

Unmanned Aircraft Systems: An Overview of Strategies and Opportunities for Missouri



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TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. cmr 18-009	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Unmanned Aircraft Systems: An Overview of Strategies and Opportunities for Missouri		5. Report Date June 18, 2018 Published: June 2018	
		6. Performing Organization Code	
7. Author(s) Damon Lercel, Ph.D. Richard Steckel, Ph.D. Joe Pestka		8. Performing Organization Report No.	
9. Performing Organization Name and Address UAViation 19 Country Fair Lane St. Louis, MO 63141 Aviation, Inc. 931 Wildwood Drive, Suite 101 Jefferson City, MO 65109		10. Work Unit No.	
		11. Contract or Grant No. MoDOT project # TR201808	
12. Sponsoring Agency Name and Address Missouri Department of Transportation (SPR) Construction and Materials Division P.O. Box 270 Jefferson City, MO 65102		13. Type of Report and Period Covered Final Report (February 20, 2018 to May 31, 2018)	
		14. Sponsoring Agency Code	
15. Supplementary Notes Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. MoDOT research reports are available in the Innovation Library at http://www.modot.org/services/or/byDate.htm .			
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17. Key Words Best practices; State government agencies; State of the practice; Unmanned aircraft systems; Drones		18. Distribution Statement No restrictions. This document is available through the National Technical Information Service, Springfield, VA 22161.	
19. Security Classif. (of this report) Unclassified.	20. Security Classif. (of this page) Unclassified.	21. No. of Pages 51	22. Price

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Submitted: May 31, 2018

Revised: June 18, 2018



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This research report is presented in fulfillment of 2017.MOJ.01 PAL Vendor Agreement regarding the Missouri Highways and Transportation Commission's Missouri Airport System Plan Update: Project No. TR201808 Unmanned Aircraft Systems.

Disclaimer

The opinions, findings, and conclusions expressed in this document are those of the investigators. They are not necessarily those of the Missouri Department of Transportation, U.S. Department of Transportation, or Federal Highway Administration. This information does not constitute a standard or specification.

Abstract

Many states have embraced Unmanned Aircraft Systems (UAS) and are actively utilizing the technology across a number of state and local agencies. A growing number of states' Departments of Transportation (DOT) are leveraging innovative UAS technology to creatively improve safety and efficiency while saving money. Currently 35 state DOTs are exploring, researching, testing, or using UAS. With over 1,000,000 registered UAS and over 86,000 UAS certificated pilots since 2016, the growth in UAS operations across the United States is significant. The UAS economic forecasts are even more impressive. The Teal Group's 2017 World Civil UAS Market Profile and Forecast estimates that non-military UAS production will quadruple from \$2.8 billion worldwide in 2017 to \$11.8 billion in 2026. Over the next decade, Teal predicts the UAS market will total \$73.5 billion. Similarly, Goldman Sachs Research predicts the fastest UAS market growth coming from businesses and civil governments – spending \$13 billion between 2016 and 2020.

The Missouri Highways and Transportation Commission launched a comprehensive research project to develop a new Missouri State Airport System Plan (MSASP), which included UAS – commonly referred to as drones. This research explored the adoption of UAS technology at the national and state levels – focusing on the role of transportation agencies, activities, policies, and strategies promoting safe UAS operations and economic growth. The national level was a macro look at the broader UAS adoption across the country. At the state or micro level, researchers evaluated five states within the same central United States region as Missouri. The micro level research focused more narrowly on the states' strategies, policies, activities, and the role of state agencies regarding UAS adoption. Researchers evaluated these findings along with the UAS ecosystem in Missouri, identified strategic opportunities and developed recommendations that may help accelerate Missouri's adoption of UAS, while promoting economic growth and preparing Missouri for future UAS opportunities.

Highlights:

- Missouri is behind in promotion and adoption of UAS compared with other states.
- Most state transportation agencies are using UAS technology to improve and enhance their operational processes.
- In partnership with the FAA, many state DOTs are assuming a statewide leadership role in UAS adoption.
- Getting started does not require a significant stakeholder investment in equipment or personnel – may be as little as \$5,000 to start using UAS.
- Collaboration and partnerships across state and local agencies, academic institutions, and industry partners provide cost effective and impactful UAS strategies, while helping to create economic growth.
- Many state DOT's are investing in UAS training and education, developing in-house expertise, and developing policies to support safe and legal UAS operations across state agencies.

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Introduction

The original Missouri State Airport System Plan (MSASP) was completed in 1979 and has been updated eleven times since 1983. In the fall of 2017, the Missouri Highways and Transportation Commission launched a comprehensive research project to develop a new MSASP. The purpose of this new MSASP is to help guide aviation development programs for Missouri in the coming years.

The MSASP research project includes exploring the adoption of Unmanned Aircraft System (UAS) technology at the national and state levels – focusing on the role of transportation agencies, activities, policies, and strategies promoting safe UAS operations and economic growth. The national level is a macro look at the broader UAS adoption across the country, which includes research of market forecasts, federal regulation and policy, pilot population, aircraft registration, and technology that may be deployed to manage UAS operations in the National Airspace System (NAS). At the state or micro level, researchers evaluated five states within the same central United States region as Missouri. The five focus states were Iowa, Kansas, Minnesota, North Dakota, and Oklahoma. The micro level research focused more narrowly on the states' strategies, policies, activities, and the role of state agencies regarding UAS adoption. Researchers evaluated these findings along with the UAS ecosystem in Missouri, identified strategic opportunities and developed recommendations that may help accelerate Missouri's adoption of UAS, while promoting economic growth and preparing Missouri for future UAS opportunities.

This research primarily focuses on airborne technologies, but also discusses a number of ground-based technologies related to UAS that experts predict will be critical to safely managing broader and more complex UAS operations in the NAS – technologies that may require future state investment.

Research Methodology

This research utilized both qualitative and quantitative research methodologies. Qualitative research involved an extensive literature review and interviews with representatives from federal and state agencies, academic institutions, and industry organizations. The literature review included data and reports from the Federal Aviation Administration (FAA), the United States Department of Transportation (DOT), Association of Unmanned Vehicles Systems International (AUVSI), academic journal publications, state DOT documentation, websites, and market forecasts. Researchers conducted a total of 12 phone interviews, which included representatives from state DOTs, FAA, National Aeronautics and Space Administration (NASA), academic institutions, and FAA designated UAS test sites. Quantitative research involved analyses of FAA and DOT data, and a survey of Missouri airport managers. These data collection efforts included two Freedom of Information Requests to the FAA for UAS pilot and registration data, which were granted by the FAA and the data provided to researchers. The survey and interview instruments are available for review in Appendix A.

All research participant provided information and data have been deidentified and reported in aggregate format. This research involved a macro review of UAS adoption at a national level and a micro review at the state level.

Macro level research focused on regulatory activities, policy and technology development focused on airport operations and safety, and UAS demographic data. The micro level focused on the UAS activities of five states also located in the Midwest: Iowa, Kansas, Minnesota, North Dakota, and Oklahoma. In addition to the macro level components, the micro level research looked deeper at the specific UAS activities of these five states. These activities included UAS operations, applications, promotion, and management strategies. From these research data, researchers developed a list of opportunities and recommendations for MoDOT and other Missouri agencies to consider along with strategies for supporting broader UAS adoption.

Limitations

This was an initial exploratory research project to gain a better perspective of UAS adoption at both a national (macro) level and a state (micro) level. The research scope was limited and intended to help identify areas of further research and potential next steps in developing a more comprehensive plan regarding UAS in Missouri.

The research sample size was limited – primarily due to the tight project schedule and delays encountered in the data collection approval process. Researchers were unable to interview any representatives from the state of Kansas; therefore, research for this state was limited to literature, media, and state agency websites. In addition, researchers interviewed only one or two people from the other states and due to time constraints were not able to confirm all the information shared by the interview subjects. The airport manager survey was limited to airports in Missouri. A broader survey of other managers from other states would have provided an opportunity to compare results across states. Specific data regarding financial information and resources to support UAS activity was limited either because the data was not readily available, interviewee’s knowledge was limited or they did not want to share the information, or the project schedule did not allow for contacting the appropriate people.

UAS Macro Level

FAA UAS Regulations

Background

With the explosion of UAS and UAS pilots, in addition to the already numerous Radio Control (RC) model aircraft, the FAA’s approach to ensuring the safety of the National Airspace System (NAS) for all users has evolved over time as the technology has developed and the number of UAS has increased.

In 2009, the FAA issued FAA Notice N JO 7110.512, “Unmanned Aircraft Operations in the National Airspace System” to provide guidance for public agencies to operate UAS in the NAS.¹ It should be noted that permission to operate UAS was required regardless of what airspace was

requested. A public agency would apply for a Certificate of Authorization (COA) to operate in the NAS. For a COA, pilots were required to have at least a current FAA Private Pilot Certificate and a current FAA 2nd Class Medical Certificate. To be considered “current”, the pilot was required to make at least three takeoffs and landings in a manned aircraft in the previous 90 days and complete a Biennial (every two years) Flight Review (BFR) with an FAA certificated flight instructor. An observer was required to have a current FAA 2nd Class Medical Certificate. A private organization wishing access to the NAS required the organization to apply for a Special Airworthiness Certificate-Experimental, which was a very tedious and time-consuming task to complete.^{2 3} The applicant could expect a waiting period of six months or longer to obtain approval – currently only two UAS models have been issued an airworthiness certificate. This regulatory structure did not allow for extensive commercial UAS operations. Hobbyists and recreational pilots were to follow the guidance in the FAA Advisory Circular (AC) AC 91-57, which was issued in 1981.⁴

On February 14, 2012, Congress passed Public Law 112-95 “FAA Modernization and Reform Act of 2012.”⁵ In this law, Section 333 (Special Rules for Unmanned Aircraft) allowed commercial UAS operators to apply for a “Section 333” exemption to operate UAS in the NAS.⁶ Again, all flights in the NAS required permission to fly. While this process opened the NAS to commercial operators, this process was quickly overwhelmed by requests, which resulted in long wait times for exemptions. The requirements were also burdensome on the operator, requiring that the pilot be at least a current FAA recreational pilot with a valid driver’s license. This meant the pilot was again required to make three takeoffs and landings in the previous 90 days in a manned aircraft along with a BFR.⁶

In August of 2016, the FAA released 14 CFR Part 107 “Small Unmanned Aircraft Systems” that provided regulations for UAS pilot certification and operating rules.⁷ It was at this time that commercial UAS operations exploded. Part 107 also included a waiver process to receive permission to operate outside of some rules, such as flying at night or in certain airspace.⁸ These regulations opened FAA Class G (uncontrolled) airspace for UAS operations without requiring a waiver or permission. The process for obtaining permission to Class B, C, D and E airspace (Figure 1) could at first be obtained by contacting the controlling agency. This proved unmanageable as these facilities were spending an inordinate amount of time dealing with UAS operators.⁹

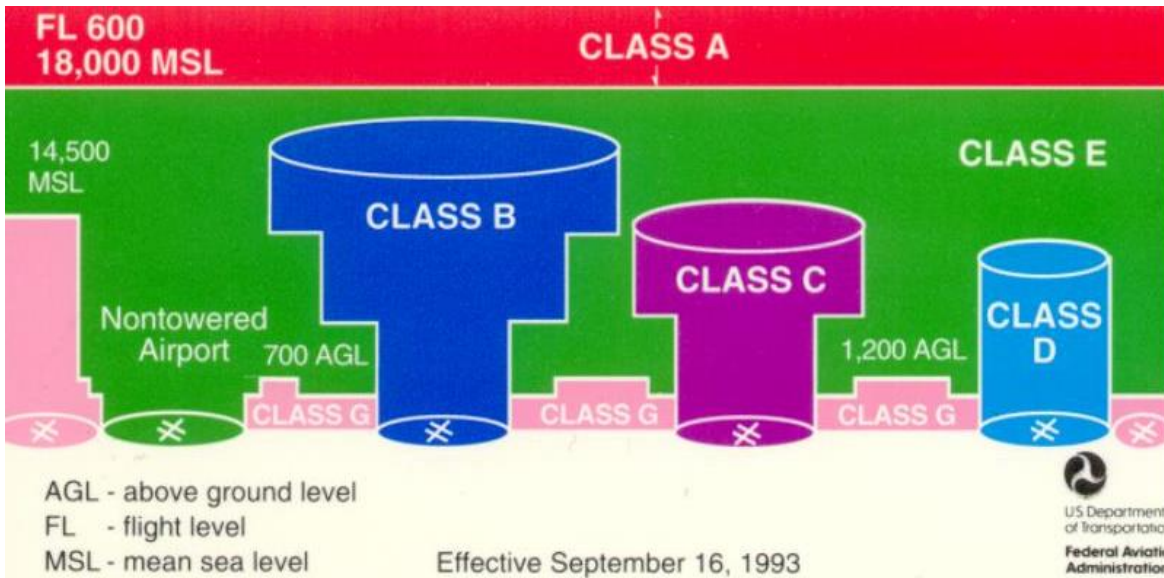


Figure 1. United States Airspace Classes at a Glance

The FAA then provided an online process for obtaining waivers that at first was effective, but eventually became bogged down due to the number of requests. It was not unusual for a waiver request to take up to a year. As a help to applicants, the FAA issued a “UAS Facility Map” (Figure 2) to assist applicants by showing what the FAA might approve as far as airspace requests. This did somewhat speed the approval process.⁹

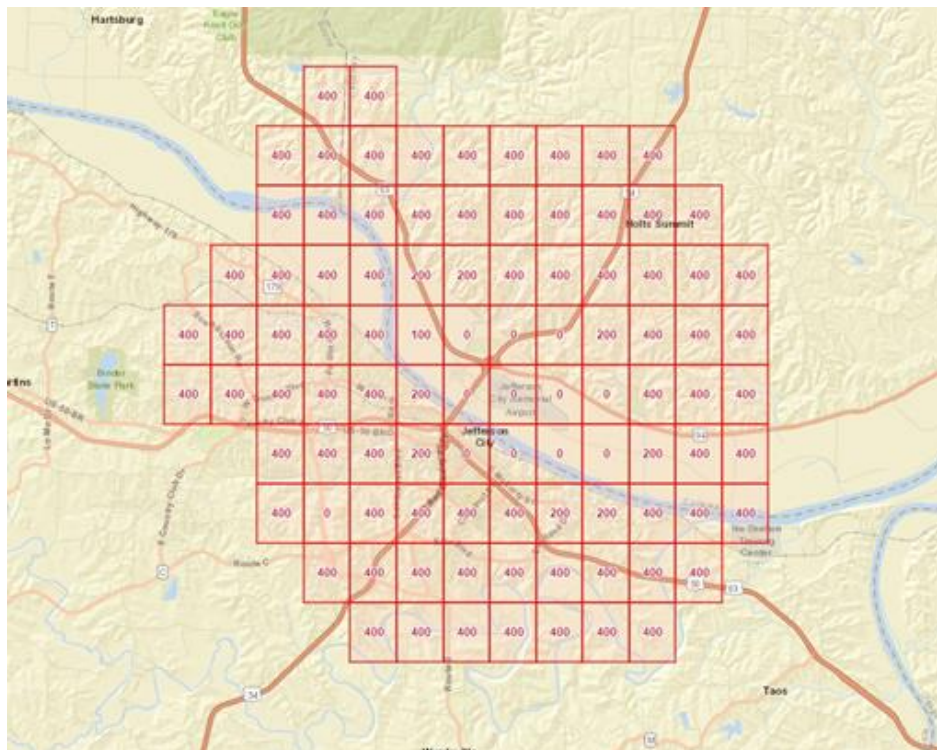


Figure 2. FAA UAS Facility Map

The FAA is making further improvements to the process. If fully implemented by September of 2018, the Low Altitude Authorization and Notification Capability (LAANC) will allow an operator wishing to access controlled airspace to make an online request to an FAA provider to obtain permission to fly in under an hour. This system will also use the facility maps (Figure 2).

Hobbyist vs. Commercial Operator

Hobbyists operate under Public Law 112-95, Section 336 “Special Rule for Model Aircraft”.¹⁰

The FAA considers UAS operations as a hobby if the pilot:

- Flies for hobby or recreation ONLY.
- Registers his model aircraft.
- Flies within visual line-of-sight.
- Follows community-based safety guidelines and flies within the programming of a nationwide community-based organization.
- Flies a UAS under 55 lbs. unless certified by a community-based organization
- Never flies near other aircraft.
- Notifies the airport and air traffic control tower prior to flying within 5 miles of an airport.
- Never flies near emergency response efforts.

Any other operation for any compensation for hire, even if the flight is not the pilot’s primary business, such as taking pictures of a house for their real estate firm, is considered a flight that must comply with the requirements of Part 107.

Pilot

To fly under Part 107 regulations, you must be an FAA certificated small UAS remote pilot. The requirements to obtain a certificate are:¹⁰

- Be at least 16 years old.
- Be able to read, speak, write, and understand English (exceptions may be made if the person is unable to meet one of these requirements for a medical reason, such as hearing impairment).
- Be in a physical and mental condition to safely operate a small UAS.
- Pass the initial aeronautical knowledge exam at an FAA-approved knowledge testing center.

Pilot Certificate Requirements

- Certificate must be easily accessible by the remote pilot during all UAS operations.¹⁰
- Certificate valid for two years – certificate holders must pass a recurrent knowledge test every two years.¹⁰

Pass the initial aeronautical knowledge test – initial knowledge test areas include:¹⁰

- Applicable regulations relating to small unmanned aircraft system rating privileges, limitations, and flight operation.
- Airspace classification and operating requirements, and flight restrictions affecting small unmanned aircraft operation.
- Aviation weather sources and effects of weather on small unmanned aircraft performance.
- Small unmanned aircraft loading and performance.
- Emergency procedures.
- Crew resource management.
- Radio communication procedures.
- Determining the performance of small unmanned aircraft.
- Physiological effects of drugs and alcohol.
- Aeronautical decision-making and judgment.
- Airport operations.
- Maintenance and preflight inspection procedures.

Aircraft

Aircraft flown under Part 107 or under Section 336 weighing more than .50 lbs. and less than 55 lbs. are required to be registered with the FAA. Hobbyists registering the aircraft (not necessarily flying it) must be at least 13 years old and be a U.S. citizen or legal permanent resident. Hobbyists may apply for one registration number and apply this one number to all of his/her aircraft. Commercial operators register the aircraft for three years and need a registration for each aircraft flown.¹⁰

Waivers

The FAA has recognized that the current Part 107 rules are very restrictive and have a waiver process for those operations that may not meet Part 107 requirements. An operator may apply online at the FAA website for a Part 107 waiver. The application requires the operator to supply a plan on how the operation will continue to be safe under the proposed waiver.¹⁰

Integration with Manned Aircraft

In 2013 the FAA released the first edition of “Integration of Civil Unmanned Aircraft Systems (UAS) in the National Airspace System (NAS) Roadmap.”¹⁰ The roadmap

“...outlines the actions and considerations needed to enable UAS integration into the NAS. The roadmap also aligns proposed FAA actions with Congressional mandates from the FAA Modernization and Reform Act of 2012. This plan also provides goals, metrics, and target dates for the FAA and its government and industry partners to use in planning key activities for UAS integration.”¹¹

The FAA foresees UAS operations as being seamless in the NAS with manned aircraft. There will be more opportunities for public and private sector research to enable UAS to fly in the NAS with manned aircraft. Pilot and aircraft certification and training,

airspace, safe separation of aircraft, air traffic procedures and regulations will need to be addressed and changed to allow these types of operations.¹¹

Demographics

According to the FAA, the United States currently has over 1,000,000 registered UAS with just over 156,000 of these registered for commercial use.¹³ The FAA has issued over 86,000 remote pilot (UAS) certificates in the U.S. since the Part 107 regulation was enacted in August 2016.¹² According to FAA data, of the 156,166 commercially registered UAS, 1.5% (2377) are in Missouri.¹³ Of the 86,438 remote pilot certificates, 1.8% (1560) have been issued in Missouri.¹² Measured on a per capita basis, Missouri ranks 31st in the number of certificated remote pilots and 44th in the number of registered UAS. The FAA issued its first 333 exemption in September 2014, which enabled initial commercial UAS operations in the United States. By September 2016 the FAA had issued over 5,500 exemptions. In Missouri, fewer than 100 exemptions had been issued.^{13 14}

Market Forecast

UAS technology provides an opportunity for significant gains in safety, security, and efficiency, along with cost savings across a broad spectrum of applications. The Teal Group's 2017 World Civil UAS Market Profile and Forecast estimates that non-military UAS production will quadruple from \$2.8 billion worldwide in 2017 to \$11.8 billion in 2026.¹⁵ Over the next decade, Teal predicts the UAS market will total \$73.5 billion.¹⁵ Similarly, Goldman Sachs Research predicts the fastest UAS market growth coming from businesses and civil governments – spending \$13B between 2016 and 2020.¹⁶ Both Teal and Goldman predict a significant increase in the number of UAS flying for civil or commercial operations, creating jobs and economic growth.^{15 16} The possible uses of UAS are endless as new applications are rapidly developing.

Many states have embraced UAS technology and are actively utilizing the technology across a number of state and local agencies. A growing number of state DOTs are leveraging innovative UAS technology to creatively improve safety, reduce traffic congestion and save money.

According to a March 2018 survey by the American Association of State Highway and Transportation Officials (AASHTO), 35 state DOTs have or are exploring, researching, testing, or using unmanned aerial vehicles to inspect bridges, assist with clearing vehicle crashes, assess flood and storm damage, and monitor wildlife, among other innovative applications.¹⁷ These states include Iowa, Kansas, Minnesota, North Dakota, and most recently Oklahoma.^{17 18} State DOTs are being tasked with supporting UAS implementation across their respective state and local agencies, such as emergency responders and public utilities.

In addition, many state governments have created UAS and/or administrative groups solely focused on promoting UAS operations across their respective states, developing regional expertise and job creation. Examples include:

- Michigan's legislature created the Unmanned Aircraft Systems Task Force to “develop statewide policy recommendations on the operation, use, and regulation” of UAS in the state.¹⁹

- Illinois legislature established the UAS Oversight Task Force.²⁰
- Georgia's governor issued an executive order creating the Commission on Unmanned Aircraft Technology.¹⁹
- New York governor announced a \$30 million grant to develop a 50-mile, low-altitude UAS flight corridor between Rome and Syracuse, a project managed by the Northeast UAS Airspace Integration Research Alliance (NUAIR) based in New York.²¹
- Texas Department of Public Safety has launched a UAS program to aid in search and rescue, disaster support, aerial observation and crime scene photography, among other uses.²²
- Nevada Governor's Office of Economic Development has a website that openly advertises for UAS operators, manufacturers and researchers to relocate to Nevada.²³

Next Gen UAS Airspace Technologies

The FAA is investigating and conducting research on several airspace technologies to improve UAS access to airspace while continuing to improve safe UAS operations.^{9 24} These technologies include Remote Identification, Unmanned Aircraft System Traffic Management (UTM), the Low Altitude Authorization and Notification Capability (LAANC), Counter Drone Technology and Remote Air Traffic Control Towers. While many of these technologies are still under development and no regulatory requirements yet exist regarding their use, states should monitor these technological developments and related policies, as they may require investment by individual states – especially with regards to advanced commercial UAS operations.

Remote Identification. UAS offer even greater operational capability and economic opportunity once the FAA allows for expanded Beyond Visual Line Of Sight Operations (BVLOS).^{9 24 25} However, before BVLOS regulations can be enacted, the FAA must develop regulatory policy that allows for UAS operations over people.^{9 24} Shortly after the execution of Part 107, the FAA's next two scheduled Notice of Proposed Rulemaking (NPRM) were flights over people followed by BVLOS operations. The flights over people rule was originally thought to be relatively easy and a draft NPRM release was expected in 2017.²⁶ However, because of security concerns over UAS identification from federal law enforcement agencies both NPRMs are now on hold.²⁶ The question of concern for law enforcement is who is flying the UAS and are they authorized to be flying at a specific location? Currently, there is no approved technology standard that allows law enforcement to answer this question, nor is there agreement to whom this requirement should apply.^{9 24} The legislative term for this technology is remote identification (ID).²⁷

The FAA established the UAS ID and Tracking Aviation Rulemaking Committee (ARC) in May 2017 in response to concerns of the national security community around expanding UAS operations.²⁷ The ARC's 74 members represented a diverse array of stakeholders that included the aviation community and industry member organizations, law enforcement agencies and public safety organizations, manufacturers, researchers, and standards entities involved with UAS. The ARC submitted its final report to the FAA in September 2017. Next, the FAA will

use the data and recommendations in the ARC report in crafting a proposed rule for public comment.²⁷

Unmanned Traffic Management System (UTM). The FAA, NASA, other federal partner agencies, and industry are collaboratively exploring concepts of operation, data exchange requirements, and a supporting framework to enable multiple beyond visual line-of-sight UAS operations at low altitudes (under 400 ft above ground level (AGL)) in airspace where FAA air traffic services are not provided.^{24 28} UTM is a "traffic management" ecosystem for uncontrolled operations that is separate but complementary to the FAA's Air Traffic Management (ATM) system.²⁸ UTM development will ultimately identify services, roles/responsibilities, information architecture, data exchange protocols, software functions, infrastructure, and performance requirements for enabling the management of low-altitude uncontrolled UAS operations.²⁸ With UTM, there is a cooperative interaction between operators and the FAA to determine and communicate real-time airspace status. The FAA provides real-time constraints to the UAS operators, who are responsible for managing their operations safely within these constraints without receiving positive air traffic control services from the FAA.^{24 28} The primary means of communication and coordination between the FAA, operators and other stakeholders is through a distributed network of highly automated systems and not between pilots and air traffic controllers via voice.²⁸ Figure 3 provides a simplified illustration of a UTM architecture.²⁹

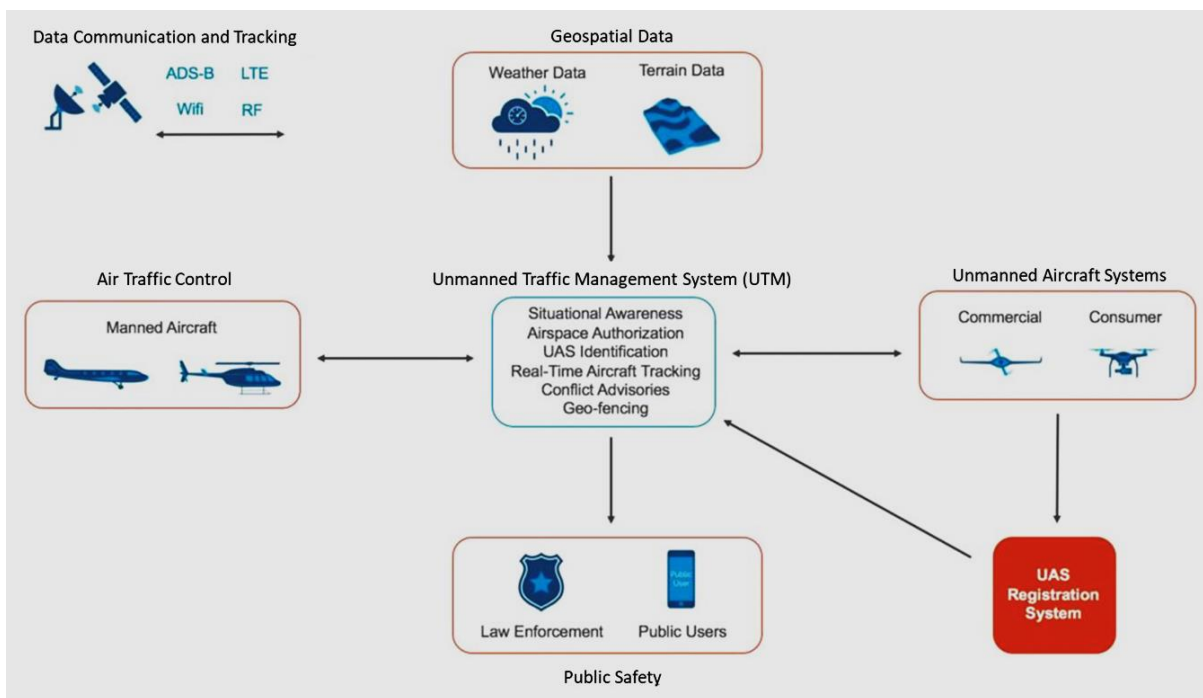


Figure 3. Unmanned Traffic Management System Architecture

LAANC. The FAA is currently implementing the first phase of UTM – the Low Altitude Authorization and Notification Capability (LAANC) system. As described on the FAA website:

“Under the FAA’s Part 107 small UAS rule, operators must secure approval from the agency to operate in any airspace controlled by an air traffic facility. To facilitate those approvals, the agency deployed the prototype Low Altitude Authorization and Notification Capability (LAANC) at several air traffic facilities last November to evaluate the feasibility of a fully automated solution enabled by data sharing. Based on the prototype’s success, the agency will now conduct a nationwide beta test beginning April 30 that will deploy LAANC incrementally at nearly 300 air traffic facilities covering approximately 500 airports. The final deployment will begin on September 13.”³⁰

UAS operators using LAANC can receive near real-time airspace authorizations. This dramatically decreases the wait experienced using the manual authorization process and allows operators to quickly plan their flights. Air traffic controllers also can see where planned UAS operations will take place.³⁰

LAANC uses airspace data provided through UAS facility maps. The maps show the maximum altitude around airports where the FAA may authorize operations under Part 107. LAANC gives UAS operators the ability to interact with the maps and provide automatic notification and authorization requests to the FAA.³⁰

Counter Drone. Counter-drone technology refers to systems that are used to detect and/or intercept UAS. As concerns grow around the potential security threats UAS may pose to both civilian and military entities, a new market for counter-drone technology is rapidly emerging.³¹ In civilian environments, counter-drone technology may be primarily used for airspace protection at airports, security during large events such as party conventions and sports games, Very Important People (VIP) protection, and counter-smuggling operations at prisons.³¹ Future common applications could include airspace defense around sensitive facilities, port security, maritime security, and personal use over private property.³¹

Pilots regularly report seeing UAS in flight and the FAA has seen a steep increase in reports of small UAS close to airports over the last two years. The FAA has been and is currently working with research organizations for the detection of UAS operations in the United States.³² Under the UAS Detection Initiative:

“...in October 2015, the FAA entered into a Cooperative Research and Development Agreement (CRDA) with CACI International to evaluate their technology’s ability to detect and identify small UAS in the vicinity of airports. A team of engineers from the FAA, the Department of Homeland Security, and CACI conducted 141 test operations over five days at the Atlantic City Airport from January to February 2016.”³²

In May 2016, the FAA expanded its detection initiative by signing CRDAs with Gryphon Sensors, Liteye Systems Inc., and Sensofusion to evaluate the companies’ prototype UAS detection systems.³² The FAA also began partnering with the Federal Bureau of Investigation (FBI) in May 2016 to evaluate a different UAS detection technology.³²



Figure 4. Example of a Hand-Held Counter Drone Technology (Battelle).³²

Remote ATC Towers. A remote air traffic control tower is a facility at an airport that is controlled by an air traffic controller in a facility not located at the airport. The remotely controlled air traffic control tower is equipped with pan-tilt-zoom high definition cameras, signal light gun and microphones. At the remote controller facility, the controller has access to multiple high-definition displays and two controller working positions with command of voice communications.³³

Remote air traffic control towers may enhance safety, reduce costs and expand air traffic control services at small U.S. airports.³⁴ Remote towers offer significant savings, especially if multiple airports are connected to a remote tower center. Estimated capital costs for a single-station remote tower facility are between \$1.5 and \$2.5 million versus an estimated \$3 million to \$7 million for federal contract towers.³⁴ Cameras spread out around an airport eliminate blind spots and give controllers more detailed views. Infrared can supplement images in rain, fog, or snow, and other cameras can include thermal sensors to see if animals stray onto the runway at the last second, improving safety.³⁵

The use of remote towers started in Europe and the number of towers is increasing. Sweden certified the first remote tower operation in the world in 2016, controlling air traffic at Örnköldsvik from a remote tower center at Sundsvall, 93 miles away.³³ The United Kingdom plans to replace the current tower at London City Airport with a remote tower. Air traffic for the four million passenger airport will then be controlled at Swanwick, about 80 miles away. Norway has plans to develop a remote tower center to control traffic at five small airports, with a goal of increasing that to 20 airports by 2020.³³

In the United States, the city of Loveland, Colorado has partnered with the FAA to test the concept of the Loveland Airport implementing a remote tower.³⁶ David Ulane, director of the Colorado Division of Aeronautics stated that this project "...will help establish Colorado as a leader in the next generation of air traffic control technology".³⁶ Defense and security company

Saab, the Virginia SATSLab, Inc. (VSATS) and the Leesburg Executive Airport are partnering to demonstrate and evaluate Saab remote tower technologies at Leesburg Executive Airport in Virginia.³⁷ This partnership will demonstrate and evaluate the remote tower system for use at non-towered airports. The Federal Aviation Administration and the Virginia Department of Aviation are advisory partners for the project.³⁷



Figure 5. Example of Remote ATC Tower (SAAB).³⁷

UAS in Airport Operations

Aircraft Inspections. Airlines and Maintenance, Repair and Overhaul organizations are required to inspect commercial aircraft on a regular basis. Today, 80% of all aircraft inspections are conducted visually, whether during planned maintenance checks or after unscheduled events such as lightning strikes.³⁸ Every inspection requires qualified personnel using cherry-pickers, elevators and other heavy equipment to find and log defects that can be anywhere on the aircraft. Typical inspections last 6 to 10 hours, costing airlines \$10,000 for every hour the aircraft is grounded.³⁸ The use of automated UAS could make the inspection 20 times faster, reducing the aircraft downtime and therefore the costs. UAS could be deployed on the ramp or the gate area to quickly conduct exterior inspections of aircraft.³⁸

Airport Infrastructure. Opportunities to utilize UAS at airports include obstruction analysis, pavement condition assessment and inspection, airfield light inspections, wildlife management, security, emergency response and construction.³⁹

Obstruction Analysis. Maintenance of an obstacle free path for take-offs and approaches is critical for safety and mandated in Federal Aviation Regulation (FAR) Part 77 “Safe, Efficient, Use, and Preservation of the Navigable Airspace.” Potential obstacles include vegetation growth,

urban growth, and other changes. Traditional obstruction analysis uses conventional aircraft photography and ground-based surveying equipment, which is expensive due to the specialized equipment and expertise required.³⁹ Obstruction analysis utilizing UAS may reduce costs as well as turnaround time, based on the successful demonstration by users such as the South Carolina Aeronautics Commission.³⁹

Pavement Assessment and Inspection. UAS may provide a less costly and more efficient method to conduct pavement assessments and inspections. Pavement condition inspections are an important component of a pavement management program and help airports maximize the lifetime and minimize lifecycle costs of pavements. During a traditional pavement inspection, inspectors walk over the pavement and identify visible distress within each designated pavement area. Benefits of UAS for pavement condition assessment and inspections include availability of high-resolution photographs that can be used for documentation of pavement condition and development of a pavement asset management program. UAS can also be used for regular pavement inspections such as daily inspections for Foreign Object Debris (FOD).^{38 39}

Airfield Light Inspections. UAS may also be used to conduct light inspections to confirm airfield lighting is operational and adequate to ensure visibility, safety, and compliance with FAA and International Civil Aviation Organization (ICAO) standards. Inspections at twilight or night confirm that lights are operational, and periodic inspections confirm that intensity is adequate. In current practice, photometric measuring devices are typically mounted on a vehicle, which drives the airfield and measures the lumens given off by airfield lights. One advantage of a system on a UAS is that it could easily be flown at different heights, eliminating the need to physically change the height of the vehicle-mounted photometric calibration equipment, in many cases a time-consuming process.^{38 39}

Wildlife Management. In the aviation industry, wildlife strikes occur 26 times per day and cause \$950M of damage per year in the US, and \$1.3B worldwide.⁴⁰ Every airport certified under FAR Part 139 “Airport Certification” is required to have a wildlife hazard mitigation program, so wildlife control is now a core component of airport operations. Potential applications for UAS to support wildlife management activities at airports are extensive. These applications include identification of nests and burrows, identification of nuisance wildlife, wildlife tracking and capturing wildlife. UAS may also house powerful sonic devices or may be disguised as a predator to discourage birds on airfields.³⁹

Security and Emergency Response. UAS may facilitate fence and gate lock inspections and may supplement other security measures through perimeter checks at random times throughout the day. Any increase in efficiency for inspections could have a significant annual impact since even a small hub airport may be required to do as many as six inspections a day. Since many airports have extensive acreage and boundaries may be far from active runways and over area that is not populated, UAS may be an appropriate tool to increase security with minimal risk or impact on aeronautical activity. Advantages of UAS for perimeter security include ability to traverse challenging terrain quickly, surveillance at a faster speed than would be possible on foot, and surveillance of areas not accessible by vehicle. UAS are ideal in that they can potentially provide

timely information to emergency responders, enhance situational awareness, and reduce risk to responders.³⁹

UAS Micro Level: Five Focus States

Iowa

UAS Demographics. Iowa currently has 907 FAA certificated remote pilots, ranking it #21 in the United States in pilots per capita.⁴¹ There are 9,435 registered UAS in Iowa, ranking it #10 in number of UAS per capita.⁴²

Administration. The Iowa Office of Aviation is housed within the Iowa Department of Transportation (IDOT). The Office of Aviation advocates for and delivers services that promote and enhance a healthy air transportation system. Emphasis is placed on building cooperative working relationships, advocating for opportunities to strengthen aviation in Iowa, coordinating outreach programs, maintaining a comprehensive data collection system, and managing programs that promote a safe and secure air transportation system in Iowa.⁴³ The Office of Aviation has no official responsibility to champion UAS but given their aviation expertise, they have become the “first stop” UAS information resource for public agencies across the state.⁴⁴ The Office of Aviation has also been involved with educating legislators, the general public, and other state agencies on the safe and legal use of UAS. The Office of Aviation is working with the FAA to conduct outreach and assist in promoting UAS in Iowa, with the ultimate goal of safely integrating UAS into the NAS. Within IDOT, they are treating UAS not as a program but as a tool that may improve their work product. Across the IDOT organization many see the potential benefits of UAS, including improved safety, reduced costs, and improved data to support better decision making.⁴⁴

Activities. When the FAA issued the new Part 107 regulation for small UAS, IDOT moved forward exploring the use of UAS in various applications.⁴⁴ Since then, the state Office of Aviation has three employees who obtained a Part 107 Remote Pilot Certificate and the department purchased two DJI Phantom 4 small UAS.⁴⁴ Leveraging this experience, the Office of Aviation has been assisting other DOT divisions with applying UAS technology into their respective business operations. Some UAS applications in Iowa have included capturing assets at airports and heliports, wetland mitigation, and assessing transportation during flood events.⁴⁴ In addition, The Iowa Emergency Management Agency and the Department of Homeland Security have been experimenting with using UAS equipped with infrared sensors in search and rescue scenarios.⁴⁴

Other state agencies are assessing acquiring their own UAS or are partnering with external UAS service providers to gain knowledge and experience with the intent of developing future in house capability. Initially, state agencies will likely outsource complex or specialty UAS operations but as their expertise increases they may increasingly insource these jobs.⁴⁴ Currently the Iowa Department of Natural Resources is considering purchasing a UAS, while the Iowa Highway Patrol is evaluating UAS for accident reconstruction, traffic operations, and crash clearance.⁴⁴

As of June of 2015, there were 10 Iowa companies and organizations that had received authorization to fly commercial UAS in Iowa.⁴⁵

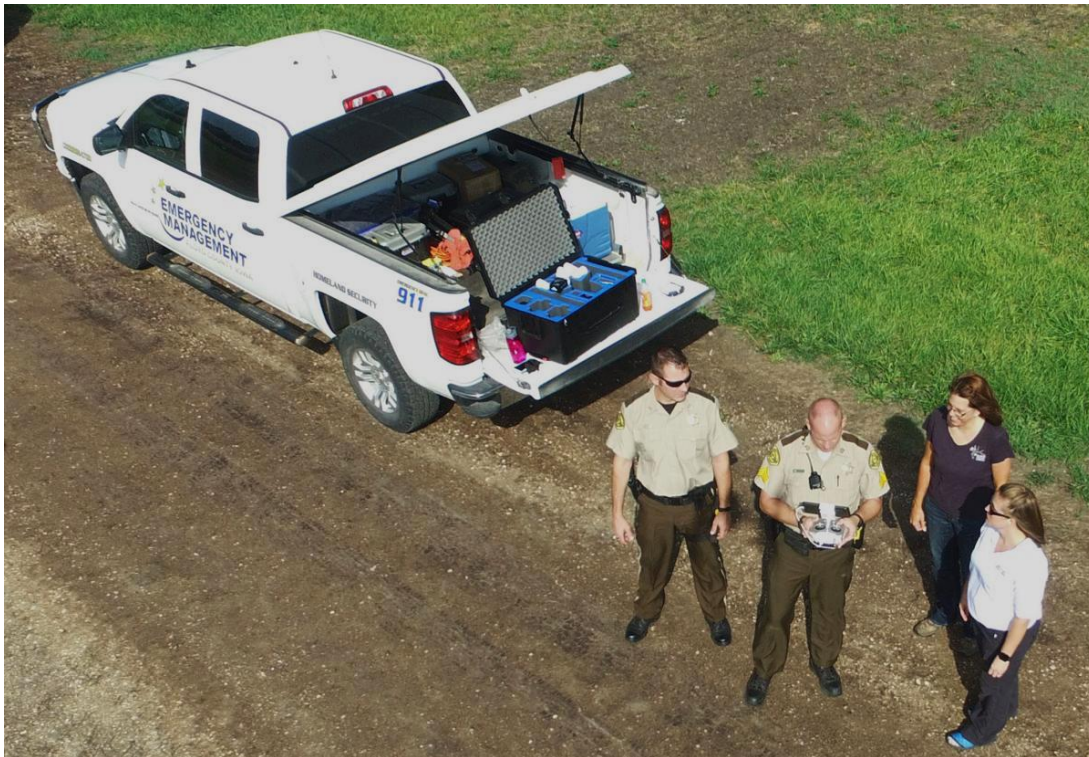


Figure 6. Floyd County Iowa Emergency Management Operating a UAS

Public Policy. As was mentioned earlier, Iowa has not created or officially designated a specific agency responsible for UAS implementation or promotion across the state. However, being the only state agency with an aviation focus, the Office of Aviation has unofficially assumed the state's UAS leadership role.⁴⁴ To date, the Office has primarily focused on being a UAS knowledge resource for the state along with promoting a safety culture that has been prevalent in manned aviation across organizations who are now just entering the aviation community via the use of UAS.⁴⁴

Currently, the state of Iowa has one state law concerning the use of UAS. This law makes it illegal for a state agency to use a UAS to enforce traffic laws and requires a warrant, or other lawful means, to use information obtained via UAS in a civil or criminal court proceeding and requires state agencies to obtain approval from the state legislature before purchasing a UAS.⁴⁶ Some municipalities have passed UAS ordinances to address trespassing and privacy issues.⁴⁴

Recently the state legislature considered a bill to address UAS operations over correctional facilities, but the bill did not proceed. Most Iowa lawmakers believe current trespass and privacy laws adequately address these concerns, but they continue to monitor the situation and the activities of other states to see if any action is needed.⁴⁴

For a brief time, the FAA required all UAS used in a commercial operation to obtain an aircraft registration similar to all manned aircraft. Iowa law requires all aircraft to be registered with

IDOT; therefore, commercial UAS operators in Iowa were required to also register their vehicle with the state.⁴⁷ However, since the FAA implemented a new UAS registration process, people in Iowa are no longer required to register their UAS with IDOT. Currently, IDOT is more focused upon the safe and legal operation of larger UAS weighing over 55lbs than they are with the small UAS operated under the FAA part 107 regulation.⁴⁴

When Iowa state agencies were first discussing the use of UAS, the general public was concerned about privacy. However, through a joint community outreach effort, the Iowa Office of Aviation and the FAA have helped address the public's concerns with commercial UAS operations. In addition, IDOT has adopted an unofficial policy of transparency regarding UAS – openly communicating its activities and addressing any public concerns.⁴⁴

Education and Training. Currently, in Iowa there are no college or university programs focused on providing UAS operational training. Within the Office of Aviation, the department procured appropriate reference and study material. The three current pilots obtained their remote pilot certificates through a program of self-study and successfully passed the FAA remote pilot exam. However, a more formal training program will be needed to support broader operations across state agencies.⁴⁴

Kansas

UAS Demographics. Kansas currently has 931 FAA certificated remote pilots, ranking it #13 in the United States in pilots per capita.⁴¹ There are 9,128 registered UAS in Kansas, ranking it #25 in UAS per capita.⁴²

Administration. Within the Kansas Department of Transportation (KDOT) is the Division of Aviation, which is responsible for the promotion of aviation activities, including the evaluation of their economic impact on the state. Their mission is to drive economic development and enhance critical services in Kansas through infrastructure improvement; and to be regarded as the state aviation expert, innovator and resource for the Kansas aviation community.⁵² The Division of Aviation is also responsible for administering the Federal Airport Inspection Program and updating the State Aviation System Plan. These activities and responsibilities include UAS – helping to spearhead the state's UAS activities.⁵² KDOT was also the first state to appoint a Director of UAS in July 2016 to provide overall policy guidance and lead statewide UAS initiatives.⁵⁴

Activities. In April 2018, Kansas State Polytechnic (KSP) started training law enforcement personnel on how to safely use UAS for specific law enforcement purposes. Pilots receive hands-on flight training in areas such as flight maneuvers, crew resource management, accident scene reconstruction, search and rescue operations, and night operations.⁴⁸

Kansas and Oklahoma partnered in creating The Unmanned Aerial Systems Cluster Initiative (UASCI), which is funded through a contract with the U.S. Small Business Administration – having been awarded \$500,000 in startup funding.⁴⁹ The UASCI serves manufacturers, investors and entrepreneurs throughout the 77 counties of Oklahoma and 105 counties of Kansas. The Cluster accelerates the growth of the Unmanned Aerial System industry by enabling established

companies and emerging entrepreneurs in Oklahoma and Kansas to connect, work together, and gain access to national technology, global capital, advanced business models and global markets.⁴⁹

KDOT partnered with AirMap, Inc. to deploy the first statewide Unmanned Traffic Management (UTM) initiative in the United States.⁵⁰ The UTM supports the growth of the state's UAS economy and ensures safer skies across Kansas. UTM is the technological infrastructure that facilitates data exchange and air traffic control for UAS. By implementing technologies that will one day be part of a nationwide UTM framework, Kansas is taking a proactive approach to protecting the privacy, safety and security of state residents while fostering a thriving UAS economy with the potential to contribute billions in economic impact and create thousands of jobs in the state.⁵¹ State agencies and higher education institutions in Kansas also have access to the AirMap platform; training is available to support local UAS operations, as well as provide safety-critical information.⁵⁰

On May 7, 2018, KDOT was selected as one of 10 participants to participate in the U.S. Department of Transportation's UAS Integration Pilot Program, an initiative aimed at shaping the future of UAS in America. The UAS Integration Pilot Program is an opportunity for state, local and tribal governments to partner with private sector entities, such as UAS operators or manufacturers, to accelerate safe UAS integration nationwide.⁵² The program aims to identify security and privacy risks, balance local and national interests related to drones and accelerate the approval of operations that currently require special authorization. It is expected to help the agriculture industry, photographers, emergency management, infrastructure inspections and commerce.⁵³ KDOT plans to deploy UAS to support beyond visual line of sight operations in rural communities. It seeks to leverage the statewide unmanned traffic management system to facilitate precision agriculture operations. Operations will use a range of technologies such as detect and avoid, Automatic Dependent Surveillance-Broadcast, satellite communications and geo-fencing. The program will use existing in-state resources such as fiber optic networks and UAS Traffic Management.⁵³

Public Policy. In May 2016, the Kansas legislature appropriated funds through Senate Bill 319 to focus on research and development efforts related to UAS by state educational institutions.⁵⁵ The law specifies a number of research focus areas, including the use of UAS for inspection and surveillance by KDOT, Highway Patrol and State Bureau of Investigation.⁵⁵ This also included appointment of the state's first director of UAS.⁵⁴ This appointment requires the director of UAS to make recommendations regarding state laws and rules that balance privacy concerns and the need for "robust UAS economic development" in the state.⁵⁵

The Kansas UAS Joint Task Force (JTF) was founded by KDOT's UAS Director. Ultimately, the JTF has equipped Kansas with a seasoned team of aviation, unmanned, and industry experts pursuing one common goal: "Lead the nation in safe, practical UAS integration."⁵⁶ The Joint Task Force is structured to enable an umbrella system of support, development, and safety through shared best practices. Together, with the Division of Aviation backbone, the JTF forms the network that is currently developing the tools and processes necessary for UAS integration at a statewide level. JTF organizational members include:⁵⁶

- K-State Polytechnic
- Wichita State University
- University of Kansas
- Department of Agriculture
- Department of Commerce
- Department of Labor
- Department of Parks & Wildlife
- Kansas Sheriff's Association
- Kansas Farm Bureau
- Secretary of State

According to the Kansas Department of Transportation and the Kansas Legislature, Kansas has one state law concerning the use of UAS in the state. This law expands the definition of harassment in the state's Protection from Stalking Act to include certain uses of UAS. All UAS operating in the state of Kansas are subject to the FAA's rules and regulations.⁵⁷

Education and Training. Kansas State Polytechnic University (KSU) is one of the first universities in the country to offer a bachelor's degree in UAS. KSU offers one minor, two undergraduate degrees and one graduate degree in unmanned aviation. A student may minor in Unmanned Aircraft Systems, major in Unmanned Aircraft Systems Flight Operations or Design and Integration, or pursue graduate degree as a Professional Master of Technology majoring in Unmanned Aircraft Systems – Information Assurance.⁵⁸

KSU hosts a number of UAS workshops and conferences, and offers UAS training courses across the state, which includes training state and local agencies in the use of UAS technologies.⁵⁹ Recently, KSU announced a series of 19 three-day short courses from June until December of 2018 on various topics that range from using Light Detection and Ranging (LIDAR) on UAS, night operations, first responder training and UAS imagery acquisition and processing.⁵⁹ KSU has also partnered with the Kansas Wildlife Department to provide UAS training for Wildlife Department employees.⁶⁰

Butler Community College, in partnership with KSU, will offer an associate degree in UAS beginning in Fall 2018. KSU will teach courses in aviation, UAS and small unmanned aircraft maintenance as a part of Butler's offerings at Rose Hill High School and at Cook Airfield west of Rose Hill.⁶¹

Three Kansas universities are members of the FAA Center of Excellence for Unmanned Aircraft Systems.⁶² Wichita State University, Kansas State University and the University of Kansas are members of the new center known as the Alliance for System Safety of UAS through Research Excellence (ASSURE), which is playing a key role in helping the FAA develop rules regulating commercial UAS.⁶² ASSURE, which is led by Mississippi State University, provides the FAA and industry with research to maximize the potential of commercial unmanned systems with minimal changes to the current system regulating manned aircraft.⁶²

Wichita State and its National Institute for Aviation Research perform UAS research and testing in many areas, including low-speed aerodynamics testing for The Boeing Company and human factors evaluation of operator stations for General Atomics.⁶³ Additional areas of expertise include material properties, susceptibility to environmental factors, computational analysis and advanced coatings applications.⁶³

The University of Kansas has a decade of experience developing and using UAS for remote sensing, specifically radar-sounding through glaciers in Antarctica and Greenland.⁶⁴ The University of Kansas is the lead institution for the National Science Foundation (NSF) Center for Remote Sensing of Ice Sheets.⁶⁴

Minnesota

UAS Demographics. Minnesota currently has 1,482 FAA certificated remote pilots, ranking it #23 in the United States in pilots per capita.⁴¹ There are 16,608 registered UAS in Minnesota, ranking it #26 in UAS per capita.⁴²

Administration. The Minnesota Department of Transportation (MnDOT) was created in 1976 by the state Legislature to assume the activities of the former Departments of Aeronautics and of Highways and the transportation-related sections of the State Planning Agency and of the Public Service Department.⁶⁵ Today the Office of Aeronautics is housed with MnDOT and administers state and federal funds for municipal airport development, maintenance, and operation; regulates, inspects, and licenses aviation operations; enforces statutes and rules relating to aviation; registers aircraft; and assists communities with aviation planning and air service issues.⁶⁶ It also provides radio and visual navigational aids; electrical and lighting systems; collects and disseminates weather information for pilots; disseminates aviation education and safety information; conducts several programs to promote aviation; and furnishes air transportation service for state officials and employees performing official business.⁶⁶ The Office of Aeronautics is managing all UAS activities within the state under current budget levels.⁶⁷ Like Iowa, Minnesota's Office of Aeronautics is utilizing its existing management structure to cover unmanned aircraft – focusing on educational outreach, safety promotion, and management.^{67 68} The Office of Aeronautics provides assistance to districts and offices that are pursuing or contracting for UAS services; in addition, they are responsible for:^{67 68}

- Reviewing proposed UAS use requests for contractor use of UAS.
- Approving the UAS Use Request and the operations manual for UAS missions flown by MnDOT staff.
- Jointly coordinating COA applications with the requesting Mn DOT office or district.
- Assisting in registering the UAS and contractors to ensure compliance with state and federal statutes and rules, as necessary.
- Conducting spot checks of UAS operations to ensure compliance and to identify opportunities for improvement of UAS operations.
- Assisting the district or office in working with the FAA on waivers and airspace authorizations.

Activities. Perceptions among state agencies and the general public have evolved from apprehension to acceptance of UAS technology.⁶⁷ One major obstacle was “people not knowing what they don't know about the NAS and FAA regulations and airspace” and changing the public to a compliance-oriented culture.⁶⁷ This change in perception may be attributed to efforts by the Office of Aeronautics, other state agencies, and industry groups conducting educational outreach through informational sessions, electronic communications, and promoting responsible

and safe use of UAS.⁶⁷ For example, when departments within MnDOT first started using UAS, most were unaware of the requirements for UAS operations.⁶⁷ The Office of Aeronautics, in partnership with local FAA, developed and administered several one-day workshops to other MnDOT and state agencies on how to operate UAS legally and safely.^{9 67} A point of emphasis for the Office of Aeronautics is to educate agencies across the state on safety and risk management protocols common in the aviation industry and indoctrinate them into the aviation safety culture.⁶⁷ These activities included the Office of Aeronautics bringing non-aviation state employees to Oshkosh to indoctrinate them into the aviation community and hosting one day ground schools to familiarize state employees with aviation and help prepare them for the FAA remote pilot exam.⁶⁷ In addition, the Office of Aeronautics developed a policy that provides UAS guidance to MnDOT employees and other state agencies.^{67 68}

MnDOT Bridge and Land Management currently owns two UAS, which they use for inspections and surveys.^{72 69} The Minnesota Pollution Control Agency and Department of Natural Resources are operating UAS to evaluate their use in various applications and have used UAS to map drainage ditches and assess water flows.⁶⁷ The Minnesota Highway Patrol is in an exploratory phase of using UAS.⁶⁷ Several counties across the state are using UAS for emergency response, accident investigation, and gathering environmental imagery and data.^{70 71}⁶⁷ Overall, users have found UAS improve information gathering – saving time, money, and reducing human exposure to hazards. However, there have been a few instances where organizations bought a UAS believing they would improve their work processes only to find they didn't work that well.⁶⁷ MnDOT recommends that buyers develop a use case for UAS technologies to specific applications and evaluate their return on investment prior to procurement – this includes consulting with various manufacturers and subject matter experts.⁶⁷ Currently, MnDOT has developed in house UAS expertise or has collaborated with external vendors on various projects. Others across the state are taking a similar approach to adopting UAS technology by developing in house operation capability through leveraged partnerships.⁶⁷

Probably the largest UAS project in Minnesota has been applied research in using UAS to conduct bridge inspections.⁷² The increasing costs of bridge inspections are a concern for MnDOT. UAS may help alleviate these costs and improve the quality of bridge inspections. The overall goal of the UAV Bridge Inspection Demonstration Project was to study the effectiveness of utilizing UAV technology as it could apply to bridge safety inspections. More research is required but the initial findings indicate UAS may be an effective bridge inspection tool. Some of the benefits outlined in the research report include:⁷²

- UAS can be used in the field during bridge inspections safely.
- UAS can provide a cost-effective way to obtain detailed information that may not normally be obtained during routine inspections.
- Associated safety risks with traffic control, working at height and in traffic could be minimized with the use of UAS.



Figure 7. UAS Bridge Inspection

Public Policy. Minnesota state law defines an aircraft as anything that flies.⁶⁷ MnDOT believes they have always regulated RC or UAS or manned aircraft. Minnesota requires all UAS be registered with MnDOT, and commercial UAS are subject to the same state tax as manned aircraft – recreational UAS are exempt from this tax and not required to register with the state.⁷³ In Minnesota, if you're an aviation UAS service provider, then the business requires a commercial operator's license and must have aviation liability insurance with minimum coverages.^{73 74} However, if a business is using a UAS to supplement its normal business activities and not providing UAS services for commerce, then the business is only required to register the UAS with the state and is not required to carry separate insurance.⁷⁴ For example, a real estate agent using a UAS for his/her business would only need to register the UAS (and the FAA requires the pilot obtain a Part 107 certificate). In Minnesota, the base tax for aircraft is \$100/year, which is the amount applied to UAS. Minnesota realizes this base level is still too much for a UAS, but the legislature has not enacted relief for small UAS.⁶⁷ Currently the legislature is discussing a future UAS usage tax that will likely be tied to resource usage and weight. These aircraft taxes support aviation infrastructure – airports, navigational aids, etc. within the state. Minnesota has relied on existing state regulations and laws to regulate UAS operations in the state. Some Minnesota municipalities have enacted laws that address UAS operations in public spaces and property, such as parks. However, to date these local laws have not included any additional NAS operational restrictions because the NAS is under FAA authority.⁶⁷

On June 18, 2015, MnDOT established a UAS policy that outlines the use of UAS for the purposes of conducting the business of the department.⁶⁸ The MnDOT Unmanned Aircraft Systems policy pertains to operations by MnDOT employees or by contractors and consultants working on behalf of MnDOT. The Office of Aeronautics must approve UAS usage by MnDOT or third-party operators hired to conduct business for MnDOT. The purpose for this policy is to provide clear and concise information on the UAS application, purchase and usage procedures, identify roles and responsibilities, and ensure compliance with state and federal laws and regulations. In summary, under this policy, MnDOT employees must:⁶⁸

- Comply with the requirements of the Federal Aviation Administration (FAA).
- Create a safety and operations plan that addresses all aspects of the intended mission.
- Contracted UAS service providers must adhere to applicable federal regulations.
- MnDOT and contractor owned UAS are required to register the aircraft as required by Minnesota and Federal regulations.
- Contractors are required to obtain a commercial operator's license from the MnDOT Office of Aeronautics.
- Obtain approval from the Office of Aeronautics prior to any operation.

Education and Training. In addition to the UAS workshops offered by the MnDOT Office of Aeronautics, there are three academic institutions that offer UAS training.

Hennepin Technical College (HTC), through its Continuing Education Program, offers an Unmanned Aircraft System Remote Pilot Ground School. The course is designed to prepare

students for the FAA Part 107 remote pilot exam. The course includes classroom training and a flight skills demonstration lab lesson.⁷⁵

Northland Community and Technical College (NCTC) and St. Cloud State University (SCSU) were awarded a National Science Foundation's (NSF) grant of \$599,997 for the advancement of geospatial information technology (GIT) and UAS education and training.⁷⁶ NCTC collaborated with industry leaders to create the first UAS maintenance-training program in the nation - preparing students for jobs in the expanding UAS field.⁷⁷ In addition, NCTC offers various "DroneTECH" educator workshops and summer camps designed to promote Science, Technology, Engineering and Mathematics (STEM) education in secondary and post-secondary institutions.⁷⁸



Figure 8. NCTC UAS Maintenance Training Students.

The University of Minnesota's Uninhabited Aerial Vehicle (UAV) Laboratories, within the Department of Aerospace Engineering and Mechanics, supports a world class, open-source, and low-cost aeronautics research infrastructure to enable research and education within the Department and worldwide.⁷⁹ Activities include flight research on navigation, guidance, and flight control systems to enable future commercial aircraft and small UAVs that are significantly safer and more fuel efficient. The UAV Laboratories support education by bringing real-world aircraft development and flight testing experiences into undergraduate and graduate level courses as well as having about 20 undergraduate and 10 graduate research assistants working on research projects at any given time.⁷⁹ The Department works with external academic institutions, local businesses, and Minnesota state agencies to explore potential UAV uses and opportunities, such as precision agriculture, as well as developing a framework for safely integrating UAVs into the national airspace.⁷⁹

North Dakota

UAS Demographics. North Dakota currently has 436 FAA certificated remote pilots, ranking it #2 in the United States in pilots per capita.⁴¹ There are 2,860 registered UAS in North Dakota, ranking it #1 in UAS per capita.⁴²

Administration. The North Dakota Aeronautics Commission (NDAC) is responsible for statewide aviation functions for both manned and unmanned aviation.⁸⁰ The Governor appoints the five members of the NDAC to the board for five year terms. The staff is composed of the Director and a support staff. The NDAU's purpose is to support aviation activities in the state through communication with state and local organizations, FAA, congressional offices, local airports, and national aviation groups.⁸¹ The commission is largely funded through aviation fuel

taxes, aircraft excise taxes, and aircraft registrations.⁸¹ In addition, the NDAC provides economic and technical assistance for the aviation community while ensuring the safe and cost-effective advancement of aviation in North Dakota.^{80 81}

North Dakota's governor issued an executive order establishing the Northern Plains Unmanned Systems Authority to oversee the operation of the UAS test site in the state.¹⁹ Northern Plains Unmanned Systems Authority is comprised of a board of representatives from the state's general aviation industry, University of North Dakota Aerospace, North Dakota State University, NDAC, North Dakota Department of Commerce (NDDOC), and the Office of the Adjutant General and is chaired by the Lieutenant Governor.⁸² The mission of the test site is to collaborate with FAA and industry partners to develop equipment, systems, rules, and procedures to safely integrate unmanned aircraft into the NAS without negatively impacting existing general or commercial aviation.⁸³

Activities. One of the nation's most rural states, North Dakota has quickly become one of the leading states for UAS research, experimentation, and testing. The primary elements attributed by many to this leadership position in UAS are: large rural areas, universities, UAS friendly policies, weather, strategic investment, and a well-coordinated effort by state leadership to promote UAS technology and investment.^{9 84}

In April 2014 the Northern Plains UAS Test Site became the first test site in the nation certified for operation by the FAA.⁸⁵ Overall, the state has invested more than \$14 million to establish the test site.⁸⁶ In 2015, the state invested \$17 million of public money to develop Grand Sky – the nation's first commercial UAS business park.⁸⁷ Located at the Grand Forks Air Force Base, the Grand Sky infrastructure is creating high-paying jobs for residents processing data collected by UAS, maintaining UAS, and piloting them.⁸⁸ A cooperative agreement with the Grand Forks Air Force Base allows Grand Sky business tenants to access the Base's 12,351 foot runway and on-base amenities. Fully supportive local and state leadership and a low cost of operations further complements the park's unique setting, making it the premier UAS testing location in the U.S.⁸⁸ Thus far, Global Atomics and Northrup Grumman have opened facilities at Grand Sky to support their UAS business.⁸⁹



Figure 9. Northrop Grumman Facility at Grand Sky.

The Lieutenant Governor sits on the board of the Great Plains UAS Commission and is very pro technology – helping to lead a coordinated effort in promoting and advancing UAS technology.⁸⁰
⁹¹ Both state and federal representatives are on the “same page” when it comes to UAS in North Dakota.⁸⁰ This positive state messaging has helped promote UAS across the state, and outreach efforts have helped educate the public on the benefits/opportunities of UAS while addressing concerns over privacy. State leaders have worked to tailor their messaging to effectively communicate UAS technology and its benefits to the general public.^{80 91}

Cross organizational board membership helps to ensure coordination across groups regarding UAS. This includes representation from the Governor’s Office, the Department of Commerce, National Guard, state universities, various aviation organizations, and other state agencies where UAS may provide a benefit.^{80 82 91} The North Dakota Aviation Council is a non-profit to benefit general aviation representing mechanics, agricultural, etc. to insure all aspects of aviation in ND are represented at the test site.⁹⁰

The Northern Plains UAS test site receives no federal funding, but funding for support staff comes from the ND Department of Commerce, which has attracted business investment that has created jobs.⁹¹ Additional operational funding is generated from test site user fees and funded research activities.⁹¹

State agencies are starting to explore use of UAS either internally or with outside contractors and view UAS as a new tool, which they need to learn how to use in a beneficial way for their respective agencies.⁸⁰ The Grand Forks County Sheriff’s Department has started to integrate UAS into their operations, mostly on calls for service such as disaster response, missing persons, or to document accident scenes.⁹² The Departments of Agriculture and Mineral Resources are also exploring the use of UAS.⁸⁰ Recently, a Norway-based manufacturer and a Scandinavian technology company have partnered with a North Dakota UAS operation to service the region’s utility and oil and gas customers.⁹³



Figure 10. Grand Forks County Sheriff UAS.

Most state agencies looking to develop UAS operational capability start by outsourcing and working alongside more experienced operators, but eventually agencies want to insource the more basic operations.^{80 91} However, agencies will base their sourcing decisions on the specific

application and what makes economic sense. Many agencies have realized benefits from UAS use but see even greater opportunity when beyond line of sight operations are approved – current regulations hinder broader applications. The training and education programs at the state’s universities ensure there is a qualified workforce to support the test site activities as well as other agencies adopting UAS technologies.^{80 91}

On May 9, 2018, U.S. Transportation Secretary Elaine L. Chao announced that the North Dakota Department of Transportation (NDDOT) had been selected as one of 10 participants in the Unmanned Aircraft Systems Integration Pilot Program, an initiative aimed at shaping the future of UAS in America.⁹⁴ The three-year UAS Integration Pilot Program will enable agencies to work on policy that can safely advance UAS operations, including beyond visual line of sight, flights over people and night operations.⁹⁵ NDDOT will be conducting a wide variety of diverse operations that incorporate advanced technologies that seek to expand UAS operations at night and Beyond Visual Line of Sight. This work will focus on data from four criteria: external systems, aircraft system technologies, training requirements, and processes and procedures.⁹⁶ Operations will be in multiple types of airspaces ranging from rural to urban areas. Working with experienced UAS research partners will lead to scalable operations for a multitude of UAS industries including linear infrastructure inspections, crop health monitoring, and media reporting and emergency response.⁹⁶

Public Policy. When UAS operations started to become more prevalent, some state representatives proposed UAS legislation focused on trespassing and privacy. However, similar to other states, North Dakota found that current trespassing and privacy regulations sufficiently addressed these concerns with regards to UAS.^{80 91} Also, the State of North Dakota does not currently require a state registration of UAS and relies on the current FAA registration process.⁸¹ North Dakota is the first state to authorize law enforcement use of armed UAS. The law limits the type of weapons permitted to those of the "less than lethal" variety, such as tear gas, rubber bullets, beanbags, pepper spray and Tasers.⁹⁷

Education and Training. At the University of North Dakota (UND), the John D. Odegard School of Aerospace Sciences began offering a Bachelor of Science degree in aeronautics with a major in UAS operations in 2009, the first U.S. school to prepare graduates to be UAS operators.⁹⁸ The UAV System Lab at North Dakota State University conducts research in the general areas of UAV system development such as wireless sensor network, aerial data processing system, data storage system, UAV enabled civil infrastructure inspection (e.g. wind turbines, railways, bridges and pipelines), intelligent damage detection, and on-board embedded system for precision agriculture.⁹⁹ Both Universities offer a variety of workshops, professional development courses, and host a number of UAS conferences aimed at providing UAS educational opportunities across the state.^{98 99 91}

General Atomics Aeronautical Systems and Northrop Grumman corporation have also created their own corporate training centers in the region, training their employees and customers to support product roll-outs.^{100 101}

Oklahoma

UAS Demographics. Oklahoma currently has 1,084 FAA certificated remote pilots, ranking it #26 in the United States in pilots per capita.⁴¹ There are 12,021 registered UAS in Oklahoma, ranking it #30 in UAS per capita.⁴²

Administration. The Oklahoma Aeronautics Commission is a state agency created "to encourage, foster, and assist in the development of aeronautics in the state and to encourage the establishment of airports and air navigation facilities."¹⁰² Other mandates include promoting aerospace safety and education. The Aeronautics Commission has been an independent state agency since 2002, reporting to the State's Secretary of Transportation. Aside from promoting aerospace development, the agency conducts systems planning of the aerospace infrastructure and provides grants for airport development and aerospace education.¹⁰²

The Unmanned Systems Alliance of Oklahoma (USA-OK) was created in February 2009 to promote the emerging unmanned systems industry in Oklahoma. USA-OK was created as a result of Oklahoma's first UAS Summit held in Guthrie, Oklahoma, where representatives from Oklahoma industry, government and academia all met to establish the framework for supporting Oklahoma's UAS industry.¹⁰³

In the summer of 2011, Oklahoma Governor Mary Fallin signed an executive order to create the Governor's Unmanned Aerial Systems Council – with the goal of making Oklahoma the “go-to” place for UAS research. Members were selected from the UAS industry, state government, academia, and the defense industry, and each was appointed by the Governor to serve in an advisory capacity. The council is chaired by Oklahoma's Science and Technology Secretary, Dr. Stephen McKeever.¹⁰⁴ The Governor's Council is charged with developing and promoting state-wide UAS initiatives collaborating with USA-OK and the Aeronautics Commission.¹⁰⁵

Activities. On May 9, 2018, the Choctaw Nation of Oklahoma was selected as a participant in the FAA's UAS Integration Pilot Program (UASIPP). The Choctaw Nation team will focus on agricultural, public safety and infrastructure inspections, with planned Beyond Visual Line of Sight (BVLOS) operations over people and nighttime operations.¹⁰⁶

As was mentioned earlier, Oklahoma and Kansas partnered in creating The Unmanned Aerial Systems Cluster Initiative, an SBA sponsored program to develop the region's UAS industry.⁴⁹

Kratos Defense & Security Solutions Inc., a California-based jet-powered UAS manufacturer, is moving at least 350 employees and part of its engineering, design and manufacturing operations to Oklahoma City. The new facility will be home to much of the company's design and manufacturing of a new version of offensive jet UAS intended to be used in combat along with manned aircraft.¹⁰⁷

Stillwater-based Central Rural Electric Cooperative (CREC), which has 20,000 customers and 4,500 miles of utility lines over seven counties, invested in a pair of UAS late last year. CEO David Swank said, “CREC is merging drone (UAS) technology with wireless network infrastructure to relay video and data back to its systems operation center for analysis. During an ice storm last winter, we had four dozers dragging our trucks through the mud because you're

trying to get to locations to basically identify damage. This is going to avoid having our crews drive through areas where they get stuck. Not only does that reduce significant costs, but it also significantly reduces the time in terms of identification of the outages and ultimately, restoration - increasing reliability and customer satisfaction.”¹⁰⁸

Several local agencies across the state are utilizing UAS in their operations. The Stillwater Emergency Management Agency (SEMA) purchased its first UAS in June 2015 and has since purchased two additional UAS and one specifically for training.¹⁰⁹ The SEMA UAS were purchased from DJI, a Chinese UAS manufacturer. Assistant Fire Chief Robert Black said the UAS recently helped first responders with fighting wildfires across the region.¹⁰⁹ The Broken Arrow Police Department received a UAS from its Police Academy Alumni Association. The department says the UAS will be used in tactical situations, for crime and crash scene investigations, search and rescue operations, emergency management scenarios and public relations.¹¹⁰ Department spokesman Officer James Koch states “the drone won’t be used for routine patrol functions, warrantless searches or as a weapons platform. Having an aerial view will help investigators put together complex scenes. It will also be a critical tool to leverage during dangerous encounters.”¹¹⁰

At the state level, several agencies are experimenting or exploring the use of UAS. The Oklahoma Department of Transportation (ODOT) is using UAS for bridge and other infrastructure inspections. The Department of Public Safety, State Fire Marshal, and Department of Agriculture are starting to explore UAS applications. Several of these agencies are developing vendor agreements that will provide agencies a list of approved on-demand UAS vendors.¹⁰⁵ Energy is the largest industry in Oklahoma and employs almost a quarter of the state’s population.¹¹¹ Oklahoma is home to the world’s largest oil storage facility and is considered the world’s pipeline crossroads.¹¹² The energy industry and supporting agencies are looking to UAS to help improve infrastructure inspections while also lowering associated inspection costs.¹⁰⁵

Public Policy. Oklahoma has one state law concerning the use of UAS, which prohibits the operation of UAS within 400 feet of any critical infrastructure facility.¹¹³ The state relies upon and enforces FAA regulations regarding UAS operations and has found existing regulation regarding trespassing and privacy to adequately address related UAS concerns.^{113 105}

Education and Training. Oklahoma State University (OSU) was the first university in the nation to have a UAS-focused graduate degree. Since the program’s implementation it has earned five UAS world records.¹¹⁴ OSU offers two options for graduate degrees in UAS. The UAS option, available for both the degrees of MS and PhD in Mechanical and Aerospace Engineering, provides students with a recognized emphasis in graduate level work in UAS. It provides students with hands-on analysis, design, construction and flight testing of UAS platforms. Flight testing and operations are conducted at OSU UAS airfields in Stillwater and at Ft. Sill, Oklahoma.¹¹⁵

Spartan College of Aeronautics and Technology in Tulsa, Oklahoma offers associate and bachelor’s degree programs, including the newest Unmanned Aircraft Systems classes. Many classes have a unique focus on UAS electronic systems. The Aviation Electronics Technology

Associate degree can be completed in 16 months and covers both traditional aircraft and unmanned aerial vehicles. Students will be required to assemble and program their own UAS, electronic trainer, and FM receiver.¹¹⁶

In 2017, Rose State College and the University of Oklahoma were awarded a two-year \$800,000 Advanced Technological Education grant from the National Science Foundation for development of UAS curriculum.¹¹⁷ The two institutions will work to develop an experiential learning based educational program at Rose State College that will train future workforce employees in the design, maintenance and use of UAS.¹¹⁷

Tulsa Community College provides training to take the FAA Part 107 Remote Pilot Certificate written exam through the Continuing Workforce Development Department.¹¹⁸

UAS in Missouri

Demographics

Missouri currently has 1,560 FAA certificated remote pilots, ranking it #31 in the United States in pilots per capita.⁴¹ There are 16,564 registered UAS in Missouri, ranking it #44 in UAS per capita.⁴²

Survey of Airport Managers

These researchers and representatives from UAviation, Inc. and MoDOT developed a survey instrument that was distributed to 108 Missouri public airport managers. The survey instrument is in the Appendix and consisted of eight multiple choice questions. The survey was intended to gain perspective of UAS activity at Missouri airports and the managers' level of knowledge regarding UAS. Respondents had the option of completing an online survey or submitting a completed hard copy. A total of 56 completed surveys were submitted.

UAS Activity

Over the past 12 months, 59% (n=33) of respondent airports have been notified by UAS pilots in advance of UAS activities taking place within 5 miles of their airport. Over this 12-month period, these airports were notified a total of 284 times. These data may suggest a significant amount of UAS activity is taking place within proximity to airports. Seven of the respondent airports have an active air traffic control tower and are in controlled airspace (Class B, C, or D). All seven of these airport managers indicated their airport has been notified in advance of UAS operations. Follow up communication with several of these airports that responded "no contact prior to UAS operations" suggested that there may be a lack of formal record keeping or processes regarding UAS operational requests.

When asked if they are involved in any FAA UAS beta programs, only 9% (n=5) of respondents indicated they were involved in a program, all five of these respondents indicated they were participating in Missouri's UAS Integration Pilot Program application. Unfortunately, Missouri

was not selected by the FAA; therefore, we may conclude that none of the respondent airports are currently involved in a UAS beta program.

Many airports across the country are beginning to use UAS to support airport operations, such as wildlife monitoring, perimeter security, and runway and taxiway inspection. Respondents were asked if they were using or exploring the use of UAS to support these types of operations; 86% (n = 48) responded “no”, while 14% (n = 8) responded “yes”. In addition, other states are exploring the use of counter-drone technology to address unauthorized UAS operations, such as UAS near airports or security sensitive infrastructure. Missouri airport managers were asked if their airport is using or exploring counter-drone technology to prevent unauthorized UAS operations at or around the airport. All respondents answered “no” to this question.

Only 2 (less than 4%) Missouri airport managers responded “yes” to the question regarding the passage of local UAS ordinances. Both airports are in very rural areas, class G airspace, and non – tower controlled.

UAS Familiarity and Training

The survey used a five-point Likert-type question to measure the respondent’s level of UAS regulatory familiarity (see Figure 11). This scale ranged from “Not at all familiar” = 1 to “To a large extent” = 5. The overall response score for this question was 3, or “To some extent familiar” – with 63% of respondent’s scores at a 3 or below. These results suggest that the managers’ level of familiarity with UAS regulations is fairly low.

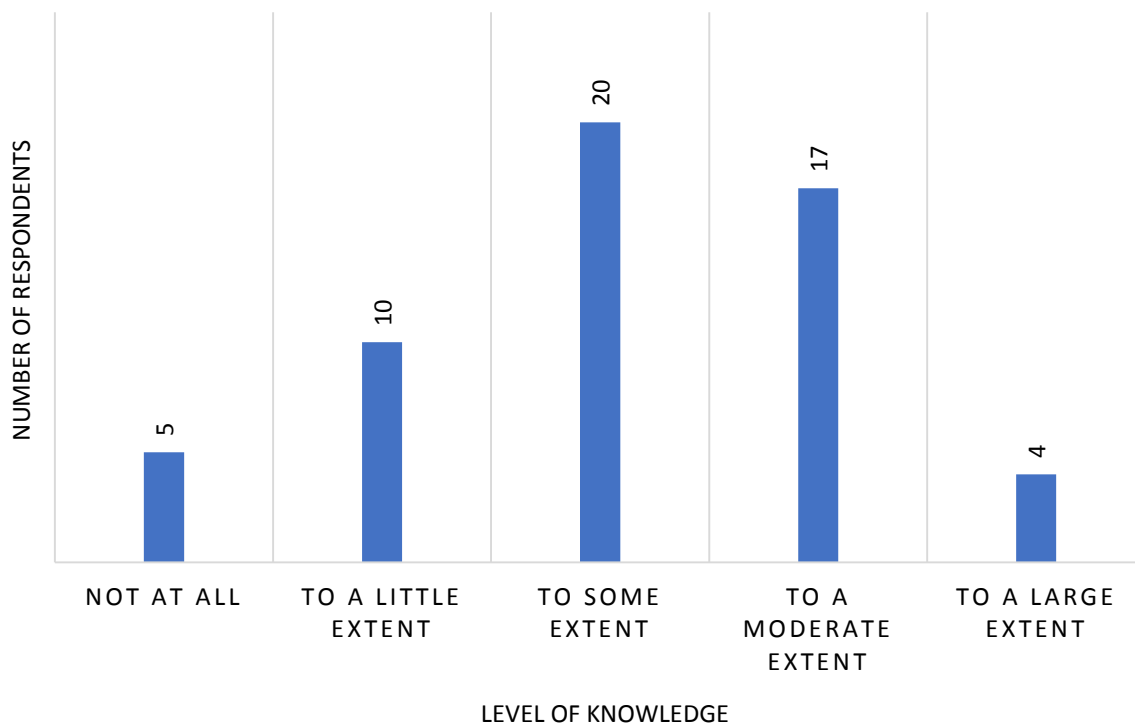


Figure 11. Airport Manager Familiarity with UAS Regulation

Respondents were asked in what subject areas their organization might benefit from additional UAS education and training. Respondents could choose from the subject areas shown in Figure 12, which also provided them the option to indicate they felt their organization was sufficiently trained. Overall, 89% (n = 50) of respondents felt their organization could use additional training in one or more of the four subject areas. Only 11% (n = 6) felt their organization was adequately trained and no one provided an “other” response. Overall, 70% (n = 39) of all respondents indicated their organization could use additional training in UAS Safety and Risk Management, 59% (n = 33) indicated UAS Airspace Waivers and Certificates of Authorization, 57% (n=32) in UAS Technology, and 48% (n = 27) indicated their organization could use additional education in UAS regulations. These results suggest that additional training regarding UAS may benefit the management staff of Missouri public airports.

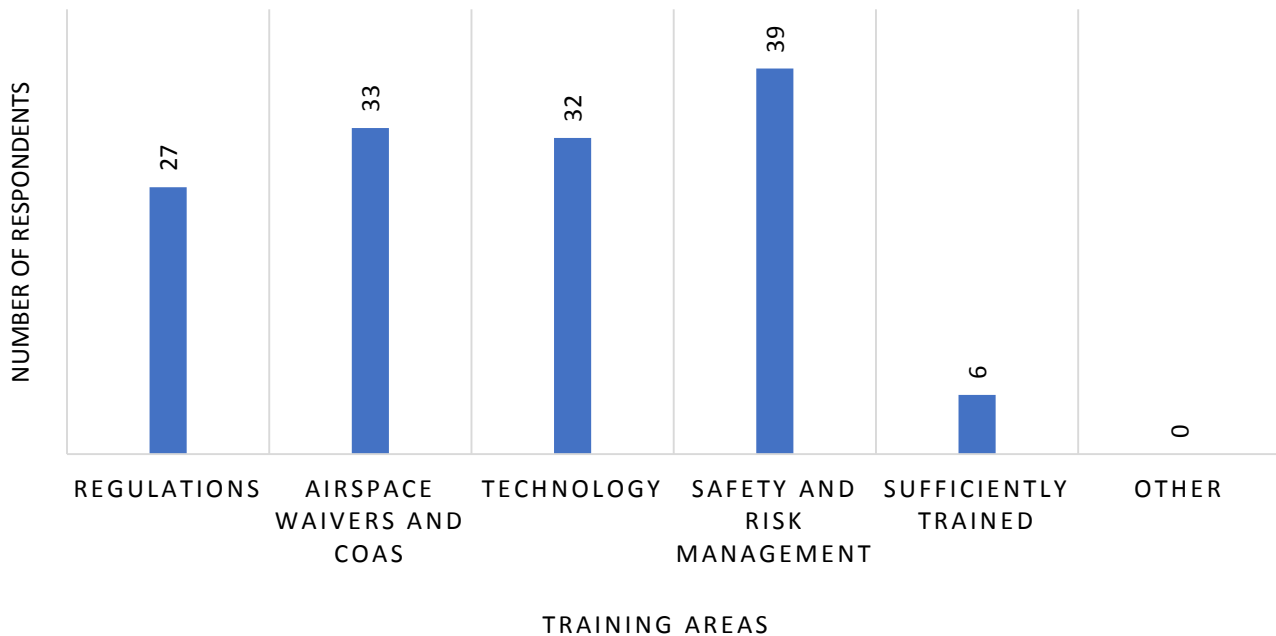


Figure 12. Airport Manager’s Areas of Additional UAS Education and Training

Federal and State Agency Opportunities

Missouri Department of Transportation

According to the Federal Highway Administration, Missouri ranks sixth nationally in the number of bridges with over 24,000. Missouri has just over 3,000 structurally deficient bridges.¹¹⁹ All bridges are inspected regularly in accordance with federal law, typically every two years.¹²⁰ Bridges with known defects may require more frequent inspection to closely monitor its condition, which equates to greater costs to taxpayers with increased inspection costs, traffic disruptions, stretches department of transportation resources, and increases workload demand and safety risks. Trial tests indicate that UAS can significantly reduce the total man hours on

bridge inspections. Larger bridge inspections may often require a team of up to seven people, while a team of only three is required when using a UAS. In addition to reduced personnel and man-hours, the use of UAS to inspect bridges will not require any maintenance of traffic activities, nor an inspection vehicle (boom truck), nor additional vehicles to carry traffic cones; therefore, significant cost savings due to less gasoline usage are expected. More importantly, the use of UAS to inspect bridges will result in fewer traffic interruptions due to lane closures, which is vital to the general motoring public's quality of life and reduces the safety risks to inspection personnel.^{121 122}

Police, Fire, and Coast Guard

Emergency response and law enforcement are estimated to account for over \$2.2B of the UAS market.¹²³ UAS provide significant benefits to first responders across many scenarios, which includes search and rescue, hostage situations, flood and tornado response, fire assessment, bomb investigation, crime scene analyses, and port security. UAS may provide first responders a cost-effective tool that improves public safety.¹²⁴

Fort Leonard Wood

Fort Leonard Wood (FLW) is home to three U.S. Army schools: the U.S. Army Engineer; Chemical, Biological, Radiological, and Nuclear; and Military Police schools. FLW annually trains over 86,000 military and civilian personnel.¹²⁵ FLW may be ideally positioned to incorporate UAS technologies across these current training disciplines. Similar to the construction industry, the Engineering Brigade may utilize UAS to assist with infrastructure projects and assessment. The Chemical Brigade may use UAS to safely inspect or assess chemical safety concerns or transportation, while the Military Police Brigade may provide officers training in the use of UAS to support base security, reconnaissance, and intelligence collection.

Army Corps of Engineers

Missouri is home to two Army Corps of Engineers district offices in Kansas City and St. Louis. These district offices have a broad mission responsibility, which includes flood risk management, disaster relief, surveying, levee safety, and ensuring navigable waterways to support commerce.¹²⁶ UAS offer a plethora of potential for the U.S. Army Corps of Engineers (Corps) Civil Works Program. UAS may track tornados, create 3D maps, protect wildlife, assist farmers, locate archaeological sites, improve metrology, and conduct search and rescue among other applications. Small unmanned aircraft systems offer the potential for cost-effective surveys of remote and/or small areas while offering new and improved tools to collect data and aerial imagery. Images and video are proving essential for Corps operations to inspect infrastructure, emergency management and communicating with the public through aerial video.¹²⁷ Several of the Corps districts are exploring the use of UAS technology in their operations (Jacksonville, Mobile, Vicksburg).¹²⁸

Training

Today there are over 900,000 UAS registered in the United States – a number that far exceeds the approximate 250,000 registered manned aircraft.¹²⁹ Unfortunately, in the United States the number of near misses and incidents involving unsafe UAS operations is increasing dramatically – challenging the economic opportunities and public benefit that UAS may provide.¹³⁰ A properly trained and certificated workforce is a precursor to safe UAS operations and advancement of any socio-economic benefits. By developing a statewide UAS training program for first responders and other state agencies, Missouri may establish the building blocks that promote broader UAS opportunities across the state while improving operating efficiencies and reducing associated safety risks.

Education

Southeast Missouri State University (SEMO) in Cape Girardeau, Missouri offers a Bachelor of Science degree (B.S.) in UAS.¹³¹ The program advertises that the student will,

“Understand the fundamental concepts required to be a professional in the field, including concepts in electronics, mechanical design, and programming, obtain a more specialized knowledge in unmanned aircraft systems, including flight, design, policy, and mission planning and have the ability to tailor the program to a more specific application area with 9 hours from areas such as agriculture, criminal justice, geographic information systems, and automation and have experience using the techniques, skills, and tools necessary for modern careers in the field of unmanned aircraft systems.”¹³¹



Figure 13. SEMO UAS Lab

The University of Missouri Columbia (MU) has a Missouri Drone Journalism program that is described as “...an interdisciplinary partnership dedicated to helping our students understand and use small, unmanned aircraft systems in service to society in ways that reflect the values of MU: respect, responsibility, discovery and excellence.”¹³²

Saint Louis Community College offers two classes for students and the public through its Professional Development and Continuing Education program. The “Introduction to Drones” is a 2-hour class “designed to provide information to individuals interested in the UAS industry.”¹³³ Students learn how these robotic vehicles operate, the history, manufacture and the current use of UAS in law enforcement, agriculture, aerial photography and more. The course also focuses on the requirements to build and regulations to fly UAS. Students also fly a Quadcopter simulator.”¹³³ The “Commercial Drones: FAA Part 107 Test Prep” class is a six-hour class that prepares students for the FAA remote pilot written exam. Subjects include regulations, airspace classifications, flight restrictions, aeronautical chart study, airport operations, radio communication, weather, human factors and more.¹³³

UAViation, LLC is a private company based in St. Louis, Missouri that provides pilot services, classroom training, agriculture, infrastructure inspection, aerial photography and mapping and surveying services. The three-day FAA Part 107 Remote Pilot Ground School prepares the student to pass the FAA remote pilot written exam.¹³⁴ There is currently no directory available to assess the number of UAS companies in Missouri.

Commercial Opportunities

Missouri is a leader in several industries where experts predict significant growth in UAS technology, which provide Missouri opportunities in areas such as research and development, manufacturing, software development, data analytics, training, and education. Cross disciplinary research and development across these areas of expertise may provide the greatest opportunity for Missouri to position itself as a UAS market leader. For example, UAS in agriculture provide significant opportunity; however, further research and development is required for the agricultural industry to realize a greater return on UAS investment. Below is a summary of these leading Missouri industries and how UAS technologies may benefit each.

Construction

Goldman Sachs and the Teal Group forecast construction as the leading growth market for UAS technologies – estimated to exceed \$11B by 2020.^{135 136} According to the 2017 Engineering News Record Top 400, seven of the top 100 construction contractors are in Missouri, which include McCarthy (St. Louis), JE Dunn (Kansas City), Alberici (St. Louis), Clayco (St. Louis), Arco (St. Louis), Burns & McDonnell (Kansas City) and Aegion (St. Louis).¹³⁷ UAS are cheaper to fly than manned aircraft and can collect data far more frequently, letting construction managers and engineers track a site’s progress with a degree of accuracy previously unknown in the industry. With the right computing tools, builders can turn sensor data into 3D structural models, topographical survey maps, and volumetric measurements (useful for monitoring stockpiles of costly resources like sand and gravel). Collectively, that intelligence allows construction companies to deploy resources around a job site more efficiently, minimize potential issues, trim costs, and limit delays.¹³⁸ Many of these organizations are currently integrating UAS into their operations.

Agriculture

Goldman and Teal rank agriculture as the second largest growth market for UAS applications - approaching \$6B by 2020.^{15 16} Missouri ranks second nationally in the number of farms and is a production leader in several crop commodities.¹³⁹ In addition, Missouri is home to major plant science companies including Monsanto (St. Louis), Bayer CropScience (Kansas City), Bunge North America (St. Louis), and BASF (Palmyra and St. Joseph).¹⁴⁰ UAS technology, coupled with advanced sensor hardware and data analytics software, may provide significant benefits to the agricultural industry. Farmers may use UAS technology for imaging purposes to assess many factors in their fields. UAS can take photographs in high resolution, superior to those taken through satellite imaging. Raw data collected by UAS may be analyzed and translated into useful and comprehensible information for farmers, thanks to specific algorithms. Information may include plant counting, plant size, plot statistics, stand number, compromised plots, and planter skips. Additionally, agronomists and farmers may determine plant height, crop height and density, and vegetation indices, such as leaf area, anomaly detection, treatment efficacy, infestations, phenology, along with water needs throughout the crop year.^{141 142 143}

Manufacturing

Goldman and Teal forecast a total UAS market of \$100B by 2020, which includes significant manufacturing growth.^{15 16} UAS will require advanced manufacturing processes in areas of composites and electronics. Other opportunities include advanced battery technologies, software development, airframe assembly, and research and development. Missouri aerospace companies include The Boeing Company (St. Louis), GKN Aerospace (St. Louis), LMI Aerospace (St. Charles), PAS Technologies (Kansas City), Aviation Technical Services (Kansas City), Alcoa (Washington), Ducommun (Joplin), and Triumph Structures (Kansas City).¹⁴⁴ With a workforce of more than three million, Missouri has a tremendous resource for advancing UAS technologies. Education and training enhances Missouri's workforce profile with nearly 140 academic institutions statewide granting 4,000 degrees annually in engineering related fields and aerospace knowledge centers around the state.¹⁴⁵

Key Findings

- This research suggests Missouri is behind in promotion and adoption of UAS technologies compared with other states.
- Collaboration and partnerships across state and local agencies, academic institutions, and industry partners provide cost effective and impactful UAS strategies – sharing information and resources while developing UAS expertise. These collaborative efforts create the foundation of a UAS ecosystem – attracting research funding, high tech workforce development, economic development and business investment.
- The research results indicate that Missouri has a fairly large number of FAA certificated UAS operators – ranking 20th in states with the most pilots.¹² Although a UAS pilot's certification is more a measure of a pilot's regulatory knowledge and not a measure of the

pilot's proficiency or abilities, the number of certificated pilots may suggest Missouri has a UAS workforce to support increased UAS operations.

- Many state DOTs are investing in UAS training and education and developing in-house expertise, while also developing policies and procedures to support safe and legal UAS operations across state agencies.
- In partnership with local FAA personnel, many state DOTs are assuming a statewide leadership role in UAS adoption – conducting educational outreach events to promote safe and legal UAS operations.
- The results of the Missouri airport manager survey suggest this population may benefit from additional UAS education.
- Across the country, many state DOTs and other agencies are using UAS technology to improve and enhance their operational processes.
- Training and education is key to safe and successful UAS operations.
- State agencies have found it best to be transparent regarding their UAS operations. This approach has been most successful in addressing the public's privacy and trespassing concerns, while also communicating the public benefit UAS may provide and garnering public support.
- Investment in future aviation infrastructure and technology by states may be required to support more advanced UAS operations and to realize the socio-economic benefits UAS may provide.
- Southeast Missouri State University offers a degree program in UAS, which may be an excellent training and education resource for Missouri. Other UAS training providers in the state offer additional UAS training options.
- Most state and local agencies are conducting UAS operations under the new FAA Part 107 regulation.

Recommendations

START NOW! Getting started using UAS does not require significant investment. This study found that many agencies started by purchasing two to three highly capable UAS with a total purchase price under \$5,000. Depending on the current skill level and aviation knowledge of in-house personnel, training and pilot certification costs may be as low as a few hundred dollars per student. The preferred approach to UAS adoption by many state agencies can be described as “crawl, walk, run”; where agency personnel begin by performing fundamental flight exercises and slowly broaden the scope and complexity of operations as they develop increased knowledge and proficiency. To support this learning process, state agencies often leverage their in-house aviation resources, obtain training and experience by working in collaboration with more experienced partners, or outsource UAS tasks to a qualified vendor and work alongside them as the work is completed.

Develop a UAS Policy for MoDOT. MoDOT should consider developing UAS policies. This research found that state DOTs are implementing UAS policies to support and manage safe and legal UAS operations within their organization. These policies provide clear and concise

information on UAS application, purchase and usage procedures, training guidelines, identify roles and responsibilities of employees, and ensure compliance with state and federal regulations. Documented standardized operating procedures help ensure consistent operation and performance, reduce the risk of human error, and ensure the aircraft is in a condition for safe operation.¹⁴⁶ Of the 35 state DOTs currently using UAS, 23 have created UAS policies.¹⁴⁷ The Minnesota⁶⁸ and North Carolina¹⁴⁸ DOT policies are two good examples that may provide a starting point for MoDOT UAS policy development. The MoDOT UAS policy may then be adopted by other state and local agencies or provide them guidance implementing UAS technologies – providing a broader benefit by promoting safe and responsible UAS operations statewide.

Develop a UAS Training Education Program for State and Local Agencies. This research suggests that airport managers may benefit from additional UAS training and education. This is likely the case with other agency populations across the state where UAS may provide operational benefits, such as MoDOT, Missouri State Police, Missouri State Emergency Management, and local first responders; however, they require training and education before beginning UAS operations. This research found that in general, states have a multi-tiered approach to training and education based on the student population. A simplified example might start with a first-tier UAS course tailored for state and local representatives and community outreach events, one to two hours in duration, which would include an introduction to UAS technology, regulations, public policy, and economic benefits. The second-tier course, longer and more in-depth, might be a one day UAS workshop tailored to those who are considering operating UAS but would like additional information. This course would focus on safe and legal UAS operations, introduction to UAS technology, use cases, potential benefits, and how to get started. The third tier would be the most detailed, a three day ground school that would prepare students for the FAA remote pilot exam and discuss a variety of related topics focused on safe and responsible UAS operations. Additional, more specialized courses may be developed based on demand and level of interest, such as flight training.

Potential UAS Training Locations. MoDOT and other agencies may want to explore partnering with The University of Missouri (MU) Extension for classroom facilities to support statewide UAS training programs. In addition, MoDOT may also explore partnering with the MU College of Agriculture, Food and Natural Resources (CAFNR) to access MU owned rural farm property to support UAS flight training activities – most of these farms also have classroom facilities.

The MU Extension primary emphasis is on jobs, which includes workforce development and continuing education – addressing a wide range of needs that fall into three grand challenges for the state of Missouri: Economic Opportunity, Educational Excellence, and Healthy Futures. MU Extension has office and classroom facilities in every Missouri county.¹⁴⁹ CAFNR owns a system of 14 Agricultural Research Centers across Missouri (see Figure 14) with a total of more than 14,000 acres to meet the regional research and demonstration needs of agricultural producers and natural resource managers.¹⁵⁰ Missouri's first FAA approved UAS Test Site was located at the MU Wurdack Research Center near Cook Station.¹⁵¹

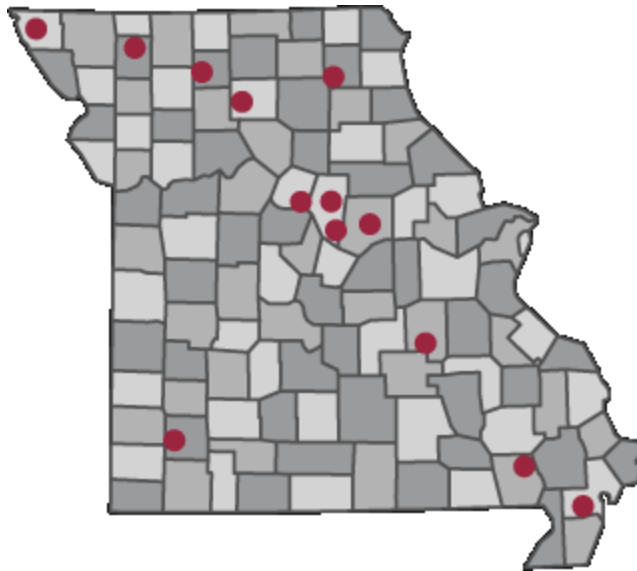


Figure 14. University of Missouri Agriculture Research Center Locations.

Measure UAS Interest Across State and Local Agencies. The cost of developing and providing UAS training may be shared across other state and local agencies who are interested in adopting UAS into their operations. In addition, organizations may realize further cost reduction by sharing the cost of equipment or specialized training. Therefore, it may be beneficial to conduct a statewide UAS survey of state and local agencies to identify those interested in using UAS and their level of interest in a cost sharing partnership.

Develop UAS Stakeholder Partnerships. Develop collaborative partnerships with agencies or organizations within the state that are interested in or actively involved with UAS operations. These organizations may include universities, first responders, agriculture, construction, or aerospace. Joining industry organizations such as the Association for Unmanned Vehicle Systems International, the Small UAS Coalition, and others are also good options. Attending UAS focused conferences and conventions provide an excellent opportunity to learn about innovative technologies, industry trends, regulatory changes, network and develop connections with subject matter experts.

Appendix

MISSOURI UAS SURVEY

1. Choose your airport: _____
2. Within the past 12 months have UAS pilots notified you in advance of UAS activities taking place within 5 miles of your airport?
 - a. Yes
 - b. No
3. Are local subdivisions or municipalities near your airport passing their own local UAS ordinances?
 - a. Yes
 - b. No
4. Does your airport currently utilize or is your airport exploring any technology solutions to prevent unauthorized UAS operations at or around your airport, such as drone jammers?
 - a. Yes
 - b. No
5. Is your airport currently using or exploring the use of UAS to support airport operations, such as runway/taxiway inspections, wildlife monitoring, perimeter monitoring, etc.?
 - a. Yes
 - b. No
6. Is your airport currently part of or considering participating in one of following UAS beta programs (click all that apply)?
 - a. NASA UAS Traffic Management System
 - b. FAA UAS Integration Pilot Program
 - c. FAA Low Altitude Authorization and Notification Capability (LAANC)
 - d. None at this time
7. What is your airport's level of familiarity with FAA regulations related to UAS?
 - a. Not at all
 - b. To a little extent
 - c. To some extent
 - d. To a moderate extent
 - e. To a large extent
8. Do you feel your airport would benefit from additional education and training regarding UAS in the following subject areas (click all that apply)?
 - a. Regulations
 - b. Airspace Waivers and Certificates of Authorization
 - c. Technology
 - d. Safety and Risk Management
 - e. My organization is sufficiently trained
 - f. Other

State Agency: Open – ended interview questions

Thank you for taking the time to talk with us today. We are conducting this interview today as part of a research project aimed at developing a new Missouri State Airport System Plan (MSASP). A component of this MSASP research project includes Unmanned Aircraft Systems (UAS) and through our discussion we hope to gain a better perspective on what Missouri might include in its new MSASP plan. We will limit the interview to 30 minutes and you may decline to answer any question or quit the interview at any time. Do you have any questions before we begin?

1. Can you confirm your current job title and organization?
2. How long have you been in this position?
3. How long has the organization been in existence?
4. What is your involvement or responsibilities regarding UAS in your state?
5. From a general perspective across the state, what is the opinion or perception of UAS technology? Apprehension/Embracing/Beneficial/Skeptical
6. Does your state have an administrative group or groups that are leading statewide UAS initiatives?
7. What have been the challenges with promoting or implementing UAS technology in your state?
 - a. What is your states strategy to overcome these challenges?
 - b. How is your state supporting UAS activities financially?
8. Are there any state agencies actively using or experimenting with UAS to support their operations?
 - a. If so, who?
 - b. How are they doing this? Internally/Partnerships/Outsourcing
 - c. If outsourcing, are you willing to share any RFP or specifications used to procure services?
9. Do you know if these agencies have realized any benefits from using UAS?
10. Does the state have in place a management structure to oversee or support UAS activities?
 - a. If so, how is this structured?
11. Are you aware of any efforts within your state to enact local or statewide drone laws and legislation?
12. Is there anyone else within your state that you recommend we interview regarding UAS?

Federal Agency (FAA – NASA): Open – ended interview questions.

Thank you for taking the time to talk with us today. We are conducting this interview today as part of a research project aimed at developing a new Missouri State Airport System Plan (MSASP). A component of this MSASP research project includes Unmanned Aircraft Systems (UAS) and through our discussion we hope to gain a better perspective on what Missouri might include in its new MSASP plan. We will limit the interview to 30 minutes and you may decline to answer any question or quit the interview at any time. Your responses will remain anonymous and will be reported in deidentified and aggregate format.

1. Can you confirm your current job title and organization?
2. How long have you been in this position?
3. What is your involvement or responsibilities regarding UAS?
4. If you could offer any advice or guidance to a state's Department of Transportation regarding UAS technology, what would it be?
5. In your opinion, what should states be planning in preparation for greater UAS operations? (investment, airports, airspace, technology, policy, infrastructure, etc.)
6. In your opinion, are there any policies or regulations that a state should enact or not enact regarding UAS operations?
7. What do you see as the greatest challenges/barriers to commercial UAS operations?
8. Do you have any additional comments or suggestions regarding this study?
9. Is there anyone else that you recommend we interview regarding UAS?
10. Does the FAA have a formal process that provides guidance to state DOT's regarding drones?

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