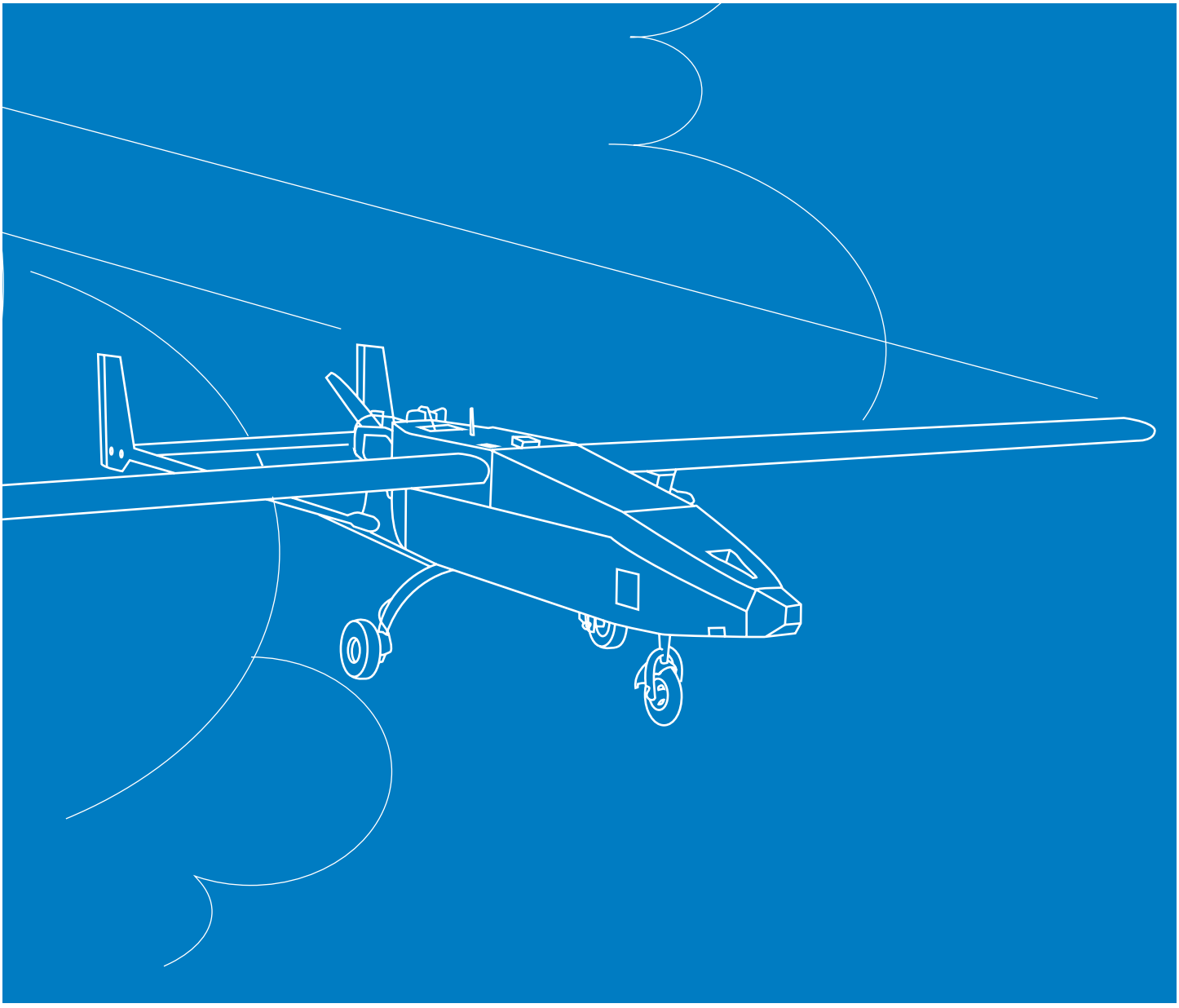
Report of the Governor's Oklahoma Unmanned Aerial Systems Council

A Strategic Plan for the Development of an Unmanned Aerial Systems Enterprise in the State of Oklahoma



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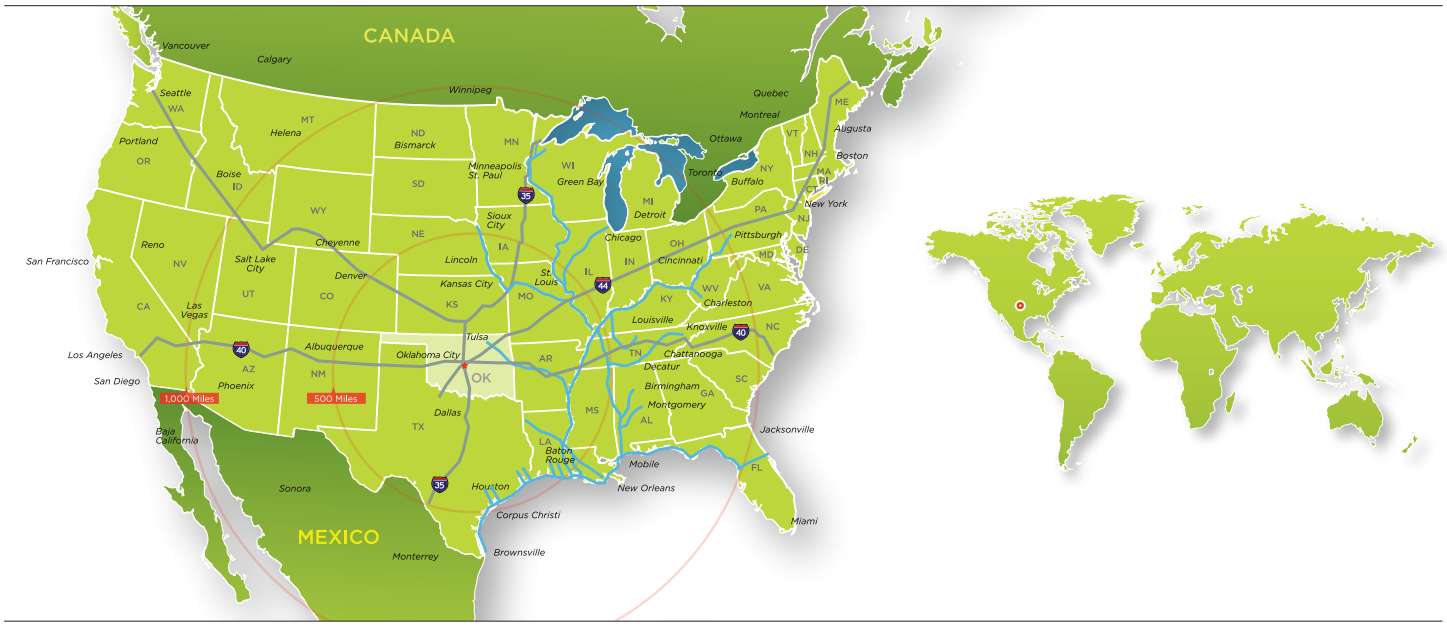

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The plan also was reviewed by external advisors from large UAS manufacturers and Oklahoma UAS-related companies.

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EXECUTIVE SUMMARY

Economic forecasts for the growth of the UAS industry, both worldwide and in the U.S., indicate a burgeoning industry set to grow rapidly. For the United States Defense Department alone, expenditures on UAS will rise from its current $3.9B per year to over $5.5B by 2025. The world market will almost triple over the next decade from the current $5.9B annually to a projected $15.1B. Seventy percent of the world Research and Development (R&D) and procurement market in UAS will belong to the U.S. by the year 2020. Some estimates suggest that the U.S. Air Force will train more UAS pilots than manned fighter and bomber pilots with one-third of the current USAF aircraft fleet being unmanned. The Pentagon will buy more UAS than manned aircraft. U.S. industry supporting this market will continue to see impressive growth and UAS is one of the few positive growth industries for the United States with significant projected job growth. For example, the military UAS job market is currently experiencing a 3.1 percent per year growth rate with an expected growth rate as high as 4.5 percent per year, up to 2025.

Current projections for revenues in the commercial market are much less (currently) but are still quite considerable. Forecasts indicate revenue from commercial use of UAS will grow from its current almost $40M per year to over $250M per year by 2025 in the United States. The issue holding back commercial growth at present is the restriction on the use of UAS in the National Airspace System (NAS). To remove these restrictions, recent federal legislation mandates the FAA to devise a plan to allow UAS use in the NAS by the year 2015. To enable this to happen, six FAA UAS Test Ranges will be established across the country. The life of the six FAA test ranges will likely extend beyond 2015, and there are also likely to be other test sites in addition to the FAA ranges.

Oklahoma currently has several major assets needed to grow a significant UAS industry in the state, creating high-paid and quality jobs. The same assets will enable the state to compete aggressively for one of the six FAA UAS test ranges or other, similar federally directed test ranges. Oklahoma assets include R&D in vehicle design, payloads and radar, as well as strong programs in applications, test and verification, education and training. Existing partnerships among and between public entities (ODOC, OAC, OSIDA, OSU, OU, UML and OKARNG) and private sector entities strengthen the competitive position of the state. Oklahoma has a robust UAS private sector, with at least 15 private companies involved in all facets of UAS. Private entities in Oklahoma have strong capabilities in UAV development, test and simulation, composites, propulsion, sensors, training and many other areas. Leadership from state government (Gov. Mary Fallin) and support from federal congressional members completes a well-rounded package that should enable Oklahoma to be a major player in the development of the UAS industry in this country.

The UAS Advisory Council was appointed by Gov. Fallin to establish a best path to success in this arena. The result is this "Strategic Plan for the Development of an *"Unmanned Aerial Systems Enterprise in the State of Oklahoma."* The council, led by the Governor's Secretary for Science and Technology, consists of individuals from the public and private sectors and is an illustration of the coordinated response from the state to the opportunities in the UAS arena. The plan is meant to be pragmatic and to build upon the strong foundation of existing UAS activities and infrastructure. Recommendations cover expansion of UAS test ranges, investment into research and development, and growth of educational and training programs. Key elements in the strategic plan are summarized in the following recommendations:

Recommendation 1: Establish a network of FAA UAS Test Sites, including the OTC-US℠, Chilocco, Clinton-Sherman, Camp Gruber, Kessler Field Station and Muldrow Heliport. Link the sites via UAS air corridors.

Recommendation 2: Build and equip the UAS Radar and Sensor Systems Center at OU.

Recommendation 3: Build and equip UAS R&D facilities and UAS Industry facilities at the Oklahoma Technology and Research Park, Stillwater.

Recommendation 4: Compete aggressively to become a federally directed (e.g. FAA, DHS, etc.) UAS Test Range.

Recommendation 5: Create a centralized administration to operate an integrated Oklahoma UAS Test Site Network.

Recommendation 6: Invest in Research and Development in UAS and compete for an ERC, UARC and/or FFRDC.

Recommendation 7: Expand and Strengthen UAS Education and Training Capabilities.

Recommendation 8: Establish and Grow Strategic Partnerships and Collaborations.

Recommendation 9: Expand Corporate UAS Manufacturing Presence in Oklahoma and State Support to Private UAS Companies in Oklahoma.

Recommendation 10: Grow Political Support and Public Advocacy.

The opportunities for Oklahoma in the UAS business are statewide, with impact across many different regions of the state. A UAS industry in Oklahoma therefore has the potential to positively impact many communities across the state and is not just centered on one area alone. The ultimate goal of the plan is to attract UAS manufacturers to the state and to establish significant UAS operations here. This will result in the growth of multiple economic development opportunities for Oklahoma and job creation for its residents.

As with all strategic plans, this is intended to be a “living document,” to be continually reviewed and, where necessary, revised to accommodate technological, political and policy developments at the federal, state and private levels.

1. BACKGROUND

1.1 The UAS Market

Unmanned Aerial Systems (UAS, also known as Unmanned Aircraft Systems) represent the fastest growth area in the aviation industry today. A 2010 report[1] from the Association of Unmanned Vehicle Systems International (AUVSI) forecasts that for the United States Defense Department (DoD) alone, expenditures on UAS will rise from its current $3.9B per year to over $5.5B by 2025. The numbers are matched by similar analyses by The Teal Group who also predict[2] that the world market will almost triple over the next decade from the current $5.9B annually (worldwide) to a projected $15.1B. As noted by The Teal Group, these numbers would be even greater if operations and maintenance (maintenance, repair & overhaul, MRO) expenditures were included. In addition, a recent UAS Global Report lists over 1,300 different Unmanned Aerial Vehicles (UAVs) currently in production or testing and development worldwide.[3,4]

The primary driver of this growth is the United States, and in particular the DoD. Almost 70 percent of the world Research and Development (R&D) and procurement market in UAS will belong to the U.S. by the year 2020. It is claimed in some reports that the U.S. Air Force will train more UAS pilots than manned fighter and bomber pilots, while the Pentagon will buy more UAS than manned aircraft. One-third of the current USAF aircraft fleet is unmanned and the U.S. Army flew approximately 1 million hours with UAS in 2010. U.S. industry supporting this market has seen impressive growth and is one of the few positive growth industries for the nation. The military UAS job market is experiencing a 3.1 percent per year growth rate with an expected growth rate as high as 4.5 percent per year, up to 2025. The next largest UAS economy outside the United States is Europe, followed by Asia-Pacific. Use of UAS in African nations continues to grow rapidly.

With current restrictions on the use of commercial UAS in the U.S. National Airspace System (NAS), spending and projections for economic growth in the commercial sector are small compared to that in the military sector. Nevertheless, forecasted revenues are still quite considerable. Current projections indicate revenue from commercial use of UAS will grow from its current almost $40M per year to over $250M per year by 2025 in the United States. As the AUVSI and The Teal Group reports indicate, the main items holding back commercial development are the lack of access to airspace for UAS flights and development, and restrictive export control regulations for U.S. manufacturers to other countries with more flexible airspace restrictions (e.g. Japan). As a result, the commercial market is slow to develop. Nevertheless, U.S. industry members surveyed by AUVSI indicated their belief that "the growth experienced by the military UAS market is miniscule when compared to the potential for the civilian and commercial UAS sectors."

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[1] *Unmanned Aircraft System Integration into the United States National Airspace System: An Assessment of the Impact on Job Creation in the U.S. Aerospace Industry.* AUVSI, 2010

[2] *World Unmanned Aerial Vehicle Systems. 2011 Market Profile and Forecast,* The Teal Group Corporation, 2011.

[3] *UAS Unmanned Aircraft Systems: The Global Perspective,* 2011-2012 Yearbook, 9th Edition, June 2011, Blyenburgh & Co.

[4] The present uncertainty regarding the federal budget may alter some of the above financial projections in as-yet unpredictable ways.

AUVSI estimates almost 50,000 jobs will be created in the primary UAS market by the year 2015, with $1.6B in wages in the five-year period between 2010 and 2015 ($106.6M annually). This does not include the secondary UAS market, including training and education, simulation, sub-systems and payloads (computers, software, sensors, navigation electronics, etc.) and MRO operations. Regardless of the commercial market, the DoD market and the required platforms will require increased sustainment activities and effort in the future as "non-throw-away" platforms age. Support for ancillary staff positions (sales, accounting, human resource management, etc.) will also grow. Finally, universities and colleges will have an influx of students interested in UAS-related careers.

1.2
FAA and the National Airspace

The vital factor to achieve this anticipated growth is the opening of the National Airspace System (NAS) in the United States to allow integration of unmanned and manned flights. Recent federal legislation – the National Defense Authorization Act (NDAA, Dec. 2011), and its associated Appropriations Act (H.R. 2055, Public Law No. 112-74, Dec. 2011) and the recent FAA Reauthorization and Reform Act (H.R. 658, Feb. 2012) – mandate the FAA to "develop a comprehensive plan to safely integrate commercial unmanned aircraft systems into the national airspace ... the plan shall provide for the safe integration of civil unmanned aircraft systems into the national airspace system as soon as practicable, but not later than Sept. 30, 2015."

In order to achieve this goal, the FAA and UAS community will have to overcome several significant challenges. These include safe UAS operations, cultural acceptance, definition of UAS standards, definition of the usable radio spectrum and satellite bandwidth as UAS moves into commercial markets, and many other issues. Safety, however, is the primary concern. Safety standards will eventually need to allow "file-and-fly" and this will require the development of "lost-link" procedures, "sense-and-avoid" capabilities, pilot training certifications, maintenance standards, etc. Although there are currently multiple technologies that allow various levels of sense and avoid, including active and passive systems, achieving the above goals is non-trivial and there is a considerable distance for the UAS community to travel. Nevertheless, the legislation requires that the FAA plan for integration of UAS into the NAS be complete and ready 270 days after the date of the act.

Other requirements of the FAA Act include:

- Requiring the FAA to create a five-year UAS road map (which should be updated annually).
- Requiring small UAS (under 55 lbs.) to be allowed to fly within 27 months.
- Requiring six UAS test sites to be established (similar to the language in the already-passed Defense Authorization bill).
- Requiring small UAS (under 55 lbs.) be allowed to fly in the U.S. Arctic, 24-hours-a-day, beyond line-of-sight, at an altitude of at least 2,000 ft., within one year.

- Requiring expedited access for public users, such as law enforcement, firefighters, emergency responders, etc.

- Allowing first responders to fly very small UAS (4.4 lbs. or less) within 90 days if they meet certain requirements. The goal is to get law enforcement and firefighters immediate access to start flying small systems to save lives and increase public safety.

- Requiring the FAA to study UAS human factors and causes of accidents.

- Exempting model aircraft, so long as the aircraft weighs less than 55 lbs. and follows a set of community-based safety standards.

A first step following enactment of the legislation will be to establish, within 180 days of the enactment, six FAA UAS Test Ranges in the U.S. to allow the use of non-exclusionary (i.e., unrestricted) airspace for integrated manned and unmanned flight operations in the NAS. The FAA will develop certification standards and air traffic management requirements for flight operations at the UAS Test Ranges, and provide verification standards for the safety of UAS and navigational procedures. The FAA is encouraged to work with NASA and the DoD, and will coordinate activities at the UAS Test Ranges with developments for NextGen, the Next Generation Air Transportation System. The location of the UAS Test Ranges will take into account varied geography, climate and the availability of research radars.

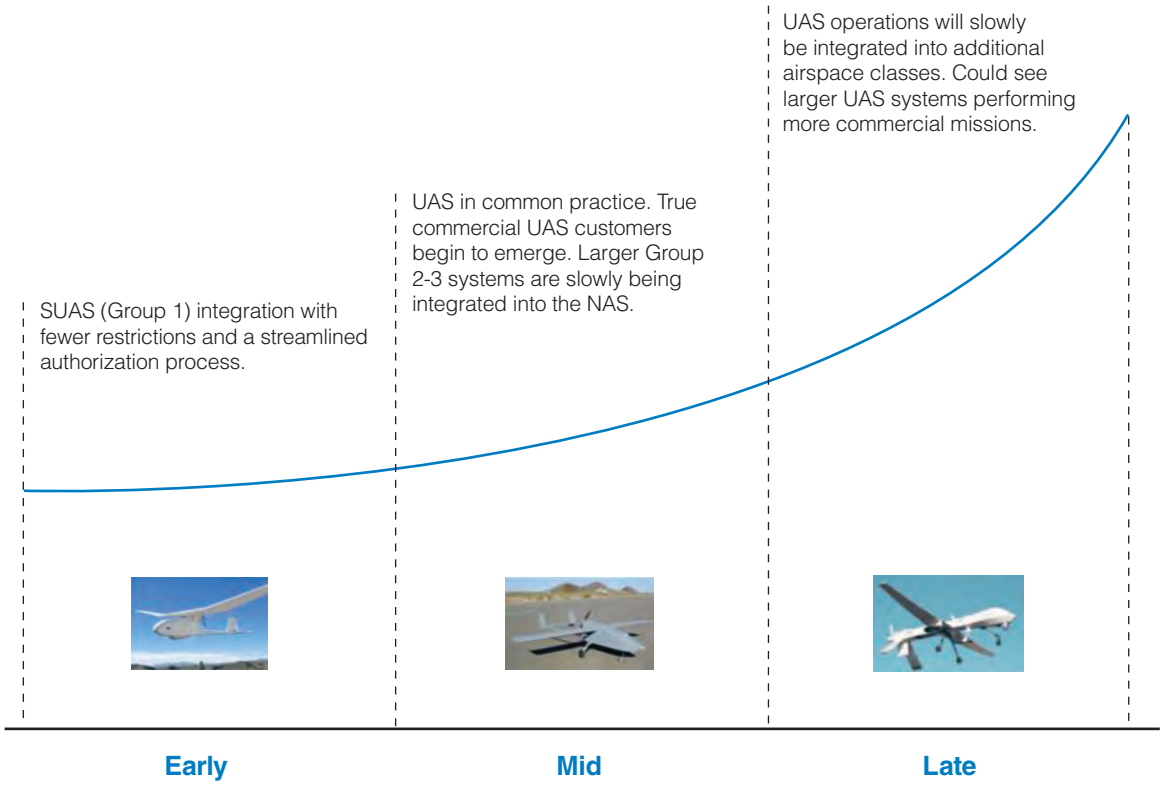


Figure 1: UAS Integration into the NAS: 2015-2025. (Adapted from AUVSI Report, ref. 1)

The projected approximate timeline for UAS integration into the NAS is as depicted in Figure 1. This assumes that small UAS will be the first to be integrated while the largest UAS will not become so for a further decade. Also under current discussion by the FAA's Aviation Rulemaking Committee are the UAS standards and necessary rules and procedures. The new rules for integration of small UAS (SUAS) into the NAS were expected as early as January 2012, but are now delayed until some later time (possibly fall 2012).

Additional opportunities include a yet-to-be-released request for proposals by the FAA for a UAS Center of Excellence (COE). In February 2012, the Department of Homeland Security (DHS) announced a program concerning a new SUAS center for technology transition to first responders to demonstrate and transition DoD SUAS investments for use by first responders and border control agents. The program is called ***Robotic Aircraft for Public Safety (RAPS)***. Both of the above represent viable opportunities for Oklahoma in addition to the FAA UAS Test Range opportunity discussed earlier.

1.3 Education and Training

Academic programs will grow alongside the UAS military and commercial opportunities. UAS education and training programs will grow and flourish. Already universities across the nation are beginning to introduce UAS-related curricula into degree programs, with Oklahoma State University being the first to offer a complete UAS Option at the graduate level, as a specialization in the M.S. and Ph.D. programs in Mechanical and Aerospace Engineering.

Different universities will specialize in different aspects of the UAS industry, with some concentrating on engineering – design and manufacture of the platform (Unmanned Aerial/Aircraft Vehicles, UAVs) – while others concentrate on pilot training, payload design, radar and RF communications, or applications. A current list of universities with UAS/UAV academic programs throughout the U.S. can be found in Appendix 1.

1.4 The Opportunity for Oklahoma

Oklahoma occupies a very favorable position in the nascent UAS industry and is contributing strongly to its growth, to the benefit of the residents of Oklahoma – more so, if the right strategic steps are taken in the immediate future. As noted earlier, immediate opportunities for Oklahoma exist in the competition for the FAA UAS Test Ranges, for the FAA COE, and for the DHS RAPS program.

As noted, a critical missing piece for the development of the UAS commercial sector is the ability to fly commercially in the NAS. This restriction applies not just to operations, but to testing and development also. In order to test new UAVs or payload systems, commercial (and military) operators have to gain access to restricted airspace, outside the jurisdiction of the FAA and typically controlled by the military, or they must apply for a Special Airworthiness Certificate. Neither is easy to come by.

In this regard, Oklahoma is at a distinct advantage over many other states because it has access to restricted airspace from a UAS flight facility controlled and operated by the Oklahoma State University Multispectral Laboratories (UML) and its partners. This arrangement stems from an exclusive agreement with the Army's FIRES Center of Excellence at Ft. Sill, which allows the UML to operate in its restricted airspace on a "not-to-interfere" basis, as long as the flights are coordinated with the Ft. Sill Air Traffic Control and Ft. Sill Range Control, and as long as the purposes are defense or homeland-security related. Since establishing this facility (known as the Oklahoma Training Center - Unmanned Systems, OTC-US℠) the UML has worked with multiple customers, from both government and government contractors, and the demand for use of the airspace has grown significantly in recent months.

Non-commercial, public entities may fly outside restricted airspace if they have a Certificate of Authorization (CoA) from the FAA. CoAs allow public entities to fly a single type of UAS for public purposes and for specified periods. CoAs allow flights in the NAS as long as stringent "lost link" and safety procedures are met. Commercial-purpose flights are not allowed and CoAs cannot be obtained for such purposes. At the time of preparation of this report, OU, OSU and the OKNARG are involved in various stages of the CoA application process for several public-purpose projects, while OSIDA and the UML are examining various CoA options.

Thus, access to restricted airspace, at any time and for any customer (as long as there is a military or security purpose or linkage) places Oklahoma at the forefront of R&D and Test and Evaluation (T&E) of UAS in the United States. Although other states also have access to restricted airspace testing, such access is usually controlled by the Department of Defense, whereas in Oklahoma access is controlled by the UML via a government-to-government (federal-to-state) Memorandum of Agreement involving the Ft. Sill FIRES Center of Excellence and the UML. This RDT&E advantage has brought national attention to Oklahoma's UAS ambitions and capabilities. A number of additional assets within the state lend further strength to Oklahoma's position. These include:

- UAS Test and Evaluation and Training sites (current and planned) in Oklahoma:

  Chilocco (Kay County) – 5,000 acres, including a former school comprised of approximately 170 acres, around 80 buildings, chemical and biological training facilities, RF test range and limited SUAS operations. Leased land. Class G airspace.

  Camp Gruber Joint Maneuver Training Center (CGJMTC) – A 33,000-acre National Guard training center comprised of firing ranges, collapsed-structure training venues, and planned refurbishment of a runway for UAS operations. Classes G & E airspace.

  Clinton-Sherman Airport (Burns Flat, OK) – A decommissioned former Strategic Air Command base with a 15,000 ft. runway and 85,000 sq. ft. of hangar space. Planned CoAs to operate UAS. Classes D or G and E airspace. Planned air corridor (via a CoA) to Ft. Sill. Classes E and G airspace.

  Muldrow Army Heliport (OK Army National Guard heliport at Lexington, OK) – Planned CoA to operate UAS (Class G airspace), and planned air corridors to access Ft. Sill restricted airspace and CGJMTC. Class G airspace.

  Kessler Atmospheric and Ecological Field Station (KAEFS) – A 350-acre site owned by OU, southwest of Norman. CoA planned in order to operate UAS. Classes G and E airspace.

- **Unmanned Systems Development Center (UDC)** – R&D and training facility to be constructed in the Oklahoma Technology and Research Park (Stillwater) to accommodate rapid development and prototyping of unmanned aircraft and their components and payloads. Includes electromagnetic compatibility (EMC) chambers (anechoic and reverberation) for "bench" testing of RF communications and procedures.

- **University Multispectral Laboratories (UML)** – A government-owned (under Oklahoma State University) contractor-operated 501(c)3 company. Sensor Laboratories for CBRNE and C5ISR payloads for UAS. Headquartered in Ponca City.

- **OSU-Tulsa - Hypobaric Test Chamber, Jones Airport, Tulsa** – High altitude test chamber.

- **University of Tulsa – Institute for Information Security (iSec)** – A multidisciplinary program on cyber security.

- **OU, Norman - Advanced Radar research** – R&D for advanced radar development and testing. A state-of-the-art radar laboratory (UAS Radar and Sensor Systems Center at the OU Radar Innovations Laboratory) will be constructed at OU beginning this summer and will be used to develop, construct, test and evaluate radar systems that can be used specifically for UAS applications.

- **OSU, Stillwater – UAS R&D (Education and Training)** – UAS Option for M.S. and Ph.D. degrees in Mechanical and Aerospace Engineering. OSU Flight Test Center for education and training; east of Stillwater. Advanced R&D for UAV construction and testing.

A map of these critical assets for Oklahoma is shown in Figure 2, below.

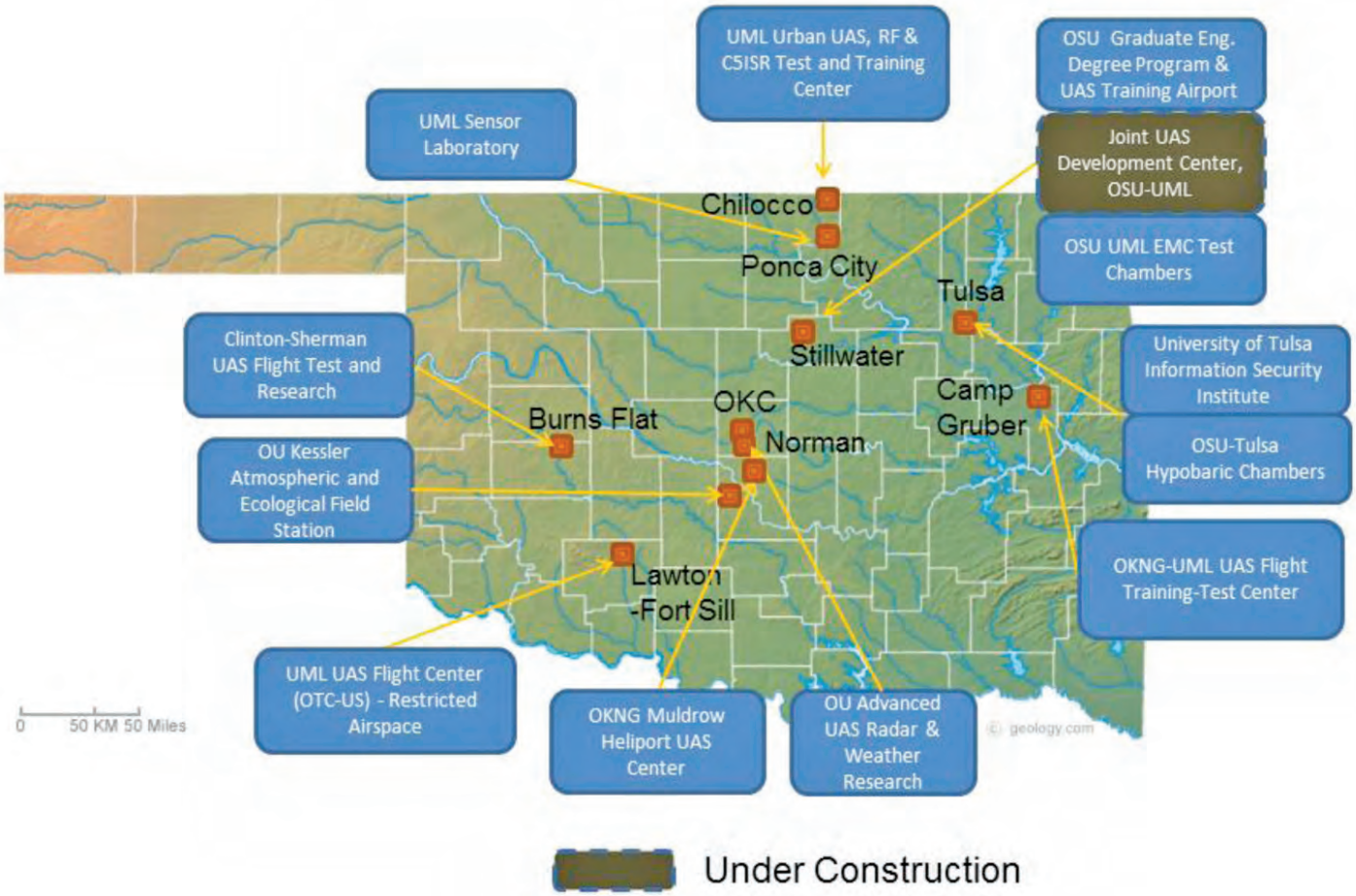


Figure 2: Existing and Planned UAS Infrastructure in Oklahoma

Additionally, Oklahoma is blessed with a wide array of Oklahoma-owned and operated research radar installations, as indicated in Figure 3, below.

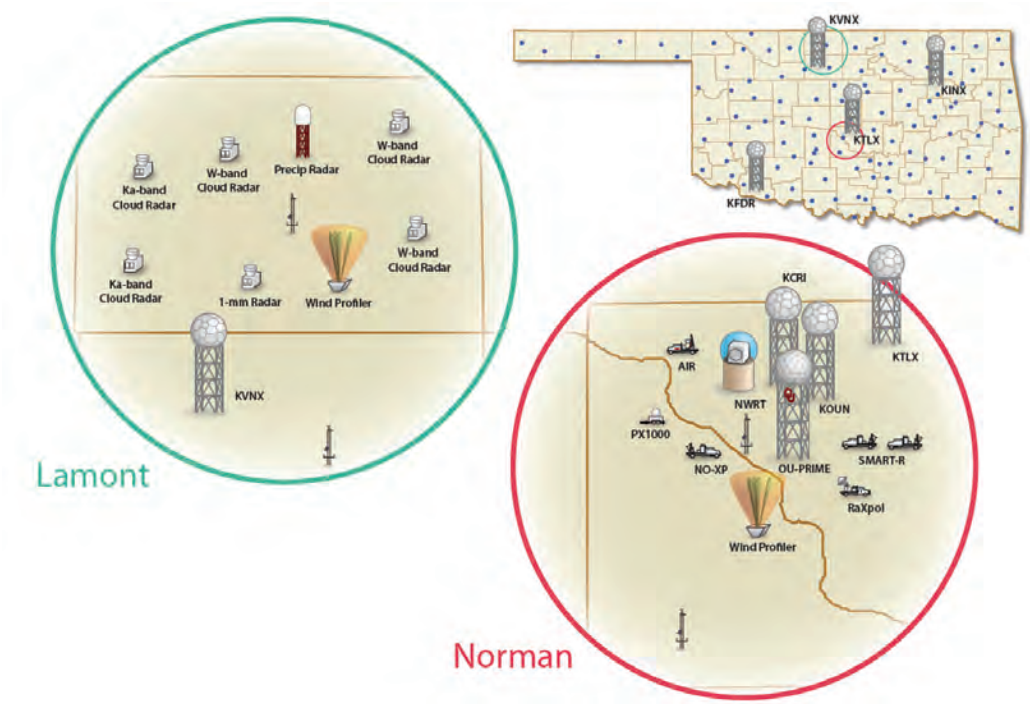


Figure 3: Oklahoma's research radar installations

Clearly, the opportunities for Oklahoma in the UAS business are statewide, with impact across many different regions of the state. A UAS industry in Oklahoma therefore has the potential to positively impact many communities across the state and is not centered on one area alone.

In addition to the existing and planned assets indicated above, it should be noted that Oklahoma is already home to many private sector companies involved in the UAS business. Existing companies with some or all of their current business in UAS include (alphabetical order):

Atria Defense Group (Lawton)
Design Intelligence Incorporated LLC (Norman and Stillwater)
Dow Aero Logistics LLC (Oklahoma City)
FlightSafety International (Broken Arrow)
FLIR Systems Inc. (Stillwater)
Frontier Electronic Systems (Stillwater)
Global ResQ Inc. (Duncan)
Objectstream Inc. (Oklahoma City)
Republic Aero Inc. (Duncan)
Supero UAS (Oklahoma City)
Tactical Electronics Inc. (Broken Arrow)
TDRS LLC (Lawton)
Triton Scientific LLC (Ponca City and Edmond)
Wave Technologies Inc. (Guthrie)
Zivko Aeronautics Inc. (Guthrie)

In addition, a number of major aerospace companies with significant UAS business already operate in Oklahoma, although not in the UAS sector; this provides a promising area for those companies to expand in Oklahoma. They include:

Northrop Grumman
Boeing
General Atomics
Raytheon
Navmar Applied Sciences Corporation

As a result of Oklahoma's continuing and successful marketing of its UAS assets, recent business relationships have also been established with multiple out-of-state and foreign manufacturers of UAS, some of which have indicated intent or interest to move to Oklahoma as a result of the activities in the state.

Federal partnerships have also been established. Apart from federal contracts between Oklahoma entities (public and private) and various federal agencies, there exist several public-private and public-public partnerships with the federal government. For example, the OTC-US℠ complex was originally established through a partnership between the UML and the Department of Defense (DoD). Furthermore, a recent agreement between OSU, the UML, the FAA and the Air Force Flight Standards Agency (AFFSA) intends to make progress toward the use of UAS in certifying airport landing systems (instrument landing systems, ILS) wherever U.S. carriers operate, including military bases. The ultimate concept is to replace manned flights to check the landing systems with unmanned flights, thereby reducing costs and improving safety. Additional federal and private-sector partnerships will be sought in the future.

1.5
Privacy and Related Issues

The growth of UAS has the potential for enormous good and economic benefit for all residents, introducing new capabilities simply not possible at present. As with any new technology, however, new capabilities come with the potential for abuse. The state of Oklahoma takes these issues and concerns seriously. We support calls for thoughtful and informed dialogue to address these concerns and for the industry to work with privacy advocates, policymakers and legislators to provide the necessary protections against misuse.

2.
FOCUS AREAS FOR RESEARCH AND APPLICATIONS DEVELOPMENT

2.1 Research

As with all new and emerging industries, the opportunities for growth are very broad. Many other states will be competing in this market and Oklahoma must distinguish itself based on its existing assets and viable, realistic growth potential. Clearly, one of the critical areas is Test and Evaluation and here Oklahoma is a national leader. T&E opportunities cover both the airframes (the UAVs themselves) as well as the payloads and communications technologies (to form a complete UAS). Leaders in these areas are the UML backed by two research universities (OSU and OU), with strong effort and support from the OK Army National Guard.

Research and Development are also strong and continuing. Again, OSU and OU are R&D leaders in their niche areas (aerodynamics, aeroacoustics, micro air vehicles (MAVs), airframes, propulsion systems, radar, weather, cyber security, etc.) and these efforts are backed by strong collaborations with the Oklahoma private sector. A partial list of current R&D strengths in the state is given below.

ACTIVE UAS-RELATED RESEARCH AREAS IN OKLAHOMA	
UAS Radar Research	NextGen Incorporation of UAS into the National Airspace Small UAS Detection Radar Sense-and-Avoid Radar Low-Power Passive Radar (stealth) Automatic Dependent Surveillance-Broadcast Weather Radar Airport Surveillance Radar (ASR)
UAS Communication	Free-Space Optics for UAS Communication RF, Including Bandwidth
UAS Aeronautics	Aerodynamics, Including VTOL UAS Flight Dynamics and Aeroelasticity Design/Fabrication/Flight Testing Semi- and Fully Autonomous Flight Payload Delivery Systems
UAS Propulsion	Long-Endurance Hybrid UAV Propulsion systems Battery-Powered Helicopters
UAS Acoustics	High Transmission Loss Structures Acoustic Liner Technology Internal Combustion Engine Noise Control Propeller Noise Control Vehicle Noise Control
Novel UAS Structures	Morphing Aircraft Unconventional Configurations, Including Biologically Inspired Micro Aerial Vehicles
UAS Payloads	Chemical Nano Electromechanical
Cyber Security	System Security and Validation Physical Systems Security (Scada Systems) Rf/Wireless Communication Security Data Encryption

Table 1: UAS Research Areas in Oklahoma

2.2
Applications

In applications of UAS, Oklahoma also has some unique capabilities and strengths. For example, OSU's UAS R&D program is based on a strong platform in design, build and fly, with state-of-the-art facilities for manufacturing and testing, including the M-AVIARI (Micro Air Vehicle (MAV) Indoor Assessment and Research Instrumentation) facility currently under development. This will enable flight testing of MAVs under controlled conditions, particularly in complex maneuvers such as perching or egress.

Using these and related capabilities, OSU has been successful for over 15 years in national and international competitions for student teams and has won many first and second place awards. This success led to a robust effort in both undergraduate and now graduate research in UAS technology. The latter is the first graduate program dedicated to UAS engineering studies in the U.S.

By leveraging these R&D and education assets, combined with the UML's strong Department of Defense customer base that requires advanced operator-focused UAS technology, OSU has successfully demonstrated a rapid-response capability in development and testing of new UAS concepts. Furthermore, OSU's UML provides multiple facilities that include a 5,000-acre outdoor test and training facility at Chilocco (including an explosive-testing capability and an RF test range) and the already-mentioned OTC-US℠ at Fort Sill with access to restricted airspace including live-fire and munitions testing. The OSU/UML team will continue to grow these capabilities and linkages in the application of UAS in the defense and security sector, including partnerships with the private sector.

The OU Atmospheric Radar Research Center (ARRC) is developing new radar capabilities to advance UAS activities in the state and beyond. The National Weather Radar Testbed (NWRT) Phased Array Radar (PAR) operated in Norman has the capability to monitor both weather and air traffic. Development continues on the Multi-function Phased Array Radar (MPAR) concept that would dramatically impact radar surveillance.

The MPAR concept is being considered as a means of integrating the different radar surveillance goals in the U.S. and the NWRT PAR could be used to track UAS flights over the OU Kessler Atmospheric and Ecological Field Station (KAEFS) and other nearby UAS flight centers. Having the radar arm of the National Weather Service and the Radar Operations Center in our state uniquely positions us in the critical area of radar development for UAS operations, as specifically called for in the FAA Reauthorization and Reform Act; H.R. 658 and the National Defense Authorization Act. This is supported by the array of military and civilian radar installations across the state enabling a precise picture of the NAS at all times. Oklahoma is able to leverage these radar assets via joint partnerships and agreements.

There is federal interest to further develop UAS capabilities for weather monitoring. Obtaining pressure, temperature and humidity data in the lower atmosphere along with observations and measurements of the wind field will provide valuable data for weather monitoring and prediction. UAVs can aid the National Weather Service and the OU Weather Center in monitoring the location and movement of the dry line and convective initiation for pre-storm environments. Small UAS platforms have been tested by OU for these purposes. Moreover, the Oklahoma Department of Environmental Quality (DEQ) is working with OU to develop an ozone sensor that can be carried on small UAVs.

Another strength is in the emerging field of radar aeroecology, which uses radar to investigate the movement and behavior of airborne animals. This is a growing and developing field in which OU is poised to become a national leader. Using NEXRAD radar we have the capability to detect the locations of birds, bats and insects and track their movements over time. Such data will be of use in developing the necessary database for integrating UAS in the NAS, promoting air-traffic safety (e.g., mitigating the risks of collisions of aircraft with birds and bats), and discriminating between birds and micro-UAVs made to resemble and emulate birds.

An additional area of importance for which Oklahoma is well positioned concerns the oil and gas industry – specifically pipeline inspection. UAS are often mentioned as the future of this important activity. A recently signed agreement between OSU-Institute of Technology (OSU-IT, Okmulgee) and a major Oklahoma company in the energy sector will place an experimental pipeline at the disposal of OSU-IT for use in R&D, education and training. This will make a perfect platform for developing UAS, including payloads, techniques and procedures, for pipeline inspection in readiness for the opening of the NAS and the inevitable growth of this application worldwide. In addition, this same UAS application could also be used to monitor/inspect rail lines and water ports for maintenance, security, traffic conflicts, etc.

Oklahoma is also blessed with some of the world's leading flight simulator companies, including FlightSafety International and L-3 Comm AMI. As UAS becomes more established and complex, the need for more sophisticated simulation programs for UAS pilots and payload operators will become apparent. Therefore, an opportunity exists for Oklahoma companies to collaborate with major UAS original equipment manufacturers, thereby growing a new business sector. This will be especially true for the larger UAVs and for complex payloads.

Another important aspect of the development of UAS will be in the field of cyber security, and here Oklahoma is also at the forefront in a national leadership role. For UAS the pilot has been removed from the vehicle to a ground station and all communication with the vehicle is via RF and heavily reliant on computer systems. Therefore, security of the communications and computer systems becomes paramount. The University of Tulsa's (TU's) Institute for Information Security (iSec) is a multi-disciplinary program of study and research tackling cyber security issues on a global scale. TU has established itself as one of the leading schools in the country for information security research and education with more than 15 years of experience in the field. The National Security Agency (NSA) designated TU as a Center of Academic Excellence for Information Assurance Education and a Center for Academic Excellence for Information Assurance Research.

With research initiatives in critical infrastructure protection, security engineering and testing, enterprise security, cyber physical systems security, network vulnerability analysis, cryptographic protocol verification, adversary characterization, dynamic risk assessment, critical infrastructure protection, digital forensics and human computer interaction, the Institute for Information Security (iSec) is developing some of the most innovative solutions available for today's emerging information security challenges. All will prove to be essential in the secure and safe operation of UAS in the NAS.

Other applications are certainly possible but the above represent the ones that are immediately in front of Oklahoma at the present time. Others will undoubtedly emerge.

3.
A UAS STRATEGIC PLAN FOR OKLAHOMA

Oklahoma has already accomplished a great deal in its focus on the UAS industry. Oklahoma's Aerospace and Defense Directory of 1,200 companies shows many that are involved in UAS RDT&E with multiple locations where UAS work is being accomplished. We have established a state chapter of AUVSI, and had a very successful joint booth (state agencies, universities and private companies) at the AUVSI North American Conference in Aug. 2011 (attended by Gov. Fallin).

We also have established significant UAS-related research at OU and OSU, and created the first UAS graduate program in the U.S. We have established UAS test facilities that are unique in their availability and sophistication. We have promoted Oklahoma's UAS capabilities internationally at overseas air shows. Finally, the establishment of the Governor's UAS Advisory Council has been critical to taking a statewide approach to expanding our UAS industry.

We also recognize that as the UAS industry expands into the civilian sector, there will be many applications that will drive a rapid expansion of the industry: agricultural monitoring, ranching/livestock tracking, environmental studies, law enforcement, national forest service activities, private security, weather, fire fighting and disaster response, traffic oversight, athletic and outdoor event monitoring, ocean and remote-area navigation and communication, and others. However, such developments are likely to be slow (over the next decade or more) and, currently, the growing military market represents the most immediate potential.

Considering the economic potential of this industry, and considering Oklahoma's current position of strength, a strategic plan for the development of the industry in our state is necessary in order to take advantage of the assets currently possessed. This is especially critical because our analysis of other states that are competitive with ours shows at least 22 other states currently investing in UAS capabilities, and each is working to be selected for one of the six FAA UAS Test Ranges, and to grow and attract the UAS industry (see Appendix 2). The technologies, capabilities and Oklahoma infrastructure associated with the UAS industry can also directly be leveraged into the Unmanned Ground and Unmanned Water Vehicle markets, which will also grow rapidly in the coming years.

3.1 RECOMMENDATIONS

The following recommendations are made in each of the strategic areas listed:

(A) TECHNICAL FACILITIES

In order to grow the state's activities in the Test and Evaluation arena for UAS and to position the state to become an official FAA UAS Test Range, Oklahoma must create multiple, attractive sites for UAS flight and testing in order to position itself competitively nationwide and to generate data on the operation of UAS in the NAS. A combination of restricted airspace (OTC-US℠) for initial technology test and evaluation, and public-use airspace for limited testing in the NAS provides for a perfect mix of airspace and experiences necessary to build safe operational capability.

Safety is paramount. Therefore, the operational concept will be to perform initial tests and evaluation of technologies and procedures inside restricted airspace before transitioning to unrestricted airspace, in controlled and safe environments. Ultimately, the testing can then be promoted into selected UAS air corridors for point-to-point testing and evaluation.

Oklahoma should establish several UAS operational centers for UAS testing and evaluation. Once the operational centers have been established air corridors for UAS flights between the centers should also be established. The envisioned air corridors are illustrated in Figure 4 (next page), and the types of UAV and their locations are listed in Table 2.

RECOMMENDATION 1:

Establish a network of FAA UAS Test Sites, including:

- Growth of capabilities and operations at the OTC-US℠
- Establish UAS operations in public-use airspace at:
  - Chilocco
  - Clinton-Sherman
  - Camp Gruber Joint Maneuver Training Center
  - Kessler Atmospheric and Ecological Field Station

Marketing and promotion of these T&E capabilities and facilities will attract UAS industry members to the state and further improve the reputation of Oklahoma in the UAS industry. Special focus should be on original equipment manufacturers (OEM), and the expansion of Oklahoma companies into the UAS global market.

Location of Site and/or Corridor	UAV Type	UAV Category	Operational Entity
OTC-US^{SM} (Ft. Sill)	Tigershark	03-Close Range, 13.6 kg payload	UML
Chilocco	Tigershark	"	UML
Clinton-Sherman	Tigershark	"	UML/OSIDA
Clinton-Sherman to Ft. Sill	Tigershark	"	UML/OSIDA
Kessler Field Station	Various	-	OU
Stillwater	Various	-	OSU
Muldrow	Shadow/Raven	05-Medium Range; 25-40 kg payload/02- Mini, 0.18 kg payload	OKARNG
Camp Gruber	Shadow/Raven	"	OKARNG
Muldrow to Camp Gruber	Shadow/Raven	"	OKARNG
Muldrow to Ft. Sill	Shadow/Raven	"	OKARNG

Table 2: Summary of Locations, UAV type and category, entity responsible for operation

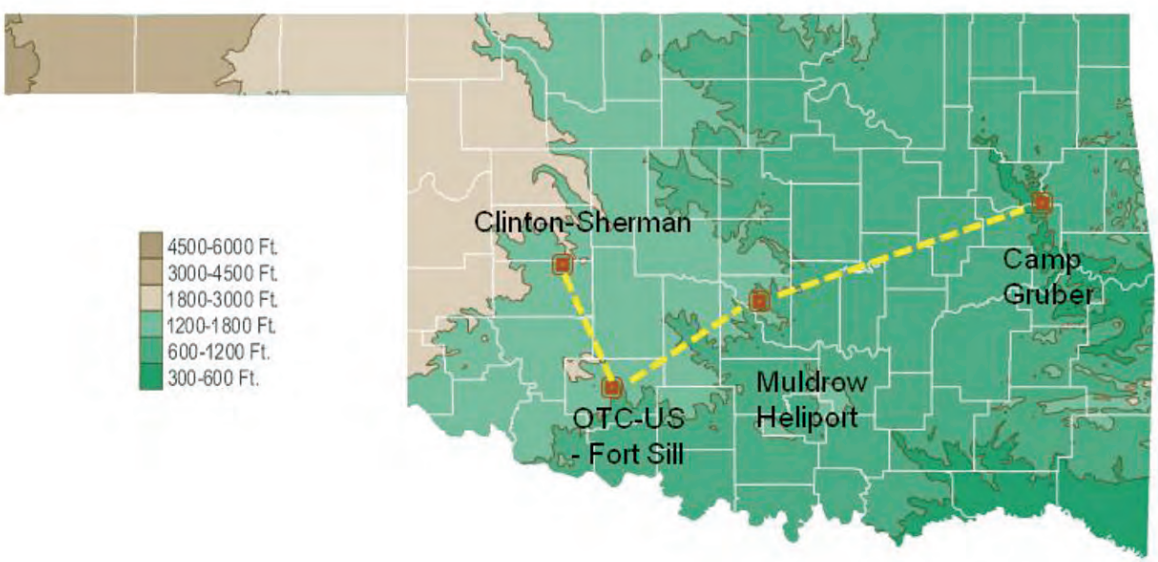


Figure 4: Proposed UAS Air Corridors (using CoAs)

To support the Test Sites and facilities, and to provide additional attractors for companies to locate/relocate in Oklahoma, investment into research and development facilities is necessary, especially centered on the state's public research universities, OU and OSU.

RECOMMENDATION 2:

Build and equip the UAS Radar and Sensor Systems Center at the University of Oklahoma to:

- Develop, construct, test and evaluate radar and sensor systems for UAS applications.
- Acquire and maintain UAS platform systems for use in UAS radar and sensor development.
- Develop and sustain a small UAS detection R&D program and extend the University of Oklahoma's aeroecology research.
- Develop and sustain a UAS atmospheric research and development program.
- Focus effort to create sense-and-avoid systems that will be accepted by the FAA to allow "file-and-fly" UAS systems outside of Restricted Airspace.

RECOMMENDATION 3:

Build and equip UAS R&D facilities and UAS Industry facilities at the Oklahoma Technology and Research Park, Stillwater, including:

- The UML's Unmanned Systems Development Center (UDC), consisting of:
  - Electromagnetic compatibility test chambers
  - Propulsion lab
  - Acoustics lab
  - Related facilities, including secure space
- The UAS University-Industry Alliance Center, consisting of:
  - OSU's entire UAS program, including research laboratories, wind tunnel, design and manufacturing lab, classrooms, offices and related facilities
  - Space for new UAS industry development, relocation and growth

(B) TEST RANGES

With the above facilities planned (Recommendations 1-3), Oklahoma should concurrently and aggressively seek to become established as a federally directed UAS Test Range. Opportunities currently open for which Oklahoma should compete include:

- One of the FAA's six official UAS Test Ranges, as outlined in the FAA Reauthorizations Act and the NDAA;
- The DHS's SUAS center of technology transition for first responders (RAPS);
- An FAA Center of Excellence for UAS.

Oklahoma should be alert to any similar UAS programs that become available. In addition to the test ranges noted above, the state should aggressively seek other opportunities. Since most of these are currently found in the military sector, the state should focus its immediate considerations on the military sphere, with a long-term view on the commercial market. As a result, the state should consider establishing a University Affiliated Research Center (UARC) or perhaps a Federally Funded Research and Development Center (FFRDC) with sponsorship from an appropriate branch of the military (Army, Navy, Air Force, Special Operations, etc.).

(B.1) FAA UAS TEST RANGE

The strategy for capturing one of the six FAA UAS Test Ranges should be linked to the FAA's five-year road map, including objectives and timeframes for each objective. Oklahoma's proposal should be aligned to FAA needs as described in this and other documents.

Based upon Oklahoma's strengths in UAS R&D and UAS applications, as outlined in Section 2 above, the following focus areas are possible priorities for Oklahoma's strategy to capture one of the six FAA UAS Test Ranges:

1) Safety analysis;
2) UAS engineering (including vehicle, design, payload, sense-and-avoid;
3) Deconfliction analysis and data collection (relevant to sense-and-avoid technologies leading to certifications for file-and-fly);
4) Pilot, payload operators and other relevant UAS Training (including degree programs);
5) Navigation and control (leveraging the existing FAA/AFFSA partnership; this is known to be a current issue of critical importance with the FAA and Oklahoma could contribute to a solution);
6) Application demonstrations (in oil & gas, weather monitoring, animal tracking, etc.).

Additionally, Oklahoma should consider integrating operator human factors research into the program through collaboration with the FAA's Civil Aerospace Medicine Institute (CAMI). Each of these specialty areas should be augmented with partnerships with other states and/or universities, as appropriate. Such application demonstrations would form the basis of specific projects for a national test site application.

The final strategy, however, will be guided by the requirements from the FAA – which are as-yet unpublished.

RECOMMENDATION 4:

Compete aggressively to become a federally directed UAS Test Range, including one or more of the following:

- One of the FAA's six official UAS Test Ranges, as outlined in the FAA Reauthorizations Act and the NDAA.
- The DHS's SUAS Center of Technology transition for first responders.

(B.2) OKLAHOMA'S OWN UAS TEST SITE NETWORK

In addition to attempting to become a federally directed UAS Test Range (e.g. FAA, DHS), the state should independently create a formal Oklahoma UAS Test Site Network using the assets and facilities heretofore described. Indeed, establishing an Oklahoma Test Site Network as soon as possible may make Oklahoma's application for a federally funded UAS Test Range more competitive. Whether or not Oklahoma is successful with one of the above federal opportunities, the state needs to devise a long-term business plan for the operation of its own Test Site Network. Therefore, planning for the long-term operation of such a network, whether or not the state is selected as a federally-directed test range, is essential. Thus, in order to compete nationally, and to ensure longevity and sustainability, the state should declare the establishment of a state Test Site Network and devise a suitable business, operational and management plan for its continued operation.

In this way, Oklahoma will become a de facto leader in the integration of UAS into the NAS even without designation as such from the FAA. The Oklahoma UAS Test Site Network will be able to provide relevant data to establish those components, operations and activities that are needed to integrate UAS into the NAS, and will be an active location for safety analysis, training, payload design and application, vehicle design and modification, development of radar, RF communications and bandwidth, and other related topics.

The OK UAS Test Site Network will not be just one location. Flights in restricted airspace will be at Ft. Sill (OTC-US℠) but all other flights will be in the NAS and allowed via CoAs. The wide range of available test facilities and the different purpose of each will provide an array of necessary data for the development of UAS.

To support the growth of the Test Site Network, the Oklahoma Department of Commerce should research and track the UAS industry nationally and internationally, provide support to both private companies and state agencies growing in the UAS field, and provide incentive analyses, aerospace directory information, company research, etc. The network should also coordinate with CareerTech to provide workforce training and support to new and growing companies.

Key entities in the Test Site Network will be the universities (OU and OSU), UML, OKARNG and OSIDA. These public entities have recently formalized an agreement and executed a Memorandum of Agreement to build on the existing partnership and develop UAS industry within the state. Each entity will provide data, assistance and coordination services to the other entities. The individual entities are already represented on the Governor's UAS Council. In order to functionally operate the Test Site Network one of the entities will be selected as the administrating entity. All groups will interact with the private sector, as appropriate, to achieve their individual and the state's goals.

Governance of the Test Site Network will be determined in consultation with requisite entities and authorities. An Oklahoma UAS Industry Advisory panel should be created as part of the governance of the Test Site Network.

RECOMMENDATION 5:

Create a centralized administration to operate an integrated Oklahoma UAS Test Site Network.

- Using the T&E facilities noted in Recommendation 1, create a formal Oklahoma UAS Test Site Network for UAS development, particularly with regard to integration into the NAS.
- Create a governance model, including a management and administrative team to oversee, coordinate, facilitate and develop the network, and devise policies and rules for its operation. The administrative team will consist of representatives from public entities, i.e. OSU, OU, OKARNG, UML and OSIDA. Partner with the private sector as necessary.
- Create an Oklahoma UAS Industry Advisory Panel to work with the administrative team, on development and use of the Test Site Network.

(C) RESEARCH AND DEVELOPMENT; UAS APPLICATIONS

The various UAS research entities within the state should collaborate on identifying strategic requirements for the UAS industry, both military and commercial, and the necessary resources required to support R&D efforts in those areas. Federal, state and private partnerships are considered to be essential in this regard.

Central to the R&D effort are the comprehensive research universities, but also a key entity for identifying federal requirements will be the UML. As already noted (Recommendations 2 & 3), completion and equipping of the Unmanned Systems Development Center (UDC), the establishment of the UAS University-Industry Alliance Center (both at the Oklahoma Technology and Research Park (OTRP) in Stillwater) and the UAS Radar and Sensor Systems Center as part of the new Radar Innovations Laboratory on the OU Research Campus in Norman will all be important aspects of this effort.

These two research clusters (one at Stillwater, one at Norman) will act as attractors to private companies and thereby contribute to strong economic development in the Norman and Stillwater regions.

Using these assets as a base, the state should examine what is necessary to become an NSF Engineering Research Center (ERC), a UARC and/or an FFRDC, each specializing in UAS. In this endeavor it will be important to leverage private Oklahoma companies working in UAS research to consult and synergize with Oklahoma university research initiatives to enhance key UAS research progress.

These R&D capabilities, activities and interests should be actively marketed and promoted.

RECOMMENDATION 6:

Invest in Research and Development in UAS and compete for an ERC, UARC and/or FFRDC:

- Building on the facilities noted in Recommendations 1-3, the state should invest in T&E and R&D activities in UAS. OCAST, OSIDA and EDGE programs should be aligned to support this effort with possible funding provided through these entities.
- Examine what is required for the state to establish an NSF ERC, a DoD UARC, or an FFRDC specializing in UAS.
- Initiate a focused effort to capture additional SBIR/STTR funding for Oklahoma UAS technology initiatives.
- This should include investigations and development of applications of UAS including, but not limited to, safety analysis, weather studies, aeroecology, agriculture, oil and gas pipeline and rail line inspection, water port inspection and security, radar development, defense and security applications, first responders, law enforcement and others. Application focus areas should play to existing strengths in Oklahoma (weather, agriculture, oil and gas, etc.) and be relevant to national funding directions (DHS, DOE, NSF, NASA, etc.).
- Expand UAS research to include low altitude, medium altitude and high altitude long endurance vehicles and missions.
- Conduct cyber security research related to UAS sustainment and operations.
- Research the use of bandwidth and fully explore cost effective use of resources.

(D) EDUCATION AND TRAINING

The growth of the UAS industry in Oklahoma will require the availability of an educated and trained workforce. This will require programs at the CareerTech and university levels. Currently, OSU has a graduate degree option in UAS for the M.S. and Ph.D. programs in mechanical and aerospace engineering. As we develop the UAS industry, OSU and OU should consider establishing degrees in UAS, at the bachelor's, master's and doctoral levels. To share resources and prevent duplication of effort, joint degree programs should be considered. Similarly, as the industry grows and workforce demands become clearer, the CareerTech system should engage with industry to determine what specialist training programs are required to support the industry.

A critical issue with the projected growth of the industry will be the need for trained payload operators and pilots. Opportunities exist for the state's universities (public and private), two-year colleges and CareerTech institutions to develop curricula appropriate to the growth of the UAS sector. Such curricula could include not just pilot and payload operator training, however, but could also include maintenance, certification and flight operations. An early emphasis on education and testing will bring activity to Oklahoma in the near term, and a training center – particularly one next to usable airspace for UAV training – will be a significant draw as the industry continues to grow. Most owners of UAVs, for other than the smallest vehicles, will want to train their operators on the ground before they ever allow them to operate their UAVs airborne.

Therefore, Oklahoma should continue to build its capabilities in UAV-related training, including such business models such as "training by the hour," which has been demonstrated by FlightSafety International to be a successful model for pilot training in the business-jet market. The development of sophisticated training simulators will enable pilots and payload specialists to control the UAS more reliably and safely, prior to flying in the NAS. High-fidelity training consoles, classrooms and instructors would be included in the training center, avoiding the need for UAV owners to make the large initial investment themselves. Having UAS airspace close to the training facility will allow trainees to complete their training and will be a complement to the other T&E and R&D facilities available in the state.

As an example, the OTC-US℠ has hosted pilot training on a limited basis already. The facility has training areas to support both classroom and hands-on training. In addition, the close proximity of Cameron University and the Great Plains Technology Center may prove beneficial if a large scale pilot training program is initiated. Other potential locations also include Stillwater, Norman and Burns Flat, and possibly others. Finally, dual use manned/unmanned equipped training platforms can move training forward in areas where restricted airspace is not available under current rule sets. There are prototypes available. Making this capability operational would give the user/institution capabilities that are not currently available elsewhere.

Considering the above, it is clear that opportunities exist for the state to develop certification programs for UAS pilots and to become a nationally recognized training center for UAS operations (perhaps specializing in, for example, applications for first responders, in agriculture, oil and gas, etc.). Certifications for airworthiness of UAVs and for cyber security should also be considered. Partnerships with the FAA's Mike Monroney Center should be explored in this context, as should public-private partnerships.

The state's UAS education and training opportunities should be appropriately marketed and promoted.

RECOMMENDATION 7:

Expand and Strengthen UAS Education and Training Capabilities:

- Continue to develop the OTC-US℠ as a training center and test center for UAS pilot and payload specialist training, in collaboration with the private sector. Consider other locations as appropriate.
- Develop necessary levels and types of training required for micro, small, HALE, MALE and VTOL.
- Establish B.S., M.S. and Ph.D. degrees specializing in UAS at OSU and OU.
- Market and promote Oklahoma's education and training opportunities.
- Collaborate with the CareerTech system to provide the technical workforce needed to support the industry.
- Include training for UAS pilots, systems operators, crews, imagery analysts, UAS technology, airframe MRO, etc.

(E) PARTNERSHIPS

Relationship and partnership building with both federal agencies (FAA, DoD, etc.) and the private sector, is essential for long-term success. Private sector partnerships (Memoranda of Understanding (MoUs), Memoranda of Agreement (MoAs), research agreements, contracts, joint ventures, etc.) with UAS original equipment manufacturers (OEMs), such as Boeing, Northrop Grumman, Lockheed Martin, Airbus, General Atomics, Raytheon, etc., will be fundamental to long-term sustainability.

Similarly, state-to-state agreements and university-to-university agreements will also prove important. Leading states (see Appendix 2) should be approached with a view to establishing MoUs or MoAs and other forms of collaborative agreement in order to share data and experiences, grow networks and build political support across state boundaries.

The UAS Advisory Council, led by the Secretary for Science and Technology, should initiate this effort. The council should, when appropriate, involve the governor, the Secretary of Commerce and other state leaders as or when necessary.

RECOMMENDATION 8:

Establish and grow strategic partnerships and collaborations with:

- The private sector, particularly UAS OEMs.
- Other leading states in the UAS industry, including:
  - State to state
  - University to university
- Federal agencies, including:
  - FAA, DoD, DHS, NASA
  - Others, as appropriate

F) CURRENT AND FUTURE STATE SUPPORT TO THE OKLAHOMA UAS INDUSTRY

The state of Oklahoma provides tremendous support to the aerospace industry in general and the UAS industry in particular. The state has numerous nationally acclaimed financial incentives that directly support job growth in the aerospace sector. In our Quality Jobs program, the state pays the company 5 percent of its payroll back to the company annually through quarterly cash payments for 10 years; our 21st Century Quality Jobs program increases this rebate to 10 percent for high-paying, high-tech, knowledge-based jobs. The Oklahoma Aerospace Industry Engineering Tax Credit provides tax incentives for both aerospace companies hiring engineers, and for the engineers they hire; and a new Prime Win program incentivizes Federal Prime Contractors to use Oklahoma labor. In addition, the state has built an Aerospace Directory that provides a listing of all the aerospace-related companies in the state, along with their products and capabilities, including UAS company information.

For the UAS industry in particular, the state has taken a statewide approach to support the UAS companies and related agencies. Our AUVSI chapter sponsors an annual Oklahoma UAS conference, bringing together companies, agencies and university researchers to enhance collaboration. The state Dept. of Commerce provides a central coordination point for the annual North American Unmanned Systems Conference; the state provides a large booth that includes state partners from higher education, private UAS companies and state UAS-related agencies. The governor, Lt. Governor, and/or other senior state officials attend the conference, spend time in the booth and support the companies and agencies by interacting with their potential clients.

Additional UAS statewide focus comes from our Oklahoma Aerospace Alliance, which sponsors an annual Oklahoma Aerospace and Defense Summit and Expo that includes significant attention to the state UAS sector. Finally, the governor's creation of a statewide UAS Council, to provide a central statewide focus on the growth and support of the state UAS industry, is indeed a great indication of our state's focus on Unmanned Aerial Systems.

RECOMMENDATION 9:

Expand corporate UAS manufacturing presence in Oklahoma and state support to private UAS companies in Oklahoma:

- Ensure all UAS companies are aware of current state and local incentives that apply to aerospace, and support programs such as the Oklahoma Aeronautics Commission Center for Aerospace Supplier Quality (CASQ) program.
- Request a portion of OCAST and i2E funds be focused on the UAS industry.
- Apply MRO sales tax exemptions to UAS industry.
- Establish public-private partnerships between university departments and research programs with UAS private sector.
- Attract a major UAS aircraft manufacturer and/or DoD to establish a significant UAS business /base in Oklahoma.
- Publicize current Oklahoma tax and business incentives for aerospace, education and training, and high-tech businesses.

However, to continue to expand the UAS sector in Oklahoma and support the growth of our private UAS companies, a number of actions should be taken, especially if the state is to become a federal UAS Test Range (FAA, DHS, etc.), which will catalyze the growth of the UAS sector in Oklahoma. First, the state needs to ensure all UAS companies are aware of the current state and local incentives that apply to the aerospace industry.

In addition, current support programs that would apply to small- and medium-size companies, such as the Center for Aerospace Supplier Quality, need to be publicized to these companies. A number of new support programs should also be used if we are to grow our Oklahoma UAS program into national and international leadership. The MRO tax exemption, used by current mainstream aerospace companies, should be applied to UAS companies. State offices and programs that provide seed funding and financially support new and innovative companies, like the Oklahoma Center for the Advancement of Science and Technology (OCAST) and Innovation to Enterprise (i2E) should focus a portion of their financial support specifically to UAS companies and projects.

Furthermore, the state should foster public-private partnerships between university research programs and UAS companies and projects. Oklahoma tax abatements and credits should be used as initial foundations of public-private partnerships are formed. Publicizing the “low cost of doing business” and all the current financial and tax incentives that Oklahoma provides to aerospace and high-tech businesses, including 21st Century Quality Jobs cash payments; the Aerospace Industry Engineer Tax Credits; and no-cost education, training and infrastructure support, will also act as appropriate incentives.

G) POLITICAL SUPPORT AND PUBLIC ADVOCACY

As the current competition to become one of the nation's FAA UAS Test Ranges is demonstrating, political support at both the state and the federal level is essential. All major UAS states are using their congressional members to solicit support for their efforts and to promote their own states. The state should take advantage of Sen. Jim Inhofe's co-chairmanship of the Senate UAS Caucus and Congressman Tom Cole's membership of the House UAS Caucus. Local support from political advocacy groups, chambers of commerce and legislators is being used to demonstrate commitment and long-term vision. It is essential that Oklahoma does the same.

Oklahoma has the Oklahoma Space Industry Development Authority (OSIDA) for the growth of the commercial space industry in the state. Similarly, the Oklahoma Aeronautics Commission (OAC) exists to promote and develop the aviation industry. However, no such bodies exist for growing the UAS industry. The UAS Council should partner with OSIDA and OAC, as necessary to promote the UAS industry statewide.

Oklahoma should continue to organize the annual UAS summit meetings, organized by the Oklahoma chapter of AUVSI and use this vehicle to focus national attention on the state.

Finally, in support of all these efforts, and to make the public, the nation and the international UAS community aware of the strength and capabilities of the Oklahoma UAS sector, the state should continue an aggressive national and international publicity campaign through press releases, publications, interviews, media tours of Oklahoma UAS companies and facilities, conferences and trade shows. Care should be taken to present the UAS industry in a positive manner that will contribute to the security and welfare of citizens while at the same time growing a new economy for the state.

RECOMMENDATION 10:

Grow political support and public advocacy:

- Promote the state's UAS efforts to the state legislature and to Congress through continual communication with appropriate state legislators, agency heads and congressional members.
- Continue the promotion of Oklahoma's UAS sector via press releases, publications, interviews, media tours, conferences, trade shows and other appropriate media outlets and venues.
- Continue the annual Unmanned Systems Alliance of Oklahoma (UAS-OK) UAS summits with leadership from the governor.

4.1 SUMMARY

Oklahoma has significant strengths in Unmanned Aerial (Aircraft) Systems. These range from fundamental and applied research on platforms, payloads and radar, to test and evaluations, applications, training and education. A large number of relevant assets already exist. Combined, these give the state the ability to compete effectively in the national and international UAS arena in order to establish Oklahoma as a "fly to" state for the development of the UAS industry. Predictions for the UAS market, both in the U.S. and worldwide, indicate a large, burgeoning market, a significant portion of which could be centered in Oklahoma.

To achieve this desired goal, investment and attention is required in several areas. An analysis of Oklahoma strengths and weaknesses by the UAS Advisory Council leads to the following recommendations:

Recommendation 1: *Establish a network of FAA UAS Test Sites, including the OTC-US^{SM}, Chilocco, Clinton-Sherman, Camp Gruber, Kessler Field Station and Muldrow Heliport. Link the ranges via UAS air corridors.*

Recommendation 2: *Build and equip the UAS Radar and Sensor Systems Center at OU.*

Recommendation 3: *Build and equip UAS R&D facilities and UAS Industry facilities at the Oklahoma Technology and Research Park, Stillwater.*

Recommendation 4: *Compete aggressively to become a federally directed (e.g. FAA, DHS, etc.) UAS Test Range.*

Recommendation 5: *Create a centralized administration to operate an integrated Oklahoma UAS Test Site Network.*

Recommendation 6: *Invest in Research and Development in UAS and compete for an ERC, UARC and/or FFRDC.*

Recommendation 7: *Expand and strengthen UAS education and training capabilities.*

Recommendation 8: *Establish and grow strategic partnerships and collaborations.*

Recommendation 9: *Expand corporate UAS manufacturing presence in Oklahoma and state support to private UAS companies in Oklahoma.*

Recommendation 10: *Grow political support and public advocacy.*

Many of the recommendations contained herein are already underway and progressing well. Due to the collaboration and unity of effort within the Governor's UAS Council and the partnerships across Oklahoma public and private enterprises, many of the recommendations will be accomplished in parallel, all focused toward the achievement of our common strategic objective to establish Oklahoma as a leading state in the growth of the UAS industry and for this industry to be an engine of economic development and job creation in the aerospace sector for Oklahoma and its residents.

Appendix 1: University UAS Analysis

From a recent analysis of Unmanned Systems research and relationships at U.S. universities, the following programs have been identified:

Universities; Unmanned Systems Research

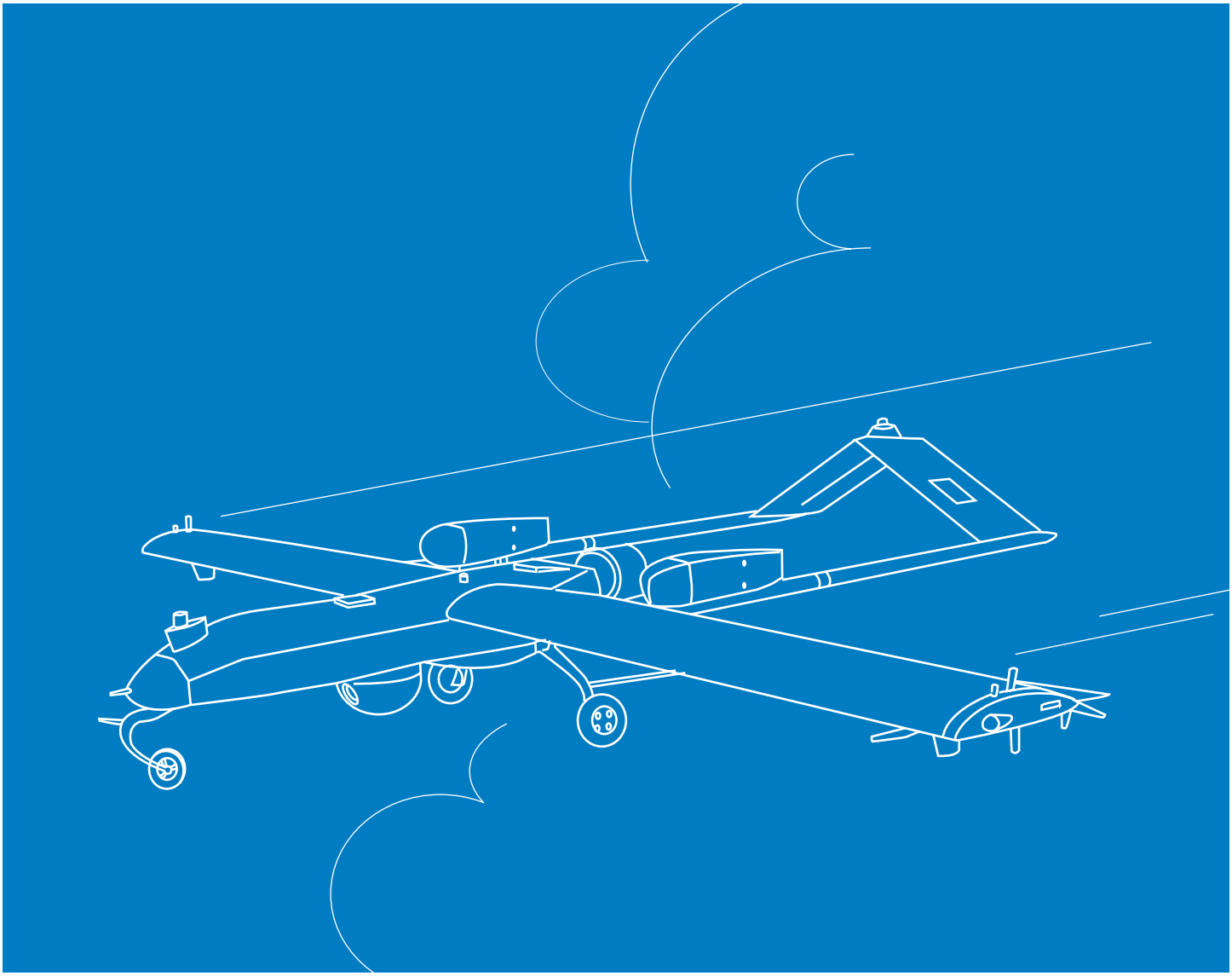
Arizona State University (ASU)
Auburn University (AU)
Boston University (BU)
Brigham Young University (BYU)
Carnegie Mellon University (CMU)
Cornell University (CU)
Embry-Riddle Aeronautical University (ERAU)
George Washington University (GWU)
Georgia Tech Research Institute (GTRI)
Johns Hopkins University (JHU)
Kansas State University (KSU)
Louisiana Tech University (LTU)
Massachusetts Institute of Technology (MIT)
Mississippi State University (MSU)
New Mexico State University (NMSU)
Ohio State University (OSU)
Oklahoma State University and the University Multispectral Labs (UML)
Penn State University (PSU)
Rutgers University (RU)
Texas A&M University (TAMU)
The University of North Dakota (UND)
United States Air Force Academy (USAFA)
University of Akron (UA)
University of Alaska (UA)
University of Central Florida (UCF)
University of Colorado (UC / Boulder)
University of Dayton Research Institute (UDRI)
University of Iowa (UI)
University of North Texas (UNT)
University of Oklahoma (OU)
University of Maryland (UM)
University of Pennsylvania (UP)
Villanova University (VU)
West Virginia University (WVU)
Wright State University (WSU)

Appendix 2: FAA UAS Test Range Competition

Listed below are those states that are known to have expressed a desire to compete for one of the six FAA UAS Test Ranges.

States that have expressed a desire to host an FAA UAS Test Range

Alaska	Louisiana	**Oklahoma**
Arizona	Maryland	North Dakota
California	Maine	Tennessee
Colorado	Montana	Texas
Florida	New Mexico	Utah
Georgia	New York	Virginia
Hawaii	Nevada	Washington
Kansas	Ohio	



Appendix 3: Oklahoma UAS Companies

Listed below are companies who actively participate in the UAS industry in Oklahoma.

Oklahoma UAS Companies

Atria Defense Group (Lawton)
Atria Defense Group oversees the operations of the Oklahoma Training Center for Unmanned Systems and provides UAS operations, flight operations, component testing, training and airspace for government entities and commercial companies in the UAS/aerospace sector.

Design Intelligence Incorporated LLC (Norman and Stillwater)
DII provides leading-edge technical solutions to both government and commercial clients. Clients include both federal and state government agencies along with Fortune 100 and 500 companies. DII's primary focus is development of advanced unmanned systems technology, such as micro air vehicles (MAVs). DII also develops advanced and highly efficient power management systems for small unmanned aircraft that utilize energy harvesting technology, as well as advanced energy storage technology (including hybrid technology).

Dow Aero Logistics LLC (Oklahoma City)
Dow Aero Logistics offers exemplary aftermarket support services for all types of military, commercial, business and regional aircraft, including specialty spare part sales, comprehensive Boeing inventory, parts exchange program, consignment bonds and logistics management services.

FlightSafety International (Broken Arrow)
FlightSafety International is the world's premier professional aviation training company and supplier of flight simulators, visual systems and displays to commercial, government and military organizations, providing more than a million hours of training each year to pilots, technicians and other aviation professionals. Backed by Berkshire Hathaway, one of the world's most successful and admired companies, FlightSafety operates the world's largest fleet of advanced full flight simulators at an extensive network of Learning Centers located in the United States, Canada, France, Japan, South Africa and the United Kingdom.

FLIR Systems Inc. (Stillwater)
FLIR is a world leader in the design, manufacture and marketing of thermal imaging infrared cameras. Founded in 1978, FLIR originally provided infrared imaging systems that were installed on vehicles for use in conducting energy audits. They later expanded their focus to other applications and markets for thermal imaging technology, such as stabilized thermal imaging cameras for law enforcement aircraft, radiometry devices for use in monitoring industrial systems, and thermal imaging systems for use in ground-based security and search and rescue. Today they are one of the world leaders in the design, manufacture and marketing of sensor systems that enhance perception and awareness for a wide variety of users in the commercial, industrial and government markets, internationally as well as domestically.

Frontier Electronic Systems (Stillwater)
Frontier Electronic Systems is a leader in the design and manufacture of innovative systems and equipment for government and commercial customers. Headquartered in Stillwater, team members innovate, design, manufacture and test electronic products and systems for aerospace and maritime global customers. Frontier focuses on innovative test and simulation systems; high-tech radar and video distribution products; avionics and electronics for aircraft; space flight electronics; and R&D innovation, prototype design/manufacture and engineering support.

Oklahoma UAS Companies (cont.)

Global ResQ Inc. (Duncan)
Global ResQ is a nonprofit corporation designed to provide effective disaster response technologies, management systems, communications and logistic services.

Objectstream Inc. (Oklahoma City)
Founded in 2004, Objectstream Inc. is a thriving 8(a) certified information technology and management consulting firm that offers a broad range of services – aviation operations, maintenance and navigation engineering services, management services, information technology services, software development services, training and staff augmentation. Objectstream is headquartered in Oklahoma City with offices in Tennessee, Maryland and New Jersey.

Republic Aero Inc. (Duncan)
Republic Aero is a for-profit company providing advanced UAS concept development, system engineering and operational support. Republic can assist with review of flight and operations plans, and connection with university researchers for project assistance.

Supero UAS (Oklahoma City)
Since its beginning more than 20 years ago, the mission of this Internal Wing Aircraft (IWA) company has been to revolutionize the business of flying by building aircraft based on its patented lifting technology. Over the past 15 years, IWA has gone from hand-held gliders to RC (radio-controlled) aircraft to MAVs (Micro Aerial Vehicles) and today – UAVs. Supero's principal and patent-holder of the internal wing aircraft, Robert Carr, a former instructor pilot, has developed this aircraft based on a new technology since 1976. Robert holds patents in the U.S., European Union, Norway and Australia.

Tactical Electronics Inc. (Broken Arrow)
Tactical Electronics Aviation specializes in developing vertical takeoff and landing unmanned aircraft systems. TE's R&D department custom designs and fabricates UAV payloads. Engineered with top-of-the-line components and integrated TE wireless technology, TE's payloads are created to provide operators with customized solutions for multiple operations.

TE aviation is continually expanding to support the needs of multiple applications, including remote sensing, payload transport, oil/gas exploration and production, and structural inspections. Advanced ground control, autopilot and payload features enable TE's unmanned aircraft systems to provide operators with immediate time critical information and enhanced situational awareness.

TDRS LLC (Lawton)
TDRS LLC provides a wide range of defense consulting services to the U.S. Army Fires Center of Excellence and to commercial business partners in the DoD business sector. TDRS offers UAS demonstration and training at the Oklahoma Training Center for Unmanned Systems near Lawton and Fort Sill. With two paved runways between 1,800 and 2,200 feet in length, Group 3 UAS and their ISR packages can be accommodated for operations and training. Specialties include training and doctrine; unmanned aerial systems; live, virtual, and constructive simulations; and tactics techniques and procedures.

Triton Scientific LLC (Ponca City and Edmond)

Established in 2007, Triton Scientific LLC is a certified HUBZone small business, and has become one of the fastest growing small businesses within Oklahoma through the award of a 20-year management service contract by Oklahoma State University (OSU)-University Multispectral Laboratories (UML). This program was established to execute all matters of business operations and financial management for the UML, which is a 501(c)(3) nonprofit, government (state) owned contractor (Triton) Operated (GOCO) entity that serves as a self-supported "trusted agent" Research, Development, Test, Evaluation and Training (RDTE&T) complex. Triton supports a wide variety of tactical needs in support of sensors technology, scientific training and technology insertion for DoD, federal, state, and local clients to include United States Special Operations Command (USSOCOM), United States Joint Forces Command, United States Air Force Nuclear Security Forces Command, Oklahoma National Guard, Defense Threat Reduction Agency and the Defense Intelligence Agency.

Wave Technologies Inc. (Guthrie)

Wave Technologies, Inc. (WTI) is a veteran-owned, HUBZone certified, small business. WTI provides ISR life cycle systems engineering and integration, analysis center solutions, systems engineering and technical assistance services (SETA), Tactical Aircraft and Weapons Systems, and unmanned aerial vehicle technical services to government clients in the Department of Defense, intelligence community and broader national security arena.

The WTI staff can provide functional management services to include requirements definition, system planning, design, and development, integration, testing and evaluation, production engineering, accreditation, configuration management, life cycle sustainment, operations and readiness.

Zivko Aeronautics Inc. (Guthrie)

Zivko Aeronautics is a woman-owned and operated company that has been involved in aircraft and aviation since its founding in 1987. The professional staff at ZAI has over 70 years of combined experience in every aspect of aviation. The staff includes experienced FAA licensed mechanics, an FAA licensed inspector, and a full-time aeronautical/avionics/mechanical engineering staff. ZAI's quality control meets private industry standards, as well as complies with the strict MIL-I-45208A and MIL-STD45662 Department of Defense requirements.

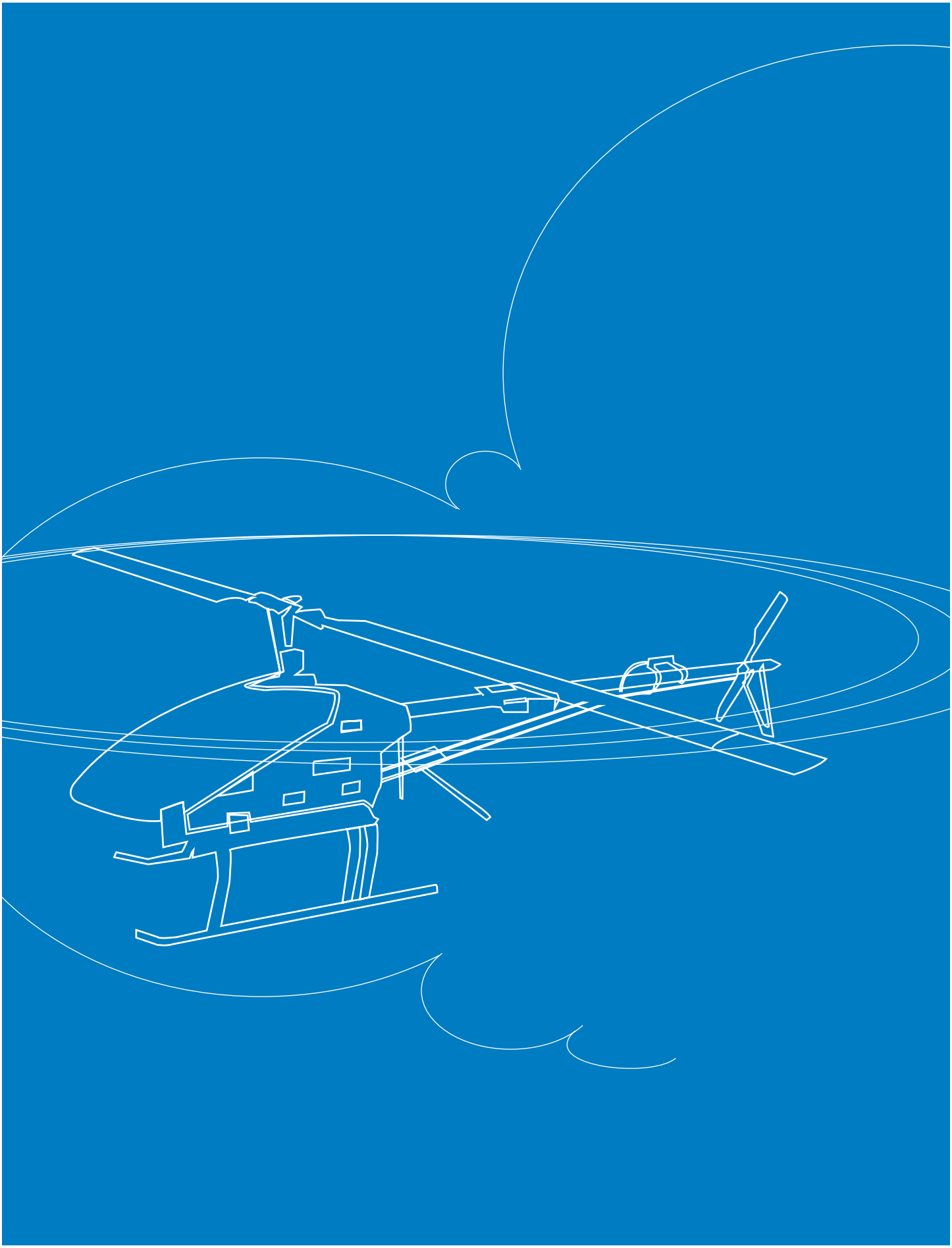
ZAI has worked extensively with several aerobatic pilots, including the 2004, 2003, 2002 & 1998 U.S. National Champion Kirby Chambliss, and the 2000 U.S National Champion, Steve Andelin. This interaction allows ZAI to fully understand the requirements of unlimited aerobatics, and to produce a highly optimized and specialized aircraft. By both thoroughly discussing the requirements of each individual customer, ZAI can produce an aircraft specifically tailored to those individual needs.

GLOSSARY OF ACRONYMS

AFFSA	Air Force Flight Standards Agency
ARRC	Atmospheric Radar Research Center
AUVSI	Association of Unmanned Vehicle Systems International
C5ISR	Command, Control, Communication, Computers, Cyber Security, Intelligence, Surveillance and Reconnaissance
CAMI	Civil Aerospace Medicine Institute
CASQ	Center for Aerospace Supplier Quality
CBRNE	Chemical, Biological, Radiological, Nuclear and Explosives
CGJMTC	Camp Gruber Joint Maneuver Training Center
CoA	Certificate of Authorization
DEQ	Department of Environment Quality
DHS	Department of Homeland Security
DoD	Department of Defense
DOE	Department of Energy
EDGE	Economic Development Generating Excellence
EMC	Electromagnetic Compatibility
ERC	Engineering Research Center
FAA	Federal Aviation Administration
FFRDC	Federally Funded Research and Development Center
FSI	Flight Safety International
ILS	Instrument Landing Systems
i2E	Innovation to Enterprise
iSec	Institute for Information Security, University of Tulsa
HALE	High Altitude Long Endurance
KAEFS	Kessler Atmospheric and Ecological Field Station
MAV	Micro Air Vehicle
MALE	Medium Altitude Long Endurance
M-AVIARI	Micro Air Vehicle Indoor Assessment and Research Instrumentation
MoA	Memorandum of Agreement
MoU	Memorandum of Understanding
MPAR	Multi-function Phased Array Radar
MRO	Maintenance, Repair and Overhaul
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NDAA	National Defense Authorization Act
NextGen	Next Generation Air Transportation System
NSA	National Security Agency
NSF	National Science Foundation

GLOSSARY OF ACRONYMS (cont.)

NWRT	National Weather Radar Testbed
OAC	Oklahoma Aeronautics Commission
OCAST	Oklahoma Center for the Advancement of Science and Technology
OEM	Original Equipment Manufacturer
OKARNG	Oklahoma Army National Guard
OSIDA	Oklahoma Space Industry Development Authority
OSU	Oklahoma State University
OSU-IT	Oklahoma State University – Institute of Technology
OTC–US℠	Oklahoma Training Center – Unmanned Systems
OTRP	Oklahoma Technology and Research Park
OU	University of Oklahoma
PAR	Phased Array Radar
RAPS	Robotic Aircraft for Public Safety
R&D	Research and Development (also RDT&E)
RF	Radio Frequency
SUAS	Small Unmanned Aerial System
SNAS	System National Airspace System
T&E	Test and Evaluation (also RDT&E)
TU	University of Tulsa
UARC	University Affiliated Research Center
UAS	Unmanned Aerial/Aircraft Systems
UAV	Unmanned Aerial/Aircraft Vehicles
UDC	Unmanned Systems Development Center
UML	University Multispectral Laboratories (owned by OSU)
USAF	United State Air Force
USSOCOM	United States Special Operations Command
VTOL	Vertical Takeoff and Landing



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