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The State of UAS Operations at Airports, A Perspective from Airport Managers

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Abstract: As the number of Uncrewed Aircraft Systems (UAS) operating in our National Airspace System (NAS) increases, so do UAS operations near or at an airport. The accelerating technology in Advanced Air Mobility (AAM) along with the related business opportunities will only further increase UAS operations at airports. This continued growth in new UAS technologies and applications introduces new hazards and risks to the airport environment. This proliferation of UAS highlights the importance of airports developing a robust Safety Management System (SMS) that includes specific UAS risk mitigations. To date, there is currently little empirical data regarding UAS traffic around airports. Nor is there a system to collect this data at a national level. This study attempted to gain insight into the commercial UAS operations across a broader airport population by surveying the airport manager population here in the United States. Research results found that 62% of airports are experiencing an increase in UAS operations in their surrounding airspace. This increase applies to all airspace classifications, with 67% of airports located in controlled airspace experiencing an increase in UAS operations. However, only 27% of airports have some type of UAS safety plan. Similarly, the increase in adverse UAS events near airports suggests that UAS operators may also lack robust safety plans or an understanding of the risks and regulations associated with operating near airports.

Keywords: aviation; safety; unmanned aircraft systems; uncrewed; airports; drones

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1. Introduction

As the number of Uncrewed Aircraft Systems (UAS) operating in our National Airspace System (NAS) increases, so do UAS operations near or at an airport [1–3]. This may include a local hobbyist flying a drone at a nearby park, a construction company using a drone to survey a new business park, or the airport using a drone to perform runway pavement inspections or support wildlife assessments. The accelerating technology in Advanced Air Mobility (AAM) along with the related business opportunities will only further increase UAS operations at airports [4,5]. This continued growth in new UAS technologies and applications introduces new hazards and risks to the airport environment. Furthermore, as UAS operations increase so does the chance of collision with manned aircraft. This proliferation of UAS highlights the importance of airports developing a robust Safety Management System (SMS) that includes specific UAS risk mitigations [6–8]. To date, there is currently little empirical data regarding UAS traffic around airports. Nor is there a system to collect this data at a national level. The Federal Aviation Administration (FAA) UAS sighting reports are subjective and lack the validity to enable data-driven safety decisions. A few empirical studies have been conducted at a select number of airports, but these studies have been limited in scope. Recent drone events that adversely affected airport operations have put a focus on UAS detection and Counter UAS (C-UAS) technologies [9–11]. However, UAS detection systems cannot determine the intent of a UAS pilot, or the potential threat posed by a UAS. Furthermore, the FAA currently does not support the use of C-UAS systems other than by federal agencies that have explicit regulatory authority to use the technology deterrent [9,12]. Nefarious actors aside, commercial UAS operations

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are only expected to grow. This study attempted to gain insight into the commercial UAS operations across a broader airport population by surveying the United States airport manager population.

2. Research Problem

This study explores the scope of UAS operations within the airspace surrounding United States (U.S.) airports. Although bad actors, or unauthorized operations, are a concern, the focus of this study is on commercial operations and attempts to address the following research questions:

1. Are airports experiencing an increase in UAS commercial operations within their airspace?
2. Which airports are experiencing an increase in UAS commercial operations?
3. Do airports experiencing an increase in UAS commercial operations also have formal UAS safety plans?

3. Background

According to the FAA, as of January 2023, there are over 863,000 UAS registered in the U.S., and over 352,000 of these are registered for commercial operations [1]. In comparison, a review of the FAA 2023 aircraft registration database found approximately 250,000 manned aircraft in the U.S. [13]. It is estimated that the commercial UAS fleet size in the U.S. will be around 955,000 by 2027 [14]. In addition, the advancement of AAM technologies will further increase the future number of uncrewed aircraft along with the potential of close encounters with manned aircraft [15,16]. This growth has experts concerned with potential midair collisions between crewed and uncrewed aircraft.

In 2010, the United Kingdom's Airprox Board began collecting UAS sighting reports from manned pilots and air traffic controllers. A review of this data found a total of 604 UAS sighting reports since 2010 [17]. Likewise, the FAA began a similar process in November of 2014 and currently receives more than 100 reports each month [18]. Although these reports suggest increasing encounters between uncrewed and crewed aircraft, the validity of these reports is questionable [19,20]. The vast majority of these reports are simply a pilot reporting that they saw "something," often with no other evidence [21]. The Academy of Model Aeronautics found a large majority of these reports are just observations of UAS in the airspace and not necessarily a hazard or near miss [22]. Currently, there is no national UAS detection and tracking system that may provide data to correlate with these observations. Additionally, these sighting reports are not investigated or validated by the FAA or the Airprox Board, further contributing to concerns over the validity of the data [19,22,23].

There have already been multiple uncrewed aircraft encounters with manned aircraft across the globe. In 2020, two separate events in the Los Angeles area involved a drone impacting a helicopter [24,25]. London Gatwick Airport was forced to close for nearly 33 hours, which resulted in a total estimated economic loss exceeding 50 million pounds [10,26]. A similar incident occurred at Newark Liberty Airport in 2019 and resulted in the suspension of airport operations for 90 minutes [11,27]. More recently, in July 2022 a drone sighting near Ronald Reagan International Airport caused a 45-minute halt in operations with an estimated financial impact exceeding $60 million [28,29]. These events highlight the need for airports to have robust UAS response plans to not only ensure safety but to minimize any economic losses.

Various studies have been conducted to collect empirical data on uncrewed and crewed aircraft interactions. Wallace et al. [30] collected telemetry data from uncrewed and crewed aircraft over a 36-month period in the airspace around Dallas-Fort Worth International Airport. During this period, researchers identified 24 instances of a near mid-air collision between a UAS and crewed aircraft. However, this study was limited in scope as the technology used only detected UAS manufactured by DJI and collected data at only one location. Similarly, Mott et al. [31] used a nearly identical methodology to evaluate uncrewed and crewed aircraft traffic in proximity to Orlando Melbourne International Airport. Over the two-week data collection period, researchers identified eight significant interactions between crewed and uncrewed aircraft. Like the Wallace study, researchers only collected data from DJI UAS and were limited to a short period at one location.

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Recently the FAA enacted a regulation that requires UAS pilots to ensure their aircraft are equipped with remote identification (RID) technology. According to the FAA, RID "is the ability of a drone in flight to provide identification and location information that can be received by other parties through a broadcast signal" [32]. This near real-time data may help the FAA and law enforcement to discern compliant and non-compliant airspace users and has the potential to significantly improve air traffic situational awareness across all airspace users [33]. RID may help improve the operational data of UAS across the broader NAS. However, the FAA delayed mandatory enforcement of the RID rule until March 16, 2024 due to the limited availability of broadcast modules and a lack of approved FAA-Recognized Identification Areas [32], further delaying the widespread collection and analyses of RID data and the potential benefits.

In June 2020 the FAA introduced FAA Order 8000.369C, which established the FAA's SMS policy [34]. This policy discusses UAS as a hazard and the need for robust SRM processes [34]. The Transportation Research Board has published a collection of guidebooks to assist airport operators with responding to the increasing UAS operations at airports [35–37]. This guidance suggests that SMS practices may improve airport stakeholders' management of risks and reduce the number of adverse incidents [38,39]. Having a formalized approach to managing risks is especially important when new technologies are introduced into the operating environment, such as AAM [37]. As future AAM operations expand, the increasing complexity of uncrewed operations will further increase the reliance on robust safety practices to ensure an acceptable level of safety [4,40].

Since 2016, the Office of Airports Safety & Standards (AAS) has several policy documents regarding the use of UAS detection and mitigation technology at airports [12]. Topics include legal considerations, potential electromagnetic interference (EMI) to communication and navigation equipment, and on-airport airspace case processing, among others. The availability of this technology is increasing and wide-ranging; however, before deployment, the FAA needs to assess the potential disruption of air traffic operation or undesirable safety and efficiency impacts [12]. Generally, this technology falls into two categories, detection and mitigation, or what is commonly referred to as Counter–UAS (C-UAS) [12,41].

UAS Detection System technologies range from infrared devices to track heat signatures, radio frequency scanning, and acoustic sensors [41]. Radio frequency and radar systems are currently the most common detection technologies [42]. C-UAS often involves some technology intervention that may disrupt, destroy, or take control of the UAS [12,41].

Currently, the FAA requires all airports certified under 14 CFR Part 139 to have an approved UAS Response Plan [6]. This plan provides specific guidance to the airport operator on steps to follow in the event of unauthorized UAS activity, including the safe return to normal operations after the event [6], but it provides little guidance on SMS processes related to authorized UAS operations within the surrounding airspace or the airports' air operations area.

4. Methodology

Research methods included both quantitative and qualitative. The first phase of the research methods involved a literature review and interviews with industry experts to gain perspective on the current situation. The second phase involved the development of a survey instrument to facilitate data collection across a broader population. The information from the first phase helped researchers in developing the survey questions. The third phase included the deployment of the survey and data collection. Finally, in the fourth phase, researchers conducted data analyses and follow-up interviews with the same industry experts to gain further perspective on the survey results.

In phase 1, researchers conducted one-on-one phone interviews. These interviews were open-ended and intended to gain insight into their experiences and activities regarding UAS operations at airports. The researcher first read a confidentiality statement and advised the interviewee that they would be taking notes, no identifying information would be recorded, and the research findings would be reported in the aggregate. Interviewees included two airport managers and two members of regulatory agencies. The following four people were interviewed:

- A general aviation airport manager in the United States,

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- An international airport manager in the United States, (one of the 100 busiest airports in the country),
- A regulator for an Asia regulatory agency responsible for airport oversight.
- A regulator for a U.S. agency responsible for UAS airspace operations.

In phase 2, researchers developed a survey instrument based on literature and interviews with aviation professionals. The survey questions were intended to gain insight into the UAS operations within the airport airspace and whether airports had a UAS response plan. Questions included information regarding airport demographics, such as airport size and airspace.

The survey instrument was first reviewed by the aviation faculty at an R1 university with expertise in airport operations and UAS. The research team discussed the survey with the faculty and incorporated appropriate changes. Next, researchers conducted a beta test of the survey by disseminating the online instrument to a small group of local airport personnel, aviation experts, and fellow aviation faculty. This group included the four interview subjects. Researchers received 20 beta surveys along with additional input from this pool of beta testers, which helped establish face validity. Next, researchers once again sent out the revised online survey questionnaire for feedback to a larger sample of aviation experts who were professional contacts of the research team. Once the final survey instrument was completed, researchers obtained the email address of airport managers from publicly available sources, such as airport directories. The survey was distributed via email to a sample size of 1,720 U.S. public airport personnel using the Qualtrics online survey. The survey was active for 30 days and consisted of multiple-choice questions and one open-ended question. Researchers sent out one reminder email to the survey population one week before it closed. Survey data were analyzed using descriptive statistics and cross-tabulations were created to compare variables.

In addition to the demographic questions, the primary variables below consisted of 'yes', 'no', or 'don't know' responses. The variable name is italicized in parenthesis below and is referenced in further discussion. To gain perspective on UAS operations at U.S. airports, researchers asked the following questions:

- Has your airport experienced an increase in commercial UAS operations? (*Commercial UAS Operations*)
- Has your airport used UAS to support airport operations, such as runway pavement inspection, wildlife monitoring, perimeter security, emergency response, etc.? (*UAS Utilization by Airports*)
- Has your airport experienced an increase in unauthorized UAS operations? (*Unauthorized UAS Operations*)
- Does your airport use a type of drone detection technology (i.e., DJI Aeroscope, DeDrone, or radar, etc.) to detect UAS operations near your airport? (*UAS Detection*)
- Does your airport have a UAS response plan? (*UAS Response Plan*)

In addition, the final survey question shown below allowed for open-ended responses or comments.

- Do you have any other comments regarding UAS operations at your airport?

Authors should discuss the results and how they can be interpreted from the perspective of previous studies and the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

5. Results

Researchers received 150 survey submissions. A total of 112 surveys were retained after data cleaning efforts.

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5.1. Demographic Data

Data collected from the survey were analyzed to examine demographic data such as airport categories, airspace classification, and location by FAA region. Below is a description of these demographic data:

- *Airport Category*: 73.21% (n=82) of the responses were *general aviation* airports, 10.71% (n=12) were *reliever*, 8.04% (n=9) were *commercial service—non-hub*, 4.46% (n=5) were *commercial service—small-hub*, 3.57% (n=4) were *commercial service—large-hub*.
- *Airspace Classification* (Table 1):

Table 1. Distribution of airports by airspace.

Airspace	Class B	Class C	Class D	Class E	Class G
Percentage	7.14% (n=8)	8.93% (n=10)	23.21% (n=26)	31.25% (n=35)	29.46% (n=33)

- *FAA Region*: All regions were represented except for the *Alaskan Region*.
- *Control Tower*: 75% (n=81) of the responses were from *non-towered airports*, whereas the remaining 25% (n=31) were from *towered airports*.

5.2. Commercial UAS Operations

Data analyses found that 49.11% (n=55) of the airports experienced an increase in commercial UAS operations, 44.64% (n=50) indicated no increase, and 6.25% (n=7) did not know. Overall, 74.19% (n=23) of the towered airports experienced an increase in commercial UAS operations in their airspace compared to 39.51% (n=32) of non-towered airports. A cross-tab analyses of *Commercial UAS Operations* and *Airspace Classification* found that the same percentage (66.7%) of airports in Class D (n=16) and Class C (n=6) airspace indicated an increase in commercial UAS operations, followed by Class E (n=16) at 48.5%, Class G (n=13) at 39.4%, and Class B (n=8) indicated no increase.

5.3. UAS Utilization by Airports

Analyses of *UAS Utilization by Airports* found that 29.46% (n=33) of respondents indicated using UAS to support their airport operations. Of these 33 airports, 7 were towered airports and 26 were non-towered. A cross-tab analysis of *UAS Utilization* and *Airspace Classification* found that 50% of airports in Class B (n=4) indicated using UAS to support airport operations, followed by Class G (n=11) at 33.3%, Class E (n=9) at 25.7%, Class D (n=6) at 23%, and Class C indicated no utilization.

5.4. Authorized UAS at Airports

Since variables *Commercial UAS Operations* and *UAS Utilization by Airports* are both indicators of the total volume of commercial operations, researchers combined these variables into a new variable called *Authorized UAS at Airports*. The following criteria were used to develop the new variable,

- 'Yes' responses to both questions were only counted once.
- 'Yes' response to one question and a 'No' response to the other were included in the new variable as a single count.
- 'No' responses to both questions were not counted.

Overall, 57.14% (n=64) of the airports have experienced *Authorized UAS at Airports.* Researchers then compared *Airspace Classification* and *Authorized UAS at Airports*. While 75% (n=6) of the airports located in Class B and 60% (n=6) in Class C airspace indicated UAS use in the airspace, airports in Class D were 73.1% (n=19), Class E was 48.5% (n=16), and Class G was 51.5% (n=17) respectively. These results suggest commercial UAS operations are increasing in the airspace surrounding airports.

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5.5. Unauthorized UAS at Airports

Analyses of this data found that 27.68% (n=31) of the airports have experienced an increase in unauthorized UAS operations, 52.8% (n=57) indicated no increase, and 22.2% (n=24) did not know. Overall, 38.71% (n=12) of the towered airports experienced an increase in unauthorized UAS operations compared to 21% (n=17) of non-towered airports. A cross-tab analyses of *Unauthorized UAS at Airports* and *Airspace Classification* found that 44.4% of airports in Class C (n=4) indicated an increase in unauthorized UAS operations, followed by Class D (n=8) at 33.3%, Class B (n=3) at 37.5%, Class E (n=8) at 24.2%, and Class G (n=6) at 18.2%.

5.6. All UAS at Airports

Similar to the variable *Authorized UAS at Airports*, a new variable *All UAS at Airports* was created to combine both authorized and unauthorized UAS operations at airports. Researchers used the data criteria described earlier to avoid double counting. Analyses of this combined found that 62.5% (n=70) of airports have experienced either an increase in commercial UAS operations, have used UAS to support operations, or experienced an increase in unauthorized UAS operations. This combined variable provided a perspective of the overall volume of UAS operations, both authorized and unauthorized, at airports. Examining *All UAS at Airports* by *Airspace Classification* was Class B 75% (n=6), Class C 60% (n=6), Class D 84.6% (n=22), Class E 51.4% (n=18), and Class G was 51.5% (n=17) respectively. Although the UAS sighting reports are not verified, the sighting report data combined with these findings suggest that UAS operations are increasing in the airspace around airports.

5.7. UAS Detection

Analyses of this data found that only 5.6% of airports (n=6) have used a type of drone detection technology. A cumulative 14.8% (n=4) of the towered airports and 2.5% (n=2) of non-towered airports have used this technology. A cross-tab analysis of *UAS Detection* and *Airspace Classification* found 37.5% of airports in Class B (n=3), 8.3% in Class D (n=2), 22.2% in Class C (n=2), and 3% in Class G (n=1) are using this technology. No airports in Class E indicated using drone detection technology.

5.8. UAS Response Plan

As discussed earlier, the FAA requires all airports certified under 14 CFR Part 139 to have an approved UAS Response Plan. The survey results found that 20.54% (n=23) of all respondents indicated their airport has a UAS Response Plan, 71.3% (n=77) indicated they do not have a plan, and 11.1% (n=12) did not know. A cumulative 32.26% (n=10) of the towered airports and 26% (n=20) of non-towered airports have a plan. A cross-tab analysis of the *UAS Response Plan* and *Airspace Classification* found that 75% (n=6) of airports in Class B, 33.3% (n=3) in Class C, 21.2% (n=7) in Class G, 16.7% (n=4) in Class D, and 9.4% (n=3) have a UAS Response Plan.

5.9. SRM for UAS

Regarding airports having formal SRM for UAS operations, only 16.1% (n=18) of all airports indicated having such processes. Overall, this research found 22.58% (n=7) of the towered airports and 13.58% (n=11) of non-towered airports have SRM processes. Cross-tab analyses found that airports in Class B 75% (n=6), Class D 15.4% (n=4), Class G 15.2% (n=5), and Class E 8.6% (n=3) have formal SRM. No airports in Class C indicated having SRM.

5.10. UAS Safety Plan

Because both the *UAS Response Plan* and *SRM for UAS* variables were indications of a type of safety plan, these variables were combined into the new variable *UAS Safety Plan*. Researchers used the same data criteria previously used to develop the *UAS Safety Plan* variable.

Analyses of this new variable found that 24.10% (n=27) of the airports have a *UAS Safety Plan,* with 11.60% (n=13) having both a *UAS Response Plan* and *SRM for UAS*. Comparing *Airspace*

Classification and *UAS Safety Plan*, the analyses found that 75% (n=6) of the airports located in Class B, 30% (n=3) in Class C, 19.2% (n=5) in Class D, 14.3% (n=5) in Class E, and 24.2% (n=8) in Class G have a *UAS Safety Plan*.

5.11. All UAS at Airports and UAS Safety Plan

Next, researchers compared the relationship between the variables *All UAS at Airports, UAS Safety Plan, and Airspace Classification*. These relationships are graphically represented in Figure 1 where across all *Airspace Classifications* differences are observed between *UAS Safety Plan* and *All UAS at Airports*. Analyses of the data found a difference of 25.0% (n=2) in Class B, 30.0% (n=3) in Class C, 65.38% (n=17) in Class D, 37.14% (n=13) in Class E, and 27.27% (n=9) in Class G airspaces between airports having a *UAS Safety Plan* and *All UAS at Airports*. Overall, across all *Airspace Classifications,* there is a difference of 39.29% in airport distribution.

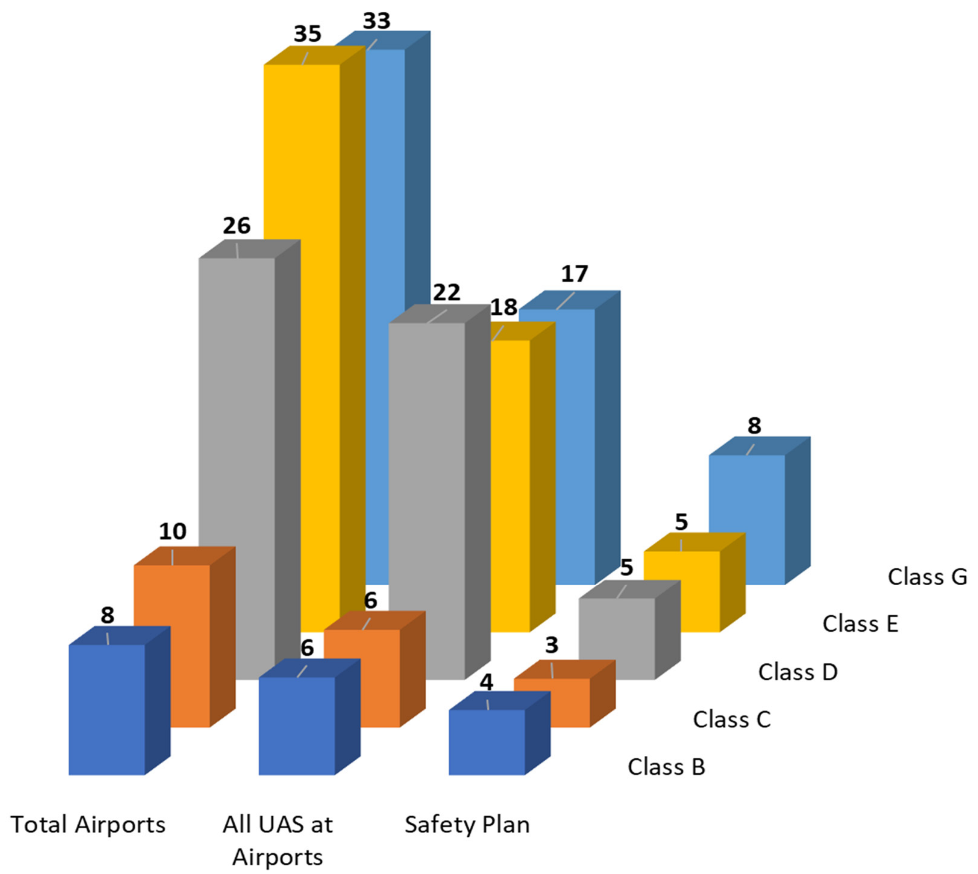

Figure 1. Airport Distribution by Airspace Classification, All UAS at Airports, UAS Safety Plan.

To better understand the relationship between *UAS Safety Plan* and *UAS at All UAS at Airports,* researchers conducted a binary logistical regression. The data was converted to binary by assigning the numerical '1' for 'Yes' and '0' for 'No" and 'Don't Know'. The statistical analyses (Table 2) were insignificant (p = 0.681). These findings suggest that airports experiencing an increase in UAS operations are more likely to not have a related safety plan.

Table 2. Binary Logistical Regression Relationship between *UAS Safety Plan*: *UAS at Airports.*

Independent Variable	Outcome	Coefficient	Chi-Square	Significance
Constant	-	0.289	0.001	0.174

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UAS Safety Plan	*All UAS at Airports*	0.321	0.342	0.681

5.12. Open-Ended Question Responses

The survey included one open-ended question with 14 people providing additional comments. Three respondents indicated experiencing a hazardous event involving a UAS and a manned aircraft near the airport. Two expressed a need for UAS detection technology to help air traffic controllers manage the airspace. Others voiced frustration and confusion over regulatory policy or a need for more robust safety guidance. Four of the airports described the benefits that UAS provided in supporting airport operations, three of these were in the area of infrastructure inspections, and one in the area of wildlife monitoring.

5.13. Interviews

The manager of a small U.S. general aviation airport in Class D airspace expressed a positive outlook on UAS operations but stressed the need for robust safety practices for both the UAS operator and the airport. The manager recognized the potential benefits of UAS in supporting airport operations such as infrastructure inspections and monitoring. The airport has worked with a couple of outside organizations to evaluate the use of small drones to inspect runway/taxiway pavement and glideslope obstacle clearances. The manager expressed a positive experience from these beta tests. The manager also mentioned that the airport has been contacted by several developers of advanced air mobility aircraft to discuss the possibility of operations at the airport. The manager mentioned a need for more guidance on incorporating these types of operations into the airport environment, which includes best practices regarding safety management.

The manager at an international airport in the U.S. stated their airport is also exploring the use of UAS to support the airport. These activities include wildlife monitoring, first responder services, and airport facility inspections. These initial experiences resulted in reduced inspection times, higher quality, and lower cost. The use of UAS technology has further decreased the reliance on traditional vendors to conduct these inspections. The introduction of these UAS operations led to the airport developing formal SMS protocols specific to UAS.

Both airport managers suggested that most airport managers lack an understanding of UAS operations, policies, and applications. This likely contributes to airports not using UAS more broadly to support airport operations and lacking a robust SMS or a UAS response plan. Both managers also expressed a significant increase in UAS operations near their airports.

Interviews with a regulator in Asia helped researchers gain perspective on UAS operations at airports abroad. The regulator said their agency has adopted a strategy that creates special fly zones that support different UAS operators such as recreational users vs. professionals. The regulator also stated that several aviation maintenance providers are using UAS to conduct structural inspections of aircraft inside their hangars and are seeking approval to conduct similar inspections outside on the ramp. This finding further supports the literature, which suggests the increasing use of UAS within the airport air operations area. The regulator also confirmed an increase in UAS operations near airports, including nefarious actors.

The U.S. regulatory representative expressed both excitement and concern over the increasing advancement of unmanned aircraft. The opportunities for increasing efficiencies and the potential public benefit are immense; however, the number of non-traditional aviation organizations developing these technologies with no historical safety experience is concerning. Adding to this concern is a shortage of experienced aviation professionals, both within the regulatory agencies and industry.

This section is not mandatory but can be added to the manuscript if the discussion is unusually long or complex.

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6. Limitations

As discussed earlier, a broad system to collect empirical data regarding UAS operations does not yet exist. This research surveyed airport operators regarding their experiences and perceptions of UAS operations and did not collect any empirical data. The results of this survey suggest that the number of airports across the population that have robust UAS response plans is low, and by extension, their recordkeeping of UAS activities is likely not robust. Therefore, survey participants likely based their responses regarding UAS activity solely on their experiences and not empirical data. Hopefully, future UAS monitoring technologies will provide researchers with more robust data. In addition, the overall survey response rate was just over 6%. Several factors may have impacted the low response rate. Jadhav et al. [40] found that airport operators may be unfamiliar with UAS or AAM, which may have led many airport operators to forgo completing the survey. In addition, airports are experiencing a significant increase in air traffic post COVID along with workforce challenges [14,43–45], which may have contributed to the low response rate due to time constraints.

7. Conclusion

This study found that 62% of airports are experiencing an increase in UAS operations in their surrounding their airspace. This increase applies to all airspace classifications, with 67% of airports located in controlled airspace experiencing an increase in UAS operations. These UAS traffic increases include operations by the airports themselves. Although the focus of this research was on commercial UAS operations, the results suggest airports are experiencing an increase in unauthorized UAS operations near airports along with an increase in adverse UAS events, such as operational interruptions. The results of this research highlight the importance of airports having a robust safety plan to address increasing UAS operations. However, this research found that only 27% of airports have some type of UAS safety plan. Similarly, these increasing adverse events suggest that UAS operators may also lack robust safety plans or an understanding of the risks and regulations associated with operating near airports.

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Informed Consent Statement: Not applicable.

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