The Next Steps to Implementation of Unmanned Aircraft Systems into the National Airspace

Contributors:
Samantha Alex, Kenneth Cook, Samantha Davis
Desiree Decoito, Lindsey Deutsch, Erwin Domingo
Ryan Frenchik, Hayley Harris, Keith Hoffmann
Michael Kvasnicka, Caleb Martineau, Myla Nawiesniak

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Disclaimer

The following is an accumulation of a student lead research project. The conclusions and recommendations are that of our student team and do not represent the views or opinions of any university, government agency, political office, or commercial entity.

Executive Summary

The United States is a leader in the unmanned aircraft industry through our military, but we wait in anticipation for the commercial implementation of unmanned aircraft into our national airspace system (NAS). Through this intensive analysis of the industry, regulation, and policy, our group was tasked with finding the most relevant issues within the unmanned aircraft industry and develop our own recommendations for the upcoming Federal Aviation Administration (FAA) proposed rulemaking standards for small unmanned aircraft systems (sUAS).

Through our research we have found that the integration of sUAS into the NAS is expected to represent an $89 billion industry by 2025 (Table 1 – Market Analysis). While the capability of this industry is virtually limitless; our research focused on the benefits sUAS would bring to private business and commercial operations. As a group we also analyzed the FAA mandated test sites in Alaska, New York, Texas, Virginia, and Nevada. These sites are each responsible for testing specific applications for UAS and through our analysis and interviews with test site directors we created several well rounded recommendations for sUAS implementation. Through our analysis of these policy changes our group developed training, certification, and licensing recommendations for sUAS implementation, piloting, operating, and maintenance. We researched the sUAS operations and regulations in other countries and evaluated the International Civil Aviation Organization (ICAO) policies to determine what did work and aligned with our goals in the United States.

Finally we turned our attention to the air traffic control procedures and sense and avoid tactics for sUAS to operate seamlessly with our manned aircraft in the NAS. We broke down the different technologies sUAS manufacturers are using for commercial applications and developed recommendations for requirements and procedures.

Through this presentation we will share our research and recommendations for the upcoming proposed rulemaking standards regarding sUAS implementation.

Background

Brief History of UAS

Widespread unmanned aircraft systems (UAS) use originated at the end of World War I to support combat, security, and stability operations of the military. The United States Army became involved in unmanned flight research in 1918 and similarly, the British military began testing the technology as well (J. Bloom, 2010). Throughout the years following, UAS technology remained and improved entirely through military means and uses. As the industry grew and improved, the military “drones” began retiring on the battle field and moving home to the US for civilian work (N. Conan, 2012). This, in part, lead to sections within the FAA Modernization and Reform Act of 2012 directly concerning the implementation of unmanned aircraft.

FAA Modernization and Reform Act of 2012

For the fiscal years of 2010 - 2014 the FAA Modernization and Reform Act was passed mandating the Federal Aviation Administration (FAA) take certain actions related to unmanned aircraft systems (UAS). This Act tasked the FAA with modernizing and reforming authorization processes, NextGen regarding air traffic and air transportation systems, safety, air service improvements, environmental streamlining, FAA employees and organization, aviation insurance, research and development, and the National Mediation Board (Federal Aviation Administration, 2012). In the Safety segment of this act, Subtitle B addresses Unmanned Aircraft Systems (UAS).

Subtitle B Section 331 defines various terms of UAS:

- Arctic: The United States zone of the Chukchi Sea, Beaufort Sea, and Bering Sea north of the Aleutian chain.
- Certificate of Waiver, Certificate of Authorization (COA): A Federal Aviation Administration grant of approval for a specific flight operation.
- Permanent Areas: Areas on land or water that provide for launch, recovery, and operation of small unmanned aircraft.
- Public Unmanned Aircraft System: An unmanned aircraft system that meets the qualifications and conditions required for operation of a public aircraft (as defined in section 40102 of title 49, United States Code).
- Sense and Avoid Capability: The capability of an unmanned aircraft to remain a safe

distance from and to avoid collisions with other airborne aircraft.

- Small Unmanned Aircraft (sUAS): An unmanned aircraft weighting less than 55 pounds.
- Test Range: A defined geographic area where research and development are conducted.
- Unmanned Aircraft: An aircraft that is operated without the possibility of direct human intervention from within or on the aircraft.
- Unmanned Aircraft System (UAS): An unmanned aircraft and associated elements (including communication links and the components that control the unmanned aircraft) that are required for the pilot in command to operate safely and efficiently in the national airspace system (NAS).

The FAA Modernization and Reform Act of 2012 also mandated the integration of civil UAS into the NAS through a comprehensive plan within 270 days to "safely accelerate the integration of civil unmanned aircraft systems into the national airspace systems" (Federal Aviation Administration, 2012). This plan was to include, at a minimum, recommendations or projections on:

- Rulemaking to be conducted in order to
  - define the acceptable operation standards and certification of civil UAS
  - ensure that any civil UAS includes sense and avoid capability and
  - establish standards and requirements for the operator and pilot licensing and registration.
- The best methods to enhance the technologies and subsystems for sUAS
- A phased in approach for the integration of civil UAS into the NAS
- A timeline for the phased-in approach
- Creation of a safe airspace designation for cooperative manned and unmanned flight operations in the NAS.
- Establish certification, flight standards, and air traffic requirements of both civil and public UAS simultaneously in the NAS.
- Incorporation of the plan into the annual NextGen Implementation Plan of the FAA.

The FAA Modernization and Reform Act of 2012 also lays out a string of deadlines for the FAA all ranging from 90 days to 18 months after the publication of the act. These deadlines included a report to congress and a document laying out rulemaking and the establishment of a training program. The plan also establishes the need for six test range locations which were developed in Alaska, Texas, New York, Nevada, Virginia, and New Jersey (Test Sites, 2014).

Post FAA Modernization and Reform Act of 2012

Since the FAA Modernization and Reform Act of 2012 there have been many monumental steps towards sUAS implementation. Industry experts and the FAA worked tirelessly to determine needed regulations for civil or public sUAS. The FAA has created a Certificate of Waiver or Authorization (COA) for public or civil operators to gain approval to fly their sUAS in designated areas at specific times for specific objectives. The FAA also created Section 333 which grants the Secretary of Transportation authority to grant exceptions:

- If an unmanned aircraft system, as a result of its size, weight, speed, operational capability, proximity to airports and populated areas, and operation within visual line of sight does not create a hazard to users of the national airspace system, the public, or pose a threat to national security; and
- Whether a certificate of waiver or authorization, or airworthiness certification under 49 USC § 44704, is required for the operation of unmanned aircraft systems identified under paragraph (1).

From here, Congress has mandated that the FAA develop an implementation plan as a Notice of Proposed Rulemaking, which was scheduled to come out this November. This paper will discuss the anticipated proposed rulemaking topics and offer recommendations based on our thorough research.

Market Analysis

Introduction

The market for small unmanned aircraft systems (sUAS) looks promising for job seekers and the aviation industry because of the demand for sUAS by other industries. Technological innovations are constantly changing industry standards and sUAS is the next step for the aviation industry. The commercial implementation of sUAS has the potential of drastically changing the utilization of aviation by other industries. Aside from being technologically advanced in the industry, the use of sUAS can reduce costs and create an economic boost by introducing new jobs in the market.

The increasing demand for commercial sUAS is driving the market because of the reduced cost and risks associated with the use of sUAS. Technological innovations have enabled sUAS to be used to perform complex operations without the need for large aircraft or manned flight operations. The success of sUAS in combat operations has increased their demand by countries in the North American, Middle Eastern, and Asia-Pacific regions (Palmero, 2014). The demand for these systems in those regions led the way for the research and development of sUAS with increased operational efficiency and even complete autonomy. As with many other technologies, the sUAS market was pioneered by military use but has been adapted to fit commercial needs. Investments have been made by several companies and entrepreneurs looking to expand the commercial use of sUAS in the public and private sectors.

This market analysis will provide an overview of the market for sUAS. This analysis has been divided into three categories. The first category focuses on the forecast market demand and utilization that will define the industries that are most likely to use sUAS. The next category will present the economic benefits and sustainability data of the market in the United States. The last category will summarize the challenges that are facing sUAS in the U.S. market.

Industry Utilization Forecast

Many different industries are finding ways to incorporate the use of sUAS technology into their business. Social networking, real estate, and film industries have all found distinctive methods to integrate sUAS into their business practices. For example, Facebook founder, Mark Zuckerberg, developed the idea to use sUAS commercially by providing wireless Internet service in remote locations around the world. Zuckerberg has shown interest in acquiring satellite alternative drones from Titan Aerospace so he could elaborate on the internet.org coalition’s plan to connect five billion people to the Internet in developing countries (Gibbs, 2014). The sUAS could be used to blanket large areas of other countries with Internet access to provide service to remote locations.

The implementation of sUAS would be advantageous for public safety and first responders. Small unmanned aircraft systems armed with cameras and sensor payloads have been used by military and border control agencies for decades to improve situational awareness (Fernholz, 2013). Commercialization has brought more sUAS to the market, making the technology more accessible to emergency departments like police, fire, EMS, and search and rescue operations. These eyes-in-the-sky tools can be used by public safety and emergency response services in a myriad of ways. From transmitting birds-eye video of a forest fire to incident commanders to mapping out hard-hit areas after a natural disaster, sUAS can provide solutions for critical situations. On October 1, 2014, the FAA approved the use of sUAS by local law enforcement officers in Charlottesville, Virginia to assist them in locating a missing student from the University of Virginia. The sensors of the sUAS were used to search areas where law enforcement and volunteer search parties had difficulties reaching. The uses and capabilities of sUAS will continue to be discovered in the vast integration of sUAS (Fernholz, 2013).

Another industry that would benefit from the use of sUAS is real estate. Taylor Blom, the owner of Front Door Photos in Grand Rapids, MI, states he would love to use sUAS in his business, which specializes in taking photographs of homes for West Michigan real estate agents. "It produces great vantage points," said Blom, a resident who started his business one year ago. "It adds a really cool visual element to that service." His DJI Phantom 2 Vision at about $1,500 is roughly half of what he had spent on his last camera lens. Furthermore, he explained that sUAS is particularly good at producing dramatic photos and videos of lakefront homes. Blom, however, is concerned about the legal aspects of using a sUAS. The FAA has yet to issue rules and regulations governing the use of sUAS, which is one of the challenges facing another industry that will be discussed. Like many other real estate photographers, Blom does not dare publish his work until the FAA issues new rules and regulations regarding the use of sUAS (Harger, 2014).

Karen Martin, executive producer of M2 Pictures in the Film industry, found a way to cut costs in her industry through the use of sUAS. “M2 Pictures… found a way to save money while enhancing its cinematic capability for TV-show production: using a ‘drone.’” Martin explains that using a sUAS, which she referred to as a drone, in the film industry is important because M2 wants to stay on the cutting edge of technology while also reducing costs for the company. Companies will be reducing costs in the long run by having a single operator during a video shoot that can attain all cinematic angles for a successful film. The cost of training for one of the sUAS used on set is $1,000 or possibly less for two days of training on the equipment and on the flight simulator (Bozick, 2014).

Market Results

UAS used for non-military purposes make up a relatively small portion of today's UAS market, with only 11 percent of all UAS technologies currently being developed and produced for civilian uses. However, by the end of the decade, the share of the market devoted to non-military commercial UAS is expected to grow to at least 14 percent of the total market for drones. Teal Group Corporation states “coverage of the civil UAS market continues to grow with each annual report, mirroring the gradual increase in the civil market itself” (Association for Unmanned Vehicle Systems International, 2014). With this trend in the market, we can expect changes in the industry to adapt for the use of this technology.

There are a variety of ways sUAS can be used and incorporated into the business world. A study from Japan has indicated that when their government allowed the use of drones in the early 1990’s that the number of registered unmanned helicopters skyrocketed to 80% (Palmero, 2014). A similar trend can be expected from the United States when the rulemaking and regulations regarding UAS is addressed.

A detailed analysis on the direct job impact from the implementation of UAS provided by the Association for Unmanned Vehicles Systems International (AUVSI) (2014) indicates a boost in the United States economy. By the year 2017, there will be roughly 95 new jobs created in the State of Alaska pertaining to the use of UAS. The State of California is impacted the most in the nation with a job growth of 12,292 by the year 2017. As time progresses, more job opportunities relating to the use of UAS will be created, resulting in a boost to our nation's economy. The AUVSI forecast focuses on these six following economic points:

- The economic impact of the integration of UAS into the NAS will total more than $13.6 billion in the first three years of integration and will grow sustainably for the foreseeable future, cumulating to more than $82.1 billion between 2015 and 2025.
- Integration into the NAS will create more than 34,000 manufacturing jobs and more than 70,000 new jobs in the first three years.
- By 2025, total job creation is estimated to be 103,776.
- The manufacturing jobs created will be high paying ($40,000) and require technical baccalaureate degrees.
- Tax revenue to the states will total more than $482 million in the first 11 years following integration (2015-2025).
- Every year that integration is delayed, the United States loses more than $10 Billion in potential economic impact. This translates to a loss of $27.6 million per day that UAS are not integrated into the NAS.

The forecast by AUVSI was created by estimating and analyzing the amount of labor required for manufacturing the number of products estimated to be sold in each of the new market areas. Furthermore, the jobs created from the manufacturing process will have a multiplier effect to the local communities. The additional money being spent and taxed in the local communities will contribute to an increase in demand for other local services. The report estimates that by the year 2025, more than 100,000 jobs will be created nationally. However, these jobs will be distributed among the states based on state laws, taxes, regulations, and infrastructure. As time progresses, more job opportunities relating to the use of sUAS are created resulting in a boost to our nation's economy.

A separate study conducted by Volpe, The National Transportation Systems Center (2014) under the Department of Transportation supports the forecast of a high demand market for sUAS. Citing the many different industries that can apply sUAS capabilities in their business practices such as small cargo delivery, pipeline inspections, and agriculture, the Volpe study shows that there is a sustainable demand for sUAS. The study's forecast goes a step further than the AUVSI study, stating that the economic value of sUAS will be about $30 billion per year and will support 300,000 jobs in the U.S. by the year 2035. The difference in numbers is not only the longer time frame, 2025 compared to 2035, but Volpe also incorporated economic benefits to industries supporting features on sUAS such the manufacturer of sensors that many sUAS will carry. Both of these studies support the expectation of a strong, sustainable sUAS market with promising economic benefits.

The delay in implementing sUAS is an important factor that should not to be overlooked. As mentioned above in the key focuses of the AUVSI report is the economic impact of delaying UAS integration. With a possible loss of $10-$30 billion in economic potential per year, it is important to consider and address the challenges facing UAS integration.

Challenges

While the commercial potential and the economic benefits are clear, integrating UAS into the United States air space will be limited to certain economic constraints and sociopolitical challenges. One of the largest constraints is the national economy as a whole. AUVSI estimates that a 3% annual growth of the GDP is required for the industry to grow as projected. Like any other market, sUAS will not be immune to the effects of a recession or other economic factors. Two additional economic constraints discussed in the AUVSI report are:

- There must be sufficient capital available to manufacturing companies.
- There must be financing available to UAS purchasers.

For the first economic restraint, the manufacturing companies need to have sufficient capital to fund their research, development, manufacturing, and delivering of sUAS. Currently, large corporations who began with government defense contracts, have been responsible for many of the military UAS while smaller startup companies have been leading the way for civil sUAS. Many of these startups have resulted from hobbyists that were given contracts to further their development and many are funded by venture capitalists. These companies are doing relatively well getting the funding they need. Unfortunately, as the industry grows, one of the unknown factors is how the manufacturing companies will be affected when the first accidents occur and how expensive insurance and regulation may hinder the market. For the sUAS industry to grow, these companies will need to continue to find funding as well as the purchasers of sUAS.

Given the wide market of sUAS the financial capital available to purchase sUAS varies greatly depending on the utilization of the sUAS. The public safety market will most likely be funded by the local governments but other markets may have more difficulty financing these systems. Banks will finance cars and planes by placing a lien on the product and using that as collateral. In agriculture, where the equipment may not have serial numbers to identify the products, a bank may finance with higher interest and use the purchasers' credit worthiness as collateral. How sUAS will be financed is yet to be seen and the AUVSI report claims that, "this may be one of the most important factors outside of regulation reform to move this industry forward."

These constraints on capital and finance will primarily affect the smaller, less technical side of sUAS, depending on certain factors. Jay Skaggs, a UAS specialist from the FAA focusing on the implementation of UAS, pointed out that many of the applications for sUAS require very expensive sensor packages and other features. The firms that can afford these are not likely to have issues with the capital or financing required for the purchase, research, or use of sUAS.
The social and regulatory challenges will affect the UAS industry as a whole. The Volpe report, Unmanned Aircraft Systems (UAS) Research and Future Analysis, written by industry specialists Chris A. Wargo, Gary C. Church, Jason Glaneueski, and Mark Strout read,

> "The time and cost barriers these policies and procedures place in the way achieving UAS benefits are well documented. Efforts are under way at the FAA and through the RTCA [Radio Technical Commission for Aeronautics] Special Committees 203 and 228 to create standards specifically for UAS of varying size and sophistication and for realistic operation procedures which would permit using their unique capabilities while still safeguarding the public."

As we move a step closer into the integration of UAS in the NAS, one distinct obstacle we need to overcome is the transition into integration for society as a whole. Until that time the UAS industry will be largely on hold with economic opportunity cost of $27.6 million per day that UAS are not integrated into the NAS.

Market Conclusion

In conclusion, the sUAS market forecast is promising for commercial operations. There are many different industries that will benefit from incorporating and utilizing sUAS. The economic advancement and sustainability is also clear, sUAS will produce thousands of jobs and provide revenue across the nation for years to come. With the research conducted, the outlook for the sUAS market is strong and sustainable. Utilization will benefit many industries and have a positive economic impact across the nation. Research and development will continue to advance the integration of sUAS in a safe manner. While there is a demand for sUAS, there are also challenges. Continued financial capital and incentives are needed to help the industry get started. And, most important, bringing together pilots, aircraft, controllers, and infrastructure all rely on one organization, the FAA. Currently, the largest barrier facing the implementation of commercial sUAS is the Federal Aviation Administration's lack of regulations pertaining to sUAS.

UAS Test Sites

As a requirement of the FAA's Modernization and Reform Act of 2012, the Federal Aviation Administration (FAA) was required to implement six test facilities for unmanned aircraft systems (UAS). The goal of these test sites is to "help the FAA develop regulatory standards to foster UAS technology and operational procedures and to eventually permit routine UAS operations in the NAS" (FAA, 2014 A). The FAA consulted with the National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD) and came up with a number of criteria to choose test sites. The criteria are as follows (FAA, 2014 A):

- Geographic diversity
- Climatic diversity
- Location and ground infrastructure
- Research needs
- Airspace use
- Safety
- Aviation experience
- Risk
- Economic impact

The six different test sites were chosen for their specific qualities that would facilitate the research they are assigned to conduct. The test sites that were selected and currently operational are the University of Alaska in Fairbanks, Alaska; the State of Nevada; Griffiss International Airport in New York; the Department of Commerce in North Dakota; Texas A&M University of Corpus Christi in Texas; and Virginia Polytechnic Institute and State University (Virginia Tech) in Virginia (FAA, 2014 B). Each of the test sites also have test ranges that are controlled by the aforementioned offices, but focus on specific portions of the overall assigned research for that test site. Together, "the six sites include over 20 test ranges that provide ample geographic and climatic diversity, well-located ground infrastructure, and strong research programs focused on key UAS needs" (United States Department of Transportation [DOT], 2013). This includes 10 distinct climatic zones that allow for operations in a wide variety of weather, topographical, and airspace conditions as well as representing each corner of the country (DOT, 2013).

These individual test sites will conduct various research that pertains towards the integration of Unmanned Aircraft Systems.

- The Alaska Test Site is primarily concerned with the development of a set of standards for unmanned aircraft categories, state monitoring, and navigation.
- The Nevada Test Site objectives concentrate on UAS standards and operations as well as operator standards
- The New York's Griffiss International Airport Test Site plans to work on developing test and evaluation as well as verification and validation processes under FAA safety oversight.
- The North Dakota Test Site plans to develop UAS airworthiness essential data and validate high reliability link technology.
- The Texas Test Site plans to develop system safety requirements for UAS vehicles and operations with a goal of protocols and procedures for airworthiness testing.
- Virginia Polytechnic Institute and State University Test Site plans to conduct UAS failure mode testing and identify and evaluate operational and technical risks areas.

Figure 1. Photo Courtesy of FAA

Alaska Test Site

University of Alaska (includes test ranges in Hawaii and Oregon).

The University of Alaska proposal contained a diverse set of test site range locations in seven climatic zones as well as geographic diversity with test site range locations in Hawaii and Oregon. The research plan includes the development of a set of standards for unmanned aircraft categories, state monitoring and navigation. Alaska also plans to work on safety standards for UAS operations.

University of Alaska surveying wildlife

The FAA has granted the University of Alaska Fairbanks a Certificate of Waiver or Authorization (COA) authorizing flights by an Aeryon Scout sUAS for animal surveys at its Pan-Pacific UAS Test Range Complex in Fairbanks. The COA is effective for two years. The team began the wildlife flight operations in May.

The main purpose of the Alaskan wildlife operation is to show how a UAS can accurately locate, identify, and count large wild animals, such as caribou, reindeer, musk ox and bear for survey operations requested by the state of Alaska. Flights are taking place at the University of Alaska Fairbanks Large Animal Research Station (LARS).

This test site became operational on May 5, 2014.

Nevada Test Site

Nevada's project objectives concentrate on sUAS standards and operations as well as operator standards and certification requirements. The applicant's research will also include a concentrated look at how air traffic control procedures will evolve with the introduction of sUAS into the civil environment and integration with NextGen. Nevada's selection contributes to geographic and climatic diversity. “The U.S. Department of Transportation’s Federal Aviation Administration today announced that the State of Nevada’s unmanned aircraft systems test site is ready to conduct research vital to integrating UAS into the nation’s airspace. Nevada is the third of six congressionally mandated test sites to become operational” (FAA, 2014)

The FAA granted the State of Nevada team a two-year Certificate of Waiver or Authorization (COA) to use an Insitu ScanEagle at the Desert Rock Airport located in Mercury, NV. Desert Rock Airport, owned and operated by the Department of Energy, is a private airport and not for general use. The ScanEagle will fly at or below 3,000 feet, monitored by a visual observer and mission commander. Initial flights will verify that a UAS can operate safely at the airport.

This test site became operational on June 9, 2014.

New York Test Site

The FAA approved the state of New York an unmanned aircraft systems (UAS) test site at Griffiss International Airport in Rome, New York. The FAA has granted the UAS Test Site and the Northeast UAS Airspace Integration Research Alliance (NUAIR) a two-year Certificate of Waiver or Authorization (COA) that permits the use of UAS.

Testing and operations

The Griffiss International Airport UAS test site will be conducting research towards the integration of UAS into the national airspace systems (NAS). The test site will also be evaluating methods for surveying agricultural fields utilizing different types of sensors that include visual, thermal and multispectral equipment. The research will enhance current methods of monitoring crops and provide additional information for continuing field research efforts. The evaluation of these methods will be beneficial to both regional and national farmers. Griffiss International Airport's projects regarding UAS include the detection of:

- Insects
- Weeds
- Diseases
- Crop characteristics
- Crop biomass
- Background soil characteristics in two farm fields

Experimental findings & future plans

The FAA issued a COA to Logos Technologies to begin flight-testing of the unmanned Tactically Expandable Maritime Platform (TEMP) UAS. TEMP is designed for a range of missions, including precision cargo-delivery to remote and inaccessible areas to assist with emergency response and other situations. Logos Technologies is the first company that has been approved to begin testing at the Griffiss International test site.

The Griffiss International Airport Test Site developed the operation and integration of UAS in class D airspace by obtaining a COA from the FAA to use Griffiss Air Traffic Control (ATC) to sequence manned and unmanned aircraft operations. The flight test that was conducted by Logos Technologies extracted valuable data that will be critical towards the development of

Para foil systems for both military and commercial operations. A typical flight test:

- Occurs at or below 400 feet
- Has a duration of 60 minutes from takeoff to landing.

The Griffiss team plans to work on developing test and evaluation processes under FAA safety oversight. They also plan on conducting research on sense and avoid capabilities to prevent collisions with other manned and unmanned aircraft. Moreover, the site will also manage unmanned agricultural research flights from Joint Base Cape Cod in the state of Massachusetts.

Successes & new knowledge

The Griffiss International Airport and Northeast UAS Airspace Integration Research Alliance successfully accomplished the operation and integration in Class D airspace. This was achieved during the experimental testing of a flight by a Logos Technologies unmanned aircraft system. The ability to develop sUAS within approved airspace could accelerate the development of such systems for many future applications, including precision agriculture, pipeline and power line monitoring, environmental monitoring, and disaster/humanitarian relief support.

North Dakota Test Site

The Northern Plains Test Site is run by the North Dakota Department of Commerce in Grand Forks, North Dakota. It was the first test site to be approved by the FAA, receiving their two- year COA on April 21, 2014. The COA covers two separate locations: initial flights will be conducted over North Dakota State University's Carrington Research Extension Center in Carrington, ND, with subsequent missions scheduled for summer of 2014 to be carried out over Sullys Hill National Game Preserve near Devils Lake, ND (FAA, 2014 D). Northern Plains was chosen as a test site for the following advantages (North Dakota Legendary, n.d.):

- UAS industry support among state and local government, industry, academia and general aviation
- Existing manned and unmanned aviation best practices
- Expertise obtaining FAA Certificates of Authorization
- History and culture of aviation safety
- Climate diversity
- Open terrain

According to a press release from the FAA (2014), "the main goal of this site's initial operations is to show that UAS can check soil quality and the status of crops in support of North

Dakota State University/Extension Service precision agriculture research studies." Their first research mission was flown in early May is using a Dragonflyer X4ES small UAS (FAA, 2014 D).

Texas Test Site

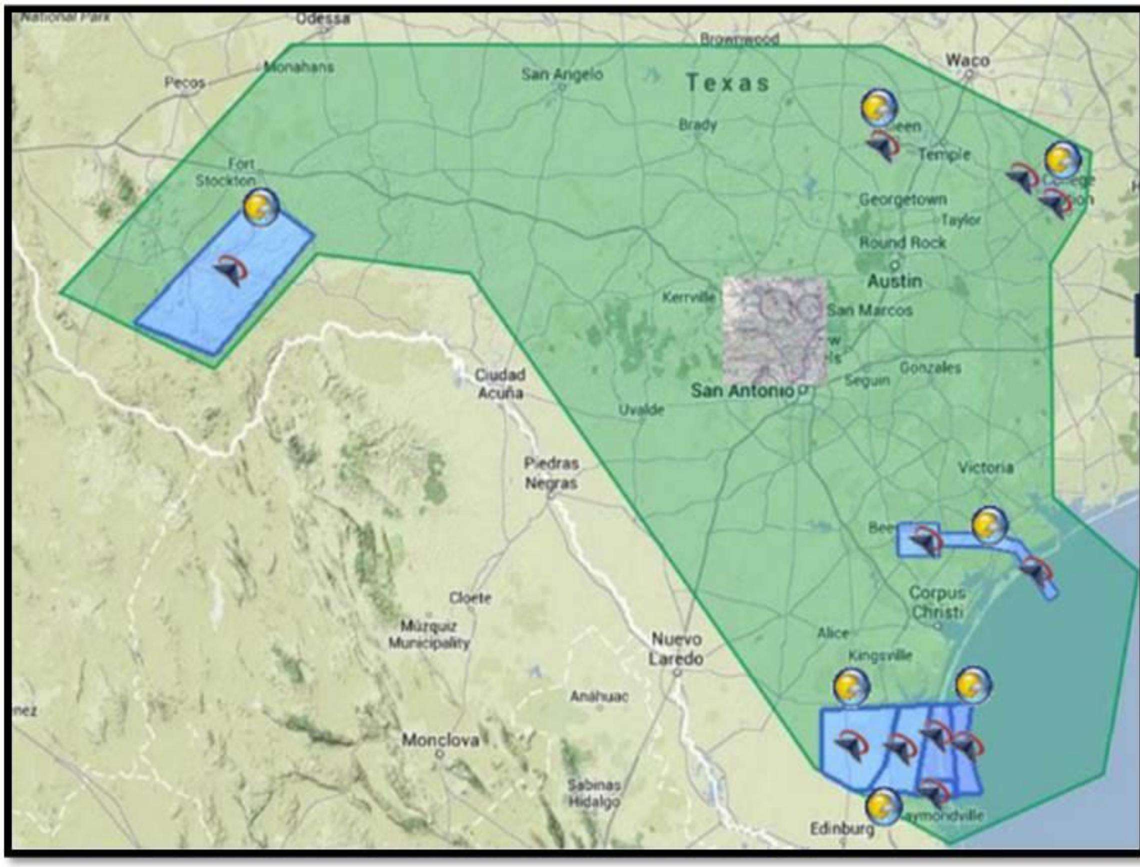
The Lone Star Unmanned Aircraft Systems Center of Excellence & Innovation (LSUASC) is run by Texas A&M University in Corpus Christi, Texas. It was approved by the FAA on June 20, 2014 and flew its first mission three days later, becoming the fourth site to become operational (Texas A&M University, 2014). LSUASC got a two-year Certificate of Authorization (COA) from the FAA to operate an AAAI RS-16 Unmanned Aircraft System. This aircraft weighs about 85 pounds with a wingspan of 13 feet (FAA, 2014 C). Using this aircraft, the LSUASC was authorized by the FAA to conduct research on six research areas (Texas A&M University, 2014):

- Safe operations and data gathering in authorized airspace;
- Establish protocols for unpiloted aircraft certification (airworthiness);
- Develop and test command and control link technologies in varying conditions;
- Develop human factor solutions for UAS control station layout and certification;
- Create sense and avoid research that allows unpiloted aircraft to see and take measures to avoid other obstacles on the ground and in the air; and
- Investigate UAS surface and air volume environmental impacts

These six initiatives are to be researched and developed using eleven test ranges under the control of the larger Texas test site (Lone Star UAS Center of Excellence & Innovation, n.d.). Each different test range within the LSUASC is responsible for different research and was chosen for specific reasons. The eleven ranges are:

- Texas A&M University Christi Corpus (TAMUCC) Padre
- Texas A&M Engineering Experiment Station (TEES) Riverside
- Disaster City
- Laguna
- Duval I
- Duval II
- Gulf Range
- Chase Field Range and Corridor

- Big Bend Range
- Fort Hood Range



TAMUCC Padre

This operational test range covers a variety of environments, from coastal ranch land to the sandy beaches of Padre Island, including a national seashore that preserves the island's pristine state. TAMUCC Padre is the largest maritime COA in the United States, at 34.5 nautical miles (NM) north to south, and 15 NM east to west at its widest point. That's a total of 517 NM^2. This test range operates at lower altitudes, testing their RS-16 no higher than 3,000 feet (Lone Star UAS Center of Excellence & Innovation, n.d.).

TEES Riverside

TEES is the Texas A&M Engineering Experiment Station. This is a relatively small COA area. It's 2.2NM at its widest point and 1.8 NM from north to south. This only makes it about 4 NM^2 in its entirety. However, this test site sits on top of a former military base very closely to the Texas A&M University campus. This provides easy access to their labs and the labs of the Center for Autonomous Vehicles and Sensor Systems (CANVASS). CANVASS is a joint venture with TEES and the Texas A&M University Dwight Look College of Engineering (COE) (Lone Star UAS Center of Excellence & Innovation, n.d.). Their mission is to unify research and development of autonomous vehicles and systems for the purpose of better serving our state and county (Schnettler, 2014). This is to be achieved by focusing to solve five significant problems:

- Networked Operations, Health Adaptive Mission Management, and On-Board Decision Making in Complex GPS-Denied Outdoor Environments
- Navigation in Global Navigation Satellite System Denied Environments
- Operations in Space
- Field-Based and Large-Scale Human-Machine Interactions
- Agricultural Cyber-Physical Systems

Disaster City

This test range is currently controlled by the director of the Center for Robot-Assisted Search and Rescue (CRASAR). They serve as a crisis response and research organization striving to direct and exploit new technology development in robotics and unmanned systems for humanitarian purposes. Their mission is to serve existing rescue organizations by providing deployable robot-assisted search and rescue teams while fostering research into SAR-specific robot systems. CRASAR has the most deployments of rescue robots of any kind: land, sea, or air. All of this takes place as super low altitudes of less than 200 feet (Lone Star UAS Center of Excellence & Innovation, n.d.).

Laguna

Laguna test site is 119 NM^2 directly south of TAMUCC test site and is 7 miles north to south and 17 miles east to west. This test range has a very broad and flat topography that connects the Gulf of Mexico with the mainland of Texas over Laguna Madre. This makes it an ideal location for visual-line-of-sight (VLOS) operational requirement testing for UAS. Additionally, it has been proposed to the FAA to include a launch and recovery site at Charles R. Johnson (CRJ) Airport (Lone Star UAS Center of Excellence & Innovation, n.d.).

Duval I

Directly west of TAMUCC, Duval I has significant topographic diversity, from estuaries in the east to brushy ranchlands in the west. As the third largest test range in Texas, it is about 860 NM^2 with a 41 NM shared boarder north to south with TAMUCC and 21 NM wide at its widest point. This site lies over a sparsely populated coastal plain devoted to agriculture, ranching, and energy production (Lone Star UAS Center of Excellence & Innovation, n.d.).

Duval II

At almost 1,043 NM^2, Duvall II runs 32 NM north to south and 33 NM east to west. This range was requested from the FAA to exist directly west of Duval I, but to have more space and altitude. They can fly as high as 6,000 MLS here. It lies directly on top of Kingsville 1 military base, but their 6,000 foot ceiling here is still 2,000 feet below the military's 8,000 foot minimum MOA. Also like Duval I, here is largely uninhabited and flat (Lone Star UAS Center of Excellence & Innovation, n.d.).

Gulf Range

As the only Texan fully maritime test site, the Gulf Range is directly east of the TAMUCC and Laguna ranges. Its boundaries enclose 451 NM^2 at 41 NM long and 11 NM at its widest point. This site, however, can operate all the way up to the beginning of Class A airspace at 18,000 feet. Gulf was proposed for use for medium to large UAS requiring launch and recovery from CRJ Airport. CRJ is proposed to be a principle component for chase-plane operations and UAS launch-and-recovery for the contiguous ranges, TAMUCC Padre, Gulf, Laguna, and Duval I & II (Lone Star UAS Center of Excellence & Innovation, n.d.).

Chase Field Range and Corridor

These test ranges are counted as two, but function as one so they are listed together. The Chase Field Range was a military training facility but is now offered as an industrial property to aviation-industry clients. The range comprises 192 NM^2 with altitudes up to 6,000 feet over the airfield's vicinity. The corridor is only 4 NM wide and exists between 4,000 and 6,000 feet. It provides access to state waters off the Texas Coast and virtually unlimited airspace over the Gulf of Mexico for long-range and high-altitude UAS operations (Lone Star UAS Center of Excellence & Innovation, n.d.).

Big Bend Range

As the largest test range in Texas, Big Bend functions as a high-altitude range over a mountainous, semiarid region, much of which is protected by state and national parks. It is largely unpopulated and encompasses more than 2,800 NM^2 of airspace, running 78 NM along its southeast boarder and 36 NM along its south west boarder, and operates up to 17,999 feet (Lone Star UAS Center of Excellence & Innovation, n.d.).

Fort Hood Range

This range operates among restricted airspace over Fort Hood, Texas. Covering 5.6 NM^2 Fort Hood Range operates immediately southwest of Robert Gray Army Airfield's (RGAA) runway system. It's primarily a training range for small UAS used in small-unit military operations operating at less than 3,500 feet. GRAA also coordinates operations for larger UAS flying in the restricted airspace. The operating procedures here enable side-by-side air traffic control of UAS and manned vehicles (Lone Star UAS Center of Excellence & Innovation, n.d.).

Virginia Test Site

The sixth and final state to become a fully operational UAS testing facility is the state of Virginia. The FAA granted the state of Virginia seven COA's for a duration of two years. Virginia along with the other test sites will be testing and collecting data regarding the integration of UAS into the NAS.

Current methods of research

UAS operations occur at test areas in Virginia, New Jersey, and Maryland. Research in the three states will eventually include agricultural spray equipment testing, development of aeronautical procedures for integration of sUAS flights in towered airspace and developing training and operational procedures for aeronautical surveys of agriculture.

Experimental findings

The Virginia site will study sUAS usage for highway safety, power line, and cellular tower inspection, agriculture study and air quality monitoring. Additionally, the sUAS will map out the landscapes of rural areas in order to create the best procedures on how to integrate the craft into the airspace.

Another project that has been granted by the FAA is utilizing UAS for search and rescue missions. Hannah Graham, a University of Virginia student, had been missing for more than three weeks and law enforcement officers were desperately seeking her whereabouts and were using all means to locate her. The FAA approved local law enforcement officers in Charlottesville, Virginia use of sUAS to help aid them in their mission to locate Hannah Graham. The sUAS was equipped with a sensitive camera that scanned expanded areas of land that law enforcement officers could not reach.

The Mid-Atlantic Aviation Partnership (MAAP) conducted research at the Virginia site that is vital towards the integration of UAS in the NAS. MAAP redefined their procedures with low-risk flights, and will be making the transition of working with larger, faster, high-flying UAS. MAAP's goal is to ensure unmanned aircraft operations are safe to operate in the same airspace as manned aircraft.

Results

The use of UAS has slowly integrated itself into society by providing a safer use for monitoring natural disasters. Manish Kumar, Associate professor in the department of Mechanical, Industrial and Manufacturing Engineering at the University of Toledo, is developing a UAS that will provide and gather information regarding wildfires in real time. Today, there are three ways firefighters gather information when dealing with a wildfire: manned lookout towers, manned aircraft and satellites. They all have their limitations, Kumar says. Lookout towers and manned aircrafts are both costly options that put lives in danger. The satellite option is safer but data processing is slow. The data may come in incrementally for a period of 10-12 hours, a timeframe that's much too long when battling a wildfire.

The sUAS Kumar and his team are building represents a safe, affordable option. The sUAS will weigh 5-6 pounds, and will be something every incident command team can carry onto the field. The sUAS will find the hot spots, relay that information to the command team as a video in real time and provide the location of the hot spot on a mapping service.

"The sUAS will map out the area and tell you on the map exactly where the hot spots are," Kumar says. "Once they have this information, they can use the real time data in fire propagation algorithms. This will help them more accurately predict where the fire is going. The incident commander teams will not only have knowledge of where the fire currently is, but how it will propagate."

Future plans for all UAS sites

Unmanned aircraft systems will be useful for agriculture, search-and-rescue missions, disaster response, research, commercial operations, and innovations. With the onset of a new technology, industries are born and new infrastructure evolves — the economic impacts will be enormous. Transitioning new types of aircraft into the nation's skies is a challenge, but will pay off because of its wide range of potential to help people and create a new industry.

Rule Making Policy

The Federal Aviation Administration (FAA) is tasked with the safety and efficiency of the national airspace. Due to the constant demand and development of new technologies, the administration must remain flexible in their regulation by allowing additions, modifications, and the deletion of policies and measures. This process is referred to as rulemaking. The input of the public is critical to the development of new policies as they are ultimately the end users of the public airspace.

Department of Transportation Rulemaking Process

The Federal Aviation Administration is organized under the authority of the Department of Transportation.

Type of Rules

- Legislative Rules- Implement a statute and are enforced by law
- Non-legislative Rules- rules that provide guidance
- Management and Procedural Rules – Agency rules that do not affect the public, such as organizational or structural rules.

The authority given to agencies for the creation of rules is provided by statue. Congress issues the mandate to create rules with varying levels of detail and discretion given to an individual agency. The authorization to create a rule can come from a need mandate, or identification from the agency. The need for a new rule is determined in the following ways:

- Statutory Mandate – Congress specifically requires a rule or beginning of the rule making process.
- Agency Identification of a Problem – Thorough out of the course of normal functioning, the agency may find an area where additional regulation is required to maintain safety.
- Petition for Rulemaking – Public petition to remove, modify, or create a rule.
- National Transportation Safety Board, Government Accounting Office, Inspector General, or similar recommendations – After an investigation by one of these agencies recommendations may be developed into rules.

Legal Requirements and Procedures

Requirements of rulemaking are laid out in the Administrative Procedure Act which serves as a guideline for the rulemaking process. Part of the requirements of the rule making process is a public comment period, when the proposed rule is listed on the Federal Register for public viewing and comment. Some rules can be exempted from this process in specific instances, such as emergency. The Notice of Proposed Rulemaking (NPRM) is published in the Federal Register containing information on the proposed rule and the process which the public must undergo in order to comment on the forthcoming legislation. The preamble of the NPRM must contain the authority of the proposed rule, and restraints, the issues, and the subject involved. The agencies must explain how it chose its proposed action. The period of public comment is 60 days from publication. Sometimes these periods are extended or shortened with sufficient justification. The NPRM is also placed in the public docket with supporting documents, studies that are not easily accessed by the public, and other comments made about the rule making.

Aviation Rulemaking Committee (ARC)

The Aviation Rulemaking Committee (ARC) functions solely in an advisory capacity. The objectives of the ARC are to improve development of Federal Aviation Administration's (FAA) regulations by involving members of the committee with the community throughout the regulation process to promote communication with the public while exchanging ideas through the ARC process giving the FAA the most relevant and updated data and insight through that communication (FAA, 2014). The ARC is composed of several positions to include: a sponsoring organization, a co-chair from the FAA and the industry, FAA Representative, FAA Attorney, FAA Economist, ARM Analyst, and ARC members. Members are elected based on relevant expertise, industry experience and leadership, and their ability to work constructively in a group and their commitment to long term participation.

Aviation Rulemaking Advisory Committee (ARAC)

The FAA Administrator established ARAC under the auspices of Federal Advisory Committee Act to improve the process of developing safety-related regulation and recommend changes on February 15, 1991. ARAC is a formal advisory committee made of aviation associations, aviation industry professionals, public interest groups, advocacy groups, and interested members of the aviation community as representatives. The FAA Administrator is the sponsor of ARAC so the committee reports directly to the FAA Administrator. The ARAC objectives are to improve FAA regulations by involving interested members of the community with first-hand knowledge through the development phase of the rule making to ensure safety, efficiency, and ensuring the regulation is relevant to the area of intended use.

Unmanned Aircraft Systems (UAS) ARC

The UAS aviation rulemaking committee's purpose is to discuss, prioritize, and resolve issues. The committee strives to provide direction of U.S. operational criteria, support the NextGen Implementation Plan, and produce U.S. consensus positions for global harmonization to include the implementation of unmanned aircraft into the NAS. The UAS ARC is committed to:

- Expeditious development of UAS criteria and standards,
- Implementation of non-rulemaking UAS National Airspace System (NAS) access and procedure improvements,
- Facilitating the maximum or ideal use of modern technologies including communication, navigation, and surveillance capabilities currently accomplished by manned aircraft
- Integrating the UAS into the NAS while supporting the reduction of risks identified by the Commercial Aviation Safety Team.

They will accomplish this by using evolving technologies to increase operational safety in concert with the International Civil Aviation Organization (ICAO) UAS study group and other organizations. These groups aim to harmonize certification, operations, procedures, and standards to support and facilitate the global aspects of aviation operations and unmanned aircraft production. The committee provides advice and recommendations to the Associate Administrator for Aviation Safety and the Air Traffic Organization (ATO) Chief Operating Officer. The committee will discuss and present information, guidance, and recommendations that the committee considers relevant such as:

- Operational objectives, recommendations, and requirements.
- Airworthiness criteria and means of compliance to meet operational objectives.
- Recommendations for rulemaking necessary to meet objectives.
- Guidance material and the implementation processes.
- Global harmonization issues and recommendations.
- Documentation and technical information to support recommendations.
- Formation and oversight of specialized work groups to research, document, and make recommendations on specific assigned topics.

The current UAS ARC is made up of representatives from General Atomics, MITRE, GE, New Mexico State University, Raytheon, National Business Aviation Association, Northrop

Grumman, Boeing, Rockwell-Collins, Honeywell, PBFA, DHS CBP, ALPA, AOPA, AUVSI, NASA, AeroVironment, and Lockheed Martin. This group was formed June 17, 2011 by the Federal Aviation Administration (Federal Aviation Administration, 2014).

Small Unmanned Aircraft System Aviation Rulemaking Committee

The small Unmanned Aircraft System (sUAS) ARC has been tasked more specifically with the implementation of small UAS as opposed to other UAS ARC missions which are broader. The sUAS ARC was focused on making recommendations for Federal Regulations for the operation of civil (commercial) sUAS to:

- Enable the operation of sUAS by assessing and mitigating the hazards posed to manned aircraft and other airborne objects operating in the NAS.
- The development of regulations authorizing specific operations of certain sUAS that could provide a means for operators to request a waiver from such a rule.
- Visual "sense and avoid" will be used by the sUAS flight crew to mitigate the risk of collision with other aircraft an airborne objects.
- Regulate right of way principles and responsibilities to all types of aircraft.
- Define operating limitations between manned and unmanned aircraft and reduce vulnerability of those on the surface.
- Initiate a formal Federal Aviation Administration safety risk assessment to ensure the proposed regulations are acceptable to the FAA from a safety perspective.
- Ensure simplicity of regulations to facilitate analysis by the FAA and other stakeholders.

The public is strongly encouraged by the Department of Transportation to make comment on proposed rules as the Department or the specific agency concerned "do not have all the answers, that the public may identify a better way for [the Department of Transportation] to achieve [their] objective." (Department of Transportation, 2014). Public comments can be as few as zero and at some times can be thousands. The agencies take all comments into account, however the final rule is not issues on the popular vote but instead based in evidence.

The Department of Transportation requests, but does not require, rules to be submitted in an organized form with clear explanations and support. In a document prepared by the Department, regarding the submission of effective comments, they have indicated the best formed comments have organized support for arguments, alternative including new rule text, and a basis for any calculations made. Examples to demonstrate any concerns will give real world relevance and make it easier to decide which changes would be most effective if the fuel is to be modified. It is important to keep in mind the statutory limitations of the organization. Such as the forthcoming sUAS NPRM, a comment stating “UAS should not be allowed to fly” would have to be set aside by the D.O.T. as UAS integration was mandated by Congress and cannot be decided by the Department of Transportation.

After the public comment period has closed the agency must move forward to modify the rule, maintain the rule as proposed, change and resubmit for public comment, or withdraw the proposed rule. Any changes to the rule must be made by ‘logical outgrowth,’ or a change that could have been “reasonably anticipated by the public” (Department of Transportation, 2014). Any changes beyond the scope of logical outgrowth must be resubmitted for a public comment period. If the rule continues forward, it will include a preamble where the agency will respond to relevant issues raised by the public.

Role of Legislative, Judicial, and Executive Branches in Rulemaking

The executive branch is tasked with the creation of the rule and publication for comment. It is a best practice the Department of Transportation office communicates with other effected offices within the executive branch such as the Environmental Protection Agency, Department of Commerce, etc. when creating a rule and prior to the term of public comment. The Legislative branch has the final authority to overturn the rule, hold hearings regarding, or adopt the rule. The courts have the same rights, as with all other legislation, to challenges its authority legally or constitutionally.

Rule Issuance and Follow up

The agency will take various actions to assist affected industry and individuals to comply with the new rule issued. This can come in the form of training materials distributed and inspections to ensure rule compliance. The Department of Transportation’s objective is to of course achieve complete compliance, which may have to be via enforcement action.

Existing and Proposed Policy

Today, unmanned aircraft systems (UAS) are flying in the national airspace system (NAS) under very controlled conditions; performing border and port surveillance by the Department of Homeland Security (DHS), helping with scientific research and environmental monitoring by The National Aeronautics and Space Administration (NASA) and The National Oceanic and Atmospheric Administration (NOAA), supporting public safety by law enforcement agencies, helping state universities conduct research, and supporting various other missions for public entities. Operations range from ground level to above 50,000 feet, depending on the specific type of aircraft. However, UAS operations are currently not authorized in Class B airspace, which exists over major urban areas and contains the highest density of manned aircraft in the national airspace system.

Current Federal UAS Regulations

- Subtitle B of the bill from the FAA Modernization and reform act of 2012 which specifically covers unmanned aircraft. Sections 331-336 of the bill mandate action by the FAA to enable permanent operating areas in the Arctic for small unmanned aircraft systems and integrations of unmanned aircraft systems in the national airspace. A comprehensive plan was put into place to safely and effectively integrate small unmanned aircrafts in the National Airspace. This time line was outlined from November 14, 2012- through September 30, 2015. Key areas that have been met or are still in the process of being met are listed below.
- The 2012 Federal Aviation Administration Modernization and Reform Act requires the FAA to integrate UAS into civilian airspace by 2015. To complete this task, the law also charges the FAA with establishing six test sites where operating standards for UAS can be researched and developed. On Dec. 30, 2013 the FAA announced their selected test sites, which will begin operating in the summer of 2013 and continue through February 2017.
- On Nov. 7, 2013 the FAA released its first annual roadmap for the safe integration of unmanned aircraft systems into the nation's airspace. In addition to the roadmap, the FAA also released Final Privacy Requirements for the UAS Test Site Program and a UAS Comprehensive Plan.
- On July 14, 2014 the FAA issued an Air Traffic Organization Policy, Unmanned Aircraft

Operations in the national airspace system (NAS), to consolidate all current regulations on UAS in the national airspace into one document.

Section 333

The FAA has been working for several months to implement the provisions of Section 333 of the FAA Modernization and Reform Act of 2012, "Special Rules for Certain Unmanned Aircraft Systems," which will allow for commercial operations in low-risk, controlled environments.

While these efforts continue, the FAA is also working to leverage the authority granted under Section 333 of the FAA Modernization and Reform Act of 2012. This will establish an interim policy that bridges the gap between the current state of sUAS use and future FAA approved regulations for sUAS in the NAS. Section 333 provides flexibility for authorizing safe civil operations in the NAS by granting the Secretary of Transportation the authority to determine whether an airworthiness certification is required for a UAS to operate in the NAS.

Section 333 authorizes the Secretary to determine:

- If certain unmanned aircraft systems, if any, as a result of their size, weight, speed, operational capability, proximity to airports and populated areas, and operation within visual line of sight do not create a hazard to users of the national airspace system or the public or pose a threat to national security.
- Whether a certificate of waiver, certificate of authorization, or airworthiness certification under section 44704 of title 49, United States Code, is required for the operation of unmanned aircraft systems.

This framework will provide operators who wish to pursue safe and legal entry into the NAS a competitive advantage in the UAS marketplace, thus discouraging illegal operations and improving safety. It is anticipated that this activity will result in significant economic benefits, and the FAA Administrator has identified this as a high priority project to address demand for civil operation of UAS for commercial purposes.

The FAA is currently considering exemptions under Section 333 from several different entities.

What are the different types of UAS operations?

There are three types of unmanned aircraft system operations: Civil, Public and Model Aircraft.

Civil UAS

Obtaining a Special Airworthiness Certificate in the experimental category for a particular UAS is currently the only way civil operators of unmanned aircraft are accessing the NAS. Experimental certificate regulations preclude carrying people or property for compensation or hire, but do allow operations for research and development, flight and sales demonstrations and crew training. The FAA is working with civilian operators to collect technical and operational data that will help refine the UAS airworthiness certification process. The agency is currently developing a future path for safe integration of civil UAS into the NAS as part of NextGen implementation.

Public UAS

For public operation, the FAA issues a Certificate of Authorization or Waiver (COA) that permits public agencies and organizations to operate a particular UAS, for a particular purpose, in a particular area. Certificates of authorization or waivers are available to public entities that want to fly a sUAS in civil airspace. Common uses today include law enforcement, firefighting, border patrol, disaster relief, search and rescue, military training, and other government operational missions. Applicants make their request through an online process and the FAA evaluates the proposed operation to see if it can be conducted safely. The FAA works with these organizations to develop conditions and limitations for UA operations to ensure they do not jeopardize the safety of other aviation operations. The objective is to issue a COA with parameters that ensure a level of safety equivalent to manned aircraft. Usually, this entails making sure that the UAS does not operate in a populated area and that the aircraft is observed, either by someone in a manned aircraft or someone on the ground.

Model aircraft

Recreational use of airspace by model aircraft is covered by FAA Advisory Circular 91-57, which generally limits operations for hobby and recreation to below 400 feet, away from airports and air traffic, and within sight of the operator. In June 2014, the FAA published a Federal Register notice on its interpretation of the statutory special rules for model aircraft in the FAA Modernization and Reform Act of 2012. The law is clear that the FAA may take enforcement action against model aircraft operators who operate their aircraft in a manner that endangers the safety of the national airspace system. In the notice, the FAA explains that this enforcement authority is designed to protect users of the airspace as well as people and property on the ground.

Training

As unmanned aircraft systems (UAS) continue to grow in popularity, safe integration into the national airspace system (NAS) is paramount. The integration of forthcoming regulations mandating the initial pilot, crew, and/or observer training must be promulgated, implemented, and enforced quickly and decisively. Getting the initial training standards right is vital as sUAS begin to share the NAS with manned aircraft. This training creates the standards for the operation of all sUAS in United States NAS, and sets the precedent for safety as the regulations for navigating the NAS continue to expand. No matter whether operating a civil sUAS over a traffic accident site, conducting military training, or a public sUAS creating a TV commercial, any addition to the traffic in the air creates hazards that the initial training must mitigate. Other countries have already initiated training standards for the operation of sUAS in their airspace and these should be taken into account as the Federal Aviation Administration (FAA) creates its own regulations. Based on these standards, it is critical that the U.S. get the initial training standards right the first time.

FAA Modernization and Reform Act of 2012

The FAA Modernization and Reform Act of 2012, Sect 332 2.(A) iii, signed by President Obama on February 14, 2012, mandated that the Secretary of Transportation, under consultation with representatives from the aviation industry, representatives from the unmanned systems industry, and Federal agencies that are currently using sUAS, make recommendations and projections on establishing standards and requirements for the operators and pilots of civil unmanned aircraft systems. These recommendations are also to include the training that will be required for the legal operation of commercial sUAS in the proposed system to ensure the safe operation of all civil and public UAS systems operating simultaneously in the NAS. While most public aircraft are required to be operated by pilots trained and tested under the FAA standards, the Department of Defense (DoD) provides its own exacting standards to operate this equipment. These two systems will be required to be melded into one in order to maintain safety in the NAS.

Aeronautical Knowledge

Basic aeronautical knowledge training for sUAS pilots, like manned aircraft pilots, must include both the aeronautical knowledge and operational components of flight. Aeronautical knowledge is a must have for any pilot. As listed in Title 14 and 49, Code of Federal Regulations (CFR), Federal Aviation Regulations and the Aeronautical Information Manual

(FAR/AIM), and as referenced in the Pilot's Handbook of Aeronautical Knowledge (PHAK), these subjects should include:

- principles of flight
- aerodynamics
- flight controls
- instruments
- weight and balance
- performance
- weather
- airport operations
- airspace
- navigation
- aeronautical decision making (FAR/AIM, 2013)

Also, all pilots must understand the four components of flight (lift, weight, thrust, and drag) in order to maintain consistent control of an aircraft. Pilots of manned aircraft are required to have a solid working knowledge of all of these subjects, which are tested in the written FAA private pilot exam. In speaking with Matt Parker, Operations Director for Precision Integrated Programs, he stated that the knowledge list for manned aircraft operation should be the same minimum aeronautical subjects that pilots of all unmanned aircraft systems are required to study and know. Mr. Parker stated that all of his UAS pilots are required to attend a company structured ground school based on specific original equipment manufacturers (OEM) recommendations and their own internal curriculum based on experience in operating UAS. Their training, which he stated was taught like an FAA ground school for manned aircraft, covers all of the FAR/AIM subjects listed above. Precision understands that safe pilots are those who understand the complexities of flying within the NAS, and the ramifications of not obeying the rules. "There is a phenomenon in the industry where somehow the UAS are not aviation to some people, and they want to completely reinvent the wheel (for training). We don't believe that at all," (personal communication, Nov 15, 2014).

In addition, UAS pilots must have an in-depth working knowledge of the system, which controls the aircraft. These systems may be as simple as a FAA approved remote control system resembling a hobby remote control aircraft system all the way up to a fully contained cockpit environment for a 2-3 person crew.

Safety is paramount in all of aviation, which now includes all UAS. While much smaller than other UAS, sUAS can create a hazardous environment for other flying aircraft, as well as people and property on the ground. Training and operation must maintain the safety level of unmanned aircraft equal to that of manned aircraft before full implementation can be allowed. In addition, the sUAS must not "put an undue burden" on the current system. (ICAO, 2013) These aircraft must be able to integrate into the system without causing changes to be made to the system to allow them to operate. A major component of safety with regards to UAS is the ability of semi-autonomous sUAS to have manned intervention in the case of an emergency. According to the FAA UAS Interim Guidance Document (2008), "Only those UAS that have the capability of pilot intervention, or pilot-on-the-loop, shall be allowed in the NAS outside of Restricted, Prohibited, or Warning areas". This level of safety will allow unmanned aircraft, which are in constant contact with Air Traffic Control at all times, to be able to make evasive maneuvers as required for traffic or collision avoidance.

Training Requirements

Training requirements, as set forth by the FAA, have yet to be formally established and implemented within the United States. In the interim, however, the guidance provided in the FAA requirements for Hollywood movie companies could be an indication of what is to come. The stringent standards for sUAS operations are expected to be at least as tight as for manned aircraft, if not more so. In an article posted on the sUAS News website titled FAA Requirements for Hollywood Exemptions (Mortimer, 2014), the requirements placed on the six movie companies, whose certificate of exemption was approved on 25 September 2014, listed in detail the requirements for those companies to be able to operate under their exemption. The training requirements set forth in the exemption included:

- A proper preflight of the aircraft as well as the ground control station.
- The Pilot In Command (PIC) must possess at least a private pilot certificate and at least a current third-class medical certificate. The PIC must also meet the flight review standards as set forth in 14 CFR § 61.56 Flight Review
- IAW 14 CFR § 61.51 (b), the PIC must have completed at least 200 cycles, totaling 25 hours of flight time as a UAS rotorcraft pilot, and at least 10 hours of flight time in a similar type aircraft as flown (single blade or multirotor). Training, proficiency and experience building is authorized under this exemption, but must meet the requirements

of 14 CFR § 91.119 for Minimum Safe Altitudes.

- Currency requirements under 14 CFR § 61.51 (b) require that the PIC have at least 5 hours in the type of aircraft flown, to include 3 take offs and 3 landings within the previous 90 days. Training, proficiency and experience building is authorized under this exemption, but must meet the requirements of 14 CFR § 91.119 for Minimum Safe Altitudes.
- The PIC and Visual Observer (VO) must have completed a qualification exam as set forth by the operator and outlined by the operator's manual. This exam must be documented in paper form and have a copy on file.
- Prior to operations, a flight demonstration, administered by an operator-approved and -qualified pilot must be successfully completed and documented. Because no official FAA Practical Test Standards have been developed, this test flight must comply with the operator's manual.
- The operator must develop UAS technician qualification criteria. These criteria must be added to the operator's manual.
- The UA must remain clear and yield the right of way to all other manned operations and activities at all times (including, but not limited to, ultralight vehicles, parachute activities, parasailing activities, hang gliders, etc.).
- The UAS cannot be operated by the PIC from any moving device or vehicle.

While not all encompassing, the training requirements listed above lend credence to the FAA's commitment to safety. (Mortimer, 2014)

UAS Operations in Other Countries

Countries other than the United States have put forth regulations regarding the operation of UAS in their airspace. While the U.S. is very methodical in their processes and does not rush into enacting regulations, with the looming deadline of September 2015 to have UAS integrated into the NAS, looking closely at other countries' regulations, as well as the standards put forth by International Civil Aviation Organization (ICAO), can provide an indication of what we can expect.

Canada

Canada put forth its first edition of a sUAS Knowledge Requirements regulation, TP 15263, in August of 2014, recognizing that sUAS operators in their airspace must require the same type of training that manned aircraft pilots undergo. TP 15263 – Knowledge Requirements for Pilots of Unmanned Air Vehicle Systems (UAV) 25 kg or Less, Operating within Visual Line of Sight, generalizes the training required to operate these sUAS within visual line of sight in Canada's airspace. A brief synopsis of the training required by Canada is listed below.

- basic Pilot Knowledge
- air law
- navigation
- meteorology
- aeronautical knowledge: including airframes, engines, and systems, theory of flight, flight instruments, flight operations, & human factors
- radiotelephony

Each section is broken down into specific subsections for knowledge training. This training is expected to be conducted by appropriate ground schools. The exams for training must be passed with a minimum of 60% to pass. Transport Canada has also set up an information page as well as a Frequently Asked Questions (FAQ) page for information on flying a UAS (Knowledge Requirements, 2012).

United Kingdom (UK)

A different approach to pilot training and licensing is the path that the UK Civil Aviation Authority (CAA) is taking. Understanding that they have not put forth any standing regulations for the operation of Remote Piloted Aircraft, the ICAO term for UAS, the CAA has recognized two civilian organizations providing UAS training as a current training and licensing standard. EuroUSC and Resource Group both provide comprehensive training and testing for the safe operation of sUAS. According to both websites, they provide the basic aeronautical knowledge courses outlined from the FAR/AIM above, but also include the hands-on training required (Unmanned Aircraft, n.d.).

ICAO

ICAO Circular 328 states that training and licensing requirements will be developed similar to those for manned aviation and will include both aeronautical knowledge and operational components. Adjustments will need to be made based on the unique characteristics of sUAS. Because of this, ICAO states that qualifications for certain categories of crew may be different from those of manned aircraft. In addition to new categories, certain crew members, such as observers for visual line-of-sight (VLOS) sUAS may need to be added. (ICAO, 2011)

U.S. Training Programs

Several U.S. universities are instituting UAS training programs in anticipation of the growing need for UAS pilots and mechanics. These degree programs are primarily Bachelors of Science degrees in Aviation with an emphasis in Unmanned Aircraft Systems. Three such universities providing this degree are Embry Riddle Daytona Beach, FL, University of North Dakota, and Kansas State University. Several other universities, including the University of Alaska Anchorage, have programs in their infancy providing from one to several classes on UAS operations. However, with the current FAA rules, these universities are only allowed to teach the classroom portion of UAS knowledge. Commercial training flights by these departments are currently prohibited, so most institutions take the training right up the point of liftoff. Military UAS training, including flight time, is authorized only when flown in authorized training areas. As FAA regulations are released, these civilian training programs are sure to incorporate flight time of UAS into their curriculum to graduate fully trained UAS pilots prepared to enter the market.

Once the FAA regulations have been released, they will have to create a system to train the trainers. These will be the initial personnel certified and/or licensed to train other sUAS pilots and observers. Like any other new system, this pool of personnel will grow slowly during the initial phases of implementation. Over a period of time, qualified personnel, much like the manned aircraft certified flight instructor (CFI), will be spread across the U.S. providing both ground and flight training for potential sUAS pilots at universities, flight schools, and throughout the private industry.

The majority of the authorized flight-testing of UAS in the United States happens at six test sites. These six test sites announced in Dec, 2013, Texas, Virginia, New York, North Dakota, Nevada and Alaska, each provide a different environment for the systems to conduct flight testing in and each having an additional separate focus for their research. Other locations, such as Middle Georgia State College, have been authorized on a case-by-case basis and, although not chosen as a test site, will continue to operate under a Certificate of Authorization (COA) (Eastman Campus, 2014).

Mission focus for sUAS is extremely varied. Each type of mission will dictate the payload, whether it is the delivery of goods, surveillance of criminal activity or observation of sea ice. With the varied missions come different crew responsibilities, some possibly requiring a crew of 2 or even 3 people once the sUAS is airborne. These crews working together are no different than any other aircraft crew in that they must be able to work together, creating a redundancy in skillsets as well as working as individuals in their assigned tasks. Crew resource management (CRM) skills training must transfer over from manned aircraft to all crew operated UAS. Many schools have recognized this fact and are already offering CRM classes for UAS crews/students. While the platform is different, the management of the crew remains the same. Human factors remain a large part of the training along with communications, team building, problem solving, risk management, situational awareness and conflict resolution.

Training Requirements for Observers

Under many of the current certificates of authorization, sUAS operations are required to have VLOS with the aircraft. As part of the operational crew, observers are put in place where they will have unobstructed and unaided view of the aircraft at all times when in flight. Observers can be either on the ground or in another aircraft, but cannot be the PIC of any aircraft when acting as an observer. Their job is to ensure the UAS maintains separation from any other aircraft in the area.

UAS supplemental pilots and observers must have:

- Training in all specific details of the UAS being operated, including normal, abnormal, and emergency procedures;
- Manufacturer-specific training (or an FAA-recognized equivalent); and
- Demonstrated proficiency and successful testing in the UAS being operated.
- Operators/applicants must maintain individual training records for all UAS personnel. The instructor must document and the trainee must initial all training.

To be eligible to perform the duties of visual observer for sUAS operations, a person must:

- Be at least 18 years of age.
- Be able to read, speak, write, and understand the English language proficiently.
- Been found competent by the PIC to serve in an observer capacity.
- Received training from a certificated sUAS pilot on the duties and responsibilities of an observer pertaining to the sUAS on which observer duty will be performed and on the aeronautical knowledge areas prescribed in Section 16.2 of this Subpart (Tarbert & Wierzbanowski, 2009).

Because observers have duties just as important as the sUAS pilots do, they too, must have an understanding of 14 CFR as pertaining to the airspace in which they are operating. Observers, while not in direct control of the aircraft, must still meet stringent requirements just as the pilots do, because they are the eyes of the pilot to ensure the UAS is maintaining itself in a safe environment. According to the FAA Flight Standards Information Management System (FSIMS), observers are considered crewmembers, and as such, will not perform crewmember duties for more than one UAS at a time. Also, the observer cannot perform duties as the observer and the UAS pilot at the same time (Unmanned Aircraft Systems, 2014).

Observers must have at least a valid second-class medical certificate issued under 14 CFR part 67, or an FAA recognized equivalent. The medical requirement applies to all crewmembers. Training for observers requires that they be able to clearly communicate with the pilot/operating crew of the UAS in order to remain clear of conflicting traffic, terrain, and obstructions; be able to maintain proper cloud clearances; and provide navigational awareness. At a minimum, their training must include knowledge of:

- Their responsibility to assist pilots in complying with the requirements of:
    - Section 91.111, Operating Near Other Aircraft;
    - Section 91.113, Right-of-Way Rules: Except Water Operations;
    - Section 91.115, Right-of-Way Rules: Water Operations;
    - Section 91.119,Minimum Safe Altitudes: General; and
    - Section 91.155, Basic VFR Weather Minimums.
- Air traffic and radio communications, including the use of approved air traffic control (ATC)/pilot phraseology.
- Appropriate sections of the Aeronautical Information Manual (AIM).

Other UAS qualified personnel include ancillary personnel such as Systems Operators and payload operators, or mission specialists. These personnel must be thoroughly familiar with, and possess operational experience with the equipment being utilized.

Licensing

Pilots have always pushed themselves and their equipment to the edge. In the early years of aviation, accidents were frequent and commonplace, especially during the barnstorming days of the 1920's. It was during this time that federal regulation of the aviation industry was recognized as a necessity. As the idea of aviation becoming a viable industry flourished, the federal government passed the Air Commerce Act of 1926 which was put in place to try and gain the public's confidence in flying. Among other things, the Air Commerce Act implemented the first licensing process for pilots. Now, in order to fly legally, pilots had to pass knowledge and flight tests. Passing these tests meant that you had the federal government's approval to fly. Once in hand, pilots were reluctant to do anything that would have their license revoked. This in itself created the first real environment of safety in the aviation industry.

In today's business market, the use of unregulated small unmanned aircraft systems (sUAS) has become a growing problem for everyone. Small unmanned aircraft systems have been in the news as of late for creating safety problems over airports and in the flight paths of commercial and public flight operations. The federal government, as well as the private industry, recognizes the usefulness of sUAS, and understands the need to regulate their use within the national airspace systems (NAS). Among the numerous areas that require the Federal Aviation Administration (FAA) regulation is the need to license pilots operating sUAS for commercial uses and to specify the exact regulated use of sUAS. Licensing pilots for commercial sUAS uses helps to ensure the safety of the flying and non-flying public.

The FAA Flight Standards Information System (FSIMS) Document 8900.1, Vol 16, Ch 4, Sec 1: Pilots, (2014) starts out by stating that UAS pilots are responsible for having the "appropriate level of understanding of the Title 14 CFR sections applicable to the airspace where UAS operate" (Unmanned Aircraft Systems, 2014). These standards will set the regulations for pilots, crew, and observers to ensure when UAS are operating in the NAS that they do not create a hazard to other aircraft. It also states that Civil UAS pilots may be required to have instruction by an FAA-certified UAS flight instructor (CFI). Specifics on qualifications for CFI's have yet to be determined. As CFI's are trained to not only give flight instruction, but also recognize hazardous attitudes in pilots, the possibility that all UAS pilots be required to be trained by a UAS CFI still exists.

General Operational Requirements for Pilot in Command

Additional General Operational Requirements listed that apply to all UAS pilots, small and large are:

- One Pilot in command (PIC) must be designated at all times.
- The PIC of an aircraft is directly responsible for, and is the final authority of, the operation of that aircraft.
- Each PIC controls only one unmanned aircraft (UA) at a time.
- Pilots are not allowed to perform concurrent duties both as the pilot and the visual observer (VO). In the case of Optionally Piloted Aircraft (OPA), the airborne pilot may assume the role of PIC at all times, but will only be the observer when the control station (CS) pilot operates the OPA.
- Unless undergoing initial qualification training, pilots must be qualified on the aircraft being flown.
- Only one PIC per aircraft is authorized, and the PIC must be in a position to assume control of the aircraft (Unmanned Aircraft Systems, 2014).

PIC Additional Responsibilities

- As the PIC, they will have additional requirements they are responsible for including:
- Has been designated as PIC before or during the flight.
- Is responsible for the UAS flight operation as described under 14 CFR part 91, & 91.3, or an FAA-recognized equivalent.
- Is responsible for determining whether the UAS is in condition for safe flight.
- Must land as soon as safely practical when any condition occurs that causes operations to be unsafe.
- May be augmented by supplemental pilots; however, the PIC retains complete and overall responsibility of the flight, regardless of who may be piloting the aircraft.
- Has the ability to assume the duties of an internal or an external UAS pilot at any point during the flight.
- May rotate duties as necessary to fulfill operational requirements.
- Must have a thorough knowledge of the Certificate of Waiver or Authorization (COA) issued to the organization when conducting a public aircraft operation, and must retain a copy to reference during flight.
- Must be trained and qualified on the specific UAS for the conduct of the flight.

- May assume the duties of VO or PIC if piloting an OPA when the OPA is being utilized as a UAS and being flown by the CS pilot (Unmanned Aircraft Systems, 2014).

Current ratings requirements for UAS PIC is dependent on the type of operation being conducted and can fall into two categories:

- Operations that require at least a private pilot certificate or FAA-recognized equivalent.
- Operations that do not require at least a private pilot certificate or FAA-recognized equivalent.
    - This decision of whether a private pilot license is required will be based on:
        - The location of the planned operations
        - The mission profile
        - The size of the aircraft
        - Whether or not it is a Visual Line of Sight (VLOS) operation

Through the inventiveness of the private industry UAS operators and manufacturers, as well as the government use of sUAS, missions for sUAS continue to expand. It can be easily foreseen that numerous sUAS missions could easily fall into the second category above, operations that do not require at least a private pilot certificate. Even though the private pilot certificate might not be required to handle a sUAS during VLOS operations, this does not absolve the PIC of their duty to fully understand 14 CFR as well as the limitations of the airspace in which they are operating. (Unmanned Aircraft Systems, 2014)

The current requirements for the PIC to hold, at a minimum, an FAA private pilot certificate or FAA-recognized equivalent are:

- All flight at or above 400 feet above ground level (AGL), including Class A, B, C, D, E, and G airspace.
- Instrument flight rules (IFR) (must have instrument rating) operations.
- Night operations.
- At joint-use or public airfields.
- Requiring a chase aircraft.
- At any time the FAA has determined the need, based on the UAS characteristics, mission profile, or other operational parameters (Unmanned Aircraft Systems, 2014).

Operations without a pilot certificate may be allowed when all of the following conditions are met:

- The PIC has successfully completed, at a minimum, FAA private pilot ground instruction and passed the FAA private pilot written examination or FAA-recognized equivalents (Airman Test Reports are valid for the 24 calendar-month period preceding the month the individual completed the exam, at which time the individual must repeat the instruction and written examination).

- Operations are during daylight hours.
- The operation is conducted in a non-congested location.
- Operations are approved and conducted solely within VLOS in Class G airspace.
- VLOS operations are conducted no further than one-half nautical mile (NM) laterally from the UAS pilot at an altitude at or below 400 feet AGL at all times. See Volume 16, Chapter 1, Section 2, for the definition of VLOS.
- Operations are conducted no closer than 5 NM from any FAA-designated airport or heliport other than the airport from which the aircraft is operating.
- The operation is conducted from a privately owned airfield, military installation, or off-airport location (Unmanned Aircraft Systems, 2014).

Recent Pilot Experience

The operator/applicant must provide a process that ensures that pilots maintain an appropriate level of recent pilot experience for the position they are assigned in the UAS being operated. The operators/applicants will record documentation showing the pilots maintain an appropriate level of recent pilot experience in the UAS being operated or in a flight simulation-training device (FSTD). At a minimum, the PIC must conduct three takeoffs (launch) and three landings (recovery) in the specific UAS within the previous 90 days, or as prescribed by the operator/applicant's recurrent training and currency program. This does not apply when the PIC is not required to be involved in the launch and recovery of the UAS operation. Recent flight experience and recertification rules apply as listed:

- For those operations that require a certificated pilot, the PIC, to exercise the privileges of his or her certificate, must have flight reviews and maintain recent pilot experience in manned aircraft per part 61, as appropriate, or FAA-accepted equivalent.
- For flights approved for night operations, the PIC must conduct three takeoffs (launch) and three landings (recovery) each, in the specific UAS at night, to a full stop in the previous 90 days.
- For operations approved for night or IFR, the PIC must maintain recent pilot experience

per part 61, § 61.57 or an FAA-accepted equivalent, as applicable.

- The PIC must maintain, at a minimum, a valid FAA second-class medical certificate issued under 14 CFR part 67, or the FAA-recognized equivalent. The second-class medical certificate expires at the end of the last day of the 12th month after the month of the date of the examination shown on the medical certificate listed in § 61.23.

In addition to the training required for a pilot certificate, UAS PICs must have the following additional training (or FAA-recognized equivalent): Normal, abnormal, and emergency procedures in all specific details of the UAS being operated;

- Manufacturer-specific training;
- Demonstrated proficiency; and
- Testing in the UAS being operated.

Operators/applicants must maintain individual training records of all UAS personnel. All training and testing will be documented in the individual's training record by the instructor and initialed by the trainee (Unmanned Aircraft Systems, 2014).

Supplemental Pilots are those pilots assigned UAS flight duty to augment the PIC. It is common for operators to have both an internal and an external UAS pilot. The supplemental pilot can take either of these positions. Additional information for Supplemental Pilots is listed below.

Ratings

Supplemental pilots must have, at a minimum, successfully completed private pilot ground school and passed the written test or FAA-recognized equivalents. The ground school written test results are valid for 2 years from the date of completion, at which time the individual must repeat the instruction and written examination. If a supplemental pilot assumes the role of PIC, he or she must comply with the PIC rating, currency, medical, and training requirements listed in subparagraph 16-4-1-3B (Unmanned Aircraft Systems, 2014).

Medical

Currently, pilots must maintain, at a minimum, a valid FAA second-class medical certificate issued under part 67 or the FAA-recognized equivalent. The second-class medical certificate expires at the end of the last day of the 12th month after the month of the date of the examination shown on the medical certificate, according to § 61.23. Section 91.17, or an FAA-recognized equivalent, applies to all UAS crewmembers. The Alcohol and Drug policy in

Section 91.17 or an FAA-recognized equivalent applies to all UA crewmembers. (Unmanned Aircraft Systems, 2014)

Operations requiring a medical certificate

Commercial UAS pilots will need at least a second class medical with limitations to UAS operations. This medical would certify that the pilot has visual ability consistent with description contained in second class medical certificate requirements as defines in 14 CFR Part 67.203 and hearing consistent with the description contained in 14 CFR 67.205.A.1. As well as no physical limitation that would prevent carrying out the duties and responsibilities of operations. These rules are because of the damage a UAS could create if it were to go rogue at any point (ARAC, 2009, p.39).

Duration of Medical Certificate

The duration of a second class medical related to a UAS should be 36 months. This is due to the fact that all operations involve no passengers. This could be the same for all ages, once again be due to the nature of UAS operations.

Certification

With respect to certification and the regulatory process, stakeholder groups, and governmental entities have repeatedly expressed concerns that there has not been a coordinated, timely effort to allow unmanned aircraft systems (UAS) and small unmanned aircraft systems (sUAS) to fly in the national airspace system (NAS) in a manner similar to manned aircraft (Service, 2012). The Federal Aviation Administration (FAA) Modernization and Reform Act enacted in February of 2012 brought greater focus to integrating the small and large UAS into the NAS.

Airworthiness certification is a process that the FAA uses to ensure that an aircraft design complies with the appropriate safety standards in the applicable airworthiness regulations. Design approvals received from the FAA indicate that the FAA evaluated the safety of the unmanned aircraft design and all its systems, which is more rigorous than simply making a determination that the sUAS is airworthy.

Airworthiness standards for existing manned aircraft are codified in Title 14 of the Code of Federal Regulations, with processes described for FAA type certification in FAA Order 8110.4 and airworthiness certification in FAA Order 8130.2. The FAA has the authority and regulations in place to tailor the design standards to specific sUAS applications, and plans to use this authority until further experience is obtained in addressing the design issues that are unique to sUAS. The challenge with this approach is the time required for individual review and certification for each sUAS class, as the pace of growth is greater than the agency resource pool.

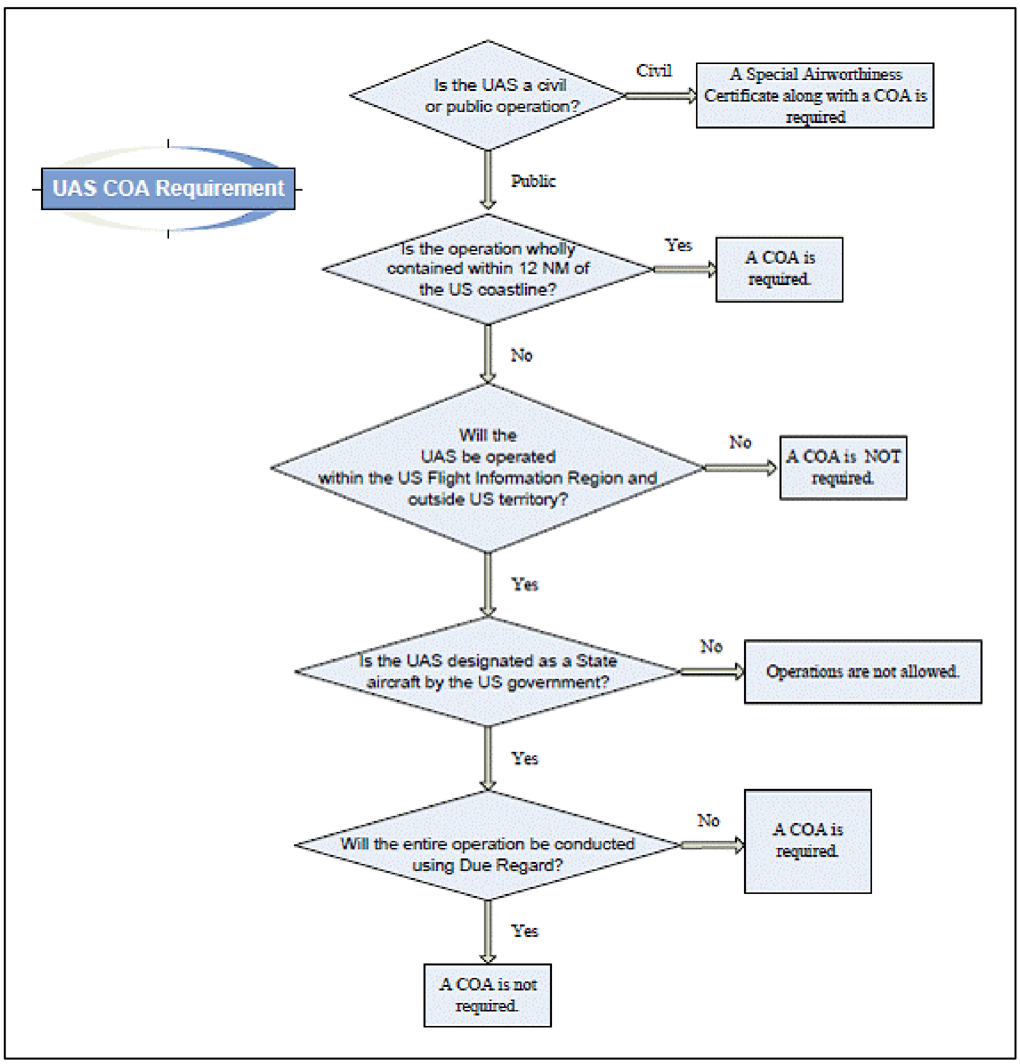
Civil sUAS are currently accommodated with experimental certificates under FAA Order 8130.34. The FAA is still working on coordinating with the users of sUAS to move away from the existing experimental design philosophy, toward a design philosophy more consistent with reliable and safe civilian operation over populated areas and in areas of manned aircraft operation.

The primary process to certify sUAS has not changed over the past few years. For governmental entities the Application for Certificate of Waiver or Authorization (COA) is the primary approval process. The current certification process is primarily defined in the form of Advisory Circulars (AC) for airworthiness certificates and experimental approvals for private entities. Private entities must have one or more of the following forms approved:

- AC 21-12C, Application of U.S. Airworthiness Certificate, using Form 8130-6 which includes sUAS options

- AC 45-2D, Identification and Registration Marking of Aircraft, must comply with current manned aircraft marking requirements
- AC 91-57, Model Aircraft Operating Standards
- FAA Form 7711-2, Application for Certificate of Waiver or Authorization
- Section 333, Special Rules for Certain Unmanned Aircraft Systems Exemption

The current certification process allows the FAA to authorize military and non-military (academic institutions, private sector entities, federal, state, and local governments) sUAS operations on a limited basis after conducting a safety analysis. Only governmental agencies can be granted a Certificate of Waiver or Authorization (COA). Private sector entities may apply for a special airworthiness certificate in the experimental category that would allow them to operate a UAS on a case-by-case basis as determined by the FAA (Whitlock, 2014).



Existing Airworthiness Standards

The existing airworthiness standards have been developed from years of operational safety experience with manned aircraft and need to be reworked to apply to the unique issues associated with sUAS.

Currently the governments' philosophy is that detailed consideration of sUAS in the certification process will be limited in number until significant consideration is given to existing standards, regulations, and policy. This will be exacerbated by sUAS manufacturers making an application for each type design to be approved by the FAA. This process will take an extended length of time to cycle certifications through the agency as designers and manufacturers modify each sUAS models. The FAA believes that the sUAS community will be best served by the use of an incremental approach to gaining type-design and airworthiness approval. This incremental approach is planned to involve the following steps:

- Allowing existing sUAS designs to operate with strict airworthiness and operational limitations to gain operational experience and determine their reliability in very controlled circumstances, as under the existing COA concept or through regulations specific to sUAS;
- Developing design standards tailored to a specific sUAS application and proposed operating environment. This step would enable the development of useful unmanned aircraft and system design and operational standards for the sUAS to facilitate safe operation, without addressing all potential sUAS designs and applications. This would lead to type certificates (TC) and production certificates with appropriate limitations documented in the aircraft flight manual;
- Defining standards for repeatable and predictable FAA type certification of a sUAS designed with the redundancy, reliability, and safety necessary to allow repeated safe access to the NAS, including seamless integration with existing air traffic.

Because the sUAS community is well established under its current operational assumptions, it is unlikely the FAA or sUAS industry will establish an entire set of design standards from scratch. As additional UAS airworthiness options are considered and UAS airworthiness design and operational standards are developed, type certification may be more efficiently and effectively achieved.

Certificate of Authorization (COA)

Experimental certificates and COAs will always be viable methods for accessing the NAS, but typically come with constraints and limitations. In the long-term, the principal objective of the aviation regulatory framework is to achieve and maintain the highest possible uniform level of safety while maintaining or increasing the efficiency and the environmental performance of the NAS. In the case of sUAS, this means ensuring the safety of all airspace users as well as the safety of persons and property on the ground (FAA, 2013).

COAs issued

2009	146
2010	298
2011	313
2012	257
2013	373 (as of October 31)

There were 545 COAs active as of December 4, 2013.

European Certification

Europe is using the ICAO standards expressed in Circular 328, which considers remote piloted aircraft systems (RPAS) as aircraft. Therefore RPAS must comply with the aviation rules as they apply to manned aircraft.

The RPAS operator must hold a valid RPAS operator certificate.

Canadian Certification

Canada requires special Flight Operation Certificates for sUAS that are less that 35kg (77 lbs), used for work or academic. Generally, it takes about 20 working days to obtain the certificate. Fines can be levied if approval is not secured, the fines can range from $3000 to 15,000 dollars. Between 2010 and 2013 the Canadian government granted 1,527 certificates to applicants. (Transport Canada, 2014)

Accidents & Incidents

Accidents have long been a factor in the development of small unmanned aircraft systems (sUAS). Between 1943 and 1959, more than two dozen piloted research airplanes and prototypes were lost in accidents, over half of which were fatal. By the 1960s, researchers began to recognize the value of using remotely piloted vehicles, ICAO nomenclature for UAS, as one type of means to mitigate the risks associated with flight testing (Merlin, 2013). Remotely piloted aircraft vehicles were developed for military uses as early as World War I, but drone weapon systems were technologically crude and designed simply to fly a one-way mission from which the vehicle would not return. Advances in electronics during the 1950s greatly increased the reliability of control systems, rendering development of UASs more practical. Early efforts focused on guidance and navigation, stabilization, and remote control. Eventually, designers worked to improve technologies to support these capabilities through integration of improved avionics, microprocessors, and computers (Merlin, 2013).

In a 2004 Department of Transportation report, it was shown that human factors contributed up to 68% of small and large UAS accidents (Williams, 2004). In a study by Tvaryanas, Thompson, and Constable (Thompson, 2005), human factors were analyzed in detail with respect to accident causation based on the Human Factors Analysis and Classification System (HFACS) premise that latent failures associated with organizational influences, unsafe supervision, and unsafe preconditions lead to unsafe acts. In this study a quantitative analysis was done of both active and latent human failures in UAS mishaps within the U.S. military services. This was significant because latent failures contribute to mishaps more frequently than active failures. Such a comparison may determine which human factors are common and likely to inherent all sUAS operations which are service specific (reflecting different policies and processes) or are unique to specific models of aircraft. The researchers examined 271 mishaps between 1994 and 2003 that involved a variety of remotely piloted aircraft used by the Air Force, Army, and Navy/Marines. Typically, any single mishap had several contributing human factors associated with it. The investigators only used the causes and contributing factors identified during the original accident investigations. Although no new causal factors were identified, mishap codes reflected any instance in which a reasonable inference could be made as to embed human causal factors based on the original mishap narrative, findings, or recommendations.

Researchers found that the pattern of latent failures predisposing error among UAS operators varied markedly between the services. Latent failures in Air Force UAS mishaps involved instrumentation and sensory feedback systems, automation, and channelized attention. Navy/Marine UAS mishaps were more often found to be associated with workload, attention problems, and risk-management issues. Latent failures associated with Army sUAS operators typically involved procedural guidance and technical publications, training, operator overconfidence, communications, and crew coordination. Skill-based errors were more common among Air Force operators while Army operators were more prone to procedural violations. There was no difference among the services with regards to the frequency of decision errors.

Learning from past experiences is fundamental to the development of safe and efficient systems, as well as improving existing systems. Future accidents might be best avoided through collecting, archiving, and studying past mishaps to learn valuable lessons. Quick responses to customer requirements and reduced program costs resulted from the elimination of redundant systems (usually added for crew safety), man-rating tests, and through the use of less-complex structures and systems (Merlin, 2013).

Researchers at the National Aeronautics and Space Administration's (NASA) Dryden Flight Research Center (DFRC), Edwards, CA, have used UASs to pioneer innovative new concepts and contribute to the development of technologies for current and future aircraft. Low-budget radio-controlled models, as well as more complex subscale and full-scale research aircraft, have been successfully used for tasks that would have been hazardous or physically challenging for a human crew (Merlin, 2013). Experimental and operational use of this cutting edge technology has also resulted in a number of mishaps that may provide valuable lessons for future sUAS operators, or for anyone involved in aircraft operations.

By examining sUAS mishaps and accidents, we better understand the causes and consequences that will help narrow in on the resultant corrective actions. Most undesired outcomes usually do not occur because of a single event, but rather from a series of events and actions involving equipment malfunctions and/or human factors (Merlin, 2013). These lessons are not unique to the sUAS environment, and are applicable to aviation and space flight activities. Common elements include crew resource management, training, mission planning issues, management and programmatic pressures (e.g., schedule, budget, resources), cockpit/control station design, as well as other factors (Merlin, 2013).

It is also important to remember that although there are no people onboard sUAS, there are numerous people involved in all aspects of its operation. Human factors affect sUAS safety at every level of design, management, maintenance, and flight operations. Historical case studies show that during development and testing of large and small unmanned aircraft systems there has been a large number of incidents involving improper procedures, training deficiencies, management problems, and supervisory failures. Additionally, it seems apparent that many accidents could be prevented with simple modifications to the human-machine interface. For example, inexpensive video cameras could provide a sUAS operator with peripheral vision. A ground cockpit could be equipped with an aural cue to alert the pilot to engine failure. A switch lockout or onscreen popup display could serve as a fail-safe to prevent mistakes when switching from one control console to another. Such common sense ideas seem fundamental, but many have yet to be adopted.

Because human factors are consistently cited as a major cause of sUAS accidents, an understanding of the causal factors associated with these accidents is essential for improving the reliability of sUAS. This is especially true if sUAS are to be integrated into the National Airspace System. Review and analysis of accident data can help researchers identify important human-factors issues, but different operating agencies use different investigation and reporting taxonomies. The Human Factors Analysis and Classification System offers investigators a standardized human-factors framework for most sUAS accidents.

Culturally, most organizations would prefer not to publicize their failures, but sometimes it is necessary for the greater good. It is important to remember that no organization in this field is immune to failure.

It is the goal of analyzing lessons learned from past accidents will prevent future mishaps and promote safe practices in the use of sUAS and, indeed, any type of aircraft.

Airspace and Arctic Ops

Arctic Operations - Arctic Areas

The Southern Arctic Area is the portion of the Anchorage Continental Control Area (CTA) Flight Information Region (FIR). This is the area overlying the Bering Sea, North of the Aleutian chain and south of the Bering Strait beyond domestic U.S. airspace. The Bering Strait Area is an area connecting the Southern and Northern Area through the Bering Strait. This allows unmanned aircraft systems (UAS) to assist with SAR operations and shipping lane ice surveys. Northern Arctic Area is the Anchorage Arctic CTA/FIR areas of the Chukchi Sea and the Beaufort Sea beyond domestic U.S. airspace. The floor of this area is flight level 230 and the airspace below is Class “G” or uncontrolled. (FAA, 2012, p.4)

Operating in the Arctic

The standard approach for this area is to use FAR PART135-Operating Requirements: Commuter and on Demand Operations. Only small UAS (55 lbs. or less in gross takeoff weight) are allowed to operate in Arctic operations. (FAA, 2012, p.4) UAS are not allowed to operate in warning areas, when the military are operating in these areas. In these areas manned aircraft must give way to the UAS. This is due to the relative “newness” of UAS operations. (FAA, 2012, p.3)

Beyond-line-of-sight (BLOS)

In the summer of 2013 the FAA hired a program manager to authorize a BLOS. The initial project tasks included forming a safety risk management (SRM) panel to identify risks and mitigation. The SRM panel considered 3 UAS BLOS operations in the Chukchi and Beaufort Sea. This SRM document was signed by the FAA on July 15, 2013. Rules and Code of Federal Regulations (CFR) applicable to manned aircraft were used to authorize the operations. (FAA, 2014, website)

Current Operations

Since the Arctic Implementation Plan was released in 2012, two commercial UAS operations have commenced in the Arctic. The first was ConocoPhillips. ConocoPhillips began using Insitu’s ScanEagle in September 2013. They use this UAS for their marine mammal and ice surveys. The second operator in the Arctic was BP. BP uses AeroVironment’s Puma AE. They use this UAS to survey its pipelines, roads, equipment at Prudhoe Bay, Alaska (FAA, 2014, Website).

While speaking with the creator of BP's UAS program and member of BP Alaska's Crisis Management team, Regina Ward, I was able to find out about how BP instituted the use of Puma sUAS on the slope. Her main recommendation was that the FAA should be as quick as possible with the rulemaking because right now it's very tedious and redundant to apply for these permits. She also said that if it became more costly than it already is, it would be hard for companies to invest in UAS.

She also spoke of the strengths of UAS. In her world oil spills and fires can be big problems. However, UAS allow them to see breaches before arriving, allowing them to know the danger of a spill. UAS also can see well above a visual range from the ground. Overall UAS can increase the safety of the industry as long as they stay a monetarily viable choice. (R. Ward, personal communication, November 20,2014)

Five Focus Areas of UAS Integration in the NAS

NASA's UAS integration into the NAS program

NASA's Armstrong Flight Research Center at Edwards, CA. is leading a project to help integrate UAS into the NAS. This project falls under the Integrated Systems Research Program office, at NASA's Headquarters, by NASA's Aeronautics Research Mission Directorate. This program is spread among four aeronautics research centers. The research centers are: Armstrong, Ames Research Center, Langley Research Center, and Glenn Research Center.

The project will provide data to key stakeholders and customers including but not limited to: FAA and RTCA Special Committee 203 (formerly the Radio Technical Commission for Aeronautics). NASA will do system-level tests to address safety and operational challenges of UAS in the NAS. The project is focusing on five sub-projects: Separation Assurance, Communications, Human Systems Integration, Certification and Integrated Tests and Evaluations (NASA, 2011, Website).

Separation assurance

Separation Assurance will focus on three areas. First, it will focus on how NASA will provide an assessment on NextGen separation assurance systems with different functional allocations perform for UAS in mixed operations with manned aircraft. The next area of focus will be on the performance of NASA's NextGen separation in flight tests with realistic latencies and uncertain trajectories. The final focus will be on access to functional allocations ranging from today's ground-based, controller-provided aircraft separation to fully autonomous airborne self-separation (NASA, 2011, Website).

Communication

Communications will focus on three areas as well. First is developing data and rationale to obtain appropriate frequency spectrum allocations to enable safe and efficient operation of UAS in the NAS. Next it will focus on developing and validating candidate secure safety-critical command and control system/subsystem test equipment for UAS that complies with UAS international/national frequency regulations, standards and recommended practices and minimum operational and aviation system performance standards for UAS. Finally it will focus on performing an analysis to support any recommendations for integration of safety-critical command and control systems and air traffic communications to ensure safe and efficient operation of UAS in the NAS (NASA, 2011, Website).

Human systems integration

Human Systems Integration (HSI) will develop a research test bed and corresponding database to provide data and proof of concept for Ground Control Station (GCS) Operations. HSI will also coordinate with standards organizations to develop human-factors guidelines for GCS operations in the NAS (NASA, 2011, Website).

Certification

Certifications will be split into two sections. The first define a UAS classification scheme and approach to determining FAR airworthiness requirements applicable to all UAS digital avionics. Secondly, to provide hazard and risk-related data to support the development of type design criteria and best development practices (NASA, 2011, Website)

Integrated tests and evaluations

Integrated tests and Evaluations starts with integrating and testing mature concepts from technical elements to demonstrate and test viability. NASA will also evaluate the performance of technology development in a relevant (NASA, 2011, Website).

FAA Expected Timeline/ Goals

Short term goals

Initial Capability would include commercial UAS being flown outside of class B/C airspace and not over populated areas and using mitigation for UAS limitations to comply with 14 CFR Part 91 requirements (JPDO, 2013, P.9); and standardized language between ATC and pilots to communicate properly (FAA, 2013, p.33). Full Capability would include operations in all applicable domestic airspace class subject to airspace requirements and UAS compliance with revised operating requirements addressing unique UAS attributes (JPDO, 2013, p.9).

Long term goals

In the future UAS regulations will need to adapt to new abilities. UAS will need to be able to be IFR certified as well as fly IFR flight plans. UAS will also need to be equipped with ADS-B (out) and a transponder with altitude-encoding capability. UAS will also need to be able to fly instrument approaches (FAA, 2013, p.33).

Over time, airports would need to be integrated incrementally for UAS operations. This would include standardized pattern operations, operations in low visibility, and light gun signals. UAS would need to be able to operate within NextGen requirements. To operate in the NAS UAS would need to be able to operate under similar expectations.

General limitations

The Aviation Rulemaking Committee (ARAC) has recommended the following: UAS should remain clear of clouds; UAS cannot be operated in IMC conditions, as well as a need for three mile visibility to fly. These rules would be needed due to UAS having to stay within line of sight. UAS shall not operate within 3 nautical miles of an airport, heliport, or seaplane without ATC approval. Due to the busy nature of operating in those zones, these rules are necessary within Operational Areas Prohibited (ARAC, 2009, p.11).

UAS would have to be barred from certain airspace areas due to the inherent safety measures necessary to keep these areas operating safely. UAS would not be allowed to operate in the following areas: prohibited, restricted or warning areas without permission from a controlling agency. UAS could not operate within any 100ft from any person, vessel, vehicle, or structure that is not associated with the operations. ATC must be notified of every flight. The UAS must be able to provide position and altitude data to the PIC (ARAC, 2009, p.29).

Take-off and Landing Area

The PIC of any UAS needs to ensure sufficient space is available at the flying location to conduct both take-off and landings without worrying that the UAS could not either land or takeoff from the flying location. The PIC must also ensure that the area is clear of persons and property, and not to pose a threat to either (ARAC, 2009, p.15).

Right-of-Way Rules

UAS must yield the right-of-way to all other aircraft. UAS flight crews must assume that other pilots will not see their aircraft and therefore the burden of maneuvering for potential collision risk shall be on the UAS PIC. Maneuvering of the UAS should be done early to prevent potential conflicts. Descending would be the best choice, however the PIC should decide on the most appropriate maneuver for each situation. During an emergency the safety of the manned aircraft must be given priority over the UAS (ARAC, 2009, p.14).

Cloud Clearances

UAS will need to follow traditional cloud clearances in all airspace. This will keep the UAS PIC visual so as to identify possible collision threats from clouds (ARAC, 2009, p.18).

Fly-away Protection

UAS would need to have a technical mechanism which executes a strategy to retain the aircraft if there is a loss of control. This mechanism would be to get the UAS out of the air as fast as possible. However these standards would have to be discussed by a consensus standard (ARAC, 2009, p.20).

Air Traffic Control

Requirements

With the September 2015 congress mandated deadline for the FAA to implement the use of Unmanned Aircraft Systems (UAS) for commercial purpose in U.S. airspace rapidly approaching, the FAA has still yet to develop a system on how they will integrate UAS into current airspace operations. It is estimated that on any given day there are more than 87,000 flights in the United States airspace. (Datasets, 2014). The FAA predicts that 7,500 unmanned aircraft will be operating in the U.S. by 2018 (FAA, 2014), and the number of SUAS will likely surpass the number of current aircraft being operated in U.S. airspace. A research company known as Teal Group found in their 2008 market study that UAS spending will more than double over the next decade from current worldwide UAS spending of $3.4 billion annually to $7.3 billion, totaling close to $55 billion in the next ten years. (Teal Group, 2014)

Integrating UAS into the current airspace system is a difficult challenge but must be addressed and implemented without delay as the use of SUAS continues to grow with each passing day and continues to go unregulated producing risks for collisions. In order to integrate UAS into the current air traffic system they must adhere to the same standards as the current system does for aircraft and provide separation, safety, and efficiency. To ensure these requirements are meet and all regulations are followed a system will need to be in place to monitor the transportation of SUAS and to regulate the airspace SUAS will operate in. Current ATC operations are dived between three facilities known as Tower, Center, and Tracon. Tower and Tracon provide separation in the airspace surrounding busy airports, while Center provides separation for all other airspace including smaller airports. One option the FAA has is to create a fourth division of its current air traffic control system specially geared towards providing separation for SUAS and the airspace it operates in. Having this fourth branch implemented will make it easier to ensure SUAS will not conflict with any other air traffic operations. The system will need to consist of employee trained specifically in the field of SUASs operations and a way to monitor SUAS operations. The system would most likely be best paired with Center operations (the same way Tower and Tracon collaborate together) as it covers a vaster amount of airspace.

Small UAS operations differ from current aircraft operations drastically and thus will require a specialized unique system to monitor them. One major difference between UAS and modern aircraft is a UAS can launch virtually anywhere. While the current air traffic control system monitors most aircraft ascending from airports or helipads a SUAS can ascend from remotely anywhere. This will make monitoring and controlling select airspace much more difficult. While class G airspace is currently uncontrolled the increase of sUAS operations will likely require new regulations to monitor this airspace.

Current Operations

The FAA currently regulates all U.S. airspace from the ground level up. UAS operations are divided between three separate operations: Civil UAS, Public UAS, and Model Aircraft. Most of the current sUAS operations are being conducted under Model Aircraft Operations. Recreational use of airspace by model aircraft is covered by FAA Advisory Circular 91-57; which generally limits operations for hobby and recreation to below 400 feet. Public UAS operations is reserved airspace for public entities such as law enforcement, firefighting, border patrol, disaster relief, search and rescue, military training, and other government operational missions. In order to operate in Public UAS the FAA requires one to obtain a certificate of authorization. Public operations are mainly conducted in restricted airspace, thus providing separation from most current air traffic operations. Lastly, Civil UAS operation requires one to obtain a special airworthiness certificate and precludes carrying people or property for compensation or hire, but does allow operations for research and development, flight and sales demonstrations, and crew training, unless granted an exemption under Section 333 of the FAA Modernization and Reform Act of 2012 (FAA,2014) Currently the FAA has granted this exemption to only six fil companies. The film companies must operate on a closed controlled set, below 400 feet, and within line of sight of the operator.

A majority of SUAS operations will be conducted in class G airspace which is between 0 -1200 feet. (Laksman, 2013). Many current SUAS's such as the pocket drone can reach an altitude of up to 11,000 feet which is beyond a controller's visual range, raising worries about midair collisions with helicopters. It is probable the FAA will implement restrictions that will limit SUAS flights to daytime hours, keep them away from helipads, and require an operator's license. (Laksman, 2013)

Air Traffic Control Communications

The main factor sUAS will need in order to monitor air traffic activity is a way to relay information back to the control center. As the regulations currently exist, no aircraft can operate within controlled airspace without being in contact with Air Traffic Control (ATC) facilities. This means that when operating under Instrument Flight Rule (IFR) procedures, and while in Class A, Class B, Class C, and Class D airspace, the Pilot in Command (PIC) must be communicating with Air Traffic Control. Beyond this, permission must be explicitly given from ATC to enter Classes A and B airspace (FAA, 2014 D). This presents a special problem for Unmanned Aircraft, as there is no Pilot in Command on-board the aircraft to be in contact with the controllers.

Currently, aviation communication takes places on the Very High Frequency (VHF) radio spectrum. Specifically, civil aviation operates between frequencies 118MHz and 137MHz ("8.33 kHz,"). Radio communication is not practical for Unmanned Aircraft Systems (UAS) because the person remotely piloting the UAS may not be anywhere near the location that the aircraft is flying. A radio wave communication is line-of-sight based. This would indicate the potential for the pilot to not be able to receive the frequency in which the local ATC controller is using. The Institute of Electrical and Electronics Engineers did a study to determine the best method for communication for Unmanned Aircraft Systems (Frew, 2009). It examined four possible methods to address the communication problem: direct link communication, satellite communication, cellular communication, and mesh networking.

Direct Link Communication

Direct link communications is the simplest form of communication and relies upon line-of-sight technology so tall obstructions such as building or mountains can interfere with the signal. It also requires a high powered transmitter, steerable antenna, or significant bandwidth for high-data rate downlinks and long ranges. All of these things would be too large and bulky to be equipped on a sUAS. Also, the bandwidth in one area would not support numerous Unmanned Aircraft Vehicles (UAVs) in the vicinity.

Satellite Communication

Satellite communication already has a limited bandwidth, so this would hinder UAS transmissions to both the pilot controlling the vehicle, and to Air Traffic Control. The UAS would then also require a dish antennae to receive the communication. This would be unsuitable for these small aircraft. This form of communication also has the problem of reduced bandwidth, and therefore an increase in communication delays with the number of systems in the area (Frew, 2009).

Cellular Communication

Cellular communication would work just like it does for cellular phones: a tower in the area sends and receives transmissions to connect communication. However, existing cellular towers are not designed to deal with ground-to-air transmissions, and so a new infrastructure would have to be built to support this, as well as ensure that the signal is protected and reliable to adhere to FAA standards. On the other hand, it's efficient in that the aircraft would hand off to different stations as needed during flight automatically, making for a much smoother communication system. Also, the aircraft would naturally pick up the strongest signal, so if the tower closest to it is producing a poor signal it would automatically pick up the next tower, producing a strong signal (Frew, 2009). The problem of limited bandwidth is easily fixed with cellular communication. By adding more stations, the bandwidth can be reused multiple times over to meet the demand as needed.

Mesh Communication

Lastly, mesh network communication is a wireless connectivity of small radio transmitters, or nodes, that function basically the same way as a wireless router (Roos, 2007). Data can transfer long distances by jumping from one node to the next. This is promising for Unmanned Aircraft Systems because each UAS can be equipped to be a node itself (Frew, 2009). Therefore multiple UASs in an area can all communicate with each other, and back on the ground. This is especially promising in areas where communication infrastructure does not currently exist, or where many UAS will be operating simultaneously.

Weather

Another key component the system will need is the ability to receive and interpret weather data. Many weather conditions such as high winds or hail can easily disrupt the course of a UAS. NASA is currently working with a startup company known as Airware in order to develop a system which includes this key element (KPCB,2014). They are currently testing out an internet based UAS system that will be able to detect bad weather conditions, interpret them, and redirect the unmanned aircrafts course of travel.

Separation

In order to provide safety and efficiency, UAS will need a way to ensure proper separation. Two methods that need to be looked at will be self-separation and controlled separation. Self-separation relies on a system known as "Sense and Avoid". This system will detect any obstructions in the aircrafts path, and will allow the aircraft to read just its course to steer clear of the object. Controlled separation is how current air traffic operations are conducted. They are based on things such as regulations, standards (based on aircraft size, weight, and speed of the aircraft), and monitoring equipment. When I conducted an interview with Cliff Sweatte, the FAA's Arctic sUAS Integration Program Manager, he informed me that the new air traffic control monitoring system known as "NextGen" will go hand in hand with UAS implementation, as they both rely on the transformation of data.

Training

Current training methods for air traffic controllers are to complete a 12 week course at the academy in Oklahoma City. The first few weeks of basic training at the academy is followed by training directly in the field of operation one will be working in, whether it be Tower Tracon, or Center. In order to best prepare individuals for working with sUAS, the FAA will need to implement UAS information into their training for new controllers, as well as with current controllers. Since most factors of maneuvering and separation are based on knowing the capabilities of the aircraft and how the system works, all current air traffic controllers, along with those in charge of monitoring UAS operations will need to be up to date on all UAS information.

Employment

In 2014 the FAA changed its hiring process for recruiting Air Traffic Controller's to what is known as "off the street hire", hiring individuals with a qualification of 3 years of work experience in any field, a bachelor's degree, or a combination of post – secondary education and work experience equivalent to three years (FAA-A,2014). The recent change in hiring has angered many individuals who obtained a degree in Air Traffic Control from an Air Traffic Collegiate Training Initiative school and caused an uproar in the aviation community. The FAA claims its actions to implement the new hiring process was to expand its selection process. One solution that would help deal with this issue is increasing the amount of individuals hired by installing the new training program for SUAS. This would grant an opportunity to more individuals and help reduce the backlash from the recent change, while allowing the FAA to keep its current hiring process.

Funding

One major concern the FAA will need to look is the cost of creating a system to monitor UAS' and required to train individual to do so. Currently The FAA provided documents estimating that it cost $250,000 to fully train each air traffic controller figure, including costs that are borne by the FAA directly (Laing, 2014). The FAA will need to factor these costs in while developing its budget.

Future Outlook

A future outlook will need to be taken into consideration when developing UAS in order to best prepare for what may come, and to best prevent the possibility for errors. Two main factors to consider will be the risk of overabundance of aircraft, and how international travel will be conducted.

SUAS implementation will allow a large amount of business's that aren't airlines to take over the sky. While current regulations allow for a massive market to own and operate UAS, it is likely that future regulations and finances will significantly cause a reduction of operators. Jay Skags stated he believes we (manned aircraft) will be sharing their (unmanned aircraft) airspace in the future, but regulations will help weigh it down. If the FAA requires a pilot's license to operate a UAS in the future less people will be qualified to operate one.

In the early stages of UAS implementation it is likely that all operations will remain U.S. bound, but it's only a matter of time before companies such as Google, Amazon, UPS and FedEx will want to break international barriers. This will be difficult as current foreign countries possess many different standards and laws for UAS then those of the U.S. The FAA will have to work closely with other nations and ICAO.

International Civil Aviation Organization (ICAO)

The International Civil Aviation Organization (ICAO) works with the Convention's 191 Member States and global aviation organizations to develop international Standards and Recommended Practices (SARPs) which States reference when developing their legally-enforceable national civil aviation regulations (ICAO). ICAO refers to UAS as RPA meaning Remotely Piloted Aircraft; a term discarded by the United States due to the fact that Unmanned Ariel Vehicle, UAV could be programmed to be autonomous meaning no human input required to function.

ICAO mandates that all manned aerial traffic are responsible for detecting and avoiding potential collisions and other hazards. They suggest the same requirement exist for a sUAV (RPA) as well. ICAO insists adequate technology must exist to provide the remote pilot with knowledge of the aircraft's environment to fulfill this responsibility. This technology must be incorporated into the aircraft as well as the pilot's command station (ICAO). The aircraft either manned or unmanned needs to be able to attract other traffic's attention through movement, lights, or pyrotechnic signals. ICAO is also concerned with right of way procedures between manned and unmanned aircraft. They state, "Integration of RPA may not require a change to the standards, however as RPAS technology advances, alternate means of identifying collision hazards will have to be developed with appropriate SARPs adopted. Regardless, the right of way rules will remain essential for the safe operation of aircraft, with or without a pilot on board" (ICAO).

Considering each of the above, ICAO insists RPAS detect and avoid solutions will be required to meet specified requirements which include the ability to:

- Recognize and understand aerodrome signs, markings and lighting
- Recognize visual signals
- Identify and avoid terrain
- Identify and avoid severe weather
- Maintain applicable distance from cloud
- Provide "visual" separation from other aircraft or vehicles
- Avoid collisions

In turn, air traffic services are intended to ensure that flying on international air routes is carried out under uniform procedures designed to improve the safety and efficiency of air operations. ICAO recommends that air traffic management provisions need to be amended to accommodate unmanned aircraft taking the unique operational characteristics of the aircraft and their automation capabilities into account as well as the emergency and contingency procedures in the event of an uplink, downlink, or lost link event, parachute emergency descents, and flight termination.

ICAO dictates that regardless of the aircraft's manned or unmanned status, provisions of the air traffic systems should remain the same as long as introduction of RPA doesn't increase the risk involved with other aircraft or third parties. This statement understands the likelihood that an unmanned aircraft cannot respond in the same manner as an on-board pilot. Air traffic management procedures will need to take the operational differences into account.

Detect and Avoid

Overview

A critical part of integrating Unmanned aircraft systems (UAS) into the National Airspace (NAS) is the development of a reliable and safe sense and avoid technology(SRC, 2014). The United States military has utilized sense and avoid technology to fly UAS missions of their own, and now commercial companies are starting to develop some of their own as well. An air based sense and avoid technology is ideal to UAS, and would allow UAS exemplary vision of the airspace, and the opportunity to react to any aircraft infringing on the airspace. Infringement would occur when an aircraft is directly within the overall mission area of the UAS itself. The issues with air based sense and avoid is cost and weight of the system. For small UAS's, air based sense and avoid technology is not the most ideal solution, because sensor packages could outweigh the platform. William Semke, associate professor at the University of North Dakota's mechanical engineering department, believes that it will take at least five years — and that would be an aggressive timeline. "Things would have to go very well for that. … Seven to 10 [years] is a more realistic timeline without any major stumbling blocks," he said. (Insinna, V. (2014, May 1).

Ground Based Sense and Avoid (GBSAA) systems, however, prove to be beneficial to small UAS's. GBSAA systems can be portable, relatively small in size, and have smaller sized packages that are on the platform. These systems provide communication between UAS operators and other aircraft that are in the airspace in order to prevent collisions. GBSAA systems use basic radar technology from a stationary component on the ground to survey UAS mission airspace. The system can be placed in almost any environment, including in truck beds, on rooftops, and in rough terrain due to its compact size.(SRC, 2014) While range can vary in regards to unit effectiveness, GBSAA systems greatly increase UAS situational awareness while operating within NAS. GBSAA systems also provide operational airspace coverage over the entirety of the UAS mission area, thus eliminating the possibility of overflying the system.

Authorization

Congress has set a 2015 deadline for the FAA to start phasing drones into National Airspace under the FAA Modernization and Reform Act. Sense and avoid technology is a crucial part of safely implementing this phase. For small UAS's, ground based radars provide greater benefits than air based sense and avoid systems by not sapping UAS processing power, or weighing them down. The U.S. Army has utilized a ground based sense and avoid system for years now, and its proven to work because Army drones fly low and in congested environments, but airborne systems have difficulty operating close to the ground because their radars and cameras see a lot of clutter. A ground-based radar can look up and direct aircraft more accurately. (Insinna, V. (2014, May 1). The Army Aviation Engineering Directorate has already approved the ground-based system's design and requirements and will give final approval. The FAA will authorize it for operational use in U.S. airspace as early as next year. (Insinna, V. (2014, May 1). This is a crucial step in phasing UAS's into the National Airspace. When there is final FAA approval, this will allow further progression in NAS integration. Perhaps the bigger issue with authorization is which company the FAA will decide to contract to produce sense and avoid systems for small UAS's. Many companies are currently "fighting" for the right to obtain an FAA contract for these systems. UAS test bed sites are currently using a system called LSTAR, which is developed by SRC.

Experimental Operation

In an interesting development, the University of North Dakota's unmanned aircraft engineering lab combined commercial as well as off the shelf hardware in order to create a special algorithm in order to allow sense and avoid capability for UAS's. The team of faculty and students used an ADS-B transceiver to collect and broadcast data on the velocity, position and direction of a UAS. Algorithms mine the data for evidence of potential collisions, and then override the autopilot system to direct the aircraft in a safe direction. (Insinna, V. (2014, May 1). This algorithm can be used with the previously mentioned ground based radar, and would allow the UAS to avoid wildlife as well as nonparticipating aircraft. The size and weight of sense-and-avoid equipment has dramatically changed since the program started. Initially, the lab's payload weighed 30 pounds, but that has shrunk to about four pounds and could be reduced to under a pound by using the latest equipment available on the market. (Insinna, V. (2014, May 1).

This development is crucial due to the fact that the sensor package employed on the UAS will not significantly weigh down the system. Since this project started, students at the University have refined this algorithm so their unmanned aircraft actually follow the same right of way rules as commercial aircraft themselves. This would allow UAS's to react in the same manner as a commercial aircraft if another aircraft was detected within its airspace. (Insinna, V. (2014, May 1). The UAS would then automatically override its own autopilot system, and would maneuver itself to a safe position in order to prevent a possible collision.

Along with the University of North Dakota, a privately owned company, SageTech, is also experimenting with ADSB transceivers as sense and avoid tools. SageTech currently offers two versions of ADSB transceivers, the Clarity and the Clarity SV. (Sagetech, 2014) These systems can be installed onto small aircraft, or sUAS in order to provide another aspect of sense and avoid technology. The sensors developed by SageTech are the smallest and lightest in the world, measuring 3.5” x 0.7” and only weighing 100 grams. (Sagetech, 2014) These sensors are compliant up to 60,000 feet in altitude and would allow a computer to read constant data from the sensor itself. These sensors are highly functional with most flight computers, and can even be uplinked to an iPad, which makes the system useful nearly anywhere. (Sagetech, 2014) While this system is an extremely reliable sense and avoid technology, it does require all aircraft to be participating In order to function at it’s highest capacity.

In the case of small UAS’s the most feasible option of sense and avoid currently available is the LSTAR system created by SRC. This ground-based system allows the use of UAS’s in airspace without requiring a ground observer or a chase plane to be present. The system would allow constant communication between UAS operators and LSTAR in order to maintain proper separation from other aircraft within the same airspace. LSTAR has proven itself to be capable in low visibility weather, as well as at night. (SRC, 2014, January 1). The system also greatly enhances a UAS’s area of operation, and greatly increases the operational time a UAS can spend on a mission. The LSTAR system also inherits one very crucial benefit to small UAS’s, portability. LSTAR can be deployed in practically any location a UAS wishes to execute a mission, and instantly provides UAS operators a robust surveillance network of the operating airspace, which meets the strict requirements posed by FAA. The LSTAR system can be employed on a tripod, rooftop, or even a vehicle to provide airspace coverage to UAS platforms. LSTAR can also be integrated with other sensors, and the alerting system keeps the UAS operator aware of potential collisions, and a data recording ability helps with mission reviews. Users have the option of viewing data on our unique, user-friendly data display, or it can also be integrated into a customer-preferred data display. Ground-Based Sense and Avoid Radar System. (SRC, 2014, January 1).

Among ground based sense and avoid systems, LSTAR has an array of features that could greatly increase sense and avoid technology for sUAS. These features include:

- Provides 3-D target position

- 98% track reliability
- High mean time between failure (MTBF)
- Full integrated logistics support
- Flexible installation options
- Tripod or pedestal - Rooftop or tower - Vehicle mount
- Flexible power options (AC grid, generator, or 24 VDC vehicle)
- Unattended remote operation over IP network
- ASTERIX or custom interfaces

Greater than 98% track reliability is a crucial component to this ground based system. If utilized, this system would provide untouched safety reliability when discussing sense and avoid technologies. Combined with a low life cycle cost, and the possibility of being connected with other sensors, the LSTAR system looks like an extremely viable option for small UAS's. (SRC, 2014, January 1).

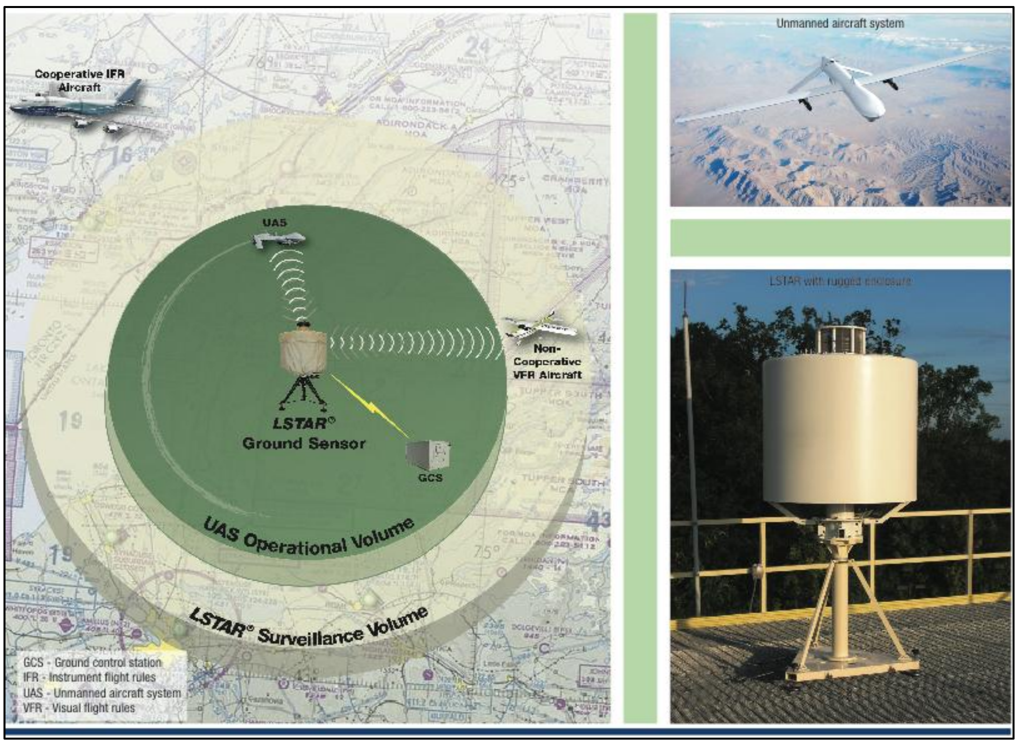


Figure 2, SRC, 2014, January 1

As the graphic illustrates, the LSTAR system allows UAS's to essentially detect nonparticipating aircraft within the airspace, and steer clear of these aircraft. The LSTAR's surveillance radius is vastly greater than the operation radius of the UAS itself; therefore never creating a situation where a UAS would outfly the ground based sense and avoid system. The graphic also illustrates how relatively small the ground based sense and avoid system is. Ground-Based Sense and Avoid Radar System. (SRC, 2014, January 1).

Ground based sense and avoid is essential in implementing UAS's into NAS by the 2015 deadline that has been set. (Insinna, V. (2014, May 1). The United States Army has proven the capability to operate this system within National Airspace effectively and safely. Since there is no pilot in UAS's, the ground based sense and avoid provides an alternate compliance to FAA's see and avoid pilot rule by having the system sense other traffic in the area, using a 3D radar system, and use algorithms to determine if there is danger of collision and how to avoid that danger. That information is then provided to the UAS operator.

Alternative Sense and Avoid Concept

Another alternative sense and avoid concept that has been proposed by multiple professionals, is using chase planes and/or ground observers with conjunction of the UAS mission. There are many operational considerations when conducting a UAS mission, and the use of a qualified ground observer to monitor airspace for collision hazards may be deemed appropriate, as well as cost efficient. There is significant rationale behind the concept of a visual observer, in the fact that visual see and avoid is the primary mechanism of ensuring safe separation and avoiding collisions. (Tarbert and Wierzbanowski, 2009) Certain circumstances would dictate the use of a visual observer from the ground, and if the entity conducting the mission does not have a GBSAA system available, visual observers may be the only option.

Multiple components of a situation will determine whether a ground observer is required during a UAS mission. The Person in Command (PIC) of the mission will be the one responsible for determining if a qualified visual observer is necessary for the mission. The PIC is also responsible for a multitude of other responsibilities such as avoidance maneuvers, and monitoring air traffic communications within the mission area. Some sUAS can be the roughly the size of a bird, so for sense and avoid, diving would be the most beneficial tactic to avoid a potential collision, as that would mimic the avoidance used by wildlife. While a ground based observer may not have the best judgment on altitude of the UAS from the ground, descending safely to as close to the ground as possible would be the most ideal option in this situation. The responsibility of this maneuver relies on the PIC, and manned aircraft safety should take priority over sUAS function. Similarly with right of way, communication guidelines must also be followed within the airspace the sUAS is operating. sUAS PIC's or qualified ground observers must always monitor ATC traffic within the area to maintain situational awareness of the overall airspace picture. Monitoring appropriate frequencies would aid the PIC and/or visual observers in being aware of other aircraft potentially in the airspace. (Tarbert and Wierzbanowski, 2009)

A visual observer is deemed necessary for the following requirements: (Tarbert and Wierzbanowski, 2009)

- If the sUAS is operated by a PIC either in a shelter or “heads down”, the operation requires the use of a qualified visual observer.
- For operations >400 AGL one dedicated qualified visual observer is required.
- If the PIC determines that a visual observer is necessary to maintain the safety of the operation.

These considerations make it clear when additional qualified visual observers are required. Given that there is more likely to be other aircraft above 500’ AGL increasing the probability of a collision, an additional visual observer is added for sUAS operations over 400’ AGL to aid in the ability to see and thus avoid other aircraft. (Tarbert and Wierzbanowski, 2009). Along with using a visual observer during a specific mission, these observers are responsible for a variety of duties. These duties include, but are not limited to:

- PIC or qualified visual observer (close proximity of PIC) must maintain position of the sUAS through direct visual observation in order to avoid creating a collision hazard with other aircraft, airborne hazards, and persons on the ground, terrain, or obstructions. (Tarbert and Wierzbanowski, 2009)
- The qualified visual observer, if used, must maintain effective two-way communications with the PIC. (Tarbert and Wierzbanowski, 2009)
- When using other aids to vision, such as binoculars, field glasses, or telephoto television, qualified visual observers must use caution to ensure that the unmanned aircraft remains within the approved visual limitation distance. Due to field of view and distortion issues, the use of such aids can be used to augment the qualified visual observer’s visual capability, but cannot be used as the primary means of visual contact. (Tarbert and Wierzbanowski, 2009)

These clearly defined duties regulate what each qualified visual ground observer is responsible for, and defines how they are the “see” component in the sense and avoid system. This means an observer is not necessarily required to maintain 100% visual contact with the sUAS, however must be scanning surrounding airspace for potential collisions with other aircraft while maintaining overall sUAS situational awareness. Potential issues could arise with the use of a visual observer, due to the heavy reliance on human factors. An observer and/or manned aircraft pilot within the airspace may experience a lapse in overall situational awareness, and therefore could create a potential collision hazard. With GBSAA systems, there is constant communication between UAS operators, and the ground based system, thus making operators completely aware of surrounding airspace conditions. With a ground based visual observer being used in place of a radar system, there are right of way rules and communication standards that must be set in order to ensure uniformity and safety within airspace in which the UAS is operating. sUAS must yield right of way to all other aircraft, which may be operating within the airspace. Operators must assume other aircraft cannot visually acquire their system, and take proper action to avoid a collision. The PIC must follow a multitude of rules in order to assure safety within the operational airspace regarding right of way. These guidelines are:

- The PIC must yield the right-of-way and when a manned aircraft is detected, always maneuver early to prevent a potential conflict. The preferred means of conflict avoidance is to descend and maneuver closer to the landing area and the PIC and/or qualified visual observer.
- Although sUAS should descend as its primary means of collision avoidance; the PIC should use the most appropriate maneuver for the situation.
- During an emergency, the safety of manned aircraft must be given priority over the sUAS.
- For sUAS encounters with other sUAS, the right-of-way rules defined in 14 CFR 91.113 apply, except that all sUAS must yield the right-of-way to manned aircraft. (Tarbert and Wierzbanowski, 2009)

Manufacturing

In the spring of 2013, there were 420 unmanned aircraft system manufacturers. Of those manufacturers, only seventy-nine are from the United States and many of these manufacturers are focused on military UAS. Market analysis shows that only 11 percent of the UAS market is for non-military use. By 2020, the civil UAS market is expected to grow to at least 14 percent of the total market (AUVSI, 2013). The United States' regulatory agency is one of the reasons behind the slow growth of civil UAS because of the lack of consistent regulations in place for operations other than research and development.

Some of the more well-known manufacturers include:

- Boeing (including Insitu)
- Northrop Grumman Corporation
- General Atomics
- AeroVironment
- Lockheed Martin
- BAE Systems
- DJI

Uses

Compared to the original uses of UAS in the military, technology has advanced bounds and leaps towards civil uses either for public and/or commercial purposes. Aside from cost savings, the use of UAS has become largely sought out because of their ability to reach remote areas, go to places where manned operations are too risky to carry out, and lowered impact on the environment. Manufacturers' research and development teams are engineering new sUAS with today's needs in mind, such as security awareness, disaster response and search and rescue, communications and broadcast, cargo transportation, spectral and thermal analysis, critical infrastructure monitoring, and aerial photography and mapping (FAA ROADMAP).

Security awareness

The National Oceanic and Atmospheric Administration (NOAA) has experimented with the use of its drones for law enforcement, searching for illegal fishing operations off the coasts of Florida and California. The United States Department of Homeland Security did a program called Robotic Aircraft for Public Safety (RAPS) program to showcase the use of small unmanned aerial systems as viable solutions to protect, secure, and respond to potentially dangerous situations. During a demonstration one of Aerovironment's sUAS known as the Raven located two people walking, tracked a person who dropped a gun, and then ran and located two missing people who had pretended to fall in a creek (AUVSI, 2013).

Designed for rapid deployment and high mobility, the Raven is lightweight, does not need a runway, and is fully autonomous or can be operated manually. The sUAS has a 4.5 ft wingspan, weighs 4.2 lbs, has a 10km range and can fly for 1-1.5 hours with a rechargeable battery. It can carry payloads up to 6.5 oz which typically include electro optical and infrared cameras. The Raven is ideal for low-altitude intelligence, surveillance, and reconnaissance (ISR), providing aerial observations at line-of-sight ranges up to 10 km, day or night.

Figure 3

Disaster response, search & rescue

There are many uses for sUAS during disasters and emergencies. A UAS can spot wildfires without running the risk of damaging the engine(s) of a manned aircraft, as well as conducting search and rescue operations for lost persons in a tight area that manned aircraft cannot get access to or see in poor weather, smoke, or under trees. Another excellent use for UAS is to deliver emergency supplies to those affected by disaster who cannot get access to basic necessities.

Google X, Google's clandestine tech research arm, has been developing Project Wing- a prototype UAS. The goal of their drone is to be used for disaster relief by delivering medical supplies and other necessities to remote areas.

The aircraft's total weight, including contents of the packages (about 5 lbs.) being delivered are about 22 lbs. Project Wings' sUAS has a wing span of about 4.9ft and has a blended wing design, which means that the entire body of the aircraft provides lift. With four electrically driven propellers, this sUAS is unique in that the propellers have two modes- props straight up for takeoff and landing without a runway and hovering, or horizontal for quick and efficient flight. Unlike remote controlled drones where a pilot must keep visual contact, Project Wing has these drones pre-programmed with a destination it will fly to. Because of the tight regulations in the United States, the testing has been conducted in remote farms in Queensland Australia (Stewart, 2014).

Figure 4, Screenshot from Google's YouTube channel

Communications and broadcast

In the event of a disaster or event where communications are down, sUAS can be used to eliminate the disruption within the first 72 hours when other options are unavailable. This technology is known as deployable aerial communication architecture (DACA). The United States military has successfully used DACA technologies to provide communications in the absence of available infrastructure. According to the Federal Communications Commission (FCC), the use of DACA on sUAS would fill the gap for civilian communications which would also strengthen and enhance the security and reliability of the nation's communications infrastructure (FCC, 2012). Aerovironment has demonstrated the use of their sUAS, equipped with the company's Digital Data Link (DDL), and a communication relay payload successfully to areas that are beyond line-of-sight, long distance, and without ground based antennas. The Digital Data Link, which can be equipped on any of Aerovironment's sUAS, enables flexibility and interoperability between airborne and ground systems with limited power availability and bandwidth to maximize the number of systems that can operate within an area.

One of the Aerovironment's systems that can be used to improve communications is the

Puma AE. The Puma is very flexible. It can be used in diverse environments such as high altitudes and hot climates. It is also waterproof which allows the Puma to be used for maritime operations. The Puma boasts a wingspan of 9.2 ft, weighing 13.5 lbs, and can fly a range of 15 km for over 3.5 hours. An optional transit bay underneath the wings increases its payload capacity to carry a third-party communications relay device. Aerovironment's ground control station (GCS) is compatible with their entire fleet of unmanned aerial systems. The GCS allows for an operator to control the sUAS manually or to program it for autonomous flight using GPS-based navigation.

Figure 5, photo courtesy of Aerovironment

Cargo Transport

With small UAS, cargo is one of the uses with the most economic benefits. Many areas that have geographical barriers or without the infrastructure to support large manned aircraft full of cargo can be serviced. Where it is uneconomical to service due to low volumes of cargo, UAS can easily access those areas with its lower cost to operate (Platform Unmanned Cargo Aircraft).

Companies like Amazon, Inc. have filed for exemptions under Section 333 of the FAA modernization act of 2012 in order to conduct experiments outdoors. Before their approval, Amazon has been developing and experimenting with sUAS in their indoor facilities or overseas locations. Currently they are testing their eighth and ninth generation sUAS on a range of capabilities, such as its agility, flight duration, and sense-and-avoid sensors. Their sUAS are battery driven, use rotor propellers, and will carry packages that are 5 lbs. or less. Amazon hopes to use their sUAS for 86% of products sold online, which are 5 lbs. or less and deliver them at a speed of 50 mph (Platform Unmanned Cargo Aircraft, 2014).

Figure 6, photo courtesy of Amazon

Spectral and thermal analysis

Thermal infrared (TIR) remote sensing is a tool for collecting, analyzing and modeling energy fluxes and temperature variations. Traditionally, this process has been done through manned aircraft, satellite, or ground TIR systems. Because of the limitations and high costs, other platforms have been sought out such as sUAS. This has caused groups such as the Center for Self Organizing and Intelligent Systems (CSOIS) in Utah State University (USU) to develop AggieAir in 2008 (IEEE, 2010). AggieAir's Minion is its second generation sUAS for TIR. The Minion has a wingspan of eight feet, takeoff weight of 14lbs., with the ability to carry 4 lbs., and can go 30 miles during its total flight time of one hour. The Minion is a fully autonomous sUAS but can be used with a remote control receiver as a safety pilot backup.

Figure 7, photo courtesy of AggieAir, Utah State University

Photography and mapping

The Federal Aviation Administration has approved seven aerial video and photography companies this year to use unmanned aerial systems on closed sets. The most recently approved company, Flying-Cam Inc., filed a Section 333 exemption petition to their own proprietary remote controlled helicopter. The exemption restricts the pilot in command to have 200 flight cycles and 25 hours of UAS rotorcraft experience along with 5 hours with the aircraft to be used. The exemption also limits each UAS flight to 30 minutes or to 25 percent battery power, whichever comes first (Kesselman, 2014).

A Chinese company, DJI, manufactures sUAS specifically for photography and videography. Their latest sUAS is called Spreading Wings S1000+, is made of carbon fiber, eight rotor propellers, and with a maximum takeoff weight of 11kg (about 24 lbs.) can carry your heaviest camera. The UAS itself is 4.4 kg (almost 10 lbs.) and with a 9.5kg payload, will fly for up to 15 minutes. A 40A electronic speed controller (ESC) is built into each arm which gives a maximum thrust of 2.5kg in each arm. The motor uses a single wire stator design, which offers improved heat dissipation, better performance making it more reliable.

Figure 8, photo courtesy of DJI

Critical infrastructure monitoring

The National Oceanic and Atmospheric Administration (NOAA) have been using UAS to monitor the environment to close the gap between satellites and instruments on the Earth's surface collecting data and observing dangerous and/or remote areas. These areas include the North and South poles, oceans, volcanic islands, and wildfires (Doughton, 2013). Most notably, UAS have been used to observe wildlife and their habitats.

For-profit companies, such as BP and Conoco Phillips have been approved by the FAA to use sUAS to monitor the pipelines in Alaska. Previously, ground crews would spend up to a week checking a two mile section of pipeline. With sUAS, the job can be in 30 minutes. BP uses Aerovironment's Puma, however theirs are equipped with LiDAR technology- remote sensors that use laser pulses to create 3D images of the ground from 200 ft. (Biederman, 2014). The use of sUAS is important because it allows a safer and more cost-effective solution to monitoring critical infrastructure in the U.S. in areas that are too dangerous or risky for human performance.

Obstacles to UAS Implementation

Although the implementation of UASs have made many advances in the recent years, there are still obstacles in the way that are causing the process to be delayed (Pope, 2014). Along with the other main factors of perfecting the system covered in this paper such as providing rules and regulation for operating in the National Air Space, there are additional concerns that are also delaying the process such as the concern for privacy rights and concerns in regards to law enforcement and monitoring illegal activity being conducted with UASs. These issues must be perfected in a timely manner to avoid further delaying the process of UAS implementation.

Privacy

In June 2011 outside of Grand Forks, North Dakota the first UAS assisted arrest took place. The Grand Forks Police enlisted the help of a Predator Drone from the Department of Homeland Security to overfly the house of Rodney Brossart, whom was involved in an armed standoff with police. The drone was used to ensure the suspect was not armed as police approached his property to perform an arrest (Hendriksen, p. 209, 2013). Counsel representing Mr. Brossart claims the vehicle violated his civil rights by conducting a search therefore entering his personal property without a warrant. As UAS devices are becoming increasingly popular for use in the areas of law enforcement, search and rescue, and boarder protection, questions are being raised regarding the use of these devices in relation to citizens' rights. The basis for one's right to privacy in the United States is addressed in the Fourth Amendment of the constitution, which protects citizens from "unreasonable search and seizures" and protects the right of the people to be "secure in their persons, houses, papers, and effects" (U.S. Const. Amend. IV). It is believed a UAS could be used, such as in the case above, to intrude upon a person's property and perform warrantless surveillance.

Electronic surveillance precedence

"Manned aircraft are expensive to purchase, operate, and maintain. This has always imposed a natural limit on government's aerial surveillance capability. Now that surveillance can be carried out by unmanned aircraft, this natural limit is eroding" (Stanley & Crump, p. 1, 2011). The American Civil Liberties Union makes the claim the FAA is tasked with protecting the safety of the national air space as well as protecting the people on the ground. They feel the FAA's obligatory duty to protect people on the ground should extend to protecting their privacy (Stanley & Crump, p. 2, 2011).

Unmanned aircraft systems in law enforcement have always been on the forefront of integrating these systems into everyday use to conduct searches, patrols, and provide situational awareness for officers on the ground. In a report from the Department of Justice, the agency had received word more the 100 law enforcement agencies were interested in using UAS by June 2012, up from around a dozen agencies in 2008 (Hendriksen, p. 217, 2013). Concerns arise when using UAS in this manner, such as they did for surveillance in the case from North Dakota. The Department of Homeland security has been using UAS in their operation along the border of the United States since 2005 and predicts that they will have 24 in operation by the year 2016 (ALCU, 6, 2011).

Electronic means to conduct law enforcement have been around for many decades with technology such as wire taps and aerial photography. In a 1967 case presented to the United States Supreme Court, Katz v. United States, the constitutionality of a surveillance search was under question. The case was regarding evidence collected against the defendant by placing wiretap on a public phone booth used frequently by Katz to conduct illegal activity. A warrant was not secured for the wiretap as it was seen as a public place. The opinion of the court, being the wiretap was an unconstitutional invasion, was on the basis of perceived and a reasonable assumption of privacy (Katz v. United States). The conversation was not obtainable my non-technological means, and despite being in a public phone booth the defendant was observable only visually. It was discussed the constitution protects people and not places, as found by the Supreme Court in Katz v. United States. However the individual must have the reasonable expectation of privacy, even when in a public setting (Hendriksen, p. 219, 2013). This decision represented a turn in the interpretation in the law, which had previously focused on property, rather than a person’s privacy (Thompson, 7, 2012).

More closely related to the direct operation of UAS, aerial searches have been part of cases brought to federal and state court in questions of constitutionality, such as Dow Chemical Co v. United States in a case when Environmental Protection Agency agents overflew an industrial complex taking photos from an aircraft. This case was found to be fairly different from a case against a person as commercial properties have a lower expectation of privacy. In California v. Ciraolo officers over flew fields with heavy marijuana growth, which is an illegal activity in that state. The courts rules in favor of the law enforcement agencies citing no warrantless search occurred as there was not a reasonable expectation of privacy in this case. Aircraft are common and any user of the public airspace could have spotted the illegal activity from the air. However, the court did recognize the potential for high quality equipment being used which may at one point violate constitutional rights to privacy, as it would cross into an area of illegal search (Hendriksen, p. 223-225, 2013).

In Riley v. Florida the defendant, similar to the case against Ciraolo, was observed growing illegal marijuana plants from the air. The search was argued as illegal in regards to the fourth amendment since the defendant should have had a reasonable expectation of privacy. Unlike the earlier case in California, Riley had taken precautions to cover his activities from ground as well as aerial views. Law enforcement officials were only able to gain visual access through holes in the roofing visible from a helicopter hovering at 400 feet. Points were made this was outside the ‘navigable’ airspace used by fixed wing aircraft, therefore a reasonable expectation of privacy was maintained. However it is within FAA regulations to allow the operation of a helicopter at 400 feet (Nagy, p. 154, 2014). The Supreme Court found this was not considered a warrantless search as the helicopter was operating within the confines of the law.

In the cases where over flights were permitted to gather evidence they were not seen as a warrantless search due to the nature of the night. Within FAA regulations the aircraft must maintain a certain altitude and produce a level of search that would not be uncommon in cases such as aerial photography. Unmanned Aircraft present a different operation as many are operated at very low altitudes and in a process not common to the reasonable expectation of a typical property over flight by civilians. A citizen of the United States is afforded the reasonable expectation they are able to conduct activities in private on their own property considered technological advances in place now. The rapid implementation of UAS in to the National Airspace does not afford the average citizen the knowledge of types of operation and capabilities of UAS technology. Fourth amendment violation “will likely depend on several contextual factors, most importantly the location and behavior of the aircraft and in the image-capturing or sense-enhancing technology used” (Hendriksen, p. 227, 2013). Constitutionality will also be “heavily influenced by FAA guidelines” such as in cases where the search was only deemed legal since the aircraft were operating within regulation. (Nagy, p. 155, 2014)

In a case not directly linked to flight, Kyllo v. Unites States, the court found the use of technology that is not available to the public in general is considered a search. Many UAS technologies can fall under this consideration, such as the use of high-powered cameras or thermal imaging devices (Thompson, 9, 2012). Although a citizen can expect a certain level of privacy within their home, searches are not limited to activities conducted in common sight (as acknowledged by the plain view doctrine). A person must act with a reasonable intention and understanding of privacy to be subject to the protections found in the fourth amendment.

Regulation and Legislation on a National Level

With exception of the definitions contained within the Fourth Amendment of the Constitution, there are no national laws concerning rule that must be followed when conducting an aerial search. The court has found in favor, multiple times, as long as the aircraft is operating within the navigable airspace and following regulation its activities cannot be considered an illegal search in reference to the cases discussed earlier. UAS, however, present a different operating environment. The equipment they are able to carry and the spaces they are able to occupy will put to test the theory if it can legally operate in the airspace, it can conduct a warrantless search. Citizens are concerned with the introduction of this technology and an absence of law to regulate violations of privacy.

Part of the difficulty enacting law regarding UAS operations is finding the correct department to take on the task. The FAA will not issue regualtions regarding privacy as it is outside their scope as a regulator concerned with safety. However, they have required the current test sites to develop privacy and data retention policies to follow and comply with the current law in the operating area. (Hendriksen, p. 230, 2013). “The FAA maintains its mission is safety and not privacy, it will require [test] site operators to comply with is final privacy requirements” (Hendriksen, p. 214, 2013). The test site privacy policies were separate and uninvolved from the research and development goals of the organizations. However during the integration process of UAS into the National Airspace these policies “may ‘inform that dialogue’ when a framework is developed” (Hendriksen, p. 214, 2013).

Several bills regarding Unmanned Aircraft Systems were introduced in the United States House of Representatives specifically regarding impacts of privacy and personal freedoms. The Bills, summarized below, did not make it out of congressional committee.

HR 972 – Preserving Freedom from Unwarranted Surveillance Act of 2013

- Would require a warrant from any federal agency conducting surveillance with a UAS
- Exceptions include detecting or deterring the transport of illegal substances into the United States or if prompt action will protect and endangered life
- This act would create the right to sue for violations

HR 637 – Preserving American Privacy Act of 2013

- Restricts the use of information collections that could reasonably identify and individual or any elements of a person's property not in plain view.
- Exceptions to this rule are searches covered by a warrant, border searches within 25 miles of a national border, from consent of the individual being observed, or in emergency situations.
- Evidence obtained in violation will be inadmissible in court
- Also provides any agency applying for a certificate or license to operate a UAS must file a data collection certificate with the Attorney General which includes their purpose, data collection capabilities, information retention policies, place for citizen feedback, the agency responsible, and the audit and oversight procedures in place.
- The act would allow the Attorney General to request a revocation of rights to fly if they do not submit the information above.

HR 1262 – Drone Aircraft Privacy and Transparency Act of 2013

- Designed as a modification of the FAA Modernization Act of 2012
- Mandates the Secretary of Transportation studies threats to privacy posed by the use of UAS in the National Air Space
- Would prohibit the use of UAS aircraft unless the license application contained a data collection statement. The statement includes individuals authorized to operate the aircraft, the period when it will be used, and the location of the flights.
- The personal collection of data will required additional elements to the data collection statement, such as how long the information will be stored, the kind of information collected, how the information will be used and if the information will be sold.
- Under this act law enforcement agencies would be required to have a 'data minimization statement' which includes policies that will minimize data collected that is not relevant to the investigation, require the destruction of data not needed, and establish oversight procedures.
- Enforcement can come via the FAA in license revocation, and the Attorney General of each state would be empowered to file a civil suit.

Regulation and Legislation on a State Level

Last year 42 states put legislation on the floor to restrict UAS operations on the basis of privacy. Of these states, only eight had proposed legislation become law, however more are expected to follow. A majority of these laws are to restrict law enforcement agencies from using UAS in certain ways without securing a warrant. In a few of the states like Idaho or Texas, laws are now on the books restricting use by private users (The Economist, 2013). In the Texas law the more stringent regulation fall on the private user while law enforcement enjoys fewer rules (Bohm, 2013).

In addition the limitation on use of UAS during a warrantless search, both Illinois and Tennessee have enacted laws that would restrict the length of time data could be retained that was not pertinent to the investigation being conducted. The Illinois law restricts the data retention time to 30 days, where Tennessee only allows 24 hours until the data must be deleted (Bohm, 2013).

The Alaska State legislature passed House Bill 255 in the summer of 2014, which went into effect in October of the same year. This law specifically addresses law enforcement agencies and their ability to collect evidence in a criminal investigation. The law states a warrant must be obtained in order for the search to take place with exception for emergencies and judicial precedence. In speaking with a member of the Legislative Task Force that helped to draft this bill, Ro Bailey, she stated state drafted law would be the most effective form of legislation as local legislators have an understanding of current laws and an understanding of the functions within their state.

As the possibilities to infringe on these rights advance, we too must advance and create a system to ensure that no such thing is taking place. As the ability to commit crimes from different means arise, new laws must be implemented to address them. California has already amended section 1708.8 of the civil code to state anybody caught using a camera UAS to take pictures of somebody "under circumstances in which [they] had a reasonable expectation of privacy," and where said picture could not have been taken without trespassing if the UAS hadn't been used, will face serious penalties" (California, 2014). Agency's will have to be created to monitor those using UASs (both civilian and government) to ensure privacy rights are upheld. The president plans to put together an executive order asking the National Telecommunications and Information Administration to come up with rules relating to consumer privacy, unmanned aircraft, and the interaction between the two (Wilhelm, 2014).

Another option to ensure privacy is UAS blinding software. Tim Faucet CEO of APLUS Mobile has developed a system includes software and sensors and will be able to identify nearby

UASs based on their electromagnetic signature, alert the owner of the system, and neutralize the UAS capability to see you with its camera (Stone, 2013). The system will not do any harm to the UASs camera; it will only disable the UAS from filming a certain radius with the software

Illegal activity

With the possibility of UASs being easily convenient use for the transportation of illegal goods there must be a way to monitor and regulate the system. A slew of recent reports confirm that Mexican drug cartels have begun manufacturing their own UASs to smuggle narcotics across the border into the United States. (Tucker, 2014) While drug cartels and terrorist organizations can transfer illegal goods extremely easy the future outlook of UASs my show government systems used to ground any suspicious UASs. It may also need to enforce future tracking devices into UASs and require registration in case a UAS is being used to conduct illegal activity so the operator can be held reliable for their actions.

Law enforcement UASs and cameras may also be used to monitor activity as some options. Anytime a new form of transportation is developed there will be people who abuse the system and use it to transport illegal goods. Are you going to catch them all? No. But there has to be a process to stop a majority and detour individuals from committing these acts.

Privacy Recommendations

The ALCU is taking a stand against the use of UAS for surveillance as it is seen as an affront to personal privacy for American individuals. They submitted a list of recommendation for legislation in their document titled "Protecting Privacy from Aerial Surveillance: Recommendation for Government Use of Drone Aircraft". The measures they advise are enacted include:

- Adding use restrictions such as limiting mass surveillance or spying on first amendment protected activities. General exceptions are allowed for life threatening emergencies or in situations where a warrant has been secured.
- Implementation of image retention restrictions
- The use and procedures of unmanned surveillance should be made public
- Controls and policies should be made via the democratic process and not by local police (Stanley & Crump, 15-16, 2011).

Conclusion

The President's signing of the FAA Modernization and Reform Act of 2012 put into action the first steps in integrating sUAS into the National Airspace System. Since that time, manufacturers have made great advancements in the technology of sUAS available to the public. The FAA's approval of six test sites gives manufacturers the ability to quickly move toward certification of their systems, while Air Traffic Control integration and Sense and Avoid technology is close behind. Although the FAA is working hard to create an atmosphere where expanding technologies are integrated quickly, the rate at which these aircraft are being produced and sold for commercial operations requires the integration of forthcoming regulations to be quickly implemented and rigidly enforced. The time for action is now. The FAA's Notice of Proposed Rule Making on sUAS must be finished and released, comments received and regulations passed in order to safely integrate these sUAS into our skies.

Recommendations

- Require pilots of commercial sUAS operations to have at minimum a Private Pilot license.
    - Create a certification (by weight of aircraft) specifically for UAS pilots through a FAA training and licensing program.
    - Create a training and testing program specifically for observers to standardize observer's practices and certification.
    - Require currency requirements for pilots of commercial sUAS every 90 days.
    - Require pilots of sUAS to conduct annual recurrent training.
    - Require that pilots and observers of commercial sUAS have at least a valid 3^{rd} class medical.
    - Require that FAA examiners conduct all flight-testing for certification of pilots and FAA testing centers conduct all written testing for certification of pilots and observers.
    - Require manufacturers be held to the same standards as manned aircraft in respect to safety, reliability and redundancy.
    - Allow manufacturing design standards to be developed for specific application and operating environment without needing to address all designs and applications.
    - Implement a specific area of Air Traffic Control specifically geared towards UAS.
    - Incorporate sUAS into the NEXTGEN planning to ensure there are no limitations on their use as NEXTGEN is fully implemented.
    - Supersede overly restrictive state legislation enacted within the recent past.

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Group Member Contact Information

Samantha Alex	samantha.alex@hotmail.com
Kenneth Cook	ka.cook@gmail.com
Samantha Davis	samanthakathleen@hotmail.com
Desiree Decoito	aviationaddiction@gmail.com
Lindsey Deutsch	lindsey.deutsch@gmail.com
Erwin Domingo	domingoet@gmail.com
Ryan Frenchik	r.frenchik@yahoo.com
Hayley Harris	hayleylharris@yahoo.com
Keith Hoffmann	hoffkeit@gmail.com
Michael Kvasnicka	mjkvasnicka@gmail.com
Caleb Martineau	calebmartineau@hotmail.com
Myla Nawiesniak	mfnawiesniak@alaska.edu