Unauthorized Unmanned Aerial Systems Operations in the National Airspace System: Understanding the Safety Implications for America's Airports

by

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A Graduate Capstone Project Submitted to the College of Aeronautics,

Department of Graduate Studies, in Partial Fulfillment of

the Requirements for the Degree of

Master of Science in Aeronautics

Embry-Riddle Aeronautical University
Worldwide Campus
May 16, 2021

Abstract

This capstone research project analyzed the current data available regarding unauthorized unmanned aerial system (UAS) operations in the national airspace system (NAS) to determine the safety implications they pose to America's airports. The methodology of this study included the analysis of historical research gathered from the Federal Aviation Administration's (FAA) *Reported UAS Sightings* reports. A data set of 300 reported UAS sightings were randomly selected and analyzed to determine the breadth of the problem across the NAS, and to identify key themes applicable to all events. This study found that 161 (54%) reports stated that a reported UAS sighting occurred within 5 nautical miles (NM) of an airport. Pilots flying fixed-wing aircraft during critical phases of flight were the most common reporters of UAS sightings. All reported UAS sightings occurred within controlled airspace without the approval of air traffic control as mandated by federal regulations. This study also determined that the current reporting process utilized by the FAA was inadequate and required additional law enforcement response information to be useful. To mitigate unauthorized UAS operations in the NAS, it was recommended that Title 14 of the Code of Federal Regulations Part 139 (14 C.F.R § 139) be updated to include UAS procedural information. Moreover, airport managers should develop local UAS procedures applicable to their airport in conjunction with local law enforcement and air traffic control agencies.

Keywords: airports, air traffic control, law enforcement, policy, safety, unmanned aerial systems, 14 C.F.R § 107, 14 C.F.R § 139

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Chapter I

Introduction

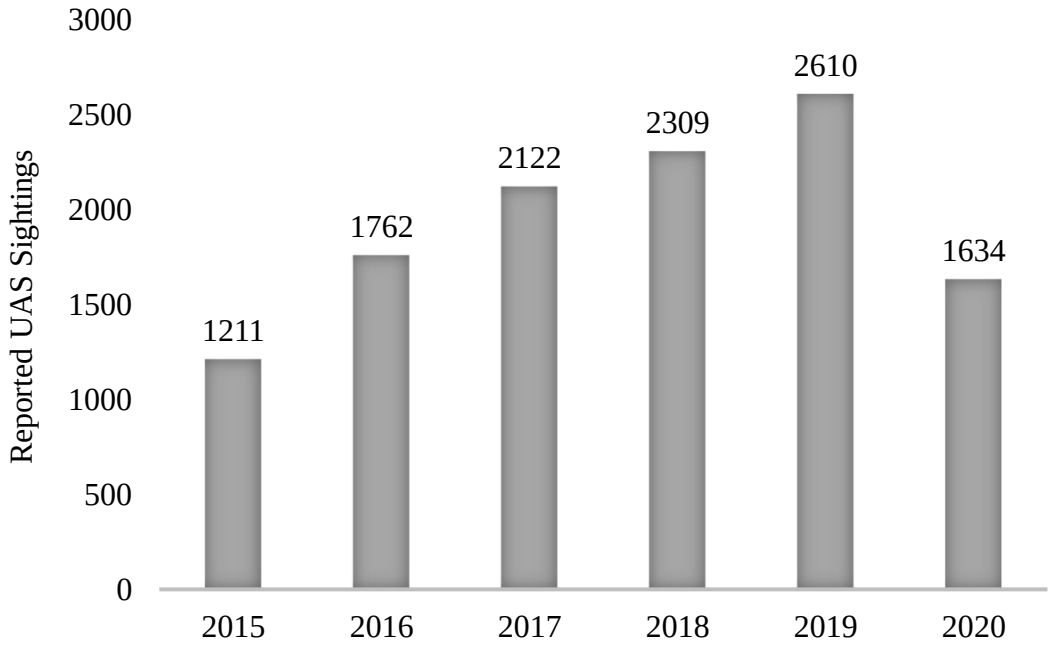
Over the past decade, unmanned aerial systems (UAS) technology has advanced to the point that it has become readily available in both the public and private sectors. The United States government defines UAS as "an aircraft operated without the possibility of direct human intervention" (Small Unmanned Aerial Systems, 2016, para. 12). Moreover, UASs are delineated by weight, with small unmanned aircraft (sUAS) being defined as "unmanned aircraft weighing less than 55 pounds on takeoff, including everything that is on board or otherwise attached to the aircraft" (Small Unmanned Aerial Systems, 2016, para. 13). These types of UASs are the systems that are normally operated by the public, available at retail stores and referred to by the colloquial term "drone." In 2016, a formal U.S. government regulation was published as Title 14 of the Code of Federal Regulations Part 107 (14 C.F.R. §107) *Small Unmanned Aircraft Systems*, which defined how UASs must be operated and certified to fly within the national airspace system (NAS) (Federal Aviation Administration, 2016; Small Unmanned Aerial Systems, 2016). Procedures included in this regulation encompass operating rules, remote pilot certification, operations over human beings, and waivers (Small Unmanned Aerial Systems, 2016).

Since UAS technology has become more readily available and at reduced costs to consumers, the aviation industry has been inundated with an increasing number of unauthorized UAS operations near airports and within controlled airspace. The Federal Aviation Administration (FAA) actively tracks UAS sightings and states that they receive at least 100 such reports a month (FAA, 2021). A synopsis of the reported sightings is published by the FAA on a quarterly basis for public review (FAA, 2021). These reports identify the date, time, and

location of the UAS sighting along with a summary of the incident. Figure 1 provides a depiction of the reported UAS sightings occurring between calendar years 2015 – 2020.

Figure 1

Reported UAS Sightings by Calendar Year



Note. This bar chart was developed using the data published in the FAA's quarterly *UAS Sightings Reports* for the calendar years 2015 – 2020 (FAA, 2021).

In addition to the significant safety issues that UAS operations pose to manned aircraft, there is a significant lack of standardized 14 C.F.R. §107 enforcement policies. The current position of the FAA is that "the FAA is responsible for the safety of U.S. airspace and enforces Federal Aviation Regulations. UAS are aircraft, and the FAA regulates UAS operations" (FAA, 2018, p. 1). In theory, this appears to be a straightforward policy position on the regulation of UAS operations. However, in application the FAA does not have the authority or capability to track unauthorized UAS operations in real-time. Instead, the agency relies on the participation of

local, state, and federal law enforcement agencies to identify, track and intercept operators that are flying UASs without authorization in the NAS (FAA, 2018). The varying level of capabilities between law enforcement agencies results in non-standardized enforcement practices and inadequate safety measures. This also puts airports and airport managers at the mercy of the local law enforcement agency's willingness to participate in UAS interdiction. At the commencement of this study, the only federal policy available regarding 14 C.F.R. §107 enforcement procedures were a non-binding FAA guidance memorandum for law enforcement agencies (FAA, 2018).

Significance of the Study

The study of unauthorized UAS operations is significant and worthy of academic study because UASs are a growing technology that have the potential to cause catastrophic damage to manned aircraft and result in the loss of human life. Additionally, the advancement of UAS technology far exceeds current U.S. government policies, procedures, and regulations that are developed to ensure a safe NAS. Additional research of unauthorized UAS operations was necessary to describe the brevity of problem, identify policy gaps, and educate the public on how to operate UASs safely. This study evaluated current FAA data to help increase flight safety and develop new FAA policies applicable to UAS operations.

Statement of the Problem

The problem is that there are a high number of unauthorized UAS operations occurring within the NAS and there is no adequate national enforcement policy applicable to all airports to rectify the issue. As previously mentioned, the FAA receives at least 100 reports of unauthorized UAS operations a month from pilots, airport, and air traffic control (ATC) personnel (FAA, 2021). This is a serious flight safety issue because there is no adequate standardized enforcement

mechanism to identify, contact, and/or stop unauthorized operations under the current regulatory structure.

Purpose Statement

The purpose of this capstone project was to analyze the current data available regarding unauthorized UAS operations in the NAS to determine the safety implications they pose to America's airports. Through data analysis, this led to the identification of key themes that were broadly applied to all airports. This research was conducted to increase flight safety of aircraft operations at the airport and offer a solution to mitigate the lack of 14 C.F.R. §107 enforcement mechanisms.

Research Questions

This capstone project evaluated the following research questions (RQ):

RQ1: How many reported UAS sightings occurred within 5 NM of an airport in the United States from 2015 – 2020?

RQ2: What common themes were applicable to UAS sightings that occurred within 5 NM of an airport in the United States?

RQ3: What standardized policies can be developed and implemented by the FAA to help mitigate the safety implications of UAS operations near airports in the United States?

Delimitations

To ensure the executability of this research study, data was limited to the information published in the FAA's *Reported UAS Sightings* reports available to the public on the FAA website between calendar years 2015 – 2020 (FAA, 2021). The emphasis of this study was on reported UAS sightings that occurred within 5 NM of an airport because they were explicitly prohibited without FAA approval in accordance with 14 C.F.R. §107 (Small Unmanned Aerial

Systems, 2016). Furthermore, this study focused on UAS sightings in general and did not delineate between small, large, private, public, or military applications because it was not necessary to meet the objectives of this capstone research project.

Limitations and Assumptions

The findings of this study may be limited because they are based on data provided by a U.S. government agency and not the researcher. This study was dependent on the capabilities of the FAA and the parties responsible for reporting the UAS sightings. It was assumed that the data was reliable because it was published by an U.S. government agency.

List of Acronyms

The following acronyms were utilized throughout this study:

AGL – above ground level

ATC – air traffic control

FAA – Federal Aviation Administration

LE – law enforcement

MSL – mean sea level

NAS – national airspace system

sUAS – small unmanned aerial system

UAS – unmanned aerial system

Chapter II

Review of Relevant Literature

A review of the current body of literature regarding UAS operations determined that research was just beginning to tackle the serious safety issues associated with this new technology. In general, current research focused on the following topics: (1) U.S. regulation and policy, (2) counter drone technologies, (3) human factors and (4) law enforcement procedures. The following literature review provides a brief overview of pertinent research that was applicable to this capstone research project.

U.S. Regulation and Policy

The FAA Modernization and Reform Act of 2012 (FMRA) was the first piece of federal legislation that addressed UASs and charged the U.S. Department of Transportation with the task of integrating them into the NAS (FAA Modernization and Reform Act, 2012). Among the requirements listed in FMRA was the development of a comprehensive plan that would define the rulemaking and acceptable standards for operating UASs within the NAS. This plan was codified in 14 C.F.R. §107, which defines the procedures for operating UASs in the NAS (Small Unmanned Aerial Systems, 2016). However, current research suggested that full UAS integration into the NAS was far from being realized. Wallace et al. (2018) argued that 14 C.F.R. §107 emphasizes the segregation of UASs from manned aircraft by altitude and airspace boundaries, rather than their integration into the ATC traffic flow. An example of this was seen through the application of the 400 foot above ground level (AGL) altitude restriction, which unintentionally left low altitude users (i.e. helicopters, agricultural, etc.) to deal with the brunt of UAS safety issues. According to Wallace et al. (2018), this conflict highlights the inadequacy of

the current federal policies regarding UAS operations and underscores the reality that UASs have not yet been fully integrated into the NAS.

Counter-Drone Technologies

One of the primary limiting factors to full UAS integration is the lack of adequate detection technologies available to help pilots, ATC or airports mitigate collisions. Most of the available research studies focused on identifying counter-drone technologies to intercept unauthorized UASs. Counter-drone technologies were normally classified as either detection or neutralization applications. More specifically, Lykou et al. (2020) conducted a survey of drone incidents and countermeasures with a focus on the areas surrounding airports and critical infrastructure. Detection and sensing technologies included, geofencing software, radar, radio-frequency detection, acoustic, and visual detection technologies. Mitigation countermeasures (i.e. neutralization) included electronic and kinetic interdiction technologies (Lykou et al., 2020). Similar research was conducted by Kustra and Nowakowski (2020), who provided a brief overview of the threats posed by UASs near airports and some of the technology being designed to neutralize their threat. Their findings were based on the interviews of personnel employed by Warsaw Chopin Airport (Poland), who suggested that UASs pose a significant threat to manned aircraft during critical phases of flight and their potential for use by terrorists.

Another type of counter-drone technology under development were ATC deconfliction tools that help controllers separate UASs from manned aircraft. Wang et al. (2019) conducted a research study to determine the level of risk posed by an unauthorized UAS in terminal airspace when limited information was available to surrounding aircraft and ATC. Although their primary context was Singapore, their work could be applied generally to other airports. To assess the risk level, the authors utilized modeling techniques associated with Alert Zones and developed a

collision prediction model that could be used by ATC to help identify UASs and deconflict aircraft under their jurisdiction.

Human Factors

Another area of UAS research sought to understand the impact of unauthorized UAS operations from the perspective of an aircraft pilot. Wallace et al. (2019) conducted a study that involved real-time flight operations where pilots were placed in scenarios that required them to identify an incoming UAS during an approach to an airport. The pilots were only able to detect a UAS during 12 out of 40 possible scenarios, resulting in a 30% detection rate. Wallace et al. (2019) argued that UASs posed a direct threat to manned aircraft on final approach because of aircrew task saturation and a pilot's forward focus on the airport in front of them. These factors combined to make it extremely difficult to recognize a UAS unless it was flying directly at the aircraft, at which point a collision was highly probable. During follow-up interviews, the pilots verbalized their difficulties with detecting a small moving object during critical phases of flight. These findings further emphasized the need for counter-drone technologies and demonstrated flight safety issues caused by unauthorized UAS operations near airports.

Law Enforcement Procedures

The FAA recognized the need for real-time interception of unauthorized UAS operations and their reliance on local law enforcement (LE) agencies for interdiction. In 2018, the FAA published a guidance memorandum directed to law enforcement agencies outlining the legal responsibilities of the FAA and LE when faced with suspected unauthorized UAS operations (FAA, 2018). Although this memorandum was helpful with describing applicable government statutes, it was non-binding and did not have the authority to mandate LE response to unauthorized UAS operations. FAA (2018) argued that it was difficult to develop a "one-size-

fits-all" federal policy that could be applied to all localities and jurisdictions. Therefore, the FAA urged local and state officials to work together to develop policies applicable to their specific airport (FAA, 2018).

Additionally, the FAA developed the Law Enforcement Assistance Program (LEAP) to assist local LE agencies with investigations that involved aircraft and airspace violations (FAA, 2020b). LEAP provides access to special FAA agents who can assist LE with unauthorized UAS operation investigations. This program also includes the *Public Safety and Law Enforcement Toolkit* which is an electronic resource that LE can access regarding UAS operations, pertinent statutes, and LE authority (FAA, 2020a). LEAP acts as a bridge between the FAA's civilian regulatory responsibility and the criminal enforcement authority afforded to LE agencies.

Summary

In conclusion, this brief literature review sought to provide an overview of the current research available regarding unauthorized UAS operations in the NAS. It was determined that most of the current literature available involves the study and critique of U.S. regulation and policy, counter-drone technologies, human factors, and law enforcement procedures. At the commencement of this study, no research could be found that explicitly analyzed the specific details of real-world unauthorized UAS operations near airports and their implications on airport safety. This capstone research project sought to fill this gap in the current body of literature and offer a mitigation strategy for airport managers.

Chapter III

Methodology

Research Approach

The research approach for this study included the analysis of historical research gathered from the FAA's *Reported UAS Sightings* reports (FAA, 2021). The information presented in these reports was descriptive in nature, therefore a qualitative methodology was implemented. The FAA published the following information regarding reported UAS sightings: date, state, city, and summary of the event. The following sections outline the methodology of this study including design and procedures, apparatus and materials, sample, source of data, validity, and treatment of data.

Design and Procedures

This study was a historical analysis of public data gathered from the FAA's *Reported UAS Sightings* reports (FAA, 2021). The following procedures were utilized in the execution of this study.

1. All available reports from calendar years 2015 – 2020 were downloaded from FAA (2021) and used to develop a dataset for this study. Each report included approximately 300 – 700 reported UAS sightings.
2. Once the reports were gathered, each received an initial review to ensure completeness and availability of information. All reported incidents were counted to determine the total number of reported UAS sightings for calendar years 2015 – 2020 in support of RQ1.

3. The researcher used the Microsoft Excel random number generator function to randomly select 50 reported UAS sightings from each calendar year 2015 – 2020 for analysis. This resulted in a data sample of n = 300 reported UAS sightings.
4. Once the data sample was selected, the information included for the 300 reported UAS sightings were transcribed into a Microsoft Excel spreadsheet that included the following categories:
    a. Date: the day that the reported UAS sighting occurred.
    b. City, State: the city and state in which the reported UAS sighting occurred.
    c. Reported By: the organization and/or person that reported the UAS sighting. The following subcategories were utilized: pilot (P), air traffic control (A), airport management (M), law enforcement (L), civilian (C), and other (O).
    d. Reported by Type Aircraft: the type of aircraft being flown when the UAS sighting occurred. The following subcategories were utilized: fixed-wing (F), helicopter (H) or not applicable (N).
    e. Altitude: the reported altitude where the reported UAS sighting occurred reported in feet above ground level (AGL) and/or mean sea level (MSL).
    f. Location: the location where the reported UAS sighting occurred in relation to an airport. The following subcategories were utilized: yes within 5 NM of an airport (Y), not within 5 NM of an airport (N), and unknown (U).
    g. Operator contacted: this category described whether the UAS operator was contacted during the UAS sighting. The following subcategories were utilized: the operator was contacted (Y), the operator was not contacted (N), and unknown (U).

h. Action taken: this category described the action taken during the reported UAS sighting. The following subcategories were utilized: operator stopped (S), law enforcement contacted (L), UAS impounded (I), no action taken (N), unknown (U) or other (O).

5. Once the data was reviewed and transcribed using the procedures listed above, the data was organized into key themes to answer RQ2.
6. The identified key themes were analyzed and used to develop recommended policies to answer RQ3.

Apparatus and Materials

This research study did not require any specialized apparatus and/or materials. All data gathering, selection, analysis, and project report publication was accomplished using Microsoft Office and Excel.

Sample

Since this is a historical research study, it was important to gather a large sample size based on the most current data available. The FAA started reporting UAS sighting information on a quarterly basis in November 2014 (FAA, 2021). An initial review of the FAA's *Reported UAS Sightings* reports determined that each report included approximately 300 – 700 UAS sightings. Given the limited timeline available for this study, it was not possible to review every UAS sighting included in all available reports. Therefore, Microsoft Excel was used to randomly select 50 reported UAS sightings from each calendar year 2015 – 2020. This resulted in a total sample size of 300 reported UAS sightings for analysis. Data from 2014 and 2021 was not included because only partial year data was available from FAA (2021).

Sources of Data

The data sample was gathered from the FAA's *Reported UAS Sightings* reports that were published on a quarterly basis by FAA (2021). This was a government owned website under the responsibility of the FAA and within the purview of the U.S. Department of Transportation. The information contained in the reports were the results of first-person reports made by pilots, air traffic control, airport personnel or civilians directly to the FAA. Therefore, it was expected that the data was reliable.

Validity

Given that this was a qualitative historical research study, ensuring the validity of findings hinged on the accurate interpretation of the data by the researcher and the availability of a large data sample. The data gathered from FAA (2021) ensured triangulation because each data point was from an independent source and provided a unique example of the phenomenon being studied. Moreover, the researcher had extensive professional knowledge of airport operations, ATC, and the NAS. This ensured an unbiased and accurate assessment of the research data to meet the objectives of this capstone research project.

Treatment of Data

The data collected from FAA (2021) was transcribed into a Microsoft Excel spreadsheet and classified into several categories as described in the design and procedures section of this paper. The transcription process determined the who, what, and where of each UAS sighting. These findings assisted with the identification of operator contact rates and actions taken in response to the UAS sightings. Findings were categorized into key themes that answered the following questions (not exhaustive):

1. How many reported UAS sightings occurred within 5 NM of an airport?

2. Where and what altitude did reported UAS sightings normally occur?
3. How often were airport, ATC, or law enforcement personnel able to contact the UAS operator?
4. Were LE agencies able to stop the reported unauthorized UAS operation or did operations continue?
5. What action was normally taken to rectify the reported UAS sighting?

These questions were used to identify key themes associated with reported UAS sightings and develop recommended policies to answer RQ3.

Chapter IV

Results

Population and Sample Information

After consolidating all information available from the *FAA UAS Sightings* reports from calendar years 2015 – 2020, the total population of all reported UAS sightings during these years were n = 11642. A random sample of 50 reported UAS sightings from each calendar year were selected using the Microsoft Excel random number generator, resulting in a sample size of n = 300. Table 1 shows how many reported UAS sightings were received by the FAA during calendar years 2015 – 2020.

Table 1

Reported UAS Sightings by Year

Year	Reported UAS Sightings
2015	1210
2016	1761
2017	2121
2018	2308
2019	2609
2020	1633
TOTAL	**11642**

Note. The above information is gathered from the FAA's *Reported UAS Sightings* reports published by FAA (2021).

Research Question 1 (RQ1)

RQ1 asked the following question: *how many reported UAS sightings occurred within 5 NM of an airport in the United States from 2015 – 2020?* Based on the analysis of the data sample (n = 300), 161 (54%) of reported UAS sightings occurred within 5 NM of an airport during the

calendar years 2015 – 2020. One-hundred twenty-four (124 / 41%) reported UAS sightings occurred outside the 5 NM boundary, while 15 (5%) reported UAS sightings did not provide conclusive location information.

Research Question 2 (RQ2)

RQ2 asked the following question: *what common themes were applicable to reported UAS sightings that occurred within 5 NM of an airport in the United States?* The following section outlines key themes that were identified during the analysis process. Only the reported UAS sightings that occurred within 5 NM of an airport were included in this section resulting in a smaller data sample of n = 161.

Personnel Responsible for Reports

This key theme area considered the type of individual responsible for submitting the report to the FAA. Pilots were the most common personnel responsible for making reports with 141 (86%). Other reports were submitted by civilians (8 / 5%), law enforcement (5 / 3%), air traffic control (5 / 3%), airport employees (1 / >1%) and unknown (1 / >1%).

Type of Aircraft Involved

This key theme area considered only the reports made by pilots and identified the type of aircraft involved during the UAS sighting. This included 141 pilot reports, of which 112 (79%) involved fixed-wing aircraft, 28 (20%) involved helicopters, and 1 (1 %) did not include any information regarding the type of aircraft being flown at the time.

Altitude of Reported UAS Sighting

This key theme area considered the altitude and location of the reported UAS sighting and its relationship to an airport. The altitude and location of reported UAS sightings occurred at all levels and phases of flight. The range in altitude included zero feet AGL up to 13,100 feet MSL.

Ninety-eight (98 / 61%) reports stated that the reported UAS sighting occured at an altitude of 2,500 feet AGL or below, which was the standard ceiling height of Class D airspace. Seventeen (17 / 11%) reports identified the reported UAS sighting between 2,500 – 4,000 AGL, which was the standard ceiling height of Class C airspace. Nineteen (19 / 12%) reports identified the UAS sighting between 4,000 and 10,000 AGL, which was the standard ceiling height of Class B airspace. Four (4 / 2%) reports included reported UAS sightings between 10,000 AGL and 13,100 feet MSL, and an additional 27 (17%) reports included no altitude information.

Lack of Reported Contact with UAS Operator

This key theme area considered whether the UAS operator was contacted following the UAS sighting. Only five (5 / 3%) reports contained information that suggested the UAS operator was contacted during the incident. One-hundred fifty-six (156 / 97%) reports did not include any information regarding contact with the UAS operator during or after the incident.

Law Enforcement Notification

This key them area considered whether law enforcement agencies were contacted about the reported UAS sighting as recommended by FAA (2018). Two-hundred and twenty-two (222 / 74%) reports stated that law enforcement agencies were contacted about the reported UAS sighting. Fifteen (15 / 5%) reports stated that law enforcement was not contacted, two (2 / >1%) reports stated that airport management was notified, one (1 / >1%) report stated that the UAS operator had permission to operate, and one (1 > 1%) stated that the UAS was stopped during operations. Fifty-nine (59 / 20%) reports contained no information about actions taken following the reported UAS sighting.

Region

This key theme area considered the region of the country where the UAS sighting occurred. Table 2 outlines the number of reported UAS sightings that occurred within 5 NM of an airport, by state, during calendar years 2015 – 2020.

Table 2

Region of the Country Where UAS Sightings Occurred

Alabama	2	Louisiana	4	North Dakota	1
Arizona	12	Maryland	4	Ohio	1
California	30	Massachusetts	2	Oregon	1
Colorado	1	Michigan	3	Pennsylvania	7
Connecticut	1	Minnesota	1	Puerto Rico	1
Florida	22	Nebraska	1	Rhode Island	1
Georgia	2	Nevada	4	Tennessee	2
Hawaii	1	New Hampshire	1	Texas	12
Idaho	1	New Jersey	5	Vermont	1
Illinois	5	New Mexico	1	Virginia	2
Kansas	2	New York	16	Washington	3
Kentucky	1	North Carolina	5	Wisconsin	2

Note. The above information is gathered from the FAA's UAS Sightings reports published by FAA (2021). This data reflects the number of reported UAS sightings that occurred within 5 NM of an airport, by state, during calendar years 2015 – 2020.

Chapter V

Discussion

The findings of this capstone research project provide valuable insight into unauthorized UAS sightings throughout the NAS and highlight limitations of the current FAA UAS sighting reporting system. The key themes presented in the findings section of this paper illustrate the complex nature of reported UAS sightings and their impact on America's airports. The following chapter elaborates on these key themes and discusses how they contribute to serious flight safety issues.

UAS Operations Violating Controlled Airspace

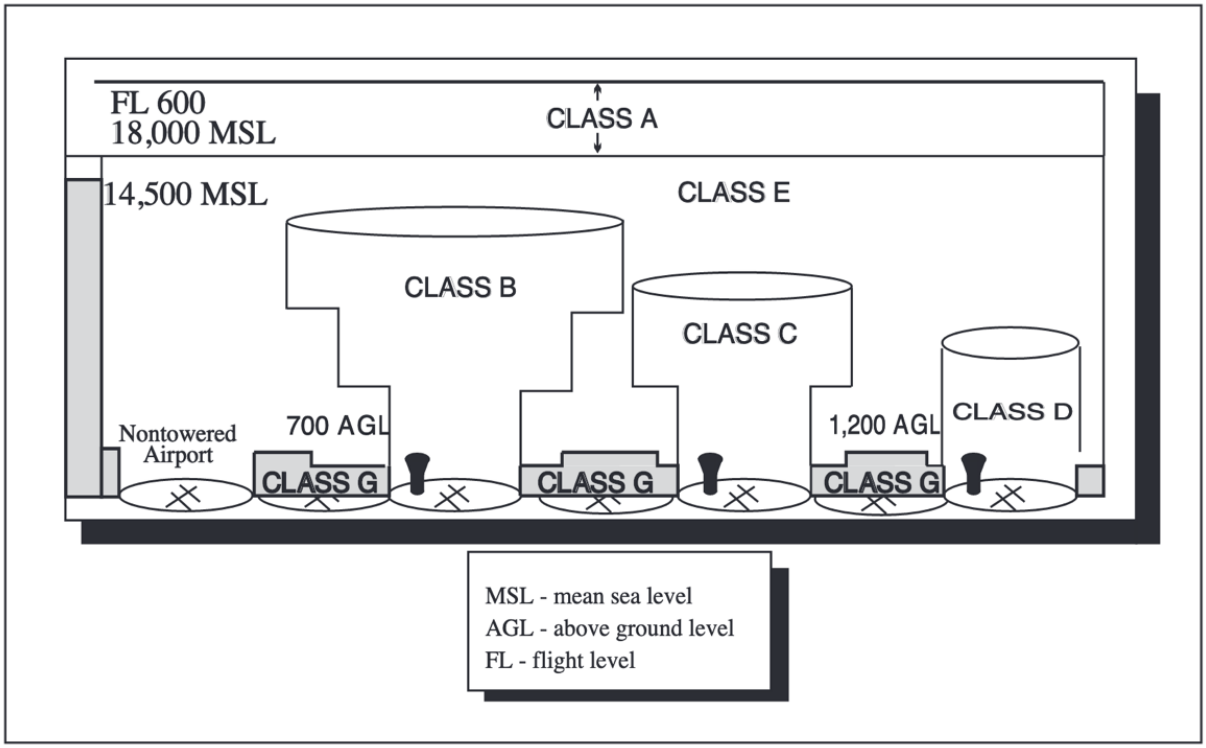
These findings suggest that the majority of UAS sightings are reported by pilot's as they operate within controlled airspace under the oversight of ATC. All 161 of the reported UAS sightings that occurred within 5 NM of an airport also occurred within controlled airspace. The Aeronautical Information Manual (AIM) defines controlled airspace as,

> A generic term that covers the different classification of airspace (Class A, Class B, Class C, Class D, and Class E airspace) and defined dimensions within which air traffic control service is provided to IFR flights and to VFR flights in accordance with the airspace classification. (FAA, 2020c)

It is important to make the distinction between controlled and uncontrolled airspace because there are specific ATC requirements that must be met by aircraft operators, including UAS operators. This discussion is focused on Class B/C/D/E airspace because they encompass most airports that maintain an ATC Tower. To operate within these airspace classes, aircraft operators must meet specific operational requirements regarding ATC authorization, communication, and equipment capabilities.

Figure 2

Airspace Classifications in the United States



Note. This figure depicts the airspace classifications defined by the FAA in the AIM. Controlled airspace includes Class A, B, C, D and E, whereas Class G airspace is considered uncontrolled airspace. This figure is adapted from FAA (2020c).

More specifically, 14 C.F.R. § 91 requires that aircraft operators (manned and UAS) must receive ATC clearance prior to operating in controlled airspace (General Operating and Flight Rules, 1989). This is coupled with the requirement for aircraft operators to have the ability to establish and maintain two-way communication with ATC (FAA, 2020c). Additionally, Class B/C airspace requires aircraft to be equipped with an operable radar beacon transponder with automatic altitude reporting capability and operable ADS−B Out equipment so that ATC can track aircraft in real-time (FAA, 2020c). In terms of UAS operations, 14 C.F.R. § 107 explicitly states that,

> No person may operate a small unmanned aircraft in Class B, Class C, or Class D airspace or within the lateral boundaries of the surface area of Class E airspace designated for an airport unless that person has prior authorization from Air Traffic Control (ATC)". (Small Unmanned Aerial Systems, 2016)

This study found that 161 (54%) of the reported UAS sightings occurred within 5 NM of an airport and within controlled airspace. An analysis of these incidents suggests that UASs were being operated within controlled airspace without ATC permission, two-way communication, or transponder capabilities in direct violation of the 14 C.F.R. § 91, 14 C.F.R. § 107, and the AIM (FAA, 2020c; General Operating and Flight Rules, 1989; Small Unmanned Aerial Systems, 2016). The primary purpose of ATC operational requirements is to ensure that ATC can safely sequence and separate aircraft under their jurisdiction. However, ATC is unable to execute their duties properly when they are forced to separate aircraft from UASs that are not in communication with ATC, nor can be seen on ATC radar equipment. This creates an unsafe airspace environment for all operators, aircraft, ATC, and civilians involved.

UAS Sightings During Critical Phases of Flight

Another concerning trend that appeared during analysis was that reported UAS sightings occurred during critical phases of flight including arrival, departure, and pattern altitude. Key themes gleaned from the reported UAS sightings within 5 NM of an airport included conflicts when aircraft were operating at pattern altitude, short final to the airport, on departure and transitioning over the field. Ninety-eight (98 / 61%) reported UAS sightings occurred at 2,500 feet AGL or below, which is the standard ceiling height of Class D airspace surrounding an ATC Tower. Depending on the facility level, the ATC Tower is busy sequencing aircraft for arrival and departure, while pilots are focused on the task saturated operations of these critical phases of

flight. Previous research has already shown how difficult it is for pilots to identify UASs during arrival/departure operations (Wallace et al., 2019). Therefore, work must be done to mitigate the presence of unauthorized UAS operations in controlled airspace before a mid-air collision occurs.

Coordination with Local Law Enforcement

In line with current FAA guidance, 116 (72%) reported UAS sightings resulted in LE agency notification (FAA, 2018; FAA, 2020a; FAA, 2020b). LE agencies at all levels were notified of unauthorized UAS sightings, including local municipalities, state agencies, and the Federal Bureau of Investigation (FBI). There was no standard law enforcement notification across all reports, nor did the incident summaries include information regarding follow-up actions. Only three (3 / 2%) reports indicated that the UAS operator was contacted by LE following the reported UAS sighting, with only one (1 / > 1%) incident ending with a UAS grounding. It was assumed that LE followed up on the reported UAS sightings, however, the current FAA *Reported UAS Sightings* reports did not include any information regarding follow-up actions. The ramifications of this limitation will be considered in more detail in the following section.

Limitations of Current FAA UAS Sighting Reporting Process

Finally, an unexpected outcome of this capstone project was the discovery of the limitations of the current FAA UAS sighting reporting process. The first concern with the FAA's *Reported UAS Sightings* reports rests in the word "sighting". In its current form, there was no information that indicated whether the UAS was operating in contradiction to federal regulations or within the parameters of a Certificate of Authorization (COA). Given that the FAA was the approval authority for UAS operations throughout the NAS, it was assumed that the reported

UAS sightings involved unauthorized UAS operations. Otherwise, it would have been unnecessary to publish reported UAS sightings that involved FAA approved UAS operations. However, this assumption could not be explicitly confirmed from the *Reported UAS Sightings* reports as currently published.

Secondly, the *Reported UAS Sightings* reports provided basic data regarding the date, city, and state of the reported UAS sighting, but the summary portion of the incidents were inadequate. More specifically, incident summaries were subjective in nature, and were dependent on the knowledge of the person filing the report (i.e. pilot, LE, airport management, etc.). In general terms, the reports provided information on who, what, and where, but did not provide an answer to "why" the reported UAS sighting occurred. It was assumed that follow-up conversations between UAS sighting reporters, FAA, LE and UAS operators took place but were not included in the *Reported UAS Sightings* reports. However, the reports in their current form made available to the public did not provide enough information to help mitigate future unauthorized UAS sightings. Additional information regarding LE follow-up and action is needed, to educate the public on the ramifications of operating UASs in controlled airspace without permission.

In conclusion, this capstone project identified some concerning key themes associated with unauthorized UAS operations near America's airports. These themes included: (1) reported UAS operations violating controlled airspace, (2) reported UAS sightings occurring during critical phases of flight, (3) coordination with local LE agencies, and (4) limitations with the current FAA UAS sighting reporting process. These findings beg the question, what actions can the FAA and airport managers take to develop additional policy and procedures to address these concerns? The next chapter of this capstone project will provide recommendations for federal

policy that could be implemented at airports across the NAS to mitigate unauthorized UAS operations.

Chapter VI

Recommendations

The findings of this research project highlight the need for additional federal policy and procedures that can help airports enforce 14 C.F.R. §107 requirements. This chapter provides a brief overview of the current FAA requirements applicable to airports and executed by airport management personnel. It also provides recommendations for future federal policies that could be enacted by the FAA to assist airport managers with mitigating unauthorized UAS operations at the local level. This section will answer RQ3 which states, *what standardized policies could be developed and implemented by the FAA to help mitigate the safety implications of UAS operations near airports?*

Current 14 C.F.R. § 139 Requirements

The portion of the United States Federal Code that dictates the operations of an airport is outlined in 14 C.F.R. § 139 *Certification of Airports* (Certifications of Airports, 2004). One of the requirements that must be met for an airport to be deemed certified is the development of an Airport Certification Manual (ACM) that is approved by the FAA. The ACM covers all operational procedures applicable to a specific airport as outlined in Figure 3. A review of the ACM elements outlined in Figure 3 confirms that UAS procedures are currently not required under 14 C.F.R. § 139.203. Therefore, the first recommendation for future action is to incorporate UAS procedures in 14 C.F.R. § 139.203 and mandate that airport managers develop official UAS procedures for their airport. These procedures should address how UAS operations will be conducted at their specific airport, including response procedures in the event of an unauthorized UAS sighting. This recommended change to 14 C.F.R. § 139.203 and the ACM,

would ensure that airport personnel are prepared to respond appropriately to an unauthorized UAS near their airport should it occur.

Figure 3

Required Airport Certification Manual Elements

Manual elements	Airport certificate class			
	Class I	Class II	Class III	Class IV
1. Lines of succession of airport operational responsibility	X	X	X	X
2. Each current exemption issued to the airport from the requirements of this part	X	X	X	X
3. Any limitations imposed by the Administrator	X	X	X	X
4. A grid map or other means of identifying locations and terrain features on and around the airport that are significant to emergency operations	X	X	X	X
5. The location of each obstruction required to be lighted or marked within the airport's area of authority	X	X	X	X
6. A description of each movement area available for air carriers and its safety areas, and each road described in §139.319(k) that serves it	X	X	X	X
7. Procedures for avoidance of interruption or failure during construction work of utilities serving facilities or NAVAIDS that support air carrier operations	X	X	X	
8. A description of the system for maintaining records, as required under §139.301	X	X	X	X
9. A description of personnel training, as required under §139.303	X	X	X	X
10. Procedures for maintaining the paved areas, as required under §139.305	X	X	X	X
11. Procedures for maintaining the unpaved areas, as required under §139.307	X	X	X	X
12. Procedures for maintaining the safety areas, as required under §139.309	X	X	X	X
13. A plan showing the runway and taxiway identification system, including the location and inscription of signs, runway markings, and holding position markings, as required under §139.311	X	X	X	X
14. A description of, and procedures for maintaining, the marking, signs, and lighting systems, as required under §139.311	X	X	X	X
15. A snow and ice control plan, as required under §139.313	X	X	X	
16. A description of the facilities, equipment, personnel, and procedures for meeting the aircraft rescue and firefighting requirements, in accordance with §§139.315, 139.317 and 139.319	X	X	X	X
17. A description of any approved exemption to aircraft rescue and firefighting requirements, as authorized under §139.111	X	X	X	X
18. Procedures for protecting persons and property during the storing, dispensing, and handling of fuel and other hazardous substances and materials, as required under §139.321	X	X	X	X
19. A description of, and procedures for maintaining, the traffic and wind direction indicators, as required under §139.323	X	X	X	X
20. An emergency plan as required under §139.325	X	X	X	X
21. Procedures for conducting the self-inspection program, as required under §139.327	X	X	X	X
22. Procedures for controlling pedestrians and ground vehicles in movement areas and safety areas, as required under §139.329	X	X	X	X
23. Procedures for obstruction removal, marking, or lighting, as required under §139.331	X	X	X	X
24. Procedures for protection of NAVAIDS, as required under §139.333	X	X	X	
25. A description of public protection, as required under §139.335	X	X	X	
26. Procedures for wildlife hazard management, as required under §139.337	X	X	X	
27. Procedures for airport condition reporting, as required under §139.339	X	X	X	X
28. Procedures for identifying, marking, and lighting construction and other unserviceable areas, as required under §139.341	X	X	X	
29. Any other item that the Administrator finds is necessary to ensure safety in air transportation	X	X	X	X

Note. This figure is a reprint of the original table published in 14 C.F.R. § 139.203 and provides a list of all required items that must be included in the ACM (Certifications of Airports, 2004, §139.203).

In conjunction with the inclusion of UAS procedures in 14 C.F.R. § 139.203, the second recommendation is that airport managers develop a Letter of Agreement (LOA) or Memorandum of Understanding (MOU) with their local LE and ATC units to address UAS procedures. These official documents can be used to establish official agreements between the organizations and outline how response actions are to take place. The findings of this study illustrate the need for local real-time UAS response procedures between the airport, LE and ATC when faced with an unauthorized UAS near an airport. Moreover, the development of a LOA / MOU can be accomplished at the local level, regardless of the inclusion of UAS procedural requirements in 14 C.F.R. § 139.203. This is an immediate mitigation strategy that can be enacted by airport managers at any airport, regardless of current federal policies, with the assistance of local LE and ATC agencies.

Finally, it was evident from the analysis of the data sample that the mechanism for reporting UAS sightings requires attention and change. In its current form, the information presented in the FAA's *Reported UAS Sightings* reports does not help the public understand the severity of unauthorized UAS sightings in the NAS, nor does it provide feedback to assist with identifying rouge UAS operators. As mentioned previously, it was assumed that conversations between the FAA and LE occurred behind the scenes during the investigation process but was not included in the reports. However, it is recommended that the FAA incorporate LE investigation findings into the *Reported UAS Sightings* reports so that the public is aware of the repercussions to those who operate UASs in the NAS without ATC permission.

Chapter VII

Conclusion

In summary this capstone research project analyzed the current data available regarding UAS operations in the NAS to determine the safety implications they pose to America's airports. This study began with a review of the current body of literature, which found that most research considered the study and critique of U.S. regulation and policy, counter-drone technologies, human factors, and law enforcement procedures. Following the literature review, was an overview of the methodology of this historical research study that utilized data from the FAA's *Reported UAS Sightings* reports (FAA, 2021). The analysis of 300 randomly selected reported UAS sightings from the calendar years 2015 – 2020 determined that 161 (54%) of reported UAS sightings occurred within 5 NM of an airport. Further analysis identified important key themes applicable to all reported UAS sightings including: (1) reported UAS operations violating controlled airspace, (2) reported UAS sightings occurring during critical phases of flight, (3) coordination with local LE agencies, and (4) limitations with the current FAA UAS sighting reporting process. A discussion of these key themes and their implications led to the development of three recommendations for future unauthorized UAS mitigation strategies including: (1) incorporating UAS procedures into the ACM requirements codified in 14 C.F.R. § 139.203, (2) encouraging airport managers to immediately develop an LOA and/or MOU with their local LE and ATC agencies defining UAS response procedures, and (3) updating the FAA's *Reported UAS Sightings* reports to include law enforcement response actions. In close, this capstone research project is only one small step in the journey of mitigating unauthorized UAS operations in the NAS. The dedicated professionals of airport management, air traffic control,

aviators and law enforcement must continue to work together to educate the public on the safety implications of improper UAS operations before a tragedy occurs.

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