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Comparative Analysis of Small Unmanned Aircraft Systems Operations Manuals

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Abstract

With over 100,000 remote pilots in the United States, individuals and companies are rapidly incorporating unmanned aircraft system technologies into their everyday life and businesses models. The companies that use these technologies must comply with federal and state regulations in order to maintain a safe environment to operate. These operations must also be accepted by the general public. Since the FAA regulations for small unmanned aircraft systems (sUAS) went into effect in 2016, supplemented by additional state and/or local requirements, some companies have generated operations manuals (OM) to ensure consistent, safe flight that meets these requirements. By analyzing the OM's of 35 companies from various industry sectors, companies can use these findings to improve their processes for recency of flight experience, additional training and knowledge beyond 14 C.F.R. Part 107 requirements, privacy concerns, and the execution of emergency procedures. The findings conclude that of the companies who impose currency requirements, 59% are defaulting to the manned aircraft requirements and 77% are mandating additional initial training. Fifty-nine percent had emergency procedures incorporated into the OM, but only 24% of companies would meet the requirements for the Trusted Operator Program Level 3 certification. Addressing the privacy concerns of the public was more prevalent in state agencies than Federal or local agencies.

Keywords: unmanned aircraft systems, operations manual, recent flight experience, privacy, training

Comparative Analysis of Small Unmanned Aircraft Systems Operations Manuals

Operating manuals are used throughout various industries to govern how a business operates. They are required for airlines operating under 14 C.F.R Parts 110-139, but not required for commercial operators flying sUAS under 14 C.F.R. Part 107. Given that companies may want to provide detailed guidance to their operators, and conduct sUAS operations consistently, some sUAS companies have generated their own OM.

The OM is designed to describe how the company intends to conduct its business, a hierarchy of roles and responsibilities, and what is required to maintain the skills of their sUAS crews. Sometimes referred to as a standard operating procedure (SOP), both these manuals include instructions on best business practices, actions to take in an emergency, and an overall outline of the business. The World Health Organization (2019) stresses the importance of using an OM to "carry out the operations correctly and always in the same manner." They state an OM contains health and safety information, applicable data for the activity and clearly defines the steps to produce the result (World Health Organization, 2019). Other sections of an OM may include a discussion on the purpose, regulations, definitions of uncommon terms, how to monitor the process, a reference to other OMs and a history of what was changed with each revision.

This research is timely given the FAA's final rulemaking for remote pilots came into effect in 2016. By the middle of 2018, there has been over 100,000 Remote Pilot Certificates issued (FAA, 2018). The Unmanned system industry is expected to expand almost exponentially through the mid-2020s. Howard, Murashov, and Branche (2017) stated that the commercial job market alone for sUAS will be in excess of 100,000 jobs and have a total investment of five billion dollars by 2025. The largest sectors of growth are for monitoring and inspections.

Various types of research have been conducted regarding pilot experience, recent flight experience and the severity of an accident. One researcher noted that mishap rates drop drastically once a pilot achieves greater than 1200 hours of flight experience (Baumann, 2017). Another set of researchers found that pilots who have recent experience flying under manual (non-autopilot) controls were able to more precisely control an aircraft simulator when tested for their study (Ebbatson, Harris, Huddlestone, & Sears, 2010). However, there has not been a federal rulemaking or a sUAS industry organization stating the best topics or minimum flight times to maintain a RPIC's skills. The only requirement is a recurrent knowledge test.

This research determines the commonalities and differences from 35 operating manuals. This analysis was conducted to provide a view of how commercial sUAS operating companies are addressing concerns by the public as well as the unique nature of operating as a remote pilot. Companies that either has a sUAS program or want to establish one can leverage these findings and ensure they are operating by industry best practices. The following questions are analyzed:

- Are their requirements for recent flight experience (currency)?
- Does the company address privacy concerns?
- Does the company specify initial and recurrent training requirements?
- Is there an imposed flight distance restriction too people?
- Does the OM address the unique characteristics of lithium batteries?
- Does the OM contain additional methods to increase safety during a flight?

History and sUAS Industry Growth

The FAA publishes their own studies and predictions for the growth of the UAS economy in form of aerospace forecasts. Backward-looking, the FAA saw a growth of over 150% in commercial UAS registrations between 2016 and 2017 with a growth projection to quadruple by

2022 (FAA, 2018a). The most recent forecast for 2019-2039 shows a sustained growth rate of greater than 40% annually, shattering the previous 2018 estimates. This growth is attributed to filming, inspections, real estate, and general UAS training.

The White House released a fact sheet in 2016 stating that the U.S. economy would be stimulated by $82 billion by the drone industry in 2025. The report focuses on the safe integration of UAS into NAS with the infusion of millions of dollars into research for UAS integration as well as education on privacy best practices (the White House, 2016).

Prior to 14 C.F.R. Part 107, commercial operators had to obtain either a Certificate of Authorization (COA) in order to operate a sUAS on a non-hobby basis. These certifications were issued on a case by case basis and required extensive input and research by the applicant. Initially, a pilot certificate was required for any operation not meeting a certain restriction. Those restrictions required operation in sparsely populated areas, within visual line of sight not to exceed one nautical mile laterally or 400ft AGL, daylight only operations and not within 5 nautical miles of any public airport or heliport. In order to issue a COA or special certification, the FAA may require sUAS operators to remain current by completing three takeoffs and three landings within the previous 90 days. Initial training on the airframe, normal and emergency operations should be conducted as well (Mirot, 2013).

Public commentary on safety concerns was captured in the federal registrar prior to the final ruling making of 14 C.F.R. Part 107. The International Association of Amusement Parks and Attractions had concerns about operations just outside the boundaries of the amusement park, specifically the operation over people or not limiting the distance from non-participating bystanders. They cited that rides can reach speeds of over 100 miles per hour and collision with a sUAS could pose a serious safety risk. Electronic Privacy Information Center and others

requested geo-fencing be mandated to protect no-fly zones. The FAA recognized this technology but stated that part of safe operations may require a pilot to enter a restricted area to avoid a manned aircraft (Operation and Certification of Small Unmanned Aircraft Systems, 2016).

In the two years since the final sUAS rulemaking, the FAA has received many requests for waivers for operations at night, airspace restrictions and multiple UAS operations (AUVSI, 2019a). These requests have spawned some proposed changes to the rulemaking. One proposal is to split the sUAS field into three categories with additional operating guidance for certain situations. Due to the heavier weight of the category 2 and 3 sUAS, if they were to be flown over people, then the manufacturer must provide the PIC with operating instructions and limitations for the specific airframe (Operation of Small Unmanned Aircraft Systems Over People, 2019). The proposed sUAS changes are further discussed under sUAS Pilot Knowledge and Experience.

With such rapid growth in sUAS operations and the evolving regulating environment, operating manuals can be used to safely operate a sUAS while complying with regulations. Companies may impose a requirement to remain familiar with the aircraft controls, or the company may continue to operate under a COA that requires pilots to remain current. Certain operating environments may pose additional risks such as operating close to large populations, at which point the commercial operator may want to impose additional restrictions for speed or distances. All these requirements can be contained in the company's operating manual.

Benefits of Operating Manuals

For this paper, the operating manual (OM) will be defined as the governing procedure to use during UAS operations. The OM contains sections that describe the specific steps to take during operation of a UAS to consistently reproduce a certain outcome or action. Operating

manuals maintained by a company are also a valuable tool for the legal operation of an unmanned aircraft system (UAS). On top of the Federal Aviation Administration's requirements for UAS operations, states may have enacted their own legislature. Nowhere does Georgia prohibit the use of a UAS to conduct surveillance on a private citizen, the state's privacy concerns are addressed under different legislation. However, if the Georgia based company performed a job across the border in Florida and by happenstance surveyed a non-consenting individual, then the company is in violation of Florida law (Rupprecht, Florida Drone Laws, 2018).

States may enact their own certification requirements or restrictions on flights for privacy concerns. Louisiana, Alaska and North Carolina all have state-mandated training and certification requirements to fly an sUAS within their borders. Some states exempt research institutions from restrictions while states like Texas exempt sUAS used for surveying or mapping (Donohue, 2018).

Szabo et al. (2015) examined the use of Emergency Manuals (EM) in crisis management. Emergency Manuals are used during times when an operator's ability to retrieve knowledge is diminished like times of high stress. These manuals aide in making important decisions or taking specific actions that can provide for a better outcome to the situation. The researchers point out that the use of EMs in a medical environment is relatively new, with widespread adoption being very slow and current best practices from across the industry not fully defined. They recommend generalizing situations that the EMs are designed for, similar to the FAAs air traffic policy that acknowledges procedures cannot account for all situations (Szabo, et al., 2015).

The operating manual for a commercial company acts like the spine does for the human body, supporting all the other functions that must occur. It is a knowledge base to allow operators to consistently perform a task using clear guidance whilst abiding by the specific laws and regulations for their unique operating environment. The OM also assigns accountability for specific activities, allowing the team to work efficiently and without unneeded conflict (Mulholland, 2017).

sUAS Pilot Knowledge and Experience

In 2015, a panel was held to determine additional areas of needed research, specifically on human performance issues with respect to remotely piloted aircraft systems (RPAS). The panel recommended that operating companies take into consideration the degradation of knowledge and skills, specifically operators who have difference certificates or overall experience levels. They specifically state that:

> A pilot who only operates an RPAS in cruise may accumulate many flight hours, but never experience a takeoff or landing. Conversely, a pilot who is assigned takeoff and landing may accumulate significant experience with this phase of flight, while logging relatively few flight hours (Shively, Hobbs, Lyall, & Rorie, 2015, p. 15).

Although the panel identified a pilots skills would degrade over time, they made no specific recommendations on specific skills or recommended times to remain familiar with the controls.

The degradation of pilot skills is also backed up by research in manned aviation mishaps when looking at the amount of recent or cumulative flight time. A negative correlation is observed between increasing flight time (experience) and the severity of a mishap. More flight time in the previous three months resulted in less severe mishaps for Naval aviators. It is also important to note that the mishap rate drastically drops by about 50% once a pilot achieves a

high accumulation of flight time (greater than 1200 hours) (Baumann, 2017). This research argues that periodic flight requirements and obtaining a high number of flight hours drastically lowers the severity of a mishap.

Other organizations have made recommendations for what they believe are best practices for training, skills, currency and proficiency when flying a sUAS. The Aviators Code Initiative is focused on developing tools to increase aviation safety. Their 2018 report called the *UAS Pilots Code* states that UAS pilots should pursue a lifelong study of aviation and participate regularly in methods to improve proficiency. This may include the development of a training program and a review of airframe specific limitations and operating characteristics. They also advocate the use of simulators that model the sUAS characteristics to conduct emergency procedures such as loss of link procedures. The code leaves out any specific currency requirements but recommends that pilots should fly often enough to maintain proficiency in manual and automatic controls for their specific certifications (Baum, Kiernan, Steinman, & Wallace, 2018).

The final ruling went into effect in August of 2016, but prior to its enactment, the public commented on the ruling's provisions. The FAA and many commenters agreed that pilots must be knowledgeable of emergency procedures and the proper actions to take if an emergency arises. The FAA also addressed the issue of flight proficiency and experience by stating sUAS pose a small risk and that flight proficiency or previous experience will not be required to operate or maintain certification. The commentators voiced opinions for and against a mandate requiring a flight examination before certification, but given the restricted weight, ability to sacrifice the aircraft for safety and NAS limitations, the risk was assessed as too low to require expensive testing prior to certification. This same argument was heard over the topic of

mandated initial training, with companies like Southern Company voicing that the FAA should not mandate a formal training course but provide material online. Many companies stated that tailored certification practices by industries would provide better training than a broad-scoped lesson administered to every potential RPIC (Operation and Certification of Small Unmanned Aircraft Systems, 2016).

The 2019 proposed modification to 14 C.F.R. Part 107 also received comments regarding the amount of training and experience that RPICs must have. The FAA acknowledged that pilot experience may be a factor when the proposed Category 2 or 3 aircraft are operated. Category 2 sUAS would be allowed to fly over people if the manufacturer could certify an impact with a bystander could not injure them beyond a certain threshold. Category 3 aircraft can be larger in size and still fly over people if additional operational restrictions are put into place. One commenter requested that additional training be required for operation over people although offered no specifics. The FAA has asked for more input on this matter, specifically what skills, experience, and currency requirements are required beyond the current regulations. The FAA declined to add any restrictions to standoff distance to bystanders, citing that there are already regulations for operating the sUAS in a manner not to pose any hazards to people or other aircraft (Operation of Small Unmanned Aircraft Systems Over People, 2019).

One final proposal is to modify the 24-month re-examination and require recurrent training modules, that can be completed online. The FAA believes this is a more cost-effective method of evaluations as well as a way to tailor additional training modules based on the RPICs level of knowledge and areas for improvement. Additionally, this opens up recurrent training and flight proficiency to be tracked by the operator's company, leveraging an already in place recurrent training program (Operation of Small Unmanned Aircraft Systems Over People, 2019).

The industry has acknowledged that remote pilot skills can degrade over time. Manned aircraft research shows that accumulating hours of flight experience as well as having more recent flight experience can reduce the severity of an accident. Although not specifically required at this time, the FAA has asked for additional input for what specific skills, experience, emergency procedure usage, and currency requirements the sUAS operators are using to remain knowledgeable on their airframes. This research into the OM's of various companies shows that initial and recurrent training are being addressed by companies above and beyond the requirements of 14 C.F.R. Part 107.

Recent Flight Experience (Currency)

In general, recent flight experience is required for PIC per 14 C.F.R. Part 61.57 (subpart A) when carrying passengers or flying a multi-pilot aircraft. A pilot remains current for the specific aircraft type by completing a set minimum number of takeoffs and landings within a given time period. This experience consists of a minimum of three takeoffs and three landings within a 90-day window (14 C.F.R. §61.57, 2019). While there are certain exemptions or substitutions, pilots are required to maintain currency in their aircraft by exercising actual flights. Refer to Appendix A for a list of abbreviations and definitions describing the differences between remaining current as well as a pilot remaining proficient. General Aviation pilots must also complete a flight review that is assessed by an evaluator to ensure the pilot is proficient in the knowledge and skills required to safely operate the aircraft type. 14 C.F.R.Part 107 for Small Unmanned Aircraft Systems, however, does not require any recent flight experience, only a biennial multiple-choice exam (14 C.F.R. §107, 2019). This places the responsibility on the company or individual operating the UAS to maintain an appropriate level of knowledge and experience.

The requirements of recent flight experience have also come into question regarding small aircraft accident rates. Nilsson (2011) researched the relationship between recent flight experience and pilot error. This research reported that over 70% of general aviation accidents were attributed to pilot error, with 50% of all accidents involving decision making and a loss of situation awareness as the main contributing factors. The exact type of situation awareness is not described in the research, but the information was obtained from the FAA training standards. Nilsson (2011) compared the hours flown in the previous 90 days before a pilot's accident to the accident cause. The goal was to determine if flight time was a direct correlation to pilot error rates, and if purely practicing aircraft handling characteristics every 90 days makes a PIC a better decision maker. Nilsson states that the majority of companies still rely on characterizing how safe a pilot will be based on recent flight experience, which reinforces their mechanical motions (stick and throttle skills) of controlling an aircraft, and not the mental process of flying an aircraft. The findings of this research are that currency is not a predictor of accidents related to pilot error, and purely having flight time does not increase a pilots ability to reduce accidents by decision making and increasing their situation awareness (Nilsson, 2011).

Small Unmanned Aircraft Systems have become very automated devices, capable of automatic take off and landings as well as the ability to fly a particular path with precision camera controls at every waypoint. Software developers have made it very easy to fly a sUAS and never have to take manual control the aircraft unless there is a malfunction. With this level of automation and only a knowledge test required for the FAA Part 107 certification, RPIC's may very rarely manually fly their sUAS.

Focusing on the manual skills potentially lost by not practicing them, Ebbatson, Harris, Huddlestone, and Sears (2010) had 66 commercial pilots use a Boeing 737-300 simulator with an

automatic flight management system that was disabled. The pilots were directed to perform a landing approach, under manual control, with factors such as crosswind and deteriorating weather conditions. The data obtained was compared to the previous week's flights, which were under computer-assisted flight management and manual control. Measurements were taken for the amount of input required to control for pitch and yaw, the deviation from the intended flight path as well as the number of control inputs needed. Results showed that pilots who flew with manual controls more often required fewer inputs into the control system and maintained a smaller deviation than those pilots who flew less often with manual controls (Ebbatson, Harris, Huddlestone, & Sears, 2010).

While manned aircraft have a currency requirement for pilots, 14 C.F.R. Part 107 does not require any recent flight experience. Research shows that pilot error is the major cause of general aviation accidents. With advancements in sUAS automation, a remote pilot may very rarely fly under manuals controls, thus having their skills and knowledge of aircraft operational characteristics decay over time. This paper shows that of those companies imposing requirements for recent flight experience, 59% are using the standards of the manned aviation community to maintain their pilot's skills.

Privacy

Some states have left the existing photography and video recording laws that were in place before sUAS became popular while other states have expanded their privacy laws. For example, in Mississippi, it is considered a felony to use a sUAS to record an individual without consent on their private property, and Louisiana has fines starting at $500 and imprisonment up to a year depending on the severity. The state's regulations of sUAS may also extend into law enforcement organizations, requiring them to obtain a warrant prior to using sUAS as part of an

active investigation. In the previous example for Florida law, warrants are required and tied to the Constitutional Fourth Amendment (Donohue, 2018).

The National Telecommunications and Information Administration (NTIA), at the direction of The White House, published a list of UAS industry best privacy practices to aide in the public adoption of this technology while maintaining the public's constitutional rights. These recommendations included:

- Notifying individuals of the purpose, what data is to be collected and whom it may be shared with.
- Identifying practices to respond to privacy or security complaints and law enforcement requests.
- Minimize the time the UAS is collecting data as well as adjusting the position or angle at which the UAS collects the data.
- Limiting how long the data is stored, how it is used and shared with stakeholders.
- The use of a written security policy to control the collection, storage and use of data. It should include a requirement to monitor for security breaches.
- Monitor and abide by the changing federal, state and local UAS legal requirements (National Telecommunications and Information Administration, 2016).

The Obama Presidential administration published a Presidential Memorandum encouraging the use of UAS while still protecting the privacy and civil liberties. The memorandum specifically requires that government organizations who use UAS shall examine the existing UAS policies and procedures governing UAS data collection or storage and update their procedures they operate by at least every three years. This policy restricts data storage for no longer than 180 days unless specifically authorized. This policy also directs the development

of policies and operating guidance that respect civil rights and liberties for data collection as well as establishing lines of accountability and oversight. Specific requirements for accountability and oversight include procedures for training for UAS operators, reporting of abuse, data sharing and authorization for work with other federal, state and local governments (The White House Office of the Press Secretary, 2015).

PrecisionHawk and Intel published an article discussing methods to limit the data obtained while controlling a UAS. Self-imposed restrictions on flight locations via geo-fencing can limit the amount of personal data obtained during the autonomous flight (Vivet & Smith, 2016). Geo-fencing uses a self-defined area set by Global Positioning System coordinates to keep a sUAS within a certain area or prevent the flight from entering a certain area. It can be characterized by two cases, keep-in or keep-out. Keep-in geo-fencing is adaptive to the environment and can allow operators to accurately collect the required data while maintaining a margin to private property. Keep-out geo-fencing is designed to protect the structures and property that is within the exclusion zones (Cho & Yoon, 2018). Companies may use this technology to restrict their flight operations to certain areas, thus limiting the amount of personal data collected during the mission.

Public input was taken prior to the 14 C.F.R. Part 107 enactment regarding privacy. The FAA states the privacy concerns were beyond the scope of the rulemaking, but they support the NTIA's and Presidential Memorandum regarding privacy best practices. Over 180 participants voiced opinions on whether the FAA should mandate measure for privacy assurance but there was no consensus. The Electronic Privacy Information Center stated that the FAA needs to establish privacy regulations as part of its fulfillment of a Congressional mandate enacting the FAA Modernization and Reform Act of 2012 to incorporate sUAS into the NAS. The FAA stated

that there is a long history of using information gathering devices on manned aircraft and that the FAA's job is to regulate and maintain safe operation of aircraft in the NAS. The FAA cited the 2012 sUAS incorporation requirement and stated that nowhere in public law is any requirement to address privacy concerns (Operation and Certification of Small Unmanned Aircraft Systems, 2016). The FAA's position on regulating privacy concerns was upheld in the recent comments regarding proposed changes to 14 C.F.R. Part 107 (Operation of Small Unmanned Aircraft Systems Over People, 2019).

Recently, Fairfax County VA established a sUAS program and held very open community events and public comment sessions to address the concerns residents had regarding the program. Community engagement was also conducted with media coverage, articles in public newsletters and national news via AUVSI. Flying a sUAS for law enforcement requires a warrant unless an Amber, Blue or Senior alert is issued or for crash reconstruction documentation under Virginia law (Fairfax County VA, 2019). An Amber alert is issued with a child is abducted, a Blue alert is when a suspect has caused serious injury to law enforcement and has not been apprehended, and a Senior alert is used when a senior adult is missing (VA §52-34, 2019). The public commented on the issue of privacy and data collection/retention during the community engagement sessions and the 30-day comment period. These concerns led to revising the Fairfax County OM prior to its final release to include a biennial review of the program with community engagement, increased information sharing to include policies and flight data, restrictions on the use for law enforcement, precautions to avoid inadvertent recording of non-mission data and the adoption of a minimum imagery collection standard (Fairfax County Virginia, 2019).

Specific state laws vary with regards to invasion of privacy and collecting private data. Operators must be knowledgeable of their state's requirements in order to operate a sUAS within

the boundaries of their state laws. The NTIA has published recommended guidelines to limit the amount of personal data collected, and a Presidential Memorandum has recommended operating procedures be updated at least every three years to remain current in privacy issues. Although the FAA has not made any rules regarding the use of sUAS and personal data capture, numerous participants have voiced their concerns regarding this issue. This research shows that even though state and federal requirements exist, and top-level recommendations have been available for over two years, less than half (47%) of the operating manuals analyzed address the issue of privacy or methods to limit data capture.

Review of Relevant Literature – Operating Manuals

There is very little academic research on the use of Operating Manuals for the sUAS community. Commercial companies are reluctant to release their OM, as they treat it as proprietary information that gives them a competitive advantage. There is, however, research on what an operating manual should contain, as well as the benefits of using an operating or emergency manual.

Operating Manuals are also designed to be a living document and updated as best practices, laws or other regulations change. Although they are very common in all different industries, there are very few references on how to write a beneficial operating manual. Lopinto (1984) describes the process and the major modules of an operating manual as follows:

- A summary illustrating the purpose of the module
- An introduction to the process
- A detailed description of the equipment or process
- A section on the routine operation of the equipment
- A section on troubleshooting and equipment malfunctions

- A section on maintenance, testing, and records
- Emergency operating guidelines and information on the emergency controls
- An appendix of drawings and figures (Lopinto, 1984).

The FAA has published Order 8900.1 with guidance on what a General Operations Manuals (GOM) needs to contain to meet the requirements of 14 C.F.R. Part 121 and 135. The manuals contain the duties and responsibilities for employees as well as guidance on how to comply with FAA operating requirements and safety practices. The hierarchy of management is required to be written out as well as descriptions of what is allowed and not allowed for a flight crew to perform. Crew manning also needs to be addressed, both for flying the airplane as well as the ground support and members to coordinate flights (FAA Order 8900.1). It is also important to note that a training program curriculum is required to be contained in the GOM for each type of airplane (14 C.F.R §121.403, 2019).

Jonathan Rupprecht is an FAA commercial pilot and lawyer specializing in aviation and sUAS law. When integrating sUAS into a large company, Rupprecht found some distinct areas that may pose a problem. First, how is the sUAS part of the company going to operate? Three areas to focus on are how is the sUAS part of the company structured and is the operating manual going to cover the different operating environments. The operations team may reside within another department like research and development, or it may be its own entity thus allowing it to provide services even outside the company. The operating manuals need to provide step-by-step procedures for each operation, whether it be nighttime operations, operations from a vehicle or within controlled airspace. Being specific with the requirements in the OM clearly defines who is responsible for the data obtained and who will ensure no data has been misplaced or not transferred to the client (Rupprecht, 2019).

Drone Deploy is one of the largest online data processing platforms for sUAS, servicing over 400,000 job sites all over the globe (DroneDeploy, 2019). In a 2017 webinar titled Building a Drone Business, Edward Schmalfeld of Dragonfly AeroSolutions discussed the importance of being an expert in a specific field when developing or incorporating sUAS into an organization. The discussion was focused on the steps taken to build a remote surveying company and the parts of the organization that he relies on to make the business work. Goals and function of his business are spelled out in an operating plan and he has filled those functional areas with specific people and resources who are accountable for those areas (DroneDeploy, 2017).

The company starting a UAS program must research and purchase the correct aircraft for the missions and abide by the FAA requirement to have a logbook and a maintenance program. The pilots also must be certified, and in some cases, the company may want a certain number of flight hours to prove a level of experience. Aircraft manuals, maintenance logs, and training manuals should be maintained and updated frequently, this includes the aircraft and controller software. The operating manual should specify these frequencies. The operating manual should include a means to receive feedback from new hazards and operating experiences, and be updated to reflect these situations (Rupprecht, 2019).

A startup UAS program within a company must also consider the pilot skills required to safely operate the aircraft and accomplish the mission. For example, does the pilot also have to be the sensor operator during flight or can this be programmed to autonomously collect the data? Will the pilots be required to work near other people and structures, thus increasing the likelihood of an incident? If so, then what additional flight training or skills maintenance should that company impose on their in-house operators? All these questions should be addressed by

the company, with legal and management input prior to operations. The OM needs to reflect these policies and company standards to ensure consistent and safe operation (Knight, 2019).

Industry Best Practices

A group of United Kingdom researchers, working with the U.K. Civil Aviation Authority (CAA) generated their own list of best UAS practices. This initiative was driven by researchers and CAA supporting members to share operating experience and is one part of the required OM that a company must generate before they are granted CAA permission for aerial work. The researchers stated that CCA credential are becoming more desired, with landowners and companies requesting the certifications more frequently. The researchers found that having the credentials made it easier to work with landowners who are cautious to give permission to work on their land. The OM and CCA credentials allowed the researchers too "demonstrate competency, safety, and reproducibility of drone operation" (Cunliffe, Anderson, DeBell, & Duffy, 2017, p. 2737).

Oak Ridge National Laboratories (ORNL) has published a document outlining best practices for sUAS use by the electrical utility industry. They advocate for initial and continuing training beyond the FAA requirements. Initial training should demonstrate safe operation during both normal and emergency operations. These exercises should resemble real-world scenarios, and contain a debrief afterward to discuss the operations, roles, checklist usage, and equipment performance. VO's should be used in these training exercises to reinforce their roles and responsibilities. Every 12 months, each crewmember should receive recurrent training on regulations, operations, airspace, safety and weather conditions.

ORNL has safe battery charging recommendations to minimize the chance of a lithium-ion battery fire. This includes specific temperature ranges for charging as well as precautions for

minimum charging temperatures and cooldown periods before/after use. Storage and disposal are discussed, specifically the battery discharge properties for long term storage and what cell voltages to expect during storage or return to operation.

The best sUAS practices for the electrical industry reference the 2016 National Telecommunications and Information Administration's (NTIA) privacy report. In addition to the NTIA recommendations, ORNL recommends the following:

- Reviewing operating practices to minimize the sUAS noise nuisance
- Selecting operating areas that are unpopulated or establishing a person free operating area
- Avoiding data that is personal in nature and responding to requests for data deletion
- Diverting sensors away from occupied structures
- A method of notifying the public of sUAS operations in their area

ORNL recommends a minimum pilot rest time between operating periods, referencing a study by the United States Navy shows that shows after 18 hours of being awake, performance efficiency drops by at least 25%. ORNL recommends a maximum duty time of 10 hours with at least 10 hours of rest between duty days (Lusk & Monday, 2017).

The Association for Unmanned Vehicle Systems International (AUVSI) has published guidelines for their Trusted Operator Program (TOP). TOP is designed to develop UAS operators through a tiered training approach and certify their skills so hiring companies and individuals know they are getting a quality operator. Using input from AUVSI members and their newly formed Remote Pilots Council, the program seeks to improve safety, risk management, and reliability (AUVSI, 2019b). The three levels of certification are as follows:

- Level 1: Routine flights per 14 CFR part 107 without waivers on aircraft weighing less than 5lbs.

- Level 2: Any flight requiring a waiver, flights requiring a VO or flights with elevated risk.
- Level 3: Operations in safety-critical areas or operating in hazardous environments. Operations during airframe development or weights over 55lbs are also included.

TOP service providers are required to have in place a management system and operating procedures. They are also required to have a training, maintenance, safety and flight-testing program in place. TOP service providers and individual pilots, seeking Level1 certification are required to stay proficient and practice complex or emergency scenarios to keep their skills sharp. Level 2 and 3 certification requires documentation for proficiency or recurrent training and a method of ensuring completion. However, the exact number of hours or scenarios to maintain proficient is not spelled out, nor are the requirements to remain current (AUVSI, 2019b).

For this study, only the TOP Level 3 certification will be used. Individuals wishing to achieve this certification must show they have a management system in place that includes a training program and UAS flight assessments. Organizations wishing to be Level 3 certified must also establish operational procedures, maintenance, and airframe inspection program, as well as a safety management program. The operating procedures of these companies must address the following areas:

- Normal, emergency, pre-flight and post-flight procedures
- Flight, maintenance and inspection logs
- A safety management program
- A method to manage risk

- Addresses OSHA requirements for fatigue, protective clothing, etc.
- Roles and responsibilities of individuals
- A training program and a method to maintain proficiency
- A flight practical assessment to assess skills
- A safety reporting program (AUVSI, 2019b)

sUAS Training

Wallace (2016) argues that remote pilots are at a disadvantage because of their lack of training in crew resource management and the lack of a positive safety culture. He states that the sUAS pilots who have not received formal manned aircraft training have not been exposed to the risk management and mitigation strategies that flight schools teach. He cites the lack of a safety culture instilled by a large aviation community and a general lack of an outlet to voice safety concerns in the form of a non-mandatory reporting method. He proposes the FAA adopt a method of re-certification and currency maintenance based on a voluntary pilot education program called WINGS This program exercises learning and flight training exercises to overcome common aviation accident situations on the premise that pilots who maintain currency and proficiency in the basics of flight will enjoy a safer and more stress-free flying experience.

The use of a program to have sUAS pilots participate in will connect them to other aviators, industry experts and regulators allowing for an open exchange of concerns and rule clarifications. It also establishes a learning culture amongst sUAS pilots, where they can experience different situations via a recurring process (Wallace, 2016). The proposal to have the FAA adopt a recurrent training program shows that maintaining current flight experience ensures an active safety culture where pilots are knowledgeable and capable of controlling their aircraft.

Benerson (2007) poses the question of who is the safer pilot; one with 10,000 hours but only 20 of those in the past year or one with 200 hours but one that has flown regularly in the past month. He discusses the requirement for a pilot examination every 24-months for manned aircraft too re-center pilots on the safe operation of their aircraft and as a breakpoint for any bad flying habits formed over the past two years. He states that pilots and their aircraft benefit from regular flight by maintaining skills and equipment at their peak conditions. Benerson encourages pilots to routinely review their Pilots Operating Handbook for airplane limitations and best operating practices. He also advocates for the FAA WINGS program as a method of maintaining pilot skills.

Summary

The rapid expansion of the sUAS market with a predicted 40% growth per year by the FAA, companies who want to incorporate sUAS into their business model need detailed operating guidance on how to safely, legally and reliably fly missions. Operating Manuals are designed to be a living document housing the best practices, operator qualifications, aircraft specific limitations, organizational structure, maintenance requirements and operating guidelines for all situations. Since laws vary between states for sUAS operations and protections of citizen's privacy, an operating company should address those issues in their OM so their pilots can legally complete their assigned missions.

When starting a sUAS program, the company should consider the job requirements and training required to learn and maintain pilot skills. While there are no federal regulations for maintaining any sort of flight currency or proficiency on the sUAS airframe normally flown, research shows that higher levels of aviation experience and more recent flight experience

correlates to a reduction in mishap rates. AUVSI's Trusted Operator Program and other industry leaders have published their recommendations for operations and sUAS industry best practices.

State laws regarding the invasion of privacy vary widely between the existing legislature and sUAS specific legislature. There may be differences in how law enforcement and other state agencies can operate sUAS within state boundaries. The White House and NTIA have provided recommendations for operators on methods to maintain personal privacy. While the FAA has upheld their responsibility for safe airspace operations, the public opinion indicates that people are concerned about their privacy as sUAS become more popular.

Methodology

A data set of 35 operating manuals from universities, state government operators, federal organizations and commercial sUAS operators flying under either 14 C.F.R part 107 or a COA were analyzed. The OMs were obtained from publicly available sources on the internet by searching for key terms like *UAS operating manual* or *UAS standard operating procedures* or by reaching out to organizations via e-mail. Multiple search engines like Google and DuckDuckGo were used to access the widest range of data and address variances in the search algorithms. Industry publications were researched, and companies were asked via e-mail to share their operating manuals or requirements for currency. Refer to Appendix B for examples of the request for information used.

The quantitative data from any recent flight experience was analyzed in Microsoft Excel and compared to the three takeoffs and landings every 90 days required for pilots of manned aircraft under 14 C.F.R. Part 61. These values are also compared to the mean values in different operating environments for commercial companies vs. universities.

If an operating manual required a certain number of flight hours instead of takeoffs and landings, the number of hours were converted to a number of flights possible given the average endurance of the airframe flown, taking into consideration if a minimum battery endurance time is required per the OM. For example, if a company requires five hours of flight time every 180 days, with a minimum of 20% battery reserves to land, and they primarily fly the DJI Phantom 4 then the company is assumed to require 13 flights every 180 days. This value will be figured by: (Total required time min) / [(Maximum flight endurance min)(useable battery %)] or in the case of the Phantom 4: (300min)/[(30min)(.8)] = 13 takeoffs and landings rounded up to the next whole number. The Phantom 4 flight time was obtained from the DJI website (DJI, 2019a).

Qualitative data was analyzed to determine to what extent companies OM's address training, privacy, battery and environmental efforts beyond existing regulations by text mining the OMs. Additionally, what methods the company used to increase safety during flight operations like having a set of emergency procedures or a minimum number of GPS signals were noted.

Assumptions

If no sUAS was stated in the OM, then the above equation maximum flight time is assumed to be 30 minutes. This value was chosen from the two most popular DJI products of the Phantom 4 and the Mavic 2 that have an average flight time of 30 minutes (DJI, 2019a). These products were chosen because as of 2018, DJI holds a market of 74% of all sUAS sold, with the Phantom 4 and Mavic 2 represents 55% of that market (French, 2018). Also, if the company requires those flights to occur within a calendar month window vs a certain day range, the analysis used 30 days per each calendar month. Values were adjusted to a base number common to all OMs which was 180 days.

Limitations and Delimitations

Limitations for this project include the limited data available publicly that a company is willing to share regarding their operating manuals. These manuals may be protected by the companies as it may give them a competitive advantage over other companies. Also, searches may return operating manuals that are designed towards a specific airframe standard operating procedure and not how the company deploys sUAS. In this case, the document is designed to operate the airframe and not how the company runs its sUAS program. Documents that do not discuss how a sUAS program functions will not be analyzed.

Delimitations include data analysis by only one researcher and that the recommendations generated from this research are intended to be applicable to companies operating in the NAS. With only one researcher compiling, analyzing and interpreting the data from the operating manuals, the interpretation of this data may be different than others. The majority of the OMs analyzed are from the United States and operate under the FAA, however, there were three manuals from the United Kingdom and regulated by the UK Civil Aviation Authority.

Summary of sUAS Operating Procedures

Embry-Riddle Aeronautical University (ERAU)

ERAU is an aeronautical university with degree programs in both manned and unmanned aviation. They rely on the flight operations manual along with a safety manual and sUAS-specific operating procedures to conduct their flight operations. Roles and responsibilities are defined, and training or certifications are listed for each position. Pilots must be qualified as a remote pilot and pass the VO, general and sUAS-specific knowledge exams prior to acting as a PIC. The minimum flight crew is the PIC, but if a first-person view system is used, then a VO is also required. The OM states that if the PIC has an AUVSI TOP certification, then they must

maintain the certification and document it in the tracking software used by the university. Emergency operations are contained in the sUAS-specific operating procedures and since the DJI Mavic Pro operating manual from ERAU is available, EOPs will be counted for increasing flight safety. Battery care is addressed to include charging precautions, identification of a faulty battery, cold weather concerns, and battery storage precautions. Privacy concerns are very high level and state that the PIC should be familiar with privacy rules and the public's expectations for privacy.

Currency for the PIC is maintained by one launch and recovery every 30 days on the sUAS they are qualified for. The flight must be at least 15 minutes to count. There is a process established for lapses in currency based on how long since the last flight occurred. ERAU imposes flight duty time limitations with required breaks between operations as a PIC as well as working day rules for maximum days worked and minimum time off requirements. Annually, PICs have to have a flight evaluation to maintain their certification. The OM states that recurrent training is to be conducted but there is no reference to specifics for this requirement (Embry-Riddle Aeronautical University, 2018).

Southern Company (SC)

Southern Company utilizes sUAS for inspections and surveys. Governed by the main body, the business model is broken down into smaller business units that support multiple sUAS flight crews. Roles and responsibilities are defined as well as the minimum level of qualification required for each position. The RPIC is ultimately responsible for the safe operation and operation of sensors in a responsible manner with regards to privacy. Privacy is maintained by limiting flights near personal space, limiting image use and destroying images with personally identifiable information.

Safety zones are established around the launch and recovery area and immediate flight path. These zones are established based on aircraft size and limit or prevent the people who are allowed inside each one for safety. SC also mandates that safety training be conducted with every member and reviewed on an annual basis. The OM discusses battery requirements under normal and cold weather conditions as well as setting a minimum battery reserve.

Initial training consists of classroom, computer-based and practical flight exercises. Recurrent training revisits the classroom and computer-based training and a flight review. Currency is maintained with three launches and recovery's in 90 days with a minimum of five hours of flight time. Additionally, every two years the PIC must demonstrate or discuss every general emergency procedure (Southern Company, 2016).

City of Los Angeles Department of Public Works

The Public Works Department of Los Angeles Bureau of Engineering's OM has compiled its recommendations from many other public procedures with a focus on safety and privacy. They focus only on public property and city-owned assets, turning the camera away from other structures and taking requests to delete private data when necessary. The OM limits flight time over private property and prohibits flights within 30 feet of people, power lines or structures. Operators should use sites that are naturally unpopulated to reduce the noise heard and prevent flights over non-participants. If this is not feasible, the PIC should have a plan to keep people clear of flight operations.

Roles and responsibilities are defined as well as a training schedule to occur every two months. This training should review flight procedures, emergency procedures, communication standards and 15 minutes of actual flight time. Currency is required with a documented flight every 90 days, which is satisfied by the recurrent training every two months. Initial training

must include topics covered under 14 C.F.R. Part 107 and additional topics of responsibilities, privacy concerns, safety and mission scenarios. There is a section for battery safety to include charging, transportation of, storage and disposal (City of Los Angeles Department of Public Works Bureau of Engineering, 2017).

California Department of Fish and Wildlife (CDFW)

CDFW OM defines the roles and responsibilities of each crew member. There are two types of pilots, provisional and certified. Provisional pilots have an FAA Remote Pilot Certificate and have completed the 2 day or 10 hours of flight time training. Certified pilots have additionally completed their policy training, passed the practical field exam and conducted at least two training missions. Training time during autonomous flight mode is limited. Recurrent training is specified, but no details are provided. Currency is maintained by logging at least three flights of five minutes every 90 days.

Privacy is addressed by not intentionally recording data where someone would have a reasonable expectation of privacy. Turning the camera away and trimming final images are methods to limit the amount of personal data obtained. Battery charging and precautions are contained in a dedicated section and general emergency procedures are included in the appendix (Brown, Laird, & Bonham, California Department of Fish and Wildlife Unmanned Aircraft System (UAS) Operations Manual, 2019).

Alabama Department of Transportation

The State of Alabama Department of Transportation (ALDOT) takes privacy into account when flying. They fly with the camera facing away from occupied structures and only use sUAS for data gathering on ALDOT projects, Alabama property such as bridges or damage assessment.

Roles and responsibilities as well as the frequency to review the OM and the aircraft specific operating procedures.

Training consists of three phases: Basic for the specific aircraft type, Advanced for the specific sUAS and its mission capabilities, and recurrent training. Recurrent training consists of a review of procedures and a semi-annual proficiency test. Operators are required to have a flight every six months. This OM states that more specific guidance for aircraft operations and emergency procedures are to be developed in the sUAS operating manual and that each operator should develop operational procedures (The State of Alabama Department of Transportation, 2017).

UAV America

UAV America is the manufacturer of the Eagle XF and Eagle X8 quadcopter platforms capable of carrying numerous payloads. The forward of their OM states that pilots should never fly directly overhead of people and that they should respect the privacy of individuals. While this manual is more like a hybrid between an operating manual for the company and an operation manual for the airframe, it was considered for this paper because of its detail into the crews operating requirements in the OM.

The vehicle specifications, components and performance limitations are discussed in independent sections of the OM. PIC requirements are stated to include a thorough knowledge of the COA (as this was released just prior to the 14 C.F.R. Part 107 rulemaking). PIC's are to be a traditionally certified pilot that maintains currency via three launches and recoveries within 90 days. Battery precautions are discussed under the Safety chapter and emergency operations are easily identifiable by a red checkered border (UAV America, 2016).

North Carolina Department of Transportation (NCDOT)

NCDOT requires that all operators have a training plan on file that is approved by the UAS coordinator. Pilots must obtain an FAA remote pilot certification, a North Carolina UAS Operator Permit and have two hours of flight time before a pilot may fly as an RPIC. Currency is maintained by a documented flight within 60 days and they impose recurrent training but do not specify the content beyond flight skills and general aviation knowledge. Flights over populated areas or heavy traffic are prohibited and a buffer of 50 feet is to be maintained between any person and the sUAS. Emergency procedures are stated to be per sUAS manufacturers manual, but NCDOT provides an emergency checklist for a basic response. The OM also discusses the use of failsafe mechanisms built into the sUAS and that flying with them turned off is not recommended (Division of Aviation North Carolina Department of Transportation, 2019).

Fairfax County Virginia

Fairfax County has launched its first sUAS program in May 2019 to improve the situational awareness of first responders and county staff. They had an in-depth public outreach session prior to implementing this program and they state that transparency and community engagement is integral to the success of their sUAS program. They clearly define when a sUAS is permitted to be used for law enforcement use and state that inadvertent recording of bystanders should be avoided by limiting angle of the camera, focus and recording time. These requirements are set in place to comply with the Code of Virginia.

Fairfax County fly's various aircraft designed to carry high definition video equipment, thermal imaging or a mission specific payload such as an automated external defibrillator. Their sUAS are designed to function autonomously with return to home functionality and obstacle

avoidance technologies. Training consists of 16 hours of ground school and airframe specific training with at least 10 hours of flight time before being certified to fly for Fairfax County. A minimum of three qualifying flights in 90 days is required to maintain skills. Recurring training is specified as well as the topics. Emergency procedures are included in the OM and a requirement to train on them is stated (Fairfax County VA, 2019).

Hover

Hover is a sUAS operating company located in Australia. They operate and consult with companies wanting to incorporate sUAs technologies into their business model. The OM contains a section to determine if the requested flight is legal and asks questions to determine if permission has been obtained, that is the maximum height (AGL), and if the mission requires flights closer than 30 meters from a person. During the pre-planning stage, privacy is to be considered, but the OM does not specify any further actions to take. As of the 2016 publication of the Hover OM, they authorize their pilots to fly the DJI Phantom 3 Professional and the Inspire 1 Pro, neither of which has obstacle avoidance technology. There are no requirements for proficiency, but there are initial training requirements specific to the policies and procedures as well as airframe specific training (Hover UAV, 2016).

Lone Star UAS Center of Excellence and Innovation (LSUASC)

The FAA and NASA have been working with the UAS test site in Corpus Christi, Texas since 2011 developing methods for incorporation of UAS into the National Air Space. This OM is the general guide on flight rules and aircrew requirements and directs the other functions of flight planning and risk assessment to other LSUASC procedures. General emergency operating procedures are contained, and the OM requires airframe specifics developed and are available during missions. Crew pre-flight briefings are required to review an emergency procedure every

day. The OM discusses precautions for cold and hot weather conditions as well as operations in high winds. Nighttime operations are allowed under certain limitations, but no flight shall occur during an active thunderstorm or lightning.

Aircrews operate on a 12-hour shift and limits to actual flight time and required rest periods are imposed based on calendar quarters as well as total flight times during the shift. These numbers vary based on the number of pilots and if an extension has been given to the previous limitations. LSUASC requires certification based on location, mission profile, size of aircraft and if VLOS will be maintained. Operations that require a private pilot certificate state that the pilot must maintain that certificate per 14 C.F.R. Part 61. Operations that don't require a private pilot certificate follow the 14 C.F.R. Part 107 guidance even though this OM was released in 2014.

Currency is maintained with three take-offs and landings every 90 days. If flying at night, the PIC must have met the same currency requirements during nighttime. Initial training is required and consists of operating procedures, manufacturer-specific training, a flight proficiency demonstration and an examination on the specific airframe.

Miami-Dade Police Department

Miami Dade Police Department (MDPD) is using their sUAS to enhance their current manned aircraft operations for high threat situations. They fly the T-Hawk developed for the defense industry where traditional manned surveillance aircraft would be threatened by hazardous operating environments. Operation of the T-Hawk requires a four-person team with the PIC required to be a private pilot certificate holder and proficient in the aircraft operations. Initial training is conducted by the sUAS manufacturer or the MDPD in house instructor. Recurrent training is specified with a minimum of one take-off and landing, but the frequency is

not stated. Currency (proficiency) is maintained by three take-off and landings in the previous 90 days.

The OM has procedures to follow for a call out as well as safety operations to include limiting flights to daylight-only operations and no flight over people. Emergency procedures are contained in the OM as well as fueling procedures as the T-Hawk is a fuel/oil powered sUAS (Miami-Dade Police Department, 2011).

NOAA

The Aircraft Operations Center for the National Oceanic and Atmospheric Administration (NOAA) governs the use of a sUAS by anybody operating for NOAA or if a NOAA employee or property is used in the flight. It allows flight under 14 C.F.R. Part 107 or under a memorandum of agreement (not a COA) in certain circumstances. Currency is maintained with three take-offs and landings every 90 days and this must occur in the sUAS to be operated. Regaining currency can be done in a simulator or under the direct supervision and a dedicated training flight. Each sUAS has a training syllabus and the PIC must receive specific training on their airframe to include normal, abnormal and emergency procedures followed by a proficiency evaluation. Pre-flight and airborne operations sections contain specific safety and management expectations. For example, a sUAS will not be launched if there are traces of frost or snow on it and battery voltage characteristics to be aware of (Silah, 2016).

Gaithersburg Maryland

This OM requires all pilots to comply with 14 C.F.R. Part 107 as well as an in-house training program to include classroom and practical training. Additionally, crewmembers attend quarterly safety meetings and annual training and evaluations on the aircraft and crew resource

management. The OM requires three take-offs and landings in the previous 90 days using the same category of aircraft. The roles and responsibilities are defined, and an organization chart is used to show the chain of command for operations. Minimum crew manning is the RPIC and a VO unless previously approved for solo flights. The OM discusses precautions to take such as minimizing other electronic equipment usages, battery use during cold weather, and minimum return home battery level. The aircraft are prohibited from flying within ten feet of anybody or when winds exceed 25 knots.

Privacy is a concern for the city of Gaithersburg. They established the role of data supervisor who is solely responsible for data storage, data disposal and addressing privacy and security concerns. They state strict compliance with the Privacy Act of 1974 and have mandated a regular review of operating policies and procedures to improve upon their privacy protection methods. The use of city-owned sUAS is prohibited for law enforcement activities or activities that would interfere with the First and Fourth Amendment. They have a 'good neighbor policy' where they inform the public before operations and limit the amount of data obtained (City of Gaithersburg Maryland, 2018).

Gowdy Brothers Aerospace

Gowdy Brothers Aerospace operate a fleet of fixed-wing, rotary and hybrid sUAS headquartered in Minnesota. The company's organization is defined, and the FAA certifications required to fly under 14 C.F.R. Part 107, or a COA. Flying under a COA requires some form of manned aircraft certification. The OM has a full section dedicated to safety covering aircraft and battery topics. Emergency procedures are color coded for easy identification and are clearly broken down into actions for specific situations. There is a detailed section on how to use the electronic tracking and logging software which addresses pre and post-flight inspections, as well

as the FAA mandated logs. The OM states that the software tracks currency requirements, but it does not specifically state the value (Gowdy Brothers Aerospace, 2016).

Southern Illinois University

Southern Illinois University (SIU) operates sUAS in their agricultural sciences, aviation technology, geography programs. They open their OM with a flight safety statement and point out that sUAS operations can be dangerous given the capable range of three to five miles for an off the shelf sUAS. SIU wrote their OM to fly under 14 C.F.R. Part 107, and restates the requirements, drawing the operator's attention to certain sections like only operating during daylight and maintaining VLOS. The OM is set up in various checklist sections from on the ground planning, pre-flight operations, emergency procedures, and post-flight log recordings. SIU's OM has a specific section for the maintenance of the DJI Inspire 1 V2.0 and includes references to the Inspire's specific manufacturers operations documentation (Southern Illinois University, 2018).

SIU employs an operating standards procedure in addition to the operations flight manual. It specifies that participants will have an individual training plan on file and that the VO must have specific training for their job, but the OM does not provide details to mandated training items. SUI requires documented flight time every two years and may issue recurrent training as needed. The rest of the operating standard procedure mirrors the flight manual for the checklists utilized for flight operations (Southern Illinois University, 2016).

Mountain Recreation & Conservation Authority (MRCA)

MRCA is a California public agency designed to maintain open spaces for residents. The OM is designed to govern sUAS operation by MRCA and any contractors that are hired. Roles

and responsibilities are defined and pilot training is clearly stated. Pilots must be 14 C.F.R. Part 107 certified, complete a task book, have 200 hours of flight time with 50 hours on the specific airframe they operate and pass a practical test. Flight time is accrued under the control of an approved pilot and requires at least two thirds to be flow in non-autonomous (manual control) modes. Their OM requires the use of a radio to monitor for manned aircraft operations in the area.

Currency is maintained by having three flights per 90 days and passing the proficiency test every 24 months. Privacy concerns are addressed by not recording residences and the surrounding property or by having the camera de-activated until on station. Another method mentioned is to have the final images trimmed to exclude any personally identifiable information (Mountains Recreation & Conservation Authority, 2018).

Northumbria University Newcastle

Northumbria University is in the United Kingdom and regulated under its Civil Aviation Authority (CAA). Their OM describes the organization, roles, and pilots who are authorized to fly. It limits the distance the sUAS may be flow to certain objects such as vehicles or groups of people. It requires that permission be grated from the owner of the property if a closer flight is desired. The OM specifies which type of operations are allowed, for example, aerial photography is allowed with semi-autonomous flight only permitted when the photography is for topographic surveying. Flight crew requirements are based on the complexity of the task or environment.

Northumbria University does not require any additional training other than initial pilot training for certification. Flight currency is maintained by flying two hours in the previous 90-day period. This equates to (120 min)/[(30 min)(.8)] = 5 flights per 90 days. Battery

maintenance, as well as actions to take if a batter battery becomes degraded via damage or charging, are discussed. Emergency procedures are easily accessible in a chart format (Westoby, 2018).

United States Department of the Interior

The Department of the Interior (DOI) governs UAS operations under their Operational Procedure Memorandum #11 (OPM-11). Pilots are required to be trained per a DOI training course and receive an initial flight evaluation. Responsibilities are defined and a limit for flight time per day is imposed. Privacy concerns are addressed by following the White House recommendations and not retaining personally identifiable data for greater than 180 days. OPM-11 uses the terms proficiency and currency differently, requiring currency for all crewmembers. OPM-11 directs flight 'proficiency' by a minimum of three launches and recoveries in the previous 90 days. Regaining proficiency is done by exercising flight and emergency procedures for the specific airframe to be flow for the mission while being observed by a current UAS pilot. Flight 'currency' is maintained by flying each airframe the PIC is permitted to fly once every 12 months. Biannual refresher training coincides with the FAA 24 month re-certification under 14 C.F.R. Part 107.

Minnesota Department of Transportation

Minnesota Department of Transportation (MnDOT) has issued a policy governing the use of UAS. State-specific statutes require all operators to be licensed before operations occur. This policy requires that all UAS purchased must have their own specific operations manual generated to cover specifics like emergency operations and flight planning. Pilots must meet 14 C.F.R. Part 107 standards or fly under a COA and receive a checkout flight prior to being able to

fly missions and complete a re-qualification flight every 24 months. Currency is required in the form of three flights per quarter (Isackson, Cherney, & Mulvihill, 2018).

Menlo Park Fire Protection

Menlo Park Fire Protection is located south of San Francisco and operates UAS for their own data collection or working with another district for data collection. The OM defines the roles and responsibilities of individuals and assigns an operating base for UAS operations. Training plans are developed on a monthly and yearly basis and assigned to all members of the UAS operations team. Initial pilot training requires a minimum number of flight hours based on the type of airframe, but specific requirements are not stated in this OM. Pilots must have some documented flight time every 90 days (this will be recorded as 1 takeoff and landing).

General operating rules state that a PIC and VO are required for all flights and that no PIC may function in that role for greater than 10 hours in any 24hr period. Pre and Post-flight checks are detailed as well as a requirement for weather checks before the flight. Menlo Park Fire Protection discusses data retention and prohibits the use of data for personal means. There is a method to request data deletion (Dennebaum & Calvert, 2017).

California Department of Water Resources

The California Department of Water Resources (DWR) utilizes UAS in their water resource management practices. They work with statewide agencies to protect waterways, water storage facilities, and wildlife environments. The OM defines the roles and responsibilities of those involved in UAS activities and requires initial ground school training prior to operating a UAS. While this manual is designed to fly under a COA in 2016, the writers have put wording in place requiring pilots to pass and maintain certification once the FAA finalizes the sUAS rules.

Recurrent training is required, and an individual training plan is developed to address those items. There is no mention of requiring recurrent flight times.

Additional sections in the OM discuss crew manning, safety checks and briefings as well as LiPo battery management. One appendix exists and is a flowchart describing the mission planning steps. There is a section discussing emergency operations, but it only discusses the requirements to report an incident (Brown, Laird, & Cowin, Unmanned Aerial Vehicle (UAV) Operations Manual, 2016).

Cambridge Drone Services

Cambridge Drone Services is regulated by the United Kingdom's Civil Aviation Authority (CAA). Currently, the company is a single member and operator flying the DJI Mavic Pro (Butcher, 2018). The DJI website lists the flight time as 27 minutes which will be used to calculate the required take-offs and landings below (DJI, 2019b). They are trying to grow the operation into a large-scale company working for the TV, film and surveying industries. The OM spells out the responsibilities of the PIC, VO and Payload Operator, and sets flight distance limitations both away from the PIC as well as minimum distance to bystanders. It also has sections for emergency operations and a risk assessment of the site and environmental conditions. It does not have specifics to minimize taking data of non-participating individuals. Cambridge Drone Services requires a PIC to be qualified to fly under the CAA, attend annual competency training and maintain a flight status of two hours in the previous 3 months. This flight time using the Mavic Pro translates to 6 takeoffs and landings every 90 days (Butcher, 2018).

Piper Mountain Aerial

Piper Mountain Aerial is an aerial photography company in Denver Colorado. They take efforts to protect the public right to privacy by flying with cameras turned down and limiting the amount of data collected. They require the PIC to be 14 C.F.R. Part 107 certified and complete annual training as determined by the UAS coordinator. At least one flight every 90 days must be accomplished to remain current. Flights require at least a PIC and VO who have the basic aviation knowledge met via initial training, but the OM is silent on any specific recurrent training requirements (Piper Mountain Aerial, 2017).

Texas Department of Safety

The Texas Department of Safety fly's UAS for general inspections, search and rescue operations as well as damage assessments. The OM has general guidance for emergency situations to include lost link and loss of power. Training to be a RPIC requires 14 C.F.R. Part 107 certification or a licensed and current part 61. Additional training consists of the Texas Government Code and mission briefing requirements. The only discussion on currency is in currently certified pilots under 14 C.F.R. Part 61. Texas Department of Safety will, however, assess a RPIC's proficiency yearly and verify the annual recertification training subjects have been completed (Texas Department of Public Safety, 2017).

Texas Department of Transportation

Texas Department of Transportation (DOT) requires at least a PIC and VO during all flights. Initial training is spelled out to include at least 5 hours of flight time and 20 takeoffs and landings. Currency is maintained by three take-offs and landings in the same UAS type within one month of the projected flight. Recurring training is conducted at least every 24 months and

focuses on regulation, emergency operations, and maintenance and pre-flight inspections. Since the Texas DOT fly's near heavy moving equipment, they have specified no-fly zones on either side of roads and railways due to wind gusts from traveling vehicles. Another prohibited flight maneuver is under an overpass when traffic is present.

The OM discusses emergency actions to take for loss of control, power, and communications (lost link). The OM also discusses how Texas DOT will maintain privacy during flight operations. Only data relevant to the mission will be stored for future use and the PIC should make every attempt to limit the data gathering during flight as Texas does have state restrictions on images captured of private property (Texas Department of Transportation, 2018).

Thurston County

Thurston County holds the state seat for Washington State. Their UAS Operations Policy/manual was obtained in its draft form from 2017. The OM specifically discusses not intruding on citizens right to privacy. Some example is that the RPIC will be aware of the camera angle at all times and that the data obtained will be maintained in accordance with the state archive requirements. The currency requirements are 120 minutes of flight time in the previous three calendar months (Thurston County, 2017).

Since Thurston County requires a flight time to remain current, and they do not state any specific aircraft normally flow in the OM, a calculation to equate time to takeoffs and landings is used for this analysis. Using the default Phantom 4 flight times, Thurston County pilots will be required to have (120 min)/[(30 min)(.8)] = 5 takeoffs and landings every 90 days.

University of California

The University of California (UC) Merced houses the UC Center of Excellence on Unmanned Aircraft System Safety. Their OM is designed to address any UAS flown on any property owned by UC. They have established a sUAS Advisory Board that reviews, updates and validates the effectiveness of the OM. The OM specifically references the different sections of 14 C.F.R. for which airframe and operation characteristics are to be used for the flight, and state laws applicable to the area of operation. For example, a person may be held liable for entering the airspace above a non-consenting person's property if the intent was to capture visual images. The OM consists of 89 pages detailing the process to register aircraft with the FAA, obtain permissions to fly, record keeping, emergency operations and evaluating for personal and environmental safety. This OM specifically discusses lithium polymer battery precautions and the chance of fire.

While the UC Operations Manual does not specify any currency requirements, the OM does state that each activity request is unique and may carry a currency requirement. Utilizing the risk assessment profile will help determine what currency requirements (if any) are needed for each request (Stark, 2018).

University of Colorado

The University of Colorado requires a currency of three flights every 90 days. If currency is lost, then they must regain it under the instruction of a flight instructor by exercising three takeoffs and landings before they are allowed to pilot a UAS on their own. Pilots who are qualified on multiple aircraft must maintain currency on each specific aircraft type. In addition to remaining current, every 24 months pilots must complete a practical test, or a flight review certified by an instructor (Hesselius, 2019).

University of Michigan

The University of Michigan operates UAS under Section 333 (COA). The OM specifies the roles of each person and the formation and responsibilities of the Institutional Autonomous System Committee. This committee governs and approves the UAS flight systems and maintains the overall program. The PIC is required to have a current pilot certificate and remain current with three launches and recoveries in a 90-day window. The flights for currency must be on the same class of UAS and in the same operating environment that is normally flown. This OM also discusses the use of dual PICs if the mission is complex or the flight uses the first-person view where the first PIC is unable to maintain a VLOS to the UAS (University of Michigan, 2016).

University of Wyoming

This university operates under a COA for teaching and university research. They require the PIC to have a conventional pilot's certificate and to fly with a visual observer. They state the restrictions of aircraft operations and flight operations requirements prior to and during operations. The OM contains appendices for documenting emergencies, accidents and the FAA COA which is required to be on hand at all times during flights. There is no further stated pilot training or requirements for currency (University of Wyoming, 2016).

Wichita Kansas Police Department

The Wichita Police Department use their sUAS for situational awareness, accident reconstruction, search and rescue as well as crime scene documentation. Pilots are trained to meet Part 107 or the Wichita COA requirements with a minimum of five hours of contact time. Currency is maintained by three flights in the previous 90 days. If currency is lost, a practice flight is required to re-certify the operator. The OM discusses the requirements of the PIC and

observers but does not address any privacy concerns. Battery's and their charging requirements are discussed as well as in the emergency operating procedures for precautions for Low and Critical battery warnings (Wichita Police Department, n.d.).

York County

York County Virginia Fire Department's operating manual immediately states that they take privacy seriously and would not collect or use any data that would violate the First Amendment rights. They normally staff the team with three individuals, a PIC, an observer and a liaison to handle communications. The OM specifies what flight data is to be recorded and that the sUAS administrator will audit those records for compliance. They reserve the right to impose continuing training for procedure and equipment changes and policy updates but do not require a specific frequency. They require training on local laws as well as the federal regulation.

Initial training consists of at least 16 hours classroom focused on sUAS operations in the NAS. Recurrent Training requires at least one takeoff and landings and annual training are to be conducted in policing and crew resource management. York County calls currency as proficiency and requires all operators to have three take-offs and landings every 90 days as a PIC (York County Department of Fire and Life Safety & York-Poquoson Sheriff's Office, n.d.).

Seattle Washington Police Department

The Seattle Police Department (PD) employs over 1,000 officers that respond to three-quarters of a million 911 calls per year. While they were probably one of the first PDs to engage with UAS technology, it was short lived. The program survived from 2012 to 2013 when the program was shut down due to overwhelming concern from the general public (Clarridge, 2013).

The operating manual was only available in a draft copy dated 2012, long before the UAS ruling by the FAA. They cite that the UAS technology will only be used for police activities and that they take reasonable efforts as to not invade any person's reasonable expectation of privacy. Some examples called out in the OM to help ensure privacy include turning cameras away from occupied structures, the data is kept within company procedures and policies, and a regular review of the OM for changing professional conduct standards. The OM covers the actions taken when a request for the UAS comes into the commander, as well as activities to deploy the aircraft. The OM outlines areas that flights are strictly prohibited, mainly Boeing Field and sets a maximum flight limit of 400 feet. Operators must already possess a fixed wing license or be enrolled in training to obtain the license. Initial training consists of airframe specific training as well as eight hours of flight training. At least one flight in 90 days but be recorded in order for the pilot to remain current (Seattle Police Department, 2012).

SkySwoop

SkySwoop operates a team of FAA-certified pilots throughout the United States that can bid on jobs as they are published via SkySwoop clients. They offer services for agriculture, insurance, construction, the energy sector, real estate, and communication equipment inspections. Equipment utilized is pilot owned and ranges the full line of DJI multi-rotor products.

The OM encourages pilots and observers to report all safety hazards without fear of disciplinary action and it directs regular audits of procedures, safety policies and current laws under which operations are conducted. All missions will contain at least a PIC with a VO required based on the complexity of the mission as determined by the SkySwoop employee. They state that privacy is a concern and that pilots should make every reasonable effort to maintain privacy. They showcase privacy by having the data obtained stored and transmitted

under bank-level encryption, not having the cameras facing occupied structures and only flying the intended mission. SkySwoop maintains a training plan that is approved by the UAS coordinator. Initial training for observers and operators include sections of 14 C.F.R. Part 91 for operations in the airspace, right-of-way rules, weather requirements, and radio communications. A minimum of 20 hours is required to show initial proficiency on the specific airframe type. Proficiency is maintained by documenting training or having flight time within a 90-day window, however, no specific hour or flight requirement is stated (SkySwoop Inc., 2019).

ESI DroneLab at the University of Exeter

The University of Exeter is a public college in the southwest corner of the United Kingdom. Their Environment and Sustainability Institute (ESI) studies environmental changes and possible solutions, partially with the use of sUAS equipped with various remote sensing instruments. The manual is set into four distinct parts: safety and organization, aircraft and control, flight planning and operating procedures. Roles and responsibilities are clearly defined with a PIC and a VO required for most flights. However, there is an allowance to only have the PIC conduct flight operations if it is deemed safe, the flight is in a remote area and conducted under autonomous flight commands. UAS pictures are included, as well as detailed sections on airframe specific limitations such as the center of gravity concerns and maximum weight. This is important since ESI outfits airframes with non-standard instruments.

The person in command of the sUAS must be at least 18 years old and have completed a qualification examination and ESI DroneLab specific training. Maintenance of this qualification is required in the form of at least one, 30-minute flight every two calendar months. This flight can be done in a simulator or as a student in a training flight. In addition to these minimum requirements, ESI states that the crew's performance will be monitored, and refresher training

will be given if needed. Flight incidences will also be analyzed for areas to improve upon and fed back to the crews in continual professional development (Cunliffe, Duffy, DeBell, & Anderson, 2016).

Results

Of the operating manuals surveyed, the mean flights per 180 days is 4.6 ($N = 35$, $SD = 3.8$) with a median and mode of 6 flights. The majority of companies (46%) are defaulting to the FAA's manned currency requirements of three flights every 90 days (6 flights every 180 days). However, almost one quarter (23%) of companies did not specify any currency requirements. This group also included those companies who said pilots must maintain their skills but did not specify any methods. Refer to Figure 1 below for the number of flights per 180 days.

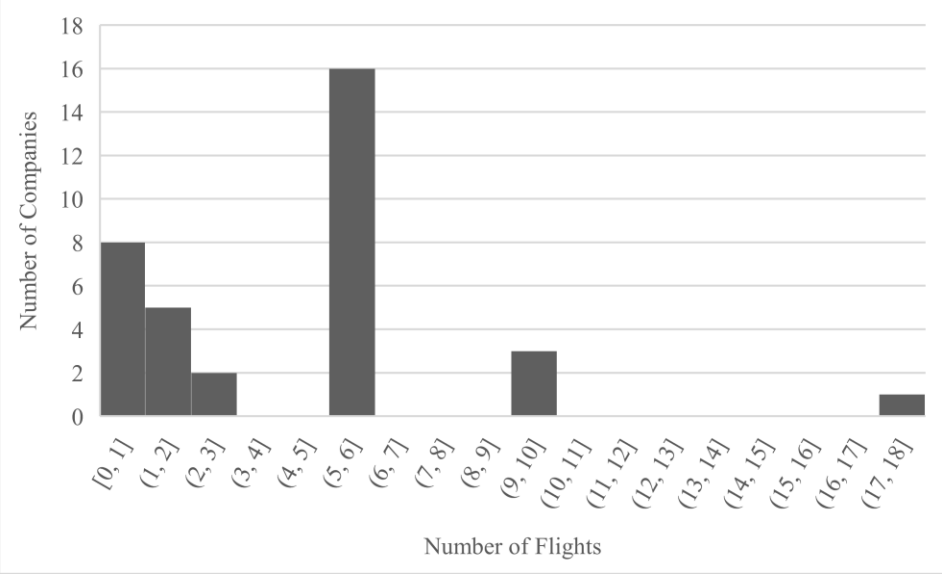

Figure 1. Flight requirements per 180 days of the 35 OM's analyzed.

Along with currency requirements, 27 of the 35 companies required additional initial training spelled out specifically in the OM. However, less than half (43%) required any specific recurrent training. It is important to note that only companies whose OM specifically stated at least one topic to retrain on were counted as having recurrent training requirements. Training and currency findings are summarized in Appendix C.

Privacy, battery requirements, flight distance restrictions, payload types and methods to increase safety were also analyzed in the operating manuals. Both privacy and battery requirements were addressed by 47% ($N = 34$) of the companies (one company only shared currency and training requirements). Some companies (41%) did impose minimum standoff distances for bystanders and operators during sUAS operations. These values varied between the companies, but all cited a need for safety as the driving force to require a minimum safe distance. Only three of the companies stated any requirements about payload configurations beyond pre-flight checks to ensure it is safely attached.

Methods to increase safety during the flight was a broad-reaching topic. Fifty-Six percent of the companies had emergency operating requirements contained in their OM. Note that the use of EOPs had to be specifically stated in the OM or the OM had to specifically say to follow the aircraft operations manual for fly-away, loss of link, low battery, etc. Both California Department of Water and Department of Fish and Wildlife required pilots to operate with the autopilot stabilization system engaged and the return to home feature enabled. One company required a minimum number of GPS satellite signals and only Fairfax County VA (the most recent OM) required the sUAS be operated with obstacle avoidance engaged. Refer to Appendix D for a summary of these findings.

The operating manuals for the companies were further categorized as governmental, educational or commercial. Governmental agencies include police, state departments, and county governments and accounted for 18 operating manuals (51%). Commercial companies accounted for 9 OM's (26%) while universities accounted for the final eight (23%). The mean flights per 180 days to maintain currency for governmental, commercial and universities were 5.1, 4.2, 3.9 flights respectfully. Fifty percent of the governmental agencies addressed privacy and nearly all the agencies (84%) required additional initial training prior to flying. These numbers both lowered as we look at commercial companies and then universities. Only half (55%) of the government companies used emergency operating procedures to increase safety during flight operations, while 78% of the commercial companies and 57% of the universities addressed emergency operations.

The AUVSI Trusted Operator Program certification Level 3 has the most requirements to become certified. It requires emergency procedures, a training program, and methods to maintain skills and proficiency as well as practical flight assessments. Given the scope of this research and the requirements for TOP Level 3 certification, only 24% of the companies could be certified given the weaknesses in their OM's for recurrent training or emergency procedures. Refer to Appendix C for a summary of companies meeting TOP Level 3 requirements.

Conclusions

Operating manuals are used to describe how a company is designed to operate, the skills required to perform the tasks, methods to perform those tasks repeatedly and methods to respond to abnormal conditions. In the analysis conducted, only half the companies analyzed have emergency operating procedures incorporated into their OM and less than half address any recurring training to maintain skills.

Although companies and industry organizations like AUVSI have recommended that continuing training be conducted, no industry body has specified a minimum number of flights, hours or topics to cover with the goal of increasing pilot skills and knowledge. Although not specifically required by the FAA to fly under 14 C.F.R. Part 107, research in manned aircraft shows that recent flight experience, specifically under manual flight controls enables the PIC to more precisely control their aircraft when placed into situations requiring manual flight controls. Research in Naval Aviation also shows that as pilot experience increases, the chance of an incident lowers. Companies that are imposing requirements for recent flight experience were more likely to default to the three flights every 90 days requirement used for manned aircraft currency

Less than half of the organizations addressed the public's privacy concerns, even though there has been a long-standing set of recommendations on how to minimize the collection of personal data. The companies more likely to address the public's privacy concerns were governmental agencies, possibly due to the public comment periods while starting a sUAS program or their constant involvement with the public in the areas they operate. Since over half the OM's obtained for this study were from governmental agencies, the university and commercial company's OM's may show an increase in privacy concerns if more OM's were publicly available for analysis.

Recommendations

The research conducted contained 35 operating manuals across many different operating environments and applications but within three distinct entities. The majority of the OM's were from governmental agencies as this information was more publicly available than university or commercial companies. Expanding the dataset for other companies as well as international

exposure would produce a broader view of the current requirements that companies are operating under. Additionally, the operating manuals of these companies were lacking in emergency operations, specific recurrent training requirements and methods to limit personal information gathering. Previous research and recommendations from academia and sUAS associations recommend these sections for operating manuals as methods to respond to emergencies and address public concerns.

Companies desiring to incorporate a sUAS program into their operations should consider the recommendations for required operating manual content as well as how they will accomplish those requirements. The jobs the pilots will be performing should be analyzed to determine initial skills and recurrent skill maintenance. Standard and emergency operating conditions should be addressed and stated in the OM to allow operators to consistently produce the desired outcome as well as respond to emergencies if they arise. Consideration should be given to the public for privacy if operations are to occur in areas of dense populations.

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Appendix A

Key Terms (abbreviations, definitions)

14 C.F.R Part 61	The Code of Federal Regulations governing the certification of pilot, instructors and ground instructors. This C.F.R. does not issue certifications for sUAS pilots. 14 C.F.R. §61.1
14 C.F.R. Part 107	The Code of Federal Regulations governing registration, certification and operation of civil small unmanned aircraft systems within the United States. 14 C.F.R. §107.1
C3	*Command, Control, and Communications* is the system in place to communicate actions and send data between a craft and its operating station.
COA	*Certificate of Authorization* (Waiver) is an authorization issued by the Air Traffic Organization to a public operator for a specific UAS activity.
CS	*Control station* means an interface used by the remote pilot to control the flight path of the small unmanned aircraft. 14 C.F.R. §107.3
Currency (Recent Flight Experience)	*Currency (Recent Flight Experience*) means that the PIC of an aircraft carrying passengers or certified for more than one pilot crewmember must make at least three takeoffs and landings within the preceding 90 days. The person must have acted as the sole manipulator of flight controls and done so in the same category, class and type aircraft. 14 C.F.R. §61.57
FAA	*Federal Aviation Administration* is the regulating body in the United States for civil aviation.
NAS	*National Airspace System* is the network of airspace, facilities, and airports in the United States regulated by the FAA and the military.
OM	*Operations Manual* is a document defining how the sUAS operating company functions
PIC (RPIC)	*Pilot in Command (Remote Pilot in Command)* is the operator of the aircraft (sUAS) who holds a remote pilot certificate, has final authority and responsibility for the operation and safety of the flight, has been designated as pilot in command, and is responsible for compliance with 14 C.F.R. regulations. 14 C.F.R. §107.19
Proficiency (Proficient)	*Proficiency* means the pilot is knowledgeable and capable of aircraft normal and emergency operations as well as types of flight for that airframe. An evaluation is required to certify that the pilot is proficient at that aircraft's operations. 14 C.F.R. §121.441
sUA	*Small unmanned aircraft* means an unmanned aircraft weighing less than 55 pounds on takeoff, including everything that is on board or otherwise attached to the aircraft. 14 C.F.R. §107.3
sUAS	*Small unmanned aircraft system (small UAS)* means a small unmanned aircraft and its associated elements (including communication links and the components that control the small unmanned aircraft) that are required for the safe and efficient operation of the small unmanned aircraft in the national airspace system. 14 C.F.R. §107.3
VO	*Visual observer* means a person who is designated by the remote pilot in command to assist the remote pilot in command and the person manipulating

	the flight controls of the small UAS to see and avoid other air traffic or objects aloft or on the ground. 14 C.F.R. §107.3
VLOS	*Visual Line of Sight* means that the RPIC, VO and person manipulating the flight controls must be able to see the sUAS with unaided vision. 14 C.F.R. §107.31

Appendix B

E-Mail or LinkedIn examples of request for Operating manuals

Dear [Name],

I am working on my final capstone project for my Masters in Unmanned Systems at Embry-Riddle Aeronautical University. For this project, I'm going to compare the operating manuals that existing companies utilize for their flight operations. I'm particularly interested in any required continuing training or flight proficiency requirements.

I'm writing to see if you would share your operating manual. The manual would only be referenced in my final academic paper and would not be used for commercial purposes.

Thank you for your time,

Stephen Cigal

Dear [Name], I am working on my final capstone project for my Masters in Unmanned Systems from Embry-Riddle Aeronautical University. I'm going to compare the operating manuals that existing companies utilize for their flight operations. Does [Company] have an operating manual for UAS?

Appendix C

Currency and OM Specific Training Requirements

Company	Flights	Initial	Recurrent	TOP Level 3
Alabama DOT	0.9	Y	Y	-
California Dept Water Resources	0	Y	Y	-
California Dept Fish and Wildlife	6	Y	-	-
Cambridge Drone Services	10	-	Y	Y
Los Angeles Public Works	2	Y	Y	-
ERAU	6	Y	-	-
ESI Drone Lab	3	Y	-	-
Fairfax VA	6	Y	Y	Y
Gaithersburg MD	6	Y	Y	Y
Growdy Brothers	0	-	-	-
Hover	0	Y	-	-
Lone Star UAS	6	Y	-	-
Menlo Park FD	2	Y	-	-
Miami-Dade FD	6	Y	Y	Y
Minnesota DOT	6	-	-	-
Mountains Rec.	6	Y	Y	Y
North Carolina DOT	3	Y	-	-
NOAA	6	Y	-	-
Northumbria	10	-	-	-
Piper Mountain	2	Y	-	-
Seattle PD	2	Y	Y	-
SkySwoop	2	Y	-	-
Southern Company	6	Y	Y	Y
Southern Illinois	0.2	-	-	-
Texas DOS	0	Y	Y	Y
Texas DOT	18	Y	Y	Y
Thurston WA	10	-	-	-
UAV America	6	Y	-	-
U of California	0	Y	-	-
U of Colorado	6	Y	Y	ND
U of Michigan	6	-	-	-
U of Wyoming	0	-	-	-
Dept of Interior	6	Y	Y	-
Wichita PD	6	Y	-	-
York VA	6	Y	Y	-

[a]The number of flights required to maintain currency is calculated for every 180 days.

[b]Texas Department of Transportation only requires currency within 30 days of a mission.
[c]The University of California only has specific initial training requirements for night operations.
[d]The AUVSI TOP requirements were assessed against companies who required recurrent training and had Emergency Operating Procedures contained in their OM. The University of Colorado did not provide information on the use of EOP's and were not factored into this assessment (*N*=34).

Appendix D

Privacy, Battery, Distance to Bystanders and Methods to Increase Safety

Company	Privacy	Battery	Distance	Safety
Alabama DOT	Y	-	-	-
California Dept Water Resources	-	Y	Y	AP, RTH
California Dept Fish and Wildlife	Y	Y	-	AP, RTH, EOP
Cambridge Drone Services	-	-	Y	EOP
Los Angeles Public Works	Y	Y	Y	-
ERAU	Y	Y	-	EOP, GPS
ESI Drone Lab	-	Y	-	EOP
Fairfax VA	Y	-	-	AP, OA, EOP
Gaithersburg MD	Y	Y	Y	EOP
Growdy Brothers	-	Y	-	EOP
Hover	-	-	Y	-
Lone Star UAS	-	Y	-	EOP
Menlo Park FD	-	-	-	-
Miami-Dade FD	-	-	Y	EOP
Minnesota DOT	-	-	-	-
Mountains Rec.	Y	Y	-	EOP
North Carolina DOT	-	-	Y	EOP
NOAA	-	Y	Y	EOP
Northumbria	-	Y	Y	EOP
Piper Mountain	Y	-	-	-
Seattle PD	Y	-	Y	-
SkySwoop	Y	-	Y	EOP
Southern Company	Y	Y	Y	EOP
Southern Illinois	-	-	-	EOP
Texas DOS	-	-	-	EOP
Texas DOT	Y	-	-	EOP
Thurston WA	Y	-	-	-
UAV America	Y	Y	Y	EOP
U of California	Y	Y	-	-
U of Michigan	-	-	-	-
U of Wyoming	-	-	Y	-
Dept of Interior	Y	-	-	-
Wichita PD	-	Y	-	EOP
York VA	Y	Y	-	-

[a]Privacy was marked as a *YES* (Y) if the OM described methods to minimize the amount of personal data collected or the OM discussed the importance of privacy for the general public.

[b]Battery was marked as a *YES* if the OM described cautions with the handling of batteries to include chagrining, use and storage.
[c]Distance was marked as a *YES* if the OM required sUAS operations to be conducted any distance away from bystanders or the flight crew. OM's that only stated that flights over non-participating individuals were not marked.
[d]Safety measures that were prescribed by the OM were noted as follows: AP - Autopilot and sUAS auto stabilization, EOP – Emergency Operating Procedure, GPS – Global Positioning System minimum requirements, OA – Obstacle Avoidance (Sense and Avoid) turned on, RTH – Return to Home functionality.
[e]The University of Colorado did not provide any information beyond currency and training requirements; therefore, they are not included in this part of the analysis.