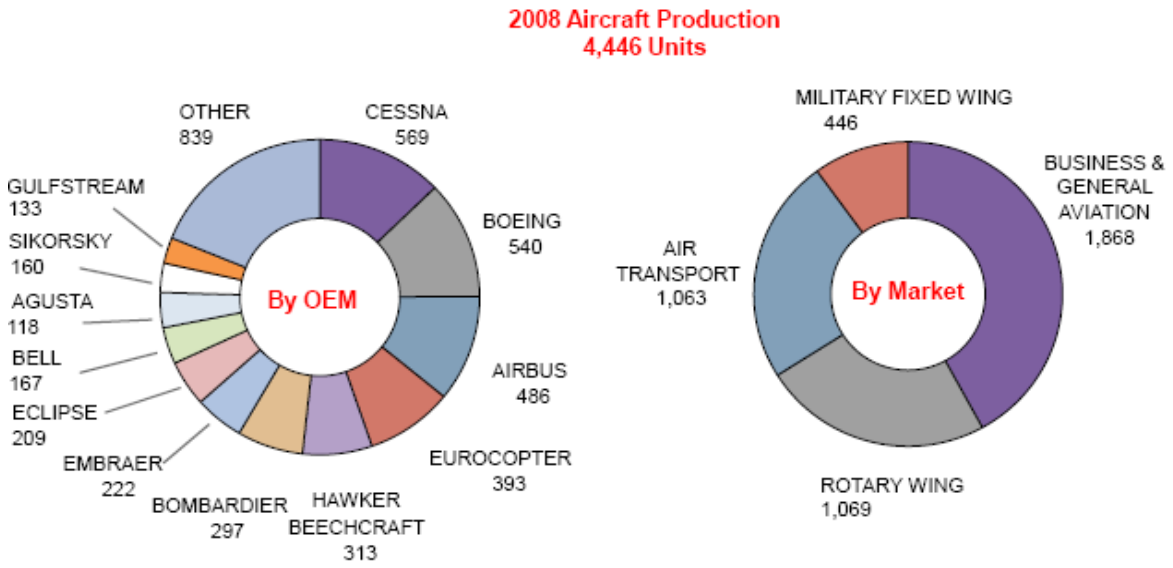
Figure 6. U.S Aerospace Market



Source: AIA and the Teal Group

The major prime manufacturers are represented in Figure 7, along with their reported 2008 production.

Figure 7. 2008 Aircraft Production by Major OEMs



Source: AeroStrategy

The segments of the aerospace OEM market that affect Oklahoma the most are civil and military aircraft and related products. These segments, while affected by the global economic downturn,

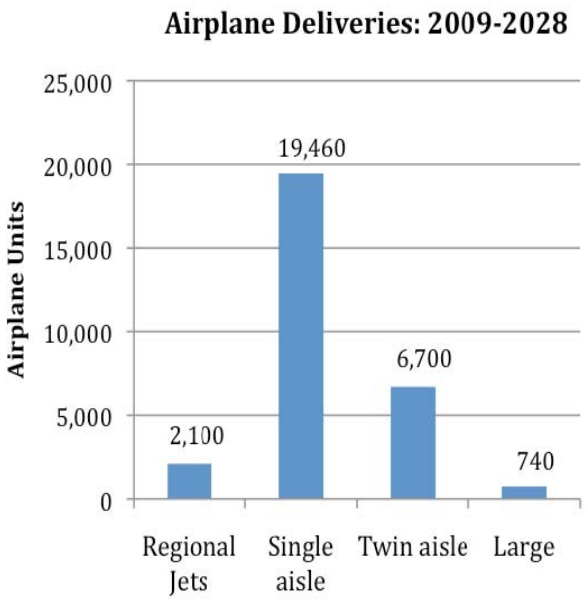
are expected to continue their general growth trend with little effect. Boeing is working on a seven-year backlog, and Airbus has a six-year backlog. Both have slowed production lines for 2009 and may continue that trend through 2010 or 2011, but analysts expect this hiatus to be temporary.

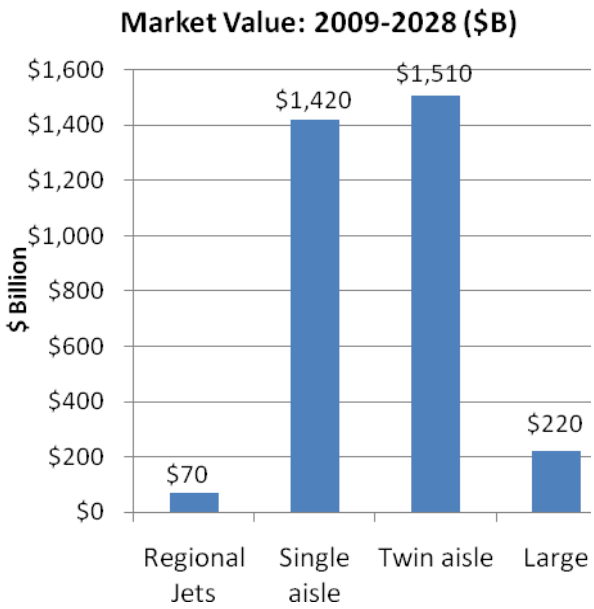
Boeing's projections, shown on their website and reproduced in Figure 8, indicate an average fleet growth rate of 3.2 percent and cargo growth rate of 5.4 percent from 2009 through 2028. They expect the global market from all aircraft manufacturers will absorb 29,000 units valued at 3.2 trillion USD (2008) by 2028.

Business jets and general aviation, on the other hand, have not benefited from generous backlogs and continuing sales. Backlogs had started to build before the economic slowdown, but they have quickly eroded with order cancellations, order delays, and recent deliveries. Analysts tend to agree that deliveries will decline or flatten through 2012 before resuming a growth pattern. It may be 2017 or 2018 before the segment achieves its 2008 level of sales.

The aircraft engine segment, led by General Electric, Pratt and Whitney, Rolls Royce, CFM, and International Aero Engines, was predicted last year by Forecast International to sell $272.7 billion in total over 10 years beginning in 2008. Over 90 percent of these sales are comprised of turbo-fan engines.

Figure 8. Boeing Forecast for Passenger and Cargo Aircraft





Source: Boeing Website (http://www.boeing.com/commercial/cmo/)

Trends in OEM

There is a well-established trend in aerospace manufacturing toward internationality. For example, the Airbus A380 is manufactured in countries all over the world, including at least four U.S. sites employing almost 1,000 people. In all, Airbus claimed in 2003 to support 120,000 contractor jobs in the U.S., having an impact of about $5.5 billion. U.S. companies make up

about 50 percent of Airbus aircraft by material and value. Boeing uses the same approach, building fully 70 percent of the 787 Dreamliner offshore, including the wings, which are made in Japan. Recently, though, Boeing has purchased two fuselage component assembly facilities from supplier Vought Aircraft Industries, demonstrating the need to gain better control of its supply chain.[14]

The days of locking up the majority of the manufacturing jobs when a community attracts the OEM are gone. Multinational companies work very hard at developing the best value for their product design, fabrication, and customer, regardless of the location of the source of expertise. On the other hand, as one interviewee pointed out, qualifying as a supplier is an ordeal that is time-consuming and expensive for both the supplier and the buyer. Therefore, once the qualification is achieved and a supplier position is established, it is usually solid for the long haul.

Other trends identified in interviews and market research included the following:

- Green design and fabrication are driving more use of composites, better processes, more sophisticated design and analytics, and holistic and sustainable approaches to aircraft design/build/maintain/retire cycles. Europe is pushing hardest, followed by U.S. manufacturing, then U.S. government (Department of Defense [DoD]).
- Next generation engine designs are more complex, requiring more parts and supplies.
- Next-generation aircraft contracts require closer cooperation with other companies (especially foreign entities), which in turn necessitates that U.S. companies become much more aware of export control requirements.
- New systems will come online for aircraft life support, avionics, weather, and aircraft and engine health monitoring. These systems will require increased levels of sophistication, more diverse and highly trained skills, and additional levels of integration with the client's data management systems, all of which open up opportunities for new markets for device and systems suppliers.
- Inflight entertainment and communications equipment will require sophisticated electronic technicians for their repair and maintenance.
- New fuels will be available and competitive, including biofuels and synthetic fuels.
- Air and ground traffic control systems will be transformed through the NextGen program, as new hardware will be required for ground and airborne systems, and new demands will be placed on workforce training for air traffic control towers and support systems, as well as for changes to flight simulation and virtual training systems; this could open new avenues of cooperation between the FAA and Oklahoma's CareerTech system.
- Composite parts manufacturing and repair methods continue to evolve at a rapid pace. Suppliers who understand the engineering aspects are highly valued compared to the fabricators who just follow the drawings. Concerns for composite materials include damage avoidance/mitigation due to corrosion (galvanic w/metals) and subsurface damage from impact or strain. For companies in the business, staying current or ahead of the curve in this area will be critical to survival.
- The increased use of composites is spurring an increased use of titanium because of the metal's high strength, light weight, and galvanic compatibility with carbon fiber-reinforced composites.
- Airframe manufacturers are increasingly looking to their suppliers to provide design as well as traditional fabrication services.

[14] *Market Watch*, "Boeing to buy Vought facility to improve 787 program," July 7, 2009.

Oklahoma Opportunities in OEM

Based on the trends in the OEM segment of the aerospace industry, opportunities are not difficult to identify. They are found at the leading edge of design and fabrication, and characterized by a frenzy of innovative activity where no clear winners have emerged. Often the opportunity spaces are rich enough to allow for multiple winners. As stated above, the aircraft manufacturers, especially those in the commercial passenger and cargo markets are looking to their supplier base for more innovation than was previously done in-house. The combination of outsourcing of major portions of the aircraft coupled with collaborative innovation provides the best possible scenario for companies to seize new market opportunities.

- Companies place high value on engineering and design expertise among their supplier base. As customers seek more design content from their suppliers, the level of experience and capability will become more important in the competition for contracts. Oklahoma should broaden their recruiting targets, going beyond the isolated manufacturing divisions of candidate OEM companies to capture their engineering and design divisions as well. Successful recruitment or growth in corporate engineering and design presence in state will be beneficial to education and workforce initiatives as well.
- Lean and green manufacturing facility and process improvements are often coupled. Organizations that will attract business will operate in an environmentally responsible way while demonstrating low-cost methods to drive down unit costs for the customer.
- Research organizations, the Air Force, and other stakeholders need to push the edge of the envelope in developing alternative fuels. States like Oklahoma with fossil and biofuel resources have the opportunity to make major moves on the technology to commercialize a viable alternative fuel. The opportunity for Oklahoma is amplified by the presence of Tinker Air Force Base and the interest in alternative fuels for the DoD, by Oklahoma's natural gas and biofuel resources, and by innovative technologies developed and acquired by the Tulsa company, Syntroleum.
- As mentioned earlier in the MRO segment discussion, the composite material field in some ways is more nascent than mature. While other regions, such as the Wichita area, have established positions in some aspects of the field, there is no clear leader in the comprehensive cradle-to-grave perspective of the design, fabrication, use, examination/testing, repair, and disposal of these materials for aerospace use. With Oklahoma's strong industry capability in composite repair and damage inspection, it has the opportunity to define and establish a center of excellence in applied aerospace composites.
- With the next-generation engines entering the market, there will be a range of needs for fabricators, component suppliers, and other supply chain entities. All of these companies in the supply chain will need to be contributors as well as suppliers to future enhancements, troubleshooting, and customer satisfaction. Innovative companies that understand their role and provide extraordinary service will capture those opportunities.
- Research and development opportunities will be plentiful. A selective approach that will support the overall Oklahoma aerospace strategy will be best. Oklahoma must take advantage of its research assets to underpin its innovation efforts in this industry. If not, many opportunities will be lost.
    - If the FAA facility needs technology support for training, an opportunity may emerge for the CareerTech system in providing advanced training techniques that use tools such as a virtual reality platform or Web 2.0 applications.
    - Composite materials, especially in the examination and repair area, continue to need innovative research and development.

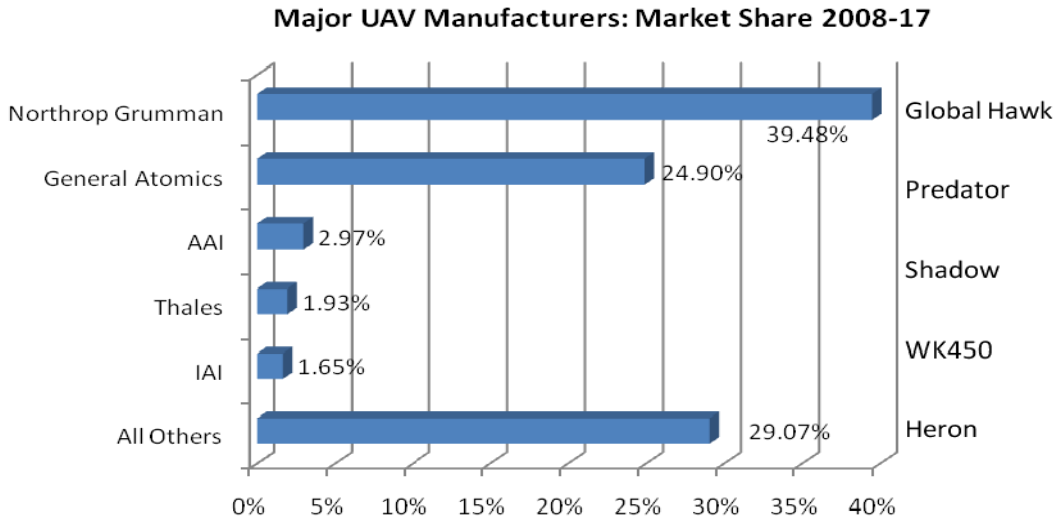
- Manufacturing methods that reduce labor and waste will always be in demand. For example, a part manufacturer may implement innovative collaborate work environment software to reduce development time by enabling virtual prototyping and model sharing with the systems integrator. Design software can be fully integrated with the manufacturing environment to move designs from development to fabrication in rapid fashion.

2.6 Unmanned Aircraft Systems (UAS)

Unmanned aircraft systems (UAS) are air vehicles equipped with sensors and software that enable the craft to fly without a human pilot onboard. UAS in use today are typically piloted by a human remotely, but the technology is headed toward allowing greater autonomy such that the aircraft takes off, flies, and lands itself. In addition to the sensors and software that control the aircraft, UAS contain payloads that include sensors for reconnaissance, surveillance, targeting, or detection of biological or chemical weapons, cargo for transport to troops in remote areas, and weapons for deployment in conducting time-critical or dangerous missions.

The UAS market is predominantly a military applications market. Commercial applications await resolution of practical and regulatory barriers. Civil government applications such as border patrol and natural disaster assistance are in the current mix at about 2 percent of the UAS usage, but flying under waivers or special orders issued by the Federal Aviation Administration (FAA). U.S. companies have a greater than 60 percent share of the UAS market and could gain control of an additional 5–10 percent over the next decade. Figure 9 shows that Northrop Grumman and General Atomics Aeronautical Systems are the top U.S. players, dominating the market at 65 percent. No other company has more than three percent of the market. There are about 200 UAS manufacturers in 43 countries, including Iran and North Korea. In addition, about 100 U.S. companies and organizations are involved in UAS research, development, or manufacturing.

Figure 9. Percent of UAS Market Share



Source: Forecast International

Market Size and Growth in UAS

UAS market forecasts are not all in agreement. A 2009 study by the Teal Group put the current UAS global market size at $4.4 billion. They predict it will rise to $8.7 billion in 10 years, totaling $62 billion in the decade. Worldwide, nations will spend another $20.8 billion on research and development through 2017. Production will exceed 7,000 units in 2009–13, largely due to purchases of man-portable systems (under 20 lbs). The U.S. represents 61 percent of the purchases and over 70 percent of the development in this market, with most of the impetus coming from DoD. Other estimates by Forecast International and G2 Solutions differ, but assumptions and coverage differ as well. The Teal figures provide a general notion that the market is significant and growing. Importantly, they do not anticipate a large upswing in UAS usage for nonmilitary applications in the near future.

Moiré, Inc. of Issaquah, Washington predicts a steady growth in the U.S. commercial market. They stated in their December 2007 forecast:

> *"Moiré projects the annual civil UAS market value will have grown to $560M in 2017. This represents an 11 percent share of the total US UAS market. Approximately 1,500 civil unmanned aircraft are projected to be in service in the US; 85 percent will be small, low altitude vehicles weighing less than 20 lb. Annual production in 2017 is projected to be 900 unmanned civil aircraft."*

Trends in UAS

In the military sector, the U.S. Department of Defense continues to invest aggressively in unmanned systems and related technologies. Table X below shows the President's FY09 budget for unmanned systems. In aerial systems, the estimated budget in FY09 is $3.4 billion, the majority of which is for procurement. Starting in FY09, the trend for research, development, test, and evaluation investment declines, showing the transition to procurement and increase in operations and maintenance funds.[15]

Table 4. President's Budget for Unmanned Systems: 2009-2013

PORs FY09PB ($M)	Funding Source	FY09	FY10	FY11	FY12	FY13	Total
UGV	RDT&E	$,1291.2	$747.5	$136.2	$108.7	$68.9	$2,353
	PROC	33.4	42.3	53.5	59.5	21.1	210
	O&M	2.9	3.9	3.0	12.8	10.1	33
UAS	RDT&E	1,347	1,305.1	1,076.4	894.0	719.5	5,342
	PROC	1,875.5	2,006.1	1,704.7	1,734.3	1,576.2	78,897
	O&M	154.3	251.7	249.0	274.9	320.2	1,250
UMS	RDT&E	57.3	73.8	63.2	70.1	76.9	341
	PROC	56.7	78.4	95.9	91.6	103.7	426
	O&M	5.0	4.5	11.3	13.5	13.9	48
Total		4,823	4,513	3,393	3,260	2,911	$18,900

UGV=unmanned ground vehicles; UAS=unmanned aircraft systems; UMS=unmanned maritime skystems; RDT&E = research, development, test & evaluation; PROC = procurement; O&M = operations & maintenance

Source: DOD FY 2009-2034 Unmanned Systems Integrated Roadmap

[15] DOD, FY2009-2034 Unmanned Systems Integrated Roadmap, 2009

The capability needs of the Warfighter for unmanned systems include the following priorities:

1. Reconnaissance and surveillance,
2. Target identification and designation,
3. Counter-mine and explosive ordinance disposal, and
4. Chemical, biological, radiological, nuclear reconnaissance.

Supporting these capabilities are the technologies that enable them. Figure 10 shows two key roadmaps for technology enablers in unmanned systems. The first graph shows enablers common to all unmanned systems regardless of platform. The second shows enablers specific to air vehicles.

Figure 10. Enabling technologies for Unmanned Systems (source: DoD Unmanned Systems Roadmap)

Technology Enablers Common to All Unmanned Systems

	2009 Evolutionary Adaptation	2015 Revolutionary Adaptation	2034
Power	Battery Powered	Next Gen Power Resource	Bio Mass Reactor Powered/ Opportunistic Power Grazing
Environmental Capability		Sensors to Enable Robust Weather Flexibility	Extreme Weather Capable
Signature Management	Passive	Active	Covert and Self Concealing Behaviors
Architecture	Proprietary	Standard	Standard Unlimited
World Model	Simple	Artificial	Highly Representative
Communication	Relays - Automatically Deployed		High Speed Intelligent Network Comms
Human Detection	Multi-Modal	On the Move	Biomimetic
Human Robot Interaction	Voice Control	Bird Dog/Warfighter's Associate	Hierarchical Collaborative Behaviors
Obstacle Avoidance	Sense and Avoid	Dynamic Obstacle Avoidance	

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Technology Enablers Specific to Air Systems

	2009 Evolutionary Adaptation	2015 Revolutionary Adaptation	2034
Navigation	Waypoint Navigation - GPS/INS Dependent	Waypoint Navigation - GPS Independent	Intelligent, Adaptive Navigation - GPS Independent
Obstacle Avoidance	Sense and Avoid	Dynamic	

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Technologies that support UAS include better, long-lasting portable power that will transition from the current battery power to future power technologies such as energy harvested from the UAS environment. This capability is needed to sustain longer missions. Lighter weight vehicles made from composite materials assist with power longevity. Better communications technologies will include more effective bandwidth management and data compression. Collaborative technologies that allow the UAS to interact with each other will also be needed for future systems.

One of the most needed technologies is an on-board sense and avoid system that can sense other aircraft or obstacles in the flight path and avoid them. This capability is needed before UAS can gain access to the National Airspace (NAS). The FAA has restricted UAS for civil use and is developing regulations to safely allow integration of civil UAS into the NAS.[16]

Aside from their military applications, UAS are becoming popular for civilian and commercial purposes. Civilian missions are those of nonmilitary governmental organizations, such as the police or border patrol; commercial is non-government. Civilian and commercial markets have long existed, dominated by unmanned crop dusters used extensively in Asia. The greater emphasis on security is changing this situation. In the U.S., the main barriers to expanded civilian and commercial use are:

- Lack of regulations and radio frequencies (FAA and Federal Communications Commission [FCC] jurisdictions, respectively)
- High cost of the UAS platforms (vehicle not including the payload)
- Competition from less expensive or less restricted options (e.g., crop-dusting airplanes)

Concurrently with the efforts under way to clear the barriers to commercial use, development efforts continuing to refine UAS applications include:

- Security surveillance (borders, ocean patrol)
- Earth observation and environmental science
- Agriculture
- Firefighting
- Power and gas line inspection

As the industry gains experience in developing, flying, and maintaining military hardware, it becomes better prepared to support commercial and civil applications. For example, military UAS pilots will come out of the service with flight experience that can be directly useful for those applications.

Oklahoma Opportunities in UAS

As noted above, there are many uncertainties concerning the timetable for resolving the barriers to wider use of UAS in the national air space. Opportunities for new UAS development are difficult to identify because of the crowded marketplace, with many systems already set in the DoD procurement process. Innovative technologies are sought to solve many issues, including lightweight materials, long-lasting propulsion systems, communications technologies, and obstacle avoidance sensor packages. Recent SBIR solicitations for UAS addressed technology issues at the component level, including the following topics: “Power Generation and Storage for Micro Aerial Vehicles (MAV),” “Analog to Information (A2I) Sensing for Software Defined Receivers,” “Reactive Real-time Planners for Coordinated Aggressive Maneuvers,” and

[16] DOD, FY2009-2034 Unmanned Systems Integrated Roadmap, 2009

"Swarm/agent Technology For Small Unit Scalable Effects." Sensor technologies and intelligent systems are the current need, as demonstrated by the open DARPA solicitation for a biomimetic vision sensor system for unmanned systems, as well as a solicitation from the Office of Naval Research for concepts for automating the sensing and understanding of a battlespace using multiple distributed unmanned platforms with disparate sensors.

More opportunities of interest may be found in full service, integrated, easy access test ranges. While other UAS test ranges are available at federal facilities and a few university sites, there appears to be a need for test facilities that can be accessed on short notice and have generous range and altitude flexibility for testing. Some federal facilities' schedules are fully booked with agency project tests, making the wait for outside company project tests long and uncertain.[17] When recently choosing a test site for their UAS, Canadian company MMIST cited favorable attributes for their decision included low population density, low obstacle terrain, good flying weather, low elevation, a UAV-friendly political climate, academic support, and an aerospace workforce.[18] As demonstrated in other service facility industries, a facility with the right customer-friendly business model, first-class technical support, and the requisite range requirements, could make a market impact.

2.7 Aerospace-Related Adjacent Markets

Energy security is important to the U.S. Department of Defense. The Air Force is one of the largest users of aircraft fuel in the U.S., burning approximately 2.6 billion gallons of jet fuel per year.[19] The Air Force's Alternative Fuels Certification Office has stated that plans are to supplement about 50 percent of their fuels with alternatives by 2016.[20]

Both military and commercial aviation are moving towards synthetic fuels use, with an ultimate goal of utilizing biofuels. The Defense Advanced Research Projects Agency (DARPA) recently invested $100 million in contracts to companies to create algae-based alternatives to jet fuel.[21] Continental Airlines flew a Boeing 737 using an algae-based jet fuel blend earlier this year.[22] The Navy just issued a $2.5 million contract to General Electric Aircraft Engines to test and qualify bio-fuel blends for the GEAE F414-GE-400 engine, which is installed on the F/A-18E/F and EA-18G aircraft. These will be the first to be certified to use a blend of bio-fuel with JP-5 fuel.[23]

The commercial aviation industry has joined together in the Commercial Aviation Alternative Fuels Initiative (CAAFI) organization with a mission to "enhance energy security and environmental sustainability for aviation through alternative jet fuels."[24] On June 24, 2009, a new synthetic aviation fuel specification was passed by the ASTM International Aviation Fuels Subcommittee. United plans to make the first synthetic fuel operational (paying) flight this

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[17] Interviews: Naval Air Warfare Center Aircraft Division, Office of Research and Technology Application, and NASA Dryden Innovative Partnership Program Office
[18] *Armed Forces International*, "Testing Unmanned Aircraft," Apr. 30, 2009
[19] *Reuters*, "U.S. Air Force eyes alternative fuel, slashing CO2"
[20] Air Force Link, "Sheppard officials test synthetic fuels"
[21] *National Defense*, "Military Invests in Algae-Based Biofuel," Aug. 2009
[22] *USA Today*, "Chicken parts as jet fuel? Pond scum? It's possible," Jan. 30, 2009
[23] Federal Business Opportunities, "Recovery: Bio-Fuel/JP5 Blend Engine Certification," May 29, 2009
[24] CAAFI website

summer.[25] This could represent a large market; in 2008 U.S. airlines burned about 19.6 billion gallons of jet fuel.[26]

2.8 Strengths and Weaknesses from Oklahoma's Industry Perspective

Comparing the array of Oklahoma's aerospace assets to potential market opportunities provides an overall view of the state's strengths and weaknesses. Having a strong presence in both commercial and military operations builds a solid foundation for the state. Expertise in applied technologies and operations can provide a ready-made test-bed for the desire to build the state's research assets in aerospace. Input from stakeholders in this process clearly indicates that the state's weaknesses revolve around an inability to connect the players and develop a focused and cohesive strategy for the industry.

[25] Flight International, United leads airline initiative to support synthetic fuel production plant, February 2, 2009

[26] *USA Today*, "Chicken parts as jet fuel? Pond scum? It's possible"

Table 5: Summary of Aerospace Strengths and Weakness

Strengths	Weaknesses
Overall breadth and scale of existing industry including a mix of large and small companies and markets in both military and civilian aerospace applications. Industry expertise and concentrations of employment in: Aircraft maintenance Precision manufacturing Composite repair National security Multi-skilled, highly motivated workforce with an exceptional work ethic, producing high quality output. Cost competitive to operate business: low cost of living, low taxes, low wages. Research base in aerodynamics, controls and intelligent systems, multi-spectral sensors, composites, and weather systems. Large military installation with expertise in engines, aircraft overhaul and modification installation, engine repair, and fuel whetted systems (oxygen systems, fuel systems). Large federal installations with aerospace training focus (air traffic controllers and pilots). Test facilities that include restricted airspace (Ft. Sill) and long/wide runways, and that are supported by technicians knowledgeable in aircraft systems. Strong CareerTech system and industry training programs. Leading-edge workforce incentives that directly benefit aerospace.	Poor state image as an impediment to attracting top talent is a concern. Uncoordinated efforts among industry groups. Lack of a cohesive brand or marketing message about the industry. Low enrollments and graduate rates in education system, from K-12 through advanced engineering degrees. Industry perceives a lack of support from legislature/state government due to its status as a low priority on the state's innovation agenda. Overall research capacity at universities is perceived by industry as weaker than competing states (Georgia, Kansas, Arizona, etc.); collaboration between industry-universities is ad-hoc, not systematic like in energy. Lack of corporate R&D, due to the fact that OEMs are not headquartered in Oklahoma, or possibly because the nature of the business does not lend itself to R&D investment. Industry perception of a lack of specific facilities including modern wide-body hangers and manufacturing facilities near major runways (yet Oklahoma has empty facilities at Ardmore Airpark and OSIDA [Spaceport]; these could be viewed as too old or obsolete).

For many markets, Oklahoma is extremely well positioned. The desire to maintain and enhance existing proficiencies in MRO and OEM reflect the state's strongest potential for maintaining a large number of well-paid aerospace industry jobs. The aspiration to expand research expertise in targeted areas is bolstered by opportunities in composites repair and damage diagnostics, engine technology and fuels. Building a robust value chain for new markets including UAS can be an effective strategy, especially starting with testing and development operations and expanding in both directions toward research and manufacturing. Specific strategies for these and other opportunities are detailed in Section 6.

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Section 3 Oklahoma Aerospace Workforce

According to the national Aerospace Industries Association, the industry directly employs approximately 600,000 workers in the U.S. The Oklahoma Department of Commerce estimates the state's aerospace workforce at over 72,000 direct employees, with a total (direct and indirect) employment impact of 143,000 jobs. Workforce issues are critical to the industry, playing out in the expanding range of occupations, and in the education of existing workers as they are kept up to date on new materials, processes and procedures.

This strategic plan includes an overview of key workforce issues and identifies areas that may require further investigation. It does not include an in-depth analysis of workforce supply and demand, much of which was covered in a statewide report less than two years ago.

3.1 Highlights of State National Workforce Issues in Aerospace

The Bureau of Labor Statistics estimates that between 2006 and 2016 the industry will add approximately 10 percent to the workforce. A recent survey of 30 major companies by AIA[27] estimated hiring needs of almost 59,000 employees in the next five years. Lockheed Martin alone estimates it will need to hire 140,000 in the next decade.

While the median age of the national workforce is 39.9, the median age of an aerospace engineer is 54, and other occupations range from 45-54[28]. Over 58 percent of the workforce is over age 50[29], indicating that the majority of employees will be eligible for retirement in the near future. Only 22 percent of the workforce is 35 years or younger—consequently, a large pool of engineers and technicians will need to be in the pipeline to meet the demands of employers. While only two percent of the workforce retired in 2007, 13 percent were eligible. If eligible employees begin to retire near average rates, current vacancies will increase significantly.

Security clearances are a common requirement in aerospace. Therefore, personal background and activities of workers (arrest, drug abuse, even activities posted on social networking sites) can play a factor in employment opportunities.

Aerospace occupations require a wide array of skill levels. Some occupations are very specialized and have only a few training centers across the country, while others have a greater base of employment with education and training programs throughout the U.S. Aerospace occupations rely heavily on proficiencies in math, engineering, mechanics, computer and electronic science, and physics. Occupations also require attention to detail, strong problem-solving or trouble-shooting skills, and the ability to work under deadline. Many jobs have skills that are transferable to other Oklahoma industries, including energy and other manufacturing sectors.

Almost 70 percent of jobs in aerospace companies relate to research and development, production, and maintenance operations[30]. Examples of these various aerospace jobs include:

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[27] Aerospace Industries Association, A Special Report: Launching the 21st Century American Aerospace Workforce

[28] Median Age from US Census Bureau and median age of aerospace workers from the Aerospace Industries Association.

[29] IBID

[30] Other jobs include sales, finance, management, office administration and support functions that are common to any business.

- Engineers & Scientists: Aerospace engineers, astronomers, atmospheric scientists, electrical engineers, electronics engineers, materials engineers, mechanical engineers, and physicists

- Technicians & Specialists: Aerospace and operations technicians, avionic technicians, electrical and electronic engineering technicians, mechanical technicians, air traffic controllers, aircraft launch and recovery specialists, air communications and airfield specialists, and radar and sonar technicians.

- Trades: Aircraft mechanic and service technicians, sheet metal workers, engine and other mechanics, first line supervisors of mechanics, and welders.

- Operators & Assemblers: Aircraft and systems assemblers, electromechanical assemblers, CNC operators, inspectors and testers, machinists, and cargo handlers.

- Supply Chain Management. Critical to any successful aerospace industry venture is an efficient supply chain and effective supply chain management.

Oklahoma's strong employment base in commercial and military MRO, as well as parts manufacturing, yields a significant number of jobs at the technician, trade, and engineering levels. Average state wages for aeronautical and electrical engineers tend to be below average when compared to other states, yet wages for technician level jobs tend to be above average. Oklahoma's aerospace employers note that the workforce is known for its high quality output, precision, and strong work ethic.

Key Factors for Growing the Aerospace Workforce

Interviews and focus groups for this project noted three key workforce issues:

- The ability to interest students in engineering and science fields that can lead to aerospace careers.

- The need to continually work with Oklahoma's CareerTech, college, and university systems to produce a steady pipeline of graduates.

- Ongoing industry training for incumbent workers that keeps employees up to date on the skills and procedures necessary to maintain a competitive edge.

3.2 Awareness & Exposure to Aerospace Careers

Youth interest in careers correlates to their exposure to different occupations, whether through friends and family, school, or community. Many states with high concentrations of aerospace employment have an array of museums, displays, or other means of emphasizing the importance of the industry to residents. For example, Georgia is home to the Georgia Museum of Aviation, Coca-Cola Space Science Center, SciTrek Science & Technology Museum, Georgia Youth Science & Technology Center, and the Children's Museum; Arizona utilizes the resources of its Pima Air & Space Museum, Titan Missile Museum, and Arizona Challenger Space Center.

Oklahoma City showcases the aerospace industry through the Museum of Women Pilots, the Science Museum Oklahoma, the Oklahoma History Center and the Tinker Air Force Base "Star Spangled" air show and open house. Tulsa hosts the Air and Space Museum and Planetarium and Weatherford displays the Thomas P. Stafford Air and Space Museum. Other air shows and aerospace days are held at Altus and Vance Air Force Bases, while the cities of Ada and Alva.

Industry support at these venues, along with public education and outreach programs, helps to keep the aerospace sector in the minds of Oklahomans.

Awareness of aerospace occupations is only valuable if the state has a strong science, technology, engineering and mathematics (STEM) education system in place. According to the July 2009 Oklahoma Innovation & Technology Plan, the state's students perform lower than average on math and science tests, and a lower percentage of students graduate with science and engineering degrees. Efforts to enhance the state's focus on proficiencies in math and science among both students and teachers are needed; the Oklahoma School of Science and Mathematics (OSSM) is a step in the right direction.

STEM Education

American students continue to fall behind other countries in math and science. According to the International Student Assessment (PISA) which measures the reading, math and science competencies in 15 year olds, U.S. students ranked 21st out of 30 countries. In math, U.S. students scored 25th [31].

Research has established that the quality of K-12 math and science instruction is one of the key factors in improving math and science achievement. Yet a Department of Education study reports that 68 percent of middle school students are taught math by educators that had neither a major nor certification in mathematics[32]. Contributing to this problem is the wage gap between what a mathematics or science major would make as a teacher versus another science or math related occupation.

Studies have found that applied learning and a hands-on curriculum increase the interest and retention rate of students in math and science related fields. In the past decade, much effort has been dedicated to increasing skill level and interest in science, technology, engineering and mathematics (STEM) careers. New curricula, teacher training, and after and in-school programs have been targeting a variety of science and technology fields. Within the aerospace industry, an array of general STEM and industry specific programs have been developed. While the following highlight a few of the major competitions, a complete listing of programs can be found at http://www.engineeringedu.com/competitions.html.

Examples of National STEM Programs

- **Project Lead the Way** is a national, not-for-profit education program that provides middle and high school students with a rigorous educational background in science and engineering. The curriculum is tied to national math and science standards and gives students hands-on learning experience in an effort to illustrate how classroom skills are applied to everyday life and careers. Nationally, Project Lead the Way is engaged in over 3,000 schools in all 50 states. In Oklahoma, over 18 school districts participate in the program (which is still a small percentage of schools compared to the state total).
- **The Intel International Science and Engineering Fair (Intel ISEF)**, the world's largest international pre-college science competition, provides an annual forum for more than 1,500 high school students from over 50 countries to showcase

[31] Aerospace Industries Association, Launching the 21st Century American Aerospace Workforce, December 2008
[32] Department of Education, National Center for Education Statistics

their independent research. The Intel ISEF is the premiere science and engineering competition in the world exclusively for students in grades 9–12.

- **FIRST (For Inspiration and Recognition of Science and Technology)** was founded to inspire young people's interest in science and technology. First hosts an array of competitions for ages 6-18. *FIRST* Robotics Competition is designed to help high-school students discover how interesting and rewarding the lives of engineers and researchers can be. The *FIRST* Robotics Competition challenges teams of young people and their mentors to solve a common problem in a six-week timeframe using a standard "kit of parts" and a common set of rules. *FIRST* teaches team building and leadership while applying a variety of science, engineering and technology skills. Three other FIRST programs target elementary and middle school including FIRST LEGO League, Junior FIRST LEGO League and FIRST Tech Challenge. Students work in teams where they can learn about designers, programmers, and team leaders.

- **MATHCOUNTS** is a middle school program that makes math a challenging and exciting school sport. More than a competition, MATHCOUNTS involves students and teachers in year-long coaching sessions to improve problem-solving skills. Each year over 250,000 students participate nationally.

- **IBM EX.I.T.E. Camps and PowerUp!** promotes interest in STEM careers through summer camps designed to show young girls careers in science and engineering and introduce them to female role models. PowerUp! Is a free multi-player 3-D online game to teach students engineering principles.

- **Society of Women Engineers** actively promotes engineering careers to females through scholarships, internships, competitions, and career exploration. SWE encourages girls to pursue engineering and technology careers through their outreach program ASPIRE and other various events.

- **Mad Science Summer Camps** help students learn about robotics, forensics, rocketry, the science of sports, and astronauts.

- **MESA (Mathematics, Engineering, Science, Achievement)** helps prepare students for college and beyond with math and science studies, career advising sessions, college preparation courses, workshops and competitions. MESA targets underserved and minority populations.

Examples of National Aerospace Focused STEM Programs

- **Team America Rocketry Challenge (TARC)** was created in 2002 and is the world's largest rocket contest. Approximately 7,000 students design, build and fly model rockets. The top 100 teams go to the national championships to compete for scholarships. The top 25 teams work with NASA in its Student Launch Initiative.

- **NASA's INSPIRE** is an online community of like-minded students interested in science, technology, engineering and mathematics. Activities include participation in video teleconferences with NASA scientists, design competitions, and learning modules. The online community allows students to interact with other students with similar interests, to ask questions and to share knowledge. Once connected, you'll get a chance to compete for a unique summer experience with NASA.

- **The Real World Design** Challenge (RWDC) is an annual event that provides high school students, grades 9 – 12, the opportunity to work on real world engineering

challenges in a team environment. Each year, student teams will be asked to address a challenge that confronts one of our nation's leading industries. Students will utilize professional quality computer-aided design software to develop their solutions and will also generate presentations that convincingly demonstrate the value of their solutions. The RWDC provides students with opportunities to apply the lessons of the classroom to the technical problems that are being faced in the workplace. The precise nature of the Challenge will change from year to year, but the underlying design principles will remain constant. Each year, a new challenge will be issued focusing on a different area of engineering. This year's Challenge will focus on aeronautics and energy usage.

- Companies like Boeing, Northrop Grumman, Raytheon, and Lockheed Martin offer online programs like **MathMovesU** along with specific student and teacher programs in states where they have active operations. Aerospace and technology companies also are participating in programs to assist with upgrading the skills and applied learning experiences of math and science teachers. Companies like IBM pay for employees to return to school to become math or science teachers.

Oklahoma Aerospace K-12 Education Efforts

Many of Oklahoma's aerospace associations and companies participate in the national STEM and aerospace education programs listed above, sponsoring team competitions, providing resources for teacher training, and advising on curriculum or program development.

The state, in partnership with industry and education, has launched several programs that will help promote careers in aerospace as well as provide K-12 math, science and technology teachers with more training to bring back to the classroom. While these efforts are needed, the scale is often very small and would require significant increases in capacity to meet expected job demands.

Oklahoma Aerospace Education Fellows is a program designed to provide an up-to-date picture of the Oklahoma Aerospace industry and the role it plays in the economy. Oklahoma teachers grades 3-12, and school counselors from public, private and CareerTech schools, are eligible to apply. 100 applicants were selected to be Fellows and were invited to attend the Education and Training Day conference as part of the Oklahoma Aerospace Summit. The program educates teachers and counselors about the employment opportunities for their students in the aerospace industry, providing teacher training sessions with aerospace STEM applications and encouraging teachers and students to engage in science, technology, engineering, and math (STEM) education with aerospace applications. The program also provides teachers with an industry professional as a mentor throughout the school year.

Recently, Lt. Governor Jari Askins and aerospace industry leaders unveiled a new 2009-2010 Aerospace Curriculum Grant. The announcement was made during the Education and Training Day of the Oklahoma Aerospace Summit, a program which encourages state teachers to develop innovative strategies to inspire their students. The grant program is a joint venture between the Lieutenant Governor, PITSCO Education Inc. and the Oklahoma Aerospace Summit. A review team will consider the applications and select three Oklahoma educators who will receive awards ranging from $500 to $2,000.

The Investigative Research Scholars Program gives twelve students from the Oklahoma School of Science and Mathematics (OSSM) the opportunity to spend a portion of their summer at the Oklahoma Health Center, the Oklahoma Medical Research Foundation and Tinker Air Force Base conducting intensive research and participating in hands-on projects with scientific mentors. The

program has become an extension of the OSSM Mentorship Program, which is designed to give seniors the opportunity to gain hands-on experience with scientists, physicists, biologists, doctors, researchers and aeronautical engineers, as well as establish professional relationships with mentors.

3.3 Post-Secondary and Career Technical Education

Compared to other industries, aerospace is heavily dependent on engineers and scientists. Over 40 percent of aerospace and defense workers are classified as engineers, scientists and IT professionals[33]. Yet science and engineering enrollments in colleges are not keeping up with demand, including programs in aerospace and mechanical engineering. For every PhD in engineering, America graduates one PhD in science, 18 lawyers and 50 MBAs[34]. From 1991 to 2000 the number of aerospace degrees awarded in the U.S. fell by 47 percent.[35] This growing gap in qualified scientists and engineers is a state and national issue.

Oklahoma is home to multiple post-secondary institutions with degrees and training programs related to aerospace occupations. Each year, Oklahoma public and private colleges graduate approximately 760 engineers in aerospace, electrical and mechanical engineering[36]. While both state and national surveys indicate a growing need for advanced degrees, only 30 percent of awards are Masters degrees or PhDs. For growing areas like UAS technologies, in addition to aerospace engineering design for airframes, skills are needed in robotics and control technologies, artificial intelligence, software planning and scheduling, and sensor technologies.

The state awards approximately 400 associate degrees each year in electrical, engineering and technology programs. Each year over 1,850 complete CareerTech training programs related to aerospace occupations. Many of the skilled workers in this group include airframe & powerplant mechanics, welders, sheet metal workers, riggers, quality inspectors, machinists, and avionic technicians. Years of downsizing and the effects of 9/11 have forced many of these workers to leave the industry. Now, as the industry is projected to see growth again, ensuring a pipeline of highly skilled technicians and operators will be increasingly important.

Career Technical Education

Oklahoma has a well-established CareerTech system that serves all parts of the state. With an enrollment of over 123,000 students in secondary programs and over 83,000 in full time and adult career post-secondary programs, the impact on the state is significant (this does not include the 330,000+ participants in industry training programs). Over 400 school districts have career tech programs and an additional 158 have technology education programs. There are 56 Technology Center Campuses statewide and 72 counties are served by the system.

Seven CareerTech programs specifically support the aerospace industry:

- Aviation maintenance: with the largest programs in Oklahoma City and Tulsa area and other programs in NW, SE and SW regions
- Computer-aided Drafting: with programs in all regions of the state
- Electronics: with programs in all regions of the state
- Industrial Technology: with programs in all regions except the NE
- Manufacturing Technology: in the Northwest region

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[33] IBID
[34] Augustine, Norm, *Is America Falling Off the Flat Earth?* National Academies, 2007
[35] The Commission of the Future of the U.S. Aerospace Industry, 2002
[36] Oklahoma State Regents for Higher Education.

- Precision Manufacturing: in all regions of the state
- Welding: in all regions of the state

Interviews and focus groups continually pointed to the CareerTech system as a strength in Oklahoma's aerospace industry. Existing partnerships between industry and the CareerTech system appear to be relatively strong and responsive. This ongoing industry-education partnership should continue to be fully supported by the state's aerospace sector.

Post-Secondary Degree Programs

According to the Oklahoma Aerospace Workforce 2007 Report, there is a growing gap between degrees awarded by the state's educational institutions and projected vacancies for aerospace and mechanical engineers, especially at the Masters and PhD levels. For example, it is estimated that in 2010 there will be over 350 vacancies for aerospace engineers with advanced degrees, and yet only about 130 students will graduate from state institutions. Industry surveys conducted by the Oklahoma Department of Commerce have also indicated significant vacancies for aerospace engineers (115 vacancies in companies surveyed) and to a lesser degree mechanical and electrical engineers. While projections vary slightly among studies, all reports note there will be a steady need for new and replacement jobs.

This gap becomes important as companies note difficulty in recruiting engineers to Oklahoma who are not from or familiar with the state. Providing internships can help keep students in the state. Current efforts to bring Oklahoma alumni back to the state can also play an essential role in helping to fill vacancies, especially for small and medium size companies where reported vacancies are greater than larger firms[37].

By comparison, the 2007 Workforce Report projected a modest surplus for various technician level occupations such as welders and airframe and power plant (A&P) mechanics. While industry surveys and focus groups vary on the difficulty in finding qualified technicians, the conversation tended to center around certain skills or experience levels, rather than the quantity of technician level job candidates. Currently, Tinker is planning to hire 250-500 technical occupation workers in 2010, especially in A&P.

Top 10 Aerospace Engineering Schools

When Oklahoma's aerospace education programs are compared to other states, they are not ranked among the leading institutions. According to the 2009 US News and World Report, the top ten engineering schools for aerospace engineering include:

- California Institute of Technology
- Massachusetts Institute of Technology
- Stanford University
- Georgia Tech University
- Purdue University-West Lafayette
- University of Michigan-Ann arbor
- University of Illinois-Champaign
- University of Texas-Austin
- Princeton University
- University of Maryland-College Park

Five institutions (Oklahoma State University, University of Oklahoma, Southeastern Oklahoma State University, Spartan College of Aeronautics and Technology, and University of Tulsa) provide the majority of degrees awarded for key aerospace occupations including aerospace, electrical and mechanical engineering. For new technologies like UAS, skills are needed in robotics and control technologies, artificial intelligence, software planning and scheduling, and sensor

[37] Governor's Council for Workforce and Economic Development, Oklahoma Aerospace Industry Workforce 2007 Report

technologies. All of these involve degrees in computer sciences, mathematics, and industrial design.

Oklahoma State University School of Mechanical and Aerospace Engineering offers Bachelor of Science, Master's and PhD degrees in mechanical (BSME), and aerospace (BSAE) engineering. A premedical option is also offered. The School is one of the largest degree-granting units in the College of Engineering, Architecture, and Technology. Labs and research facilities include:

- Advanced Controls Laboratory
- Advanced Manufacturing Processes Laboratory
- Biomedical Engineering Lab at Oklahoma State University (BELOS)
- Building & Environmental Thermal Systems Research Group
- Computational AeroServo Elasticity (CASE) Laboratory
- Hydrodynamics and Aerodynamics Laboratory
- Mechanics of Advanced Materials Laboratory
- Micro Flow Lab
- Mini/Micro Channel Heat Transfer Laboratory
- Robotics Laboratory
- Single/Two Phase Heat Transfer Laboratory
- Ultraprecision Surfaces Group

Southeastern Oklahoma State University Aviation Science Program offers degrees in aviation management and professional piloting. Aviation management offers four minors including safety, security, maintenance management and business. The school also offers a Master's Degree in Aerospace Administration & Logistics. The College has a campus on Tinker Air Force Base. Campus assets include:

- ASI Operations Building
- Flight Instructor Facilities
- Maintenance Facilities

Spartan College of Aeronautics and Technology was founded in 1928 and offers diplomas in aviation maintenance technology, avionics, and non-destructive testing; associates degrees in aviation maintenance and avionics; pilot training; and a Bachelor's of Science in Aviation Management. In addition, the college provides customized and contract training to companies and military, and FAA/FCC knowledge exams.

University of Oklahoma School of Aerospace and Mechanical Engineering offers Bachelor's of Science and Master's degree in aerospace and mechanical engineering, including an accelerated BS/MS degree. The campus houses a subsonic wind tunnel; other instructional and research labs include:

- Aerospace Vehicle Design
- Biomedical Engineering Lab
- Combustion and Flame Dynamics Lab
- Composites Research Group
- Computational Mechanics (Dr. Striz) FH 305
- Concurrent Design and Manufacturing Research Laboratory
- Dynamic Structures Sensing and Control Center
- Engineering Media Lab
- FEM Structural Optimization, MDO & Aeroelasticity
- Heat Transfer & Fluid Mechanics Lab

- Intelligent Robotics Lab
- Internal Combustion
- Materials Characterization Lab
- MEMS Research Lab
- Microscale Heat Transfer Lab
- Micro Space Vehicle Lab
- Neural Engineering Lab
- Product & Process Design Lab
- Structural Durability Lab
- Vehicle Vibration Test Center

University of Tulsa College of Engineering and Natural Sciences offers undergraduate and graduate degrees in engineering, and though it does not have a specific major in aerospace engineering, it awards degrees in electrical, mechanical, petroleum engineering as well as computational sciences, physics and related sciences. While the university focuses a significant amount of research on the petroleum and energy sector, several research groups also have expertise in aerospace including:

- Center for Boundary Integral Methods
- Institute of Alternative Energy
- Institute for Information Security (iSec)
- Institute of Nanotechnology
- Institute for Software Research (TUISR)
- Materials Research Group
- MultiAgent SysTEms ReSearch Group (MASTER'S)
- Software Engineering Architecture Team (SEAT)
- TU Center of Research Excellence (TUCoRE)

Post-Secondary Institutions also support the industry through an array of research that ranges from federal grants to industry-sponsored projects. Among the most widely recognized research efforts are:

- **The University Multispectral Laboratory** in Ponca City that is managed by Oklahoma State University and underwritten by a grant and facility from ConocoPhillips.
- **Helmerich Advanced Technology Research Center (ATRC)**, OSU-Tulsa. The 123,000-square-foot Helmerich ATRC houses laboratories, meeting facilities, and office space for up to 40 faculty and researchers and 100 graduate students. Helmerich ATRC faculty, research staff, graduate students, and visiting scholars develop and commercialize the next generation of composites and materials for advanced manufacturing in four core areas: materials science and engineering; bio-based technologies; energy technologies; and information and control technologies. Across those four areas, Helmerich ATRC develops new materials from the application of nanotechnology to ceramics, composites, aerospace materials, polymers, and metals.

3.4 Industry Training

With over 750 million people flying commercial and general aviation aircraft in 2007, precision and quality are essential attributes of the industry's training and education programs. Changes and enhancements in manufacturing materials, control systems, maintenance diagnostic and repair, and FAA procedures require constant training and skill upgrades within the current workforce.

Training needs identified by Oklahoma companies include:

- Engineers and technicians with the ability to use/repair new composite materials and strong metals as those technologies are adopted in new aircraft production.
- Technical expertise in designing and using new systems/diagnostics/testing equipment and procedures incorporating non-invasive diagnostics.
- Precision fabrication of specialty parts to keep older craft airworthy, often after the off-the-shelf supply of existing parts has been exhausted.
- Industry wide Lean applications, especially throughout the value chain and not just in the larger firms.
- Research and development of sensor technology as applied to aerospace; this is especially necessary to accelerate civilian applications of UAS.

The industry in the state has identified several key partners in their training efforts. At the forefront of incumbent worker training is the CareerTech system that provides training to over 340,000 workers in the state through their industry programs[38]. Industry reported a strong working relationship with CareerTech, where training needs are constantly being assessed and programs are consistently updated or expanded to meet these needs. The primary training concern of companies is not the responsiveness of CareerTech, but rather that training programs are focused on classical metal working and mechanical jobs supporting old aircraft technology. With new composite airframes and sophisticated avionics, programs need to adapt to support new technologies and systems. In addition, because the aerospace industry is cyclical in nature and industry demand is not consistent, it is difficult for the CareerTech system to maintain a consistent pipeline of students. This results in a feast-or-famine problem for students coming through aerospace programs.

Universities participate in an array of aerospace-related industry research. In FY08, relevant industry sponsored research projects at OSU included an Unmanned Autonomous Ultrasonic Inspection Crawler with Veracity Technology Solutions, as well as Testing and Development of Inflatable Light Rigidzable Wings for HALE Aircraft with Adherent Technology, Inc. While there are pockets of industry-university partnerships in research (mostly between individual firms and specific programs at different campuses), companies perceive a lack of comprehensive connections between the combined needs of the industry and the state's university system. However, companies interviewed noted that their need for research was low because of several reasons: MRO businesses have low margins and technical issues that are not cost effective to solve via research, and research is typically conducted with companies' engineering organizations located at their headquarter facilities which are not in Oklahoma. Even the two aerospace and mechanical engineering programs at Oklahoma's public universities do not highlight their research efforts on their web pages. Schools in comparative states of Georgia and Arizona have extensive information on research programs that is readily available online. Multiple statewide aerospace organizations, all with some type of education element to their mission, further inhibit a more systematic approach to university partnerships. The focus of the Oklahoma Aerospace Institute on aerospace research as one of its primary missions could facilitate a more streamlined way to build these partnerships.

Reducing costs and cycle times is essential for the competitiveness of the U.S. Aerospace. In 1993, the Lean Aerospace Initiative was launched by the US Air Force, MIT, labor unions and

[38] Training numbers represent services to all industries, not just aerospace.

defense aerospace businesses to actively promote continuous improvement and cost savings in operations. Oklahoma's Alliance for Manufacturing Excellence actively helps companies in the state to incorporate lean and six sigma. The result of improved process flow and quality has resulted in significant savings in labor, materials and time. Continued support of these programs in Oklahoma will be an essential part of the industry's strategic plan.

Oklahoma's investment in applied research also provides training venues for aerospace companies. Examples of these assets include:

- Helmerich Advanced Technology Research Center (ATRC), OSU-Tulsa that provides the state's existing industries with practical applications for advanced materials to improve their manufacturing processes, expand operations, and create jobs. New companies will also be created around technology developed at the center.
- The Manufacturing Center for Applied Research (MCAR) located at Tulsa Technology Center's Business and Industry Training Center, provides manufacturing solutions in a facility that houses full-size, integrated machine tools. Services include technical training and consulting, laser scanning, reverse engineering, prototyping, stereolithography cost analysis, demonstrations, process instrumentation, ISO training and consulting, LEAN Manufacturing and other process improvement methods.

Summary

The presence and depth of the aerospace industry in Oklahoma is represented by an array of education and workforce training programs. However, like many states the industry faces a lack of interest among its youth in pursuing these careers. Enrollments are stagnant while demand for jobs continues to increase and workers continue to retire. Focused efforts starting with K-12 schools and extending to post-secondary institutions are needed. Continued support by government and the industry for incumbent worker training will be essential as new materials and technologies blanket the industry. Finally making stronger connections between university research and industry, especially in applied research and development, will expand the value chain within the state. Recommendations for these issues are found in Section 6 under recommendation E.

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Section 4: Incentives to Promote Research, Talent and Job Growth

This section highlights the types of economic and workforce incentives that can accelerate the growth of research, talent or jobs in the aerospace industry. Most incentives apply to a broader set of traded-sector or innovation based companies, yet can be actively marketed to the aerospace sector.

4.1 State Policies and Programs

Competition among U.S. states for aerospace industry investments and facilities has been very aggressive in the last few years. Incentive packages for major new investments include tens of millions of dollars in financing and tax breaks, as well as new support facilities such as the University of Virginia's Commonwealth Center for Advanced Manufacturing in conjunction with Rolls Royce's new engine plant in that state. It is apparent that aerospace investment, and the accompanying jobs created, are highly prized and sought after by economic development organizations across the country and around the world.

The aerospace industry, outside of "special negotiations" made for large recruitment or business expansion cases, is often considered a subset (for economic development and policy purposes) of other larger sectors. Most frequently, states will tie aerospace initiatives in with support for manufacturing/precision manufacturing or for technology or "high tech".

The policies and programs of several states were reviewed for their focus on aerospace, even embedded within other programs, and specific examples will be called out. This is in addition to the best practice research examining, in detail, the approach to aerospace undertaken by the State of Georgia, the State of Arizona, and the Province of Ontario.

The California Research Bureau took a comprehensive look at state aerospace policies, industry support, and incentive plans several years ago. Their research categorized state initiatives as follows:

- Industry cluster support
- Property tax incentives for investments (abatements and/or accelerated depreciation schedules)
- Carry forward of net operating losses on income tax
- Tax incentives for job creation
- Research and development incentives
- Enterprise zones and special investment zones
- Supporting industry associations
- University/industry technology centers
- Equipment and facility access (especially for smaller companies)
- "Lean" process training
- Bid and collaboration assistance
- Deal-specific packages

4.2 Oklahoma's Economic & Workforce Incentives and Policies

Oklahoma already has tools in place in several of the categories identified above. Their effectiveness can perhaps be enhanced by evaluating the following additional tools that other states apply to their aerospace companies, either as a part of broader initiatives or individually.

Current Economic Incentives in Oklahoma

The State of Oklahoma has created several business and economic incentive tools to encourage companies to locate or expand in the state. In addition to statewide programs, local jurisdictions also have specific tools and incentives that can benefit companies in their communities or geographies. Statewide programs include:

Investment/New Jobs Tax Credit

Investment/New Jobs Tax Credits provide growing manufacturers with a significant tax credit based on either an investment in depreciable property OR on the addition of full-time-equivalent employees engaged in manufacturing, processing, or aircraft maintenance; this legislation was modified by Senate Bill 909. This legislation offers enhanced incentives for job creation in Oklahoma. The new legislation allows existing and new businesses in Oklahoma to take advantage of both tax rebates and tax credits, as long as they meet the criteria for payroll and job creation. Previously, employers had to choose one program or the other -- Quality Jobs tax rebates if they create new jobs with a minimum payroll of $2.5 million OR tax credits if they invest $40 million in the state.

Oklahoma Quality Jobs Program

This program provides cash payment of up to 5 percent of newly created payroll jobs for qualifying companies; this program was enhanced by the passage of Senate Bill 938, also known as the "21st Century Quality Jobs" program. This bill expands the existing Quality Jobs program to offer incentives for higher paying, knowledge-based jobs. Under this new legislation, companies creating the jobs specified in Senate Bill 938 would be eligible to receive a quarterly cash rebate of up to 10 percent of new taxable payroll if they achieve wage and performance job creation targets.

Small Employer Quality Jobs Program

This is effectively the same cash incentive as the basic Quality Jobs Program for new job creation, but with easier-to-attain requirements than those that are applied to larger companies.

Training for Industry Program (TIP)

Customized and flexible training is offered to companies through the State's CareerTech system of educational institutions.

Tax Credits and Exemptions

The State has targeted tax credits, exemptions and advantages of various kinds to businesses, investors, entrepreneurs, and workers. Many of these programs specifically apply to aerospace manufacturing, maintenance activities, and facilities, e.g. manufacturers' sales tax exemption, exemption of taxes at aircraft maintenance facilities, exemptions for aircraft repairs and modifications, etc.

Financing

Oklahoma has an array of public financing tools that are available to a broad range of businesses and industries. Public financing rates can offer companies an attractive alternative to commercial capital rates, or fill gaps between commercially available lending amounts and corporate equity limits.

Seed and Venture Capital

The state has several programs that support the start-up and expansion of new technology-based businesses, including the OCAST Technology Business Finance

Program and the Oklahoma Seed Capital Fund. These funds are managed by i2E, a national model for business assistance, which also provides comprehensive business advisory services to entrepreneurs. In addition, the Oklahoma Capital Investment Board (OCIB) supports investments that catalyze new sources of equity and near-equity capital for Oklahoma businesses, including venture capital and credit insurance to banks.

Innovation-based Workforce

Recently, the State of Oklahoma has passed several enhancements and new bills to encourage the growth of science and engineering occupations and recruit key talent to the state. **House Bill 1468** extends Quality Jobs tax incentives to companies that contract with the federal government for defense work and that hire Oklahoma subcontractors. The Quality Jobs program offers incentive payments to companies that create new, well-paying jobs, though the program was originally designed to assist manufacturing companies. HB 1468 would also extend eligibility requirements to service companies that provide testing, research, development, consulting or other services. Qualifying business could receive quarterly cash payments of up to 5 percent of new taxable payroll created. It is anticipated that the bill would encourage about 1,000 new jobs in the state. **House Bill 1953** was approved by the state legislature allowing companies that support, repair, and maintain service for wind energy companies eligible for the state's Quality Jobs Act. The legislation would seek to attract companies to Oklahoma that are involved in all aspects of the wind energy industry.

House Bill 3239, the Engineering Workforce Bill which passed in 2008, provides incentives for attracting and retaining engineering talent for the state's aerospace industry by providing tax credits to companies that hire engineers, with a larger tax credit offered for graduates of Oklahoma institutions. Tax credit support is given to engineering graduates who agree to work for an Oklahoma aerospace company, and does not exceed $5,000 per year for the first 1-5 years of employment. In addition, a tax credit is offered to employers that provide a 50 percent reimbursement of tuition to new engineer graduates, based on the average tuition of an Oklahoma public college or university, for the first through fourth years of employment.

A Glance at the State's Innovation Capacity that Supports Aerospace

The state recently completed an Innovation & Technology Plan which clearly outlines Oklahoma's current status for innovation and recommends specific actions. The actions set forth in the 2009 innovation plan would be very beneficial to the aerospace industry. This section highlights major findings of the Innovation Plan with additional insights provided by the R&D experts on the team.

According to the State New Economy Index, which compares a state's ability to compete in a "new or innovation-based economy," Oklahoma ranks 40th among states. Oklahoma's ranking in the percent of nation-wide knowledge-based jobs dropped from 36th in 2007 to 39th in 2008. Oklahoma ranks 25th in professional jobs, 41st in workforce education, 17th in manufacturing value added, and 26th in fast growing "gazelle" companies.

Likewise, the 2009 Oklahoma Innovation and Technology Plan notes:

> "Oklahoma is drastically behind other states in all three measures: the research and development dollars as a percentage of the GDP, the federal dollars coming to the state on the basis of all civilian workers, and the number of civilian workers in science and engineering occupations. With the exception of research articles published among .doctorate holders, Oklahoma is behind the national average in all other output measures: industry and academic research, and development patents. With the exception of high-technology employment as compared to employment in all business

establishments, Oklahoma lags behind the national average in all three measures: proportion of high-technology businesses, SBIR grants compared to GDP, and all measures of venture capital."

The 2009 Oklahoma Technology and Innovation Plan points out that while Oklahoma has made investments in innovation for nearly two decades, the scope of these investments and the scale of funding have not been competitive with other states. Although there has been significant focus on university research, gaps in broad based services to private sector R&D and entrepreneurs/start-up businesses remain. While Oklahoma is home to i2E, a national model for serving entrepreneurs and businesses in technology sectors, their limited funding prevents them from reaching the scale of efforts in other states including the Ben Franklin program in Pennsylvania or the Edison Technology Centers in Ohio. The Aerospace industry should join other innovation-based sectors for increased funding and program expansion of commercialization services to reach systemic levels experienced by other states.

The majority of R&D spin-offs comes from the private sector, yet Oklahoma lacks several key incentives offered by other states. The most common incentive is the R&D tax credit. A recent study by Yonghong Wu at the University of Illinois, Chicago found "that the establishment of state R&D credit programs is effective in stimulating more industrial R&D expenditure. In addition, state services in higher education and R&D-targeted programs also matter in private decision of R&D investment. This policy assessment sends a positive message to state policymakers because it shows the great potential in using R&D policy instruments to promote innovation-based economic development." For a sector like aerospace that seeks to expand its high-wage R&D efforts, not having an R&D tax credit may prove to be a disadvantage.

The majority of other states offer a tax credit for R&D expenditures that vary between 5-24 percent. Rhode Island has a credit of 22.5 percent for the first $111,000 of qualifying expenditures and 16.9 percent for investment above $111,000. California provides a 15 percent credit to incremental R&D spending, and 24 percent to basic research expenditures. Arizona has a tax credit of 24 percent on the first $2.5 million and 15 percent on additional research. Many states limit their R&D tax credit to the first $500,000 of research. States like Oregon and Arizona raised their limits for R&D tax credits which are now applied to the first $2 million and $2.5 million. Hawaii applies the R&D tax credit to all R&D expenditures, not just the incremental expenditure.

Another incentive recently being implemented is an SBIR match program where the state matches the R&D funding from the federal government given to a private sector company commercializing technologies. In Kentucky, SBIR applications and awards more than doubled the first year of the program.

Finding state general fund money for new programs can be tricky, especially in a down economy. However, Kansas implemented a funding model that uses the tax increment on taxable payroll within specific innovation sectors to fund programs that continue to build the competitiveness of these targeted sectors.

In Oklahoma, there are three state-level programs that specifically focus on innovation and technology:

- The Economic Development Generating Excellence (EDGE) endowment that was put in place to increase the State's research capacity and to provide substantial support for research and technology commercialization likely to produce more high-paying jobs in Oklahoma.

- i2E, which offers an array of programs (e.g. Technology Business Finance Program, Technology Commercialization Center, and Seed Capital Fund) to commercialize technology and assist emerging companies taking new products and services to market.
- Oklahoma Center for the Advancement of Science and Technology (OCAST), which provides research funding and other support for health, plant science, applied research and small business research assistance.

While the base programs for innovation in Oklahoma are necessary, they are not enough. More can be done, especially in the commercialization of private sector products and services, and the enhancement of STEM related education at both K-12 and post-secondary levels. Supporting the Innovation Plan's recommendations for these issues would serve the aerospace industry well.

4.3 Economic Development Tools of Other States/Regions

Texas: The State of Texas has a dedicated a large resource base to the attraction and retention of businesses, including aerospace businesses. Primary tools utilized by Texas in this effort are:

- Texas Enterprise Fund: This $295 million fund (at original inception) was created to assist Texas in "dealmaking" for very large business recruitment and expansion cases. Clearly, most states do not have the resources, ability, and/or desire to play at this level.
- Texas Emerging Technology Fund: This $200 million fund (at original inception) is directed toward three primary areas:
    - Research superiority acquisition
    - Commercialization
    - Matching grants
- Because aerospace and defense is one of the targeted clusters under this initiative, these funds can be accessed for innovation within that industry.
- Texas: Industry Cluster Initiative-Aerospace and Defense: This state initiative includes focusing state resources including staff and financial support on six industry clusters, including Aerospace and Defense. Within that cluster, opportunities include:
    - UAV/UAS
    - Alternative fuels
    - Composites and lightweight metals

Kansas: The State of Kansas considers aerospace manufacturing to be a key component of its overall manufacturing sector. In order to support manufacturing and aerospace, Kansas has developed the following specific strategies:

1. Ensure trained workers by investing over $33 million over six years in infrastructure, equipment and curriculum support for precision manufacturing and aerospace.
2. Support funding at $5 million/year for the National Institute for Aviation Research at Wichita State University.
3. Use the Information Network of Kansas ("INK") to allow Kansas manufacturers to gain information on opportunities and to facilitate collaboration among sector members.

Malaysia: The Malaysian government is directly investing in companies that are perceived to have a positive future impact on Malaysia's aerospace industry. In 2008, the government invested over $5 million in three UAV companies.

Arizona: The State of Arizona has a very basic package of incentives that it offers to companies. The primary distinguishing characteristic of the Arizona industry is the strength of the

research conducted at the University of Arizona. UA is in the top ten in NASA grants, and is #1 in space science grants.

Georgia: Georgia has created Centers of Innovation to focus attention and investments in six industries; aerospace is one of those targeted industries. The Center of Innovation for Aerospace is billed as "Georgia's 'one-stop-shop' aerospace industry authority."

New Mexico: The State of New Mexico has implemented some very aggressive tax incentives for aircraft manufacturing and aircraft refurbishing. Additionally, New Mexico State University is home to The Unmanned Aerial Systems (UAS) Technical Analysis and Applications Center (TAAC), established in 1999 with the mission to promote safe integration of UAS in the National Airspace System (NAS). In order for a UAS to be flown in the USA outside of military airspace, a certificate of authorization (COA) or an experimental airworthiness certificate must be issued by the FAA; COAs have been obtained by New Mexico State University to operate the Aerostar and Orbiter UAS and the TAAC conducts flight operations within restricted airspace. The TAAC has been involved in the testing of various UAS platforms and has produced a certification roadmap that is serving as a framework for UAS certification.

4.4 Potential Directions for Oklahoma

Oklahoma has an opportunity to focus its aerospace policies and resource allocation toward unique positioning for the state within the industry. Competitor regions have staked out their territories effectively through supporting aggressive tax and incentive programs directed at aerospace, funding research in their university system that supports their resident aerospace industry, and providing seed funding and capital access to entrepreneurs and innovators in aerospace and other technology-related endeavors.

Some of the programs that target capital formation and entrepreneurial support are undercapitalized, at least when compared to other states that support an innovation agenda. The existing programs are effective, but are limited in their scope by the amount of state funding. As a result, Oklahoma's innovation agenda is not as aggressive as its competitors.

On the whole, Oklahoma's incentives for aerospace are strong when compared to those of many other states. The breadth of incentives can support a variety of sectors within the industry. Yet industry members and economic development professionals in the state note that the combined package of incentives is not well articulated or incorporated into overall marketing and recruitment efforts, especially those outside the state. A clear picture of the state's incentives, aggressively marketed in the national arena, should be a top action item for the industry.

Section 5: Organizational Structures

For a state of Oklahoma's size, there are far too many organizations serving the aerospace industry. Among several companies and organization members there exists confusion about who does what, and perceptions that resources may not be leveraged effectively. For this reason, the consulting team was asked to evaluate the organization of three other competitor regions to understand how their industry associations were structured, and then compare those results to existing conditions in Oklahoma.

5.1 Selected Regions

Three comparable regions were selected as benchmarking targets: the State of Georgia, the State of Arizona, and the Province of Ontario. The success and vitality of the aerospace industry in these regions can provide valuable lessons for Oklahoma.

When compared to competitor regions reviewed for this study, Oklahoma's landscape of industry organizations appears much more cluttered. The rise of several different entities can be attributed a number of factors, including regionalism, different market focus, and different assets. The net result is a rather confusing (at least to the outside observer) number of organizations with overlapping missions, duplicative memberships, and uncertain financing in an era of tight budgets. The combination of these elements exacerbates what one industry observer termed the "alphabet soup" of acronyms and organizations. This picture can become fuzzier when the various regional chambers of commerce and development authorities, with their respective committees and activities, are factored in.

Figure 11 attempts to illustrate the current challenge in Oklahoma—having a number of stakeholders with no clear "hub" for the industry. It is this central hub that distinguishes the organizational structures of the competitor regions from Oklahoma.

5.2 Oklahoma Organizations Involved With Aerospace

The purpose of the organizational assessment is not to select or anoint any primary aerospace organization; rather, it is to point out the necessary functional areas that must be clearly defined and assigned with resources and responsibilities. Oklahoma can choose to have a single organization, as some regions do, or can choose to divide functions among several organizations. Regardless, there should be:

- Clarity of mission and a shared set of industry goals,
- Identification of resources and their use and intended outcomes,
- Strategic alliances among key partners, and
- Commonality of understanding among the industry, its supporters, and its allies.

The following organizations in Oklahoma are currently involved in some manner with aerospace statewide; their missions are defined as follows:

Oklahoma Aeronautics Commission:
The Oklahoma Aeronautics Commission's mission is to promote aviation, which includes fostering the growth of the aerospace industry and ensuring that the needs of commerce and communities across Oklahoma are met by the state's 114 public airports that comprise the state's air transportation system.

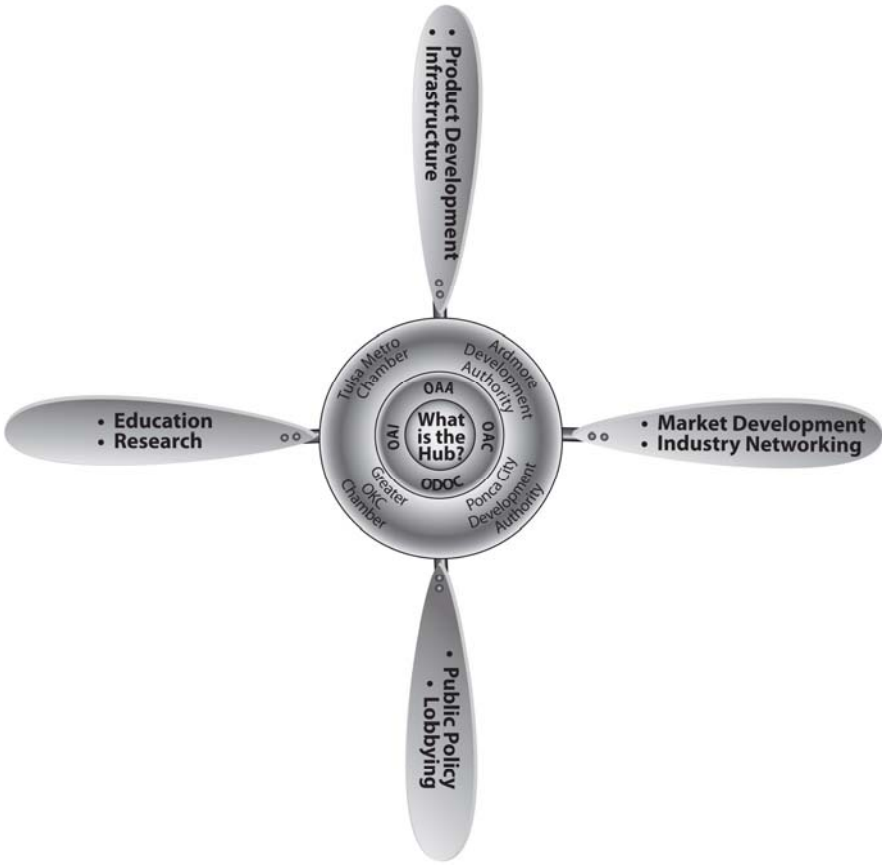
Oklahoma Aerospace Institute:
The mission of the Oklahoma Aerospace Institute is to create a partnership of service providers to more effectively respond to the needs of the aerospace industry in the areas of education and training, research, and economic development.

Oklahoma Aerospace Alliance:
The mission of the Oklahoma Aerospace Alliance (OAA) is to provide a venue for Oklahoma aerospace companies to network and to communicate with state, national and international organizations. OAA focuses on four areas:

- Networking and information sharing
- Identifying industry and employer needs
- Identifying and promoting workforce requirements
- Promoting a business friendly legislative agenda and feedback loop

Oklahoma Department of Commerce (ODOC):
ODOC works with aerospace as one of the state's targeted industries. They have information, data, and site selection expertise to assist companies in business location decisions. ODOC contracts with staff resources to provide aerospace expertise and bid/contractor assistance. ODOC staff directly participates in trade shows with and for the industry, prepares and provides marketing assistance and collateral materials, and supports industry events such as the annual Oklahoma Aerospace Summit.

Figure 11. Oklahoma Aerospace Organizational Diagram



5.3 Competitor State Aero Organization Compared to Oklahoma

The consultants interviewed selected competitor industry organizations:

1. Georgia Center for Innovation-Aerospace
2. Ontario Aerospace Council
3. Arizona Aerospace Institute

Key points of inquiry were specifically:

- The genesis of the organization; did it come about based on industry or government initiative, and is it currently directed by the public or private sector?
- Their mission; what role(s) do they play relative to the aerospace industry in:
    - Providing industry information
    - Directing/providing input to educational and training programs
    - Focusing research and development efforts
    - Collaborating with industry on marketing/market development
    - Leading lobbying and public policy development activities
- What caused the organization to function as an acknowledged industry hub in their region?
- Annual budget
- Staffing levels

Additional information was compiled on the institutions in Oklahoma that together comprise the aerospace industry organizations in the state. The following matrix compares the organizational functions in the competitor regions of Georgia and Ontario with four Oklahoma institutions that each have connectivity with the aerospace industry. The industry organization in Arizona is in its formative stages, and does not have the established experience necessary for a comparison.

Budget and Staffing Comparisons

Georgia: Georgia's Center for Innovation: Aerospace is a state-funded program completely supported by a designated portion of the State of Georgia's tobacco settlement. The Center for Innovation's annual budget is approximately $410,000/year. No membership fee is charged or solicited; in fact, the Center is "philosophically opposed" to charging fees. In addition to direct funding for staff (one director and two program specialists) the State will also pledge additional funds on a "matching" basis for specific industry-requested projects.

Ontario: The Province of Ontario's Aerospace Council is described by its director as a virtual enterprise. It has no full time staff, no office space, and very little overhead. The annual budget is approximately $180,000, raised by an $11/employee assessment on aerospace industry members; this budget supports a team of contractors with specific industry expertise. Key to the success of the Council is its close working relationship with the Ontario Ministry of Economic Development, its close partner on many of its initiatives. The base budget does not fund any projects; those are specifically funded by project sponsors, and might include funding from the provincial government.

Table 6. Organizational Function Matrix Competitor Regions and Oklahoma's Aerospace Organizations

Organization	Public/Private	Industry Information	Education	Research and Development	Marketing/Market Development	Public Policy/Lobbying
Georgia Innovation Center	Public	Yes	Yes	Yes	No	No
Ontario Aerospace Council	Private	Yes	No	No	Yes	No
Oklahoma Aeronautics Commission	Public	Yes	Yes (via OAI)	No	No	Yes
Oklahoma Aerospace Institute	Public	Yes	Yes	Yes	No	No
Oklahoma Aerospace Alliance	Private	Yes	Yes	No	No	Yes
Oklahoma Department of Commerce	Public	Yes	No	No	Yes	No

In the analysis of competitor regions, their "hubs" (i.e. the focal point of the industry) were defined in different ways:

- *Georgia*: The state Center of Innovation: Aerospace. It is one of six Centers focused on key Georgia industries which are funded by the state's tobacco settlement.
- *Ontario*: The Ontario Aerospace Council partnered with the Ministry of Economic Development. Together, with the acknowledgement of the industry, they facilitate market development and industry initiatives successfully.

The recommendation from the team is to continue to move toward a clarification of roles and the creation of a uniform aerospace agenda in Oklahoma, irrespective of what organizational determinations are made. Among key elements to consider are the organization or entity which has the power to "deliver" on major programmatic elements such as business incentives, legislative agenda that impact the industry, and infrastructure, and what entities the private sector clients view as key to their success in the state.

Section 6: A Framework for Action

Expanding markets, increasing competition, and building research expertise will require an integrated and focused action plan by which public and private sectors can work toward a common set of goals for the aerospace industry. This section provides a framework based on a clear set of economic objectives and implemented through targeted strategies. The framework also contains key milestones and a metric to track progress and measure success.

Strategic Plan Goals

- To increase the markets and competitiveness of Oklahoma's existing aerospace companies.
- To attract new aerospace companies, suppliers and workers to the state.
- To enhance Oklahoma's reputation as a leader in identified areas of research, diagnostics and testing.

"The industry is changing and the competition is global. Oklahoma companies must be able to adapt and compete…" "The Oklahoma aerospace industry represents one of the most important economic engines and one of the few true industry clusters in the state. If we wish to maintain this industry, we must support it."

Oklahoma's EDGE (Economic Development Generating Excellence) Aerospace Panel 2003

Desired Outcomes

By focusing on targeted strategies and coordinating resources, industry and economic partners intend to increase the number of jobs and quantity of research funding, as well as achieve specific regional outcomes including the following:

- Maintain Tinker AFB as one of the primary centers for aerospace, and expand the number and size of contractors and subcontractors that serve Tinker (using facilities such as the former GM plant).
- Expand MRO operations in Tulsa, maintaining a strong presence for American Airlines while generating other opportunities.
- Increase aerospace opportunities around regional airports, including Oklahoma City, Tulsa and Ardmore.
- Be a key player in UAS testing and development, using university research and testing centers/facilities throughout the state.
- Increase the number of federal contracts and amount of federal research funding for aerospace awarded to state institutions and entities.
- Ramp-up university research and spin-outs in the areas of composite development, diagnostics and repair; sensor technology development and applications; unmanned systems development, testing and operations; and alternative fuels and accompanying engine technologies for aerospace applications, including biofuels.
- Expand awareness of Oklahoma's aerospace industry locally and nationally, and strengthen the state's global aerospace presence through focused and strategic marketing and communications.
- Increase the pipeline of Oklahoma students completing aerospace education and training, closing the gap between graduates and forecast employment demand.

Turning Opportunity into Strategy

Combining Oklahoma's assets with existing and emerging market opportunities leads to a framework that includes three targeted or vertical markets combined with three cross-cutting platforms to increase competitiveness. The blending of these platforms would provide growth possibilities throughout the state, building on existing resources and partnerships.

Vertical Platforms

- Retain current strength in MRO and OEM through development of diagnostics, examination, and repair technologies for composite materials.
- Play off local strengths in aerospace, energy and agriculture to capitalize on an important industry goal in alternative aircraft fuels and supporting engine technologies.
- Become an acknowledged center of excellence for servicing aerospace-related products/processes, including developing sensor technology applied to aerospace, UAS component development, UAV/UAS testing, training in manned and unmanned control systems, and establishing operational centers as a natural extension of that training.

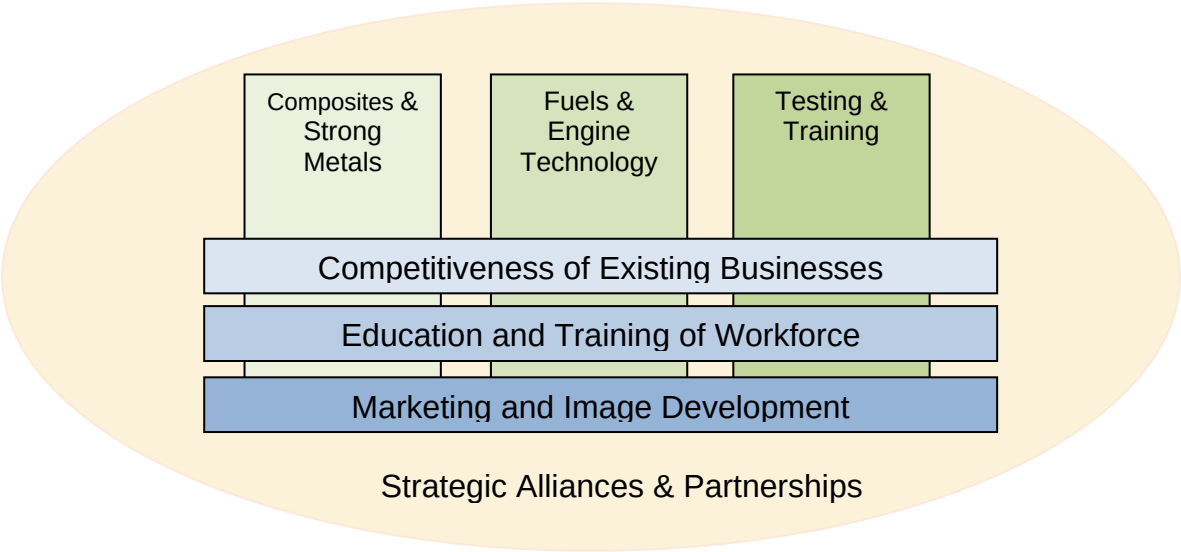
Cross-cutting Platforms

While three vertical platforms represent significant opportunities in specific markets, there are also growth prospects across the industry. To increase the overall competitiveness of Oklahoma's aerospace industry, three cross-cutting platforms are recommended:

- A focus on industry competitiveness through business expansion and retention efforts, and widespread implementation of lean and green practices that reduce operating costs, increase quality and reliability, expand market opportunities, and reduce risk, including environmental compliance.
- A focus on workforce development including continued and enhanced connections between education institutions and industries for technician and engineering related occupations, and enhanced incumbent worker training to maintain a leading edge on the use of new materials and technologies.
- A focus on marketing and recruitment that encompasses an aggressive awareness campaign focusing on the state's assets and quality of life as well as the economic incentives that make doing business in Oklahoma a cost-effective venture; indeed, defining the "product" that Oklahoma is trying to "sell".

Maximizing the outcomes of both vertical and cross-cutting platforms will require a strategy by which the multiple aerospace organizations and partners can work more effectively together to leverage resources and expertise as per our recommendations.

Diagram 2: Cross-cutting and Vertical Platforms.



Measuring Progress

Tracking progress is necessary to ensure that strategies are effective and resources are being efficiently deployed. In addition to specific milestones for each recommendation, there is a set of overall metrics that can be used to connect actions to the desired goals. These include:

- The number of aerospace jobs:
  - At a minimum, Oklahoma should grow at least as fast as the projected US average for aerospace jobs; a strategic target indicating a gain in market share would be job growth at a rate 20 percent higher than the US average growth in aerospace.

- The total payroll of aerospace jobs:
  - Technology and other competitiveness factors often mean companies grow revenues more than jobs; and jobs they do have tend to be of higher skill levels. An increase in total payroll will show a movement toward higher value operations.

- The number and amount of federal contracts awarded to Oklahoma companies:
  - The awards to Oklahoma companies of federal contracts should grow at a rate of 5 percent annually from 2010-2014.

- Number and value of research awards (research grants, SBIR/STTR awards, etc.) given to Oklahoma's university and companies:
  - Research awarded to Oklahoma institutions (universities and companies) should grow at a rate of 5 percent annually from 2010-2014.

- The number of aerospace graduates from Oklahoma institutions:
  - In recent years, the state graduated just over 400 individuals with associates' degrees and 760 individuals with degrees in aerospace, electrical or mechanical engineering. Studies suggest a gap, especially in master's degree and higher, of at least 25-40 percent. The five year goal should be to increase enrollments to levels that will cut the projected gap in half.

Recommendation A: Establish Oklahoma as a world-recognized center of excellence for the diagnostics, examination, and repair of new composites and strong metals.

Opportunity for Oklahoma:

- Provides expanded markets for the state's MRO and OEM industries.
- Enhances Oklahoma's reputation as a leader in applied aerospace technologies.

The newest generation of aircraft is increasingly incorporating composite materials. There are various influences on the direction this technology is taking, among them being aircraft weight as it relates to fuel efficiency. Many new aircraft have been designed exclusively with a combination of composites and strong metals such as titanium. While Oklahoma is not home to major airframe manufacturers, the state's industry does have a strong position and interest in MRO and aircraft OEM parts and systems related to the growing composites market. Machine shops such as ProFab specialize in finished titanium parts to support both markets.

Since the MRO providers for new aircraft need to understand new materials and technologies, there is an opportunity to create a leadership role in Oklahoma. To complement MRO activities, and to continue to support new aircraft construction, OEM suppliers need competence in the same areas. Therefore, investments in material testing, diagnostics, and repair techniques for composites and strong metals, as well as workforce training, can have a significant impact on multiple sectors of the aerospace industry.

Competitor states have already invested significant resources in support of researching and developing these new technologies. The State of Washington, backed by the FAA, has created a consortium for work in new materials called the Center for Advanced Materials in Transport Aircraft Structures. Kansas also hosts impressive efforts in new materials R & D at Wichita State University through the National Institute for Aviation Research (NIAR) and their Center of Excellence in Composites (CECAM).

The primary employers in Oklahoma aerospace have all worked with composites at some level. Using their combined experience and expertise to generate recognition of Oklahoma as a global center of excellence will be critical. This recognition will enable the Oklahoma MRO and OEM sectors to attract new business and have a consistently positive economic impact on the state and the aerospace workforce.

The Helmerich Advanced Technology Research Center (ATRC) at OSU-Tulsa will house laboratories for faculty and graduate students who will develop the next generation of composites and materials used by many Oklahoma industries. Clearly, this center and the research performed there could also contribute significantly to Oklahoma's status as a key player in the aerospace industry.

Key Strategies

Action A-1. Develop an industry-wide composite and strong materials program to focus on applied analysis, testing, and repair for aircraft:

- Create a university-industry consortium sponsored by OSU and based out of ATRC to solve pre-competitive technical issues with composites and strong metal inspection and repair. Approach MRO-focused companies such as AA's Composite Repair Division to identify research topics of interest in applied composite damage diagnostics and repair.

- Create a formal collaboration between Wichita State University, OSU ATRC and other Oklahoma institutions on applied composite material inspection and repair to leverage the expertise of Wichita's Center of Excellence in Composites. OSU ATRC's focus on applied composites repair technology and access to MRO partners may offer Wichita a new channel to apply technologies developed through CECAM.
- Partner with CareerTech to develop training programs for techniques developed through this consortium.

Action A-2. Expand on the above consortium, engaging multiple disciplines from OSU and OU in areas of materials science, vision systems, robotics, software, and mechanical, aerospace, and electrical engineering to apply innovative approaches to composites diagnostics and repair research problems (as demonstrated by OSU and Veracity Technology Solutions robotic inspection project).

Action A-3. Aggressively seek federal contracts and grants under the collaborative, targeting resources at NASA (Aircraft Aging and Durability project), at the Air Force Office of Scientific Research (BAA topic "Prognosis of Aircraft and Space Devices, Components, and Systems"), at the Naval Air Systems Command (NAVAIR) (Structures and Materials Engineering Divisions under the Air Vehicle Department open BAA), and through the FAA's Grants for Aviation Research under sub-topic Aviation Safety Technology.

Action A-4. Partner with the Aviation Safety Inspector Training group at the FAA Mike Monroney Center in light of their recent solicitation for "critical composite repair and safety issues" training to jointly explore safety issues requiring a technical solution.

Platform Milestones:

- Have a memorandum of agreement between industry partners, OSU-Tulsa, OU and OSU contributing departments, and CareerTech in place by 2011.
- Have collaborative program in place between Wichita State University and OSU-Tulsa that defines complimentary roles for both institutions in the area of new materials analysis, testing, and repair technology by 2011.
- Train XX CareerTech students in new techniques (industry should set targets) by 2012.
- Win XX in research awards or grants (industry should set targets) by 2015. As a comparative figure, Wichita's NIAR Center's operating budget is $35.8 million, with 41% federally funded, 37% industry funded, 16% state funded, and the remaining funded by the university and a state technology-based economic development organization. This budget supports 11 aerospace technology labs and five Centers of Excellence, one of which is the CECAM.

Primary Partners:

- Oklahoma Universities
- Aerospace Companies
- Wichita State University (CECAM)
- Industry Organizations
- CareerTech
- FAA Mike Monroney Center

Recommendation B: Gain recognition for leading edge fuel and related engine technology development

Opportunity for Oklahoma:

- Expands the State's presence in aerospace R&D capacity.
- Connects markets and economic opportunities for three significant sectors of Oklahoma's economy: aerospace, energy and agriculture.

Tinker AFB is acknowledged as "engine central" in the military. MRO work related to all major military engine classes occurs at Tinker, and as a consequence there is an already-established center of excellence in engine technology. This expertise extends to keeping aging aircraft airworthy by originating parts, integrating new technology and systems into existing engines, and working on new engine technology development, including new fuels.

The national and international interest in synthetic and bio fuels holds additional opportunities for Oklahoma, connecting to the states' energy and agricultural sectors. Research and testing of fuels is already underway at universities, in private research labs and at Tinker AFB.

Key Strategies

Action B-1. Focus a collaborative effort that brings together all aerospace organizations with the state's key universities and research facilities (including Tinker) to develop a comprehensive research and development plan for the aerospace industry directed at the use of alternative aviation fuels and their effects on engine technology.

- Ensure active participation by representatives of the collaboration in the Commercial Aviation Alternative Fuels Initiative (CAAFI).
- Engage in discussions with Air Force Alternative Fuels Certification Office and the Defense Energy Support Center to determine the current issues and opportunities associated with alternative aviation fuels, including opportunities for testing and certification of bio-based jet fuel.

Action B-2. Facilitate partnership discussions between Syntroleum, the state's natural gas refiners, and university energy experts to determine the feasibility of technology transfer and scale-up of synthetic fuels production.

Action B-3. Coordinate funding streams at State and Federal levels to support continued research on alternative fuel development in aerospace applications, aligning existing Tinker programs with state university and foundation research. Examples include the Energy and Environment XPrize, NASA's Alternative Aviation Fuel Experiment, and alternative fuels research funding in the Department of Energy, US Department of Agriculture, and the National Science Foundation.

Platform Milestones:

- Develop a coordinated strategy among partners to pursue alternative fuels research and development by 2010.
- Secure targeted state and federal funding for alternative aerospace fuel initiative. As a reference, Syntroleum and Tyson Foods are investing more than $150 million for a synthetic fuel plant in Louisiana for aviation and other fuel made from animal by-products that will produce 75 million gallons per year.

Primary Partners:

- Air Force Research Laboratory
- Tinker AFB
- Syntroleum
- Chesapeake Energy (and other natural gas producers/refiners)
- Petroleum Engineering departments at OSU and OU
- Mechanical and Aerospace departments at OSU and OU
- Oklahoma BioEnergy Center

Recommendation C: Become a premier center for testing/training of aerospace-related products and processes.

Opportunity for Oklahoma:

- Increases Oklahoma's reputation as the center of excellence for testing and training.
- Expands the value/supplier chain of various aerospace sectors.

The state has a very significant and unique set of assets that positions it in the top tier of testing and training for a broad range of aerospace applications.

- The Lawton UAV/UAS Testing Facility, using Ft. Sill restricted air space; this facility can be crucial in testing FAA NAS processes for developing civil UAS rules such as "detection and avoidance."
- The OK-USA (Oklahoma Unmanned Systems Alliance) effort that involves OU, OSU, and University Multispectral Lab (UML).
- Recognized aerospace related sensor testing and evaluation at OSU/UML in Ponca City.
- FAA Mike Monroney Center training capability; this facility covers a broad range of aerospace technical training focused on air traffic control.
- Oklahoma has significant assets in place for flight and air traffic control simulation for training at a variety of locations such as the U.S. Customs and Border Protection Air and Marine National Air Training Center which is focused on pilot training but also looking for UAS operator training opportunities.
- Oklahoma is well- positioned to be a center of NextGen related testing and training of ground based operators/air traffic controllers.
- NextGen related aviation weather research; "4D Weather Cube" creates a possible link with National Weather Center: OU and NOAA (National Severe Storm Laboratory) jointly develop meteorology tools for forecasting and early warning of imminent dangerous weather conditions.
- The MRO/OEM sectors in Oklahoma for both military and civilian aircraft have extensive experience in servicing aging aircraft and accompanying expertise in diagnosing and replacing damaged materials.

Key Strategies

Action C-1. Gain FAA recognition/endorsement of the Lawton UAS testing facility through the establishment of a memorandum of understanding; an interim or alternative step is to form an alliance with New Mexico State University that does have FAA recognition for their UAS program.

Action C-2. Provide the resources and political capital to make OSU/UML the center of excellence for UAS payload sensor testing in the U.S. and the focal point of testing and certification for the Federal lab system; use connection with SPAWAR and others to reach out to industry for their testing needs. Consider collaborative development of test bed flying platforms for UAS testing to enable development and evaluation of technologies such as sensor packages, avionics, and for training of UAS pilots.

Action C-3. Make Oklahoma the center for NextGen air traffic control system development and testing by establishing a partnership with the FAA Mike Monroney Center; use facilities such as Ardmore to "beta test" systems as they come on line; encourage Oklahoma small businesses working with UAS to pursue SBIR funding from NASA under topic NextGen Airspace.

Action C-4. Use the work at the National Severe Storm Laboratory, especially radar and detection technologies, to explore spin-out technologies for NextGen aviation weather needs; pursue SBIR funding from NASA under topic NextGen Airspace, and/or explore collaboration with

Daytona Beach NextGen test facility for possible severe weather testing at Ft. Sill for NextGen weather technologies.

Action C-5. Discuss with the U.S. Customs and Border Protection Air and Marine National Air Training Center the possibility of establishing a UAS pilot training center in Oklahoma; if established, pursue UAS pilot training needs with the Air Force and Navy.

Platform Milestone:

- Memorandum of agreement (or collaborative strategy) between Ft. Sill/OSU University Multispectral Lab and FAA in place by 2011.
- Win XX in new sensor testing contracts by 2013 (industry to determine target). New Mexico State University's UAV Systems and Operations Validation Program is requesting $2.9 million for inclusion in the FY10 National Defense Authorization Act.
- 50 percent increase in SBIR awards, targeting NextGen process and technology development by 2015.

Primary Partners:

- FAA Unmanned Aircraft Program Office (or New Mexico State University)
- Ft. Sill/OSU-University Multispectral Lab
- FAA Mike Monroney Center
- National Severe Storm Laboratory
- US Customs and Border Protection Air and Marine National Air Training Center
- Small UAS and sensor companies

Recommendation D: Increase the Competitiveness of Oklahoma's Aerospace Industry through targeted operational practices

Opportunity for Oklahoma:

- Increase the competitiveness of existing aerospace companies—growing revenues and jobs.
- Expand the value and supply chain of aerospace, creating new and expanded business opportunities with current assets.

"Lean and green" is not just a catch phrase; both concepts are necessary to be competitive in the global marketplace of MRO and OEM. The value chains demand responsiveness, productivity, flexibility, accuracy, and quality. Both commercial and military industry participants made similar observations: "high velocity" MRO is a key in competing for business.

Concurrent with the focus on Lean, the "greening" of operations will affect all facets of aerospace. The greening of materials and processes impacts alternative fuels research and adoption, the use of lighter weight materials in aircraft, and new air traffic control systems that can support efficiency in operations while maintaining safety. As the Federal government focuses more on sustainability and the environment, greening could become a mandated part of government contracts. In addition to the products themselves, facilities and processes should be considered as part of any lean and green initiative. The carbon footprint of operations will be important, as well as how green supply chains are, the character and amount of waste streams, water use, and energy efficiency.

Oklahoma economic developers are very active in business retention and expansion, or BRE. BRE programs are designed to assist companies to stay and prosper in Oklahoma and their home regions. Additionally, effective BRE programs are critical intelligence-gathering activities that provide information on the health and direction of companies and industries that can shape policies and programs to respond to issues and problems.

Key Strategies

Action D-1. Make "Lean and Green" training for the aerospace value chain a priority for the Oklahoma Manufacturing Alliance and economic development organizations around the state.

- Collaborate with larger companies who have already implemented to identify their key suppliers who have not yet implemented.
- Collaborate with the Oklahoma Manufacturing Alliance and the CareerTech system to determine which companies in aerospace have adopted Lean and Six Sigma protocols and green practices, and if they would mentor other companies interested in those programs.
- Use economic development groups, industry organizations, and other partners to actively reach out to those companies who have not implemented Lean/Green practices; based on their responsiveness, organize trainings, classes, and tours.
- Create statewide awards for both Lean and Green (patterned on the Shingo Prize) as applied to aerospace; regional winners (as selected by regional economic development organization) can then move on to a statewide awards format where there is Governor's recognition, press coverage, and an additional chance to tell the aerospace story.
- Use OU's Lean Institute and its work statewide, as well as the Oklahoma Manufacturing Alliance and the CareerTech system as training resources.

Action D-2. Business retention and expansion programs supported by economic development organizations around the state should collaborate on aerospace-related industry issues.

- Develop value-chain maps for major aerospace sectors.
- Identify value chain gaps to inform business recruitment and entrepreneurial efforts.
- Share critical information among economic development organizations.

Action D-3. Create a networking tool, similar to SourceNC.com, to assist Oklahoma aerospace companies in competing for projects and contracts and collaborate/supplement each others' skill sets and competencies.

- The North Carolina model involves the North Carolina Aerospace Alliance, North Carolina Military Business Center (a collaboration between business and the state community college system), and SourceHorizon, Inc. (a private sector E-supply chain management tool development company).
- Application of a networking tool would be a logical extension in Oklahoma of the Bid Assistance Network.

Platform Milestone:

- Add at least five companies/year in the aerospace value chain who have adopted Lean practices; Oklahoma Manufacturing Alliance projects costs for program implementation at $78,600 for smaller companies (under 100 employees) and $158,600 for larger companies (over 250 employees).
- Develop regional and statewide awards for Lean and Green as applied to aerospace industry.
- Have consolidated statewide industry business retention and expansion resources for aerospace in place by 2010, including shared protocols and information.
- Expand existing contracting assistance programs by adopting networking tools to facilitate collaboration among Oklahoma companies as they pursue major projects and contracts by 2011.

Primary Partners:

- Local/regional economic development partners
- Oklahoma Manufacturing Alliance
- CareerTech system
- Bid assistance program
- OU's Lean Institute

Recommendation E: Enhance the pipeline and capabilities of Oklahoma's Workforce

Opportunity for Oklahoma:

- Ability to more easily expand or attract aerospace companies.
- Increased competitiveness of Oklahoma's Aerospace companies.

Workforce continues to be a driving factor for the aerospace industry. With an aging workforce and a high percentage of employees eligible for retirement in the next decade, maintaining a healthy pipeline of qualified technicians and engineers will be essential. Once people enter aerospace careers, the continual changes in regulations, safety standards, materials, and testing procedures require a high level of ongoing skill training. The use of complex computer and communication systems, sensors, and robotics will require more technical proficiencies for workers of all skill levels. Aggravating the situation are the many young people who regard the aerospace industry as old fashioned.

Oklahoma Competence/Assets: Oklahoma CareerTech System, Oklahoma State University, University of Oklahoma, Spartan College of Aeronautics and Technology, Southeastern Oklahoma State University, and University of Tulsa.

Key Strategies

Action E-1. Much like the recommendations of the *2007 Oklahoma Aerospace Industry Workforce 2007 Report,* this plan supports enhancements of STEM education at the K-12 level.

- Oklahoma's Aerospace industry groups should actively promote company participation in STEM and national aerospace education efforts for youth 18 and younger. The state's industry should consider a goal of increasing sponsorship and mentoring for STEM competitions and camps with at least three teams progressing to national finals in competitions. Since the aerospace industry is located in various regions of the state, this will allow employers (including military bases) to sponsor various schools and increase interest in aerospace throughout Oklahoma.
- The industry should aggressively support state efforts to increase STEM related education and the training and skill development of K-12 math, science and technology teachers. STEM education should be included as part of the industry's lobbying activities with the state.
- The industry should partner with other manufacturing and technology industries to actively promote applied STEM curriculum (including Project Lead the Way) in more schools statewide, adding at least 10 additional school districts to the current list of 18 that participate in the program over the next five years.
- Increase the capacity of programs (i.e. double or triple outcomes) such as the Aerospace Curriculum Grant, Investigative Research Scholars Program, and the Aerospace Fellows Program in order to reach significantly more students and teachers.

Action E-2. Increase capacity of CareerTech programs in the areas of composites/new materials technology and precision machining. This not only supports the aerospace industry but energy, manufacturing, and other high technology sectors.

Action E-3. Enhance the ongoing ability to rapidly respond to training needs by establishing skills panels that can be either region or platform/sector based. These skill panels would include industry representatives and education and training providers, and would develop or enhance specific programs for incumbent worker and degree/certification programs. Start with training needs already identified by the Oklahoma aerospace industry, including:

- Composite examination, testing and repair
- Precision machining of replacement parts for aging aircraft
- Avionics and electronics technology

Action E-4. Improve industry-university collaboration, especially in research and knowledge transfer, through a more comprehensive approach to identifying research and education needs. A joint effort is needed that brings together each aerospace organization with the state's key universities and research facilities (including Tinker) to develop a comprehensive research and development plan for the aerospace industry. This collaboration could be used to reduce the duplication of education outreach efforts among aerospace organizations.

Action E-5. Enhance workforce recruitment efforts by aggressively promoting state workforce incentives and increasing the number of aerospace internships as part of an effort to keep Oklahoma graduates in the state and introduce potential new workers to the state.

Platform Milestone:

- By 2011, identify top three training issues related to emerging market opportunities targeted in this plan and secure funding for program development or expansion.
- By 2012, increase the number of industry sponsored K-12 STEM competitions and aerospace awareness programs by 40 percent.
- By 2013, increase the number of schools with applied STEM curriculum (e.g. Project Lead the Way) by 30 percent.
- By 2015, make significant progress in enrollment of aerospace and mechanical engineers to decrease the projected gap in degreed occupations.

Primary Partners:

- Partners include education providers, workforce investment boards, industry associations and employers.
- Potential funding sources include grants from the Department of Labor and federal recovery funds for workforce.

Recommendation F: Form "TeamAero Oklahoma" to position the Oklahoma Aerospace industry's unique assets clearly in the minds of state, national and international audiences.

Opportunity for Oklahoma

- Support and recognition from leaders within the state of the importance of the aerospace industry in the State's economy.
- Increased national and international awareness of Oklahoma's aerospace economy and opportunities.

A very consistent theme that arose from personal interviews and focus group interaction was the perceived need for a much more robust marketing and communication effort centered on the aerospace industry and its assets in Oklahoma. It was recommended that the industry should develop a clear and concise brand positioning, building internal awareness within state to enhance support for the industry and presenting a consistent external message to industry members regionally, nationally and globally. With its strengths and impact on the state's economy clearly identified, the industry should segment its internal and external audiences, identifying a partner responsible for managing the messages and the specific marketing channels through which to deliver key messages.

Key Strategies

Action F-1. Create a marketing and industry promotion team (*"TeamAero Oklahoma"*) comprised of public and private sector participants to direct branding, marketing, and business recruitment efforts for Oklahoma aerospace.

- Develop operating agreements
- Identify and commit funding resources

Action F-2. Develop a clear and concise Oklahoma aerospace brand; build brand awareness among internal audiences within state to enhance support for the industry and present a consistent external message to regional, national, and global industry stakeholders. This may be more complex for Oklahoma than Ontario or Georgia because presently a single organization is not clearly leading the effort on behalf of the state to all audiences.

- Develop an external positioning statement to concisely articulate the industry focus and strengths (e.g. Where Innovation Soars; Ontario).
- Create shared graphic assets that collaborating partners can use to represent the industry (e.g. logos, graphic standards, presentation templates).
- To the greatest possible extent conduct industry business under one name, even if separate organizations remain in existence or are collaborating in the marketing effort.
- Consistently use the aerospace brand in recruitment efforts.
- Utilize the new brand and new communication tools to reduce the need to separately promote the industry at the community-level.

Action F-3. Create a portal for Oklahoma's aerospace brand to communicate to all audiences and promote the portal as the one-stop-shop for information for the industry.

- All industry partners should consider incorporating their content and managed communication to external audiences through this vehicle; consolidation of existing web sites should be considered.
- Launch the web portal concurrently with an industry awareness campaign at national and international aerospace shows, in the trade media, and through state-wide community functions.

- Present the Oklahoma Aerospace Summit as an output of Oklahoma's industry and not as a program of any particular group or entity; communication and promotion of the summit should be a direct reflection of the brand and Oklahoma's positioning in the industry.
- Provide member-only access to Oklahoma industry partners through databases, message boards, reports and updates.
- Provide secure business-to-business communication opportunities on the site.
- Include a calendar and inventory of activities so that all partners are aware of current events and associations are made clear to external audiences.
- Assign a web master and share the cost of the resource among industry partners
- Launch the web portal concurrently with an industry awareness campaign at national and international aerospace shows, in the trade media, and through state-wide community functions.

Platform Milestones

- Work with the industry to create a statewide aerospace marketing program that focuses on Oklahoma's strengths and expertise by 2010.
    - Budget range for communication study and message development, $25,000-$50,000. Creative development for initial industry assets excluding collateral and production, $25,000-$50,000.
- Create a state aero industry web site by 2010.
    - Costs vary based on the content outline and needed interactive tools and funding source for the web master. Initially projected, $150,000 including an ongoing resource for content management.
- Develop an Oklahoma TeamAero marketing approach for aerospace that involves industry, Oklahoma Department of Commerce, and regional economic developers by 2010.
- Create a strategic marketing plan to refine aerospace marketing programs' focus on areas where Oklahoma has unique opportunities by 2011.
- Create a market intelligence system (based in business recruitment, retention and expansion efforts) that is agile and responsive to market conditions so that Oklahoma TeamAero can aggressively take advantage of opportunities that arise by 2011.

Primary Partners:

- Key aerospace industry members
- All aerospace industry organizations including Oklahoma Aeronautics Commission, Oklahoma Aerospace Alliance, and Oklahoma Aerospace Institute
- Oklahoma Department of Commerce as the primary statewide public sector marketing entity to lead Oklahoma TeamAero
- Regional economic development agencies and development authorities who can ally with their local industry members as part of marketing efforts
- State universities actively involved in aerospace industry issues

Funding Aerospace Efforts

In addition to the resources stakeholders are already providing to promote aerospace jobs in Oklahoma, this five-year plan recommends some additional funding. Based on budgets for other states, it is estimated that a state funding level increase of $4-5 million per year or $20-25 million over a five-year period is needed to keep up with and leap-frog competitor regions. This amount of funding would be used to leverage a minimum of three times this amount in federal and private funds.

Expanding Research

Oklahoma has many assets that can be used to accelerate the growth of aerospace research, including facilities like the Multispectral Lab or the Noble Foundation and statewide programs like the applied research funding from OCAST, eminent scholar programs, and others. The industry, however, lacks a coordinated approach to leveraging these resources. States like Georgia, Oregon and others have developed collaborative efforts targeting specific industries which have shown impressive results.

One example is the Oregon Nanoscience and Microtechnologies Institute (ONAMI) which includes multiple research universities, a federal lab and industry. Set up as a separate 501(c)3, in its first year it used just over $1 million of state funds to leverage $10 million in federal research grants. Industry is active in applied projects and has donated facilities and equipment. Existing university funds are matched with state funds to pay for a coordinator and grant writer, and to pool matching grants pursue larger and interdisciplinary federal awards. State funds are also used for recruitment packages to attract key researchers. In the last few years, ONAMI's budget from the state has been about $4-7 million per year to cover these costs (not counting university or federal industry contributions which bring the total budget to more than $30 million). Wichita NIAR's budget of $35 million is very similar to ONAMI's and includes about 25 percent from the state, almost 50 percent from federal grants, and 20 percent from industry.

To accelerate the amount of aerospace research, especially applied research with industry, a more focused effort is needed to combine the resources of universities, nonprofit institutions, and the industry. Having a reputation of being a center of expertise does not need to mean new buildings, especially with the breadth of resources the state already has in place. However, a small coordination staff, matching grant funds, and some additional recruitment money for researchers would take about $3-4 million per year in addition to resources already available through universities and the state. The expectation is that additional funds would leverage more than four to five times that amount in federal and industry supported research (a goal of more than $40-50 million over a five year period).

Accelerating Competitiveness

To ensure that operations are both lean and green in Oklahoma, the industry should explore a competitiveness training grant that provides small and medium enterprises with matching funds to implement these efforts. Other states have successfully used matching grant programs for a variety of issues. The aerospace industry might consider a program, by which grants are available for lean training where companies with 200-500 employees receive a 50 percent match, and those with fewer than 200 employees receive a 100 percent match (or another similar sliding scale based on company size). A grant pool of $200,000 could help implement lean at 6-10 companies. The industry should also actively pursue federal recovery funds and grants related to green training within the industry, requiring a grant writer and possibly matching funds. A total company training grant program of $300,000 per year should be allocated to build momentum for both efforts.

Developing a Cohesive State Partnership

A productive and functional industry organizational structure is necessary to lead and/or contribute to all of these efforts. A combination of state, local and industry funding should be committed in the area of $500,000 per year to be competitive with Georgia and other state organizations. Currently that level of funding in Oklahoma is committed by the public sector to support OAI and its operation, and the private sector through SpiritBank's support of OAA. While Oklahoma is home to operations for many major companies, the nature of those operations make it unrealistic to expect that industry organizing leadership would come from the private sector. As a consequence, leadership in forging a productive and effective state partnership will need to come from the public sector and its allied economic development organizations. A common funding source for industry associations, yet one lacking in Oklahoma, are contributions from private sector aerospace companies. For instance, Ontario uses a funding model of a per employee industry assessment ($11/employee) to help fund initiatives and marketing efforts. To help offset additional funding, Oklahoma may need to implement selected initiatives not already in place. The industry could put in place a company assessment of $4-5 per employee to raise approximately $250,000 per year. This assessment could pay for specific activities such as:

> *Enhancing Business Expansion/Retention/Recruitment Efforts:* As noted in the report, aerospace business assistance includes multiple state and regional players, yet there does not appear to be shared industry intelligence among each of these organizations. Developing an industry-wide database of aerospace businesses and needs, tracking collaborative opportunities, and reaching out to industry officials to facilitate those collaborations, can leverage opportunities in each region. A single analyst position with some funding for an annual statewide business survey could add value to each support organization. The cost of this would be no more than about $125,000 per year.
>
> *Collaborative Marketing:* Developing a coordinated story for Oklahoma aerospace industry will require a more robust marketing/public relations effort. Developing a message that captures the diversity of the industry yet focuses on the quality of people and assets means a new marketing plan and materials. After leveraging the marketing resources of existing partners to pay for the initial plan (~$50,000), a more comprehensive effort can be made to raise additional funds for collateral, media buying, tradeshow materials, etc. A total five-year package would likely run more than $100,000 per year. ODOC has existing relationships and contracts with P.R. firms that could be directed, at least in part, toward this effort.

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A Summary of Statewide and Regional Opportunities

Table 7: Statewide and Regional Opportunities by Recommendation

Recommendation A: *Establish Oklahoma as a world-recognized center of excellence for the diagnostics, examination, and repair of new composites and strong metals.*	
Statewide Opportunities	Enhanced abilities in composites and strong metals that OEM companies around the state will benefit from.
Regional Opportunities	▪ OSU-Tulsa Materials Center can focus on diagnostics, testing and repair of composites; use expertise in composites to enhance American Airlines MRO operations and related supply chain. ▪ Tinker AFB and related suppliers will need composites and strong metals expertise for MRO operations on new generation aircraft.
Recommendation B: *Gain recognition for leading edge fuel and related engine technology development.*	
Statewide Opportunities	Energy companies statewide engaged in traditional carbon fuels, synthetic and biofuels research have opportunities as the aerospace industry seeks commercially viable alternatives.
Regional Opportunities	▪ Norman, Stillwater, and Tulsa: University research on fuels, synthetic fuels and biofuels occurring at OU, OSU, U of Tulsa. ▪ Ardmore: Noble Foundation research in biofuels presents opportunities for spin-out commercialization activities. ▪ Tulsa: Build on the existing success of Syntroleum to expand commercially viable synthetic fuels. ▪ Oklahoma City: Expand synthetic fuel and testing program at Tinker AFB; provide a focal point for additional alternative fuel/engine technology programs for the U.S. government.
Recommendation C: *Become an acknowledged center for testing/training of aerospace-related products and processes.*	
Statewide Opportunities	▪ Oklahoma can position itself as the center of the FAA's NextGen development, testing, and training centered on the Monroney Center, and utilize uncrowded air space around the state. ▪ Strengthen connections between NOAA's National Severe Storm Laboratory and OU radar and sensor technology.
Regional Opportunities	▪ Lawton, Ft. Sill and surrounding areas: Utilize Ft. Sill's restricted air space in UAS development and testing. ▪ Norman, Stillwater and Ponca City: OK-USA (Unmanned Systems Alliance) research programs can produce technology that can be tested/proven at Ft. Sill test range. ▪ Ponca City: Expand the OSU University Multispectral Laboratory research on developing and testing sensor technologies and aerospace applications. ▪ Oklahoma City: Monroney FAA training center could be positioned as the center of FAA's NextGen air traffic control system development.

Recommendation D: *Increase the competitiveness of Oklahoma's Aerospace Industry through targeted operational practices.*	
Statewide Opportunities	▪ Utilize Oklahoma Manufacturing Alliance to create Lean and Green programs focused on the aerospace value chain. ▪ Engage primary aerospace manufacturers established in Lean processes to mentor/assist value chain members.
Regional Opportunities	▪ Oklahoma City/Norman: Build on OU's expertise at the Lean Institute at Tinker AFB to expand programs in other regions. ▪ Develop a more collaborative approach to business expansion and retention utilizing regional economic development entities for expertise/information to seize opportunities for aerospace industry clients.
Recommendation E: *Enhance the pipeline and capabilities of Oklahoma's Workforce.*	
Statewide Opportunities	▪ Support efforts to enhance STEM education in K-12 systems in order to provide a larger pipeline of students with technical interests and abilities. ▪ Enhance the capacity of the CareerTech system to keep up to date with new aerospace training and curriculum. ▪ Promote industry and education collaboration to design skills panels for aerospace that should define more specifically the skill sets needed by the industry.
Recommendation F: *Form "TeamAero Oklahoma" to position the Oklahoma Aerospace industry's unique assets clearly in the minds of state, national and international audiences.*	
Statewide Opportunities	▪ Create TeamAero Oklahoma to more effectively promote Oklahoma's aerospace industry to internal and external audiences and markets. ▪ Create network collaboration tools to assist aerospace companies in obtaining contracts and projects. ▪ Create a web portal to focus aerospace industry messaging to internal and external audiences.
Regional Opportunities	▪ Oklahoma City, Tulsa, Weatherford, Altus, Vance AFB, Ada and Alva: Utilize the network of regional air shows and museums/displays to promote the industry to Oklahoma's citizens and educate them about the importance of the industry to the state.