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Exploring the State of SMS Implementation at Airports

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Safety Management Systems (SMS) in the aviation industry are an increasingly important aspect of identifying hazards and managing the associated risks. While SMS has become commonplace and is often a regulatory requirement for air carriers, it remains voluntary for many other aviation service providers, such as airports. Over the past decade, commercial Unmanned Aircraft System (UAS) operations near airports have significantly increased along with the development of Advanced Air Mobility operations. Airports face new and emerging safety challenges. However, safety is a precursor for public acceptance and proliferation of these next-generation aviation technologies. Safety practitioners consider SMS a key enabler in ensuring the safety of the National Airspace System and may assist airports in addressing these emerging hazards and risks. This research explored the current state of SMS at airports and their incorporation of UAS hazards and risks. This research utilized a mix of quantitative and qualitative methods, which included an extensive literature review and a survey of airport stakeholders. Research results suggest a need for further development and adoption of SMS at airports, including further maturation of UAS safety practices along with education and training. This study may assist airport stakeholders and regulators with further developing robust safety and risk management practices that support the safety of the next generation of aviation operations.

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Introduction

A safety management system (SMS) for airports is known as a "formal, top-down, business-like approach to manage safety risks" (Federal Aviation Administration (FAA), 2007, p. 1) that is attributed to the airport. An SMS helps the airport identify personnel in charge of airport safety, identify hazards, manage risk, assure safety, and promote safety at the airport. Implementing an SMS is part of the safety management principles as designated by the International Civil Aviation Organization (International Civil Aviation Organization (ICAO), 2018).

Over the past decade, Unmanned Aircraft Systems (UAS) have rapidly evolved into an established and growing commercial segment of the aviation industry. UAS are becoming an increasingly integrated and essential component of the National Airspace System (NAS). The Teal Group's 2022/2023 World Civil UAS Market Profile and Forecast predicts that civil UAS production will grow from $7.2 billion annually to $19.8 billion by 2031 (Teal, 2022). Advanced Air Mobility (AAM) is the next progression of UAS and is expected to further increase the volume of air traffic. Morgan Stanley Research predicts the AAM market value nearing $1.5 trillion by 2040 (Jonas, 2019).

Consequently, there has been an exponential increase in UAS operations across a diverse population of users and applications. As of May 2022, there were about 865,000 registered UAS in the United States (U.S.) (FAA, 2022a), which far exceeds the approximate 250,000 registered manned aircraft (FAA, 2022b). The commercial UAS market is estimated to be about $63.6 billion by 2025 (Insider Intelligencer, 2022), enabling various opportunities for businesses, governments, and hobbyists, which also suggests an increase in the overall UAS air traffic within the NAS. Additionally, the U.S. Department of Transportation (DOT) continues to expand its use of UAS technologies and recently selected Alphabet, AT&T, Intel, and Apple to conduct further research in UAS applications (Reuters, 2018).

The research suggests UAS operations on or near airports are increasing along with an increase of UAS in close proximity to manned aircraft. In 2015, Ettinger et al. (2015) completed one of the first detailed analyses of incidents involving UAS and manned aircraft in the U.S. NAS. Their research found that most events occurred in close proximity to airports, with 158 incidents of UAS coming within 200 feet or less of a manned aircraft (Ettinger et al., 2015). The Federal Aviation Administration (FAA) established the Low Altitude Authorization and Notification Capability (LAANC) in 2017, which provides UAS operators with automated airspace authorizations near airports (FAA, 2022c). Since LAANCs inception, the FAA has issued over a million airspace authorizations (FAA, 2022c). Wallace et al. (2022) collected data regarding UAS airspace operations from July 1, 2021 through January 31, 2022. During this time, the research team detected 470,902 small UAS flights at 64 separate sampling locations across the United States. Approximately 30% of these flights were in controlled airspace, which further indicates the number of UAS operations near airports is increasing (Wallace et al., 2022).

Research Problem

Due to the rapid proliferation of UAS and their operation at or near airports, safety practitioners are challenged to keep pace with developing robust SMS practices that ensure an acceptable level of safety. Aviation authorities increasingly receive UAS sighting reports from manned pilots and air traffic controllers – creating a rising concern about a collision between manned and unmanned aircraft (FAA, 2022d; Pyrgies, 2019). In addition, the increase of commercial UAS operations in the airport operating area (AOA) adds to this collision risk, making safety management processes specific to UAS operations of increasing importance. As such, this research attempts to gain perspective on what is the current state of SMS at airports and their incorporation of policies that address UAS hazards and risks.

Background

Important considerations for this study include research related to UAS at airports and research related to the implementation of safety management systems (SMS) at airports.

UAS at Airports

Manned aircraft are usually flown in accordance with visual flight rules (VFR) or instrument flight rules (IFR), which are most often dissimilar to UAS flight plans (Wilson, 2018). These differences create complications in the air traffic system, which may prove to be dangerous. UAS flights may also result in disastrous collisions with manned aircraft due to the UAS lacking traditional aviation communication, navigation, and safety-related technologies. Overall, the number of close encounters between UAS and manned aircraft is on the rise. Pyrgies (2019) conducted a quantitative analysis of 139 UAS incidents and categorized 24 of these incidents to be a near mid-air collision with manned aircraft, two UAS resulted in a mid-air collision, ten UAS resulted in airport closure, and one UAS was sighted inside the airport premises. Since the FAA first started collecting UAS sightings reports in 2016, there has been a steady rise in the number of sightings. For example, a review of this data found that during the period from April through June 2021, there were 958 sightings, an increase of 79% over the same 3-month period in 2016 (FAA, 2022d).

The use of a UAS-based platform was also found to be more cost-effective for conducting basic inspections in and around the airport. Airports have increasingly started to use UAS to assist with tasks such as security, mapping, surveying, and inspections (Hubbard et al.; Mackie & Lawrence, 2019). Regulators have struggled to keep pace with this ever-changing ecosystem. Guidelines and policies that effectively address safety-related hazards and subsequent risk management of UAS have lagged behind the advancing marketplace. The projected increases in commercial air traffic will further exacerbate the demand for FAA’s Air Traffic Control (ATC) resources (Chauhan et al., 2021; Hubbard et al., 2017; Kamienski et al., 2015; Parker et al., 2018). The continued increase in air traffic, coupled with the incorporation of next-generation technologies, further signifies the importance of robust safety management practices.

An increasing number of UAS in the NAS and the lack of a mature regulatory framework have led to concerning events around the AOA. The drone events at the London-Gatwick (Wendt et al., 2020) and Dubai airports halted airport operations for a significant time and exemplify the potential hazards small UAS (below 55 lbs.) pose to airports. While the owners of the UAS being flown at London and Dubai remain unidentified, these events further demonstrate the need for an SMS to manage UAS operations inside the AOA. Airport boundary intrusions, airport threats, airspace disruption, air traffic controllers' increased workload, and runway incursions are just some of the hazards presented by small UAS. Such issues highlight the need for a structured SMS to better manage commercial UAS operations. ICAO (2018) has recommended SMS for all aviation entities. However, there may be a gap in the current SMS processes to adequately manage the associated UAS safety risks at airports.

The Gatwick airport drone incident (2018) is a prime example where a UAS was spotted particularly close to the airport multiple times (Rowlatt, 2019). This incident highlighted the need for stringent UAS mitigation techniques to combat these types of events. This incident resulted in immense financial losses, and close to a thousand flights were affected (Rowlatt, 2019). A similar incident occurred in the UAE in 2016, when Dubai International Airport was compelled to close for three times due to unauthorized drone activities for about 3 hours, leading to cumulative losses of close to $16.62 million (The National, 2016).

SMS at Airports

Current FAA UAS regulations primarily focus on UAS operations in uncontrolled airspace or within a limited area of the controlled airspace around an airport (14 CFR § 107, 2021). Airports may better prepare for these types of advanced UAS operations by proactively developing related SMS processes. ICAO started introducing elements of SMS in 1997 with the Global Aviation Safety Plan (GASP) (ICAO, 2007). This plan was a safety guide for organizations and was regularly updated until 2005. In 2006, ICAO published a Safety Management Manual (SMM) Doc 9859 (ICAO, 2018), which was the first crucial step for the development and implementation of SMS for airports, aircraft manufacturers, airlines, and many other lower-tier industries related to aviation. To encourage the adoption of SMS, ICAO launched a series of educational initiatives to familiarize aviation stakeholders with SMS.

In 2006, the FAA (2015) first started exploring SMS for aviation service providers, which included airlines, airports, MRO facilities, and manufacturers. The FAA initiated an Airport SMS Pilot Study in 2007 with 22 airports participating (FAA, 2022e). The purpose of the study was to evaluate the implementation of SMS at airports. As part of this study, each participant conducted a gap analysis to see what elements of an SMS may already exist in their organization. These analyses found only 1 participant had an existing SMS, and none had a formal process for safety risk management (SRM) (FAA, 2022e). The study found a lack of information related to smaller airports and recommended additional guidance. In addition, the study found that compliance with regulatory requirements fell short of the requirements for a functioning SMS (FAA, 2022e). In 2008, the FAA initiated a second Airport SMS Pilot Study to gather information on the scalability of SMS and how smaller airports might implement SMS (FAA, 2022f). Overall, participating airports found that meeting the SMS requirements was achievable, but the study found a wide variation in interpreting these standards, largely undefined best practices, with an unknown return on investment (FAA, 2022g).

Subsequently, Canada and Australia began the implementation of SMS in aviation, which many consider as the benchmarks for SMS. In 2015, the FAA established a rule requiring all part 121 air carriers to establish an SMS by 2018 (FAA, 2015). However, airports are currently not mandated to have an SMS. The FAA encourages airports to establish an SMS through its voluntary SMS program and provides guidance regarding SMS development. In addition, the FAA is also developing a Part 139 policy that incorporates elements of SMS that may apply to these certificated airports (FAA, 2022i). With the introduction of FAA Order 8000.369C, the FAA discusses UAS as a hazard in the aerospace system that requires the application of SRM processes (FAA, 2020).

In response to the increase in UAS operations at airports, the Transportation Research Board published a series of guidebooks on UAS operations at airports. Volume 1 describes the current regulatory framework to help airports better interact and guide UAS users who fly in their vicinity. This volume also discusses UAS considerations for an airport's SMS and provides examples of UAS contingency events (NASEM, 2020a). Volume 2 presents processes and methods to incorporate UAS into airport infrastructure planning, such as vertiport design, ground support considerations, and public policy (NASEM, 2020b). Volume 3 discusses the use of UAS to support airport operations, such as pavement inspections, wildlife surveys, and perimeter security. Similar to Volume 1, this volume also describes the incorporation of such activities into an airport's SMS (NASEM, 2020c).

The literature suggests effective SMS practices provide enhanced safety benefits to airports by helping to better manage risks and reduce the number of adverse incidents (NASEM, 2009; Mendonca et al., 2017). SMS includes formal processes for stakeholders to report hazards or incidents and a means to assess the effectiveness of any safety mitigations (NASEM, 2009). These processes are especially important when new technologies, such as UAS, are introduced as new operating and emergency procedures are required (NASEM, 2020c). In addition, SMS is complementary and may enhance similar safety programs, such as wildlife hazard or quality management (NASEM, 2015; Lercel, 2013). With future AAM operations, which include on airport operations such as cargo delivery and air taxi, the complexity of unmanned aviation operations will only further increase along with the need for robust safety management (Jadhav, 2021; Jonas, 2019).

From the literature review, researchers found that there is a lack of SMS guidance for commercial UAS operations in the AOA and the NAS as a whole. This, coupled with the increasing number of commercial UAS applications, suggests the need for robust UAS safety management processes. Additionally, the growing number of UAS sightings near airports is a concern for airport stakeholders. Advancement and investments in AAM technology have further led researchers to study conceptual workflows of manned-unmanned operations inside the AOA (Jadhav et al., 2021). Such issues highlight the need for innovative safety risk management strategies to better manage commercial UAS operations. The unique and non-traditional operation of UAS further reinforces the need for a documented SMS that assists airport stakeholders with moving from a reactive to a proactive state of managing these next-generation aviation operations.

Methodology

Researchers conducted a content analysis of UAS guidelines, regulations, and the published SMS standards of various national and international aviation regulatory bodies were analyzed as a part of the content analysis process. The content analysis enabled a chronological explanation of the current state of SMS. Table 1 below summarizes the documents that the researchers reviewed along with their regulatory area. These documents assisted researchers in understanding existing SMS practices and regulatory preparedness for next-generation aviation operations in the AOA.

Table 1
Guidance Documents from National and International Agencies

Document Name	Publisher (Date)	Applicable Region
Introduction to SMS for Airport Operators	Federal Aviation Administration (2007)	USA
Unmanned Aircraft Systems (UAS) at Airports: A Premier	Transportation Review Board (2015)	USA
Airports and UAS, Vol. 1: Managing and Engaging Stakeholders on UAS in the Vicinity of Airports	National Academies of Sciences, Engineering, and Medicine (2020)	USA
Document 9859 – Safety Management Manual (4th Edition)	International Civil Aviation Organization (2018)	International
Drones in the Airport Environment	Airports Council International (ACI, 2016)	International
CAR - UAC	General Civil Aviation Authority (2019)	UAE
Easy Access Rules for UAS	European Union Aviation Safety Agency	Europe

The analysis of SMS for airport operators by the FAA (2007) is a primary publication used in the content review phase. Some publications are based on the topic “SMS for airports.” In contrast, others are just “regulations for UAS,” indicating a lack of guidance relating to a comprehensive SMS for airports to mitigate risks due to commercial UAS. Safety guidance provided by FAA (2007) and ICAO (2018) was reviewed and referenced. The research then explored regulations and advisories pertaining to UAS in the AOA. This study employed a two-step content review process to 1) acknowledge current SMS practices at airports and 2) consider the airport’s integration of UAS risks into their SMS.

A survey was developed to obtain information about airport SMS, including knowledge and practices, as well as airport demographic information, such as airport size and category. This survey was developed based on the information gained during the content analysis of UAS and

SMS regulations and practices. The initial survey instrument was reviewed by aviation management professors at an R1 university with subject matter expertise in airport management and SMS and was beta tested by airport personnel and external aviation experts. Experts were selected for review and beta testing based on personal contacts of the research team as well as the faculty and staff of the university aviation program (there are over 50 faculty and staff members in the university aviation program); experts were selected based on their knowledge of airport activities, UAS, and SMS. These experts reviewed the survey questionnaire and provided inputs to validate the study further, which helped demonstrate face validity. Once face validity was established, the researchers sent out the survey questionnaire to a sample of aviation experts for feedback. Once the survey was developed and reviewed, researchers sent the survey to 1,720 airport personnel via email; these airport personnel worked at some of the 5,000 public-use airports in the U.S. (FAA, 2021a). Emails were collected from publicly available databases such as airport directories, and the survey was distributed using the Qualtrics survey tool. The survey consisted of multiple-choice questions and one open-ended question and is shown in the Appendix.

The survey was kept active for a period of 33 days to allow an appropriate time for survey submissions. Survey data was then initially analyzed using descriptive statistics, where cross-tabulations were created to compare individual variables. Based on survey responses, a statistical and graphical analysis was performed to interpret the survey data obtained.

Results

The survey returned 146 responses. A total of 111 surveys were retained after data cleaning efforts.

Demographics

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

- Type of Organization: 97.3% (N=108) of the 111 survey respondents indicated they were associated with an *airport*, whereas 2.7% (n=3) of respondents were associated with a “fixed-base operator” or “other.”
- Airport Category (FAA, 2021a): 76.58% (n=86) of the responses were *general aviation* airports, 10.81% (n=12) were *reliever*, 6.31% (n=7) were *commercial service – non-hub*, 4.50% (n=5) were *commercial service – small-hub* and 0.9% (n=1) were *commercial service – large-hub* and *non-primary commercial service*.
- Airspace Distribution of airports is shown in Figure 1
- FAA Region (FAA, 2021b): 32% (n=35) of the responses were from the *Great Lakes Region*, 21% (n=23) were from *Southern Region*, 14% (n=16) were from both *Southwest* and *Eastern Regions*, 13% (n=14) were from the *Central Region*, 4% (n=4) were from *Western-Pacific Region*, and 2% (n=2) were from *Northwest Mountain Region*. All regions were represented in the survey except the *Alaskan Region*.
- Control Tower: 75.68% (n=84) of the responses were from *non-towered airports*, whereas the remaining 24.32% (n=27) were from *towered airports*.

State of SMS at Airports

While examining the state of SMS implementation and adoption at airports (SMS at Airports) (n=108), survey results found 15.7% (n=17) of the airports indicated they have a documented SMS. In comparison, another 13.9% (n=15) of the airports indicated they were currently developing an SMS. In addition, a greater number of non-towered airports (n=10) indicated they have an SMS versus towered airports (n=7).

Researchers compared the current state of SMS implementation at airports based on airspace classification (n=108), which is illustrated in Figure 1. The comparison found that 33.3% (n=1) of airports in Class B, 18.2% (n=2) in Class C, and 24% (n=6) of airports in Class D airspace indicated they have a documented SMS. As most survey responses were obtained from airports situated in Class E and Class G airspace, SMS adoption at airports in these classes of airspace was 14.3% (n=5) and 9.0% (n=3), respectively. While several airports acknowledged they had a documented SMS, overall, 84.3% (n=91) of the respondents acknowledged a lack of SMS at their airports.

Researchers then included a follow-up question to *SMS at Airports* that explored if their documented SMS included elements to address UAS-related safety risks. While studying these responses, researchers found that only 4.6% (5 of 108) of the total airports indicated that their SMS addressed UAS-related hazards and risks. Comparisons based on airspace revealed that no airports in Class B, C, or E airspace indicated their SMS addresses UAS safety. Only 12% of airports in Class D and 6.1% of airports in Class G included UAS safety in their SMS. This data is graphically represented in Figure 1.

Familiarity and Guidance

The survey then explored the respondents' familiarity with FAA regulations related to UAS. *Levels of familiarity* were defined on a Likert-type scale as "not at all," "to a little extent," "to some extent," "to a moderate extent," and "to a large extent." To further explore the area of familiarity, researchers asked participants if they would like *additional guidance regarding UAS safety and risk management* (SRM), which the respondents defined by using one of the following options, "strongly disagree," "disagree," "neither agree nor disagree," "agree," and "strongly agree."

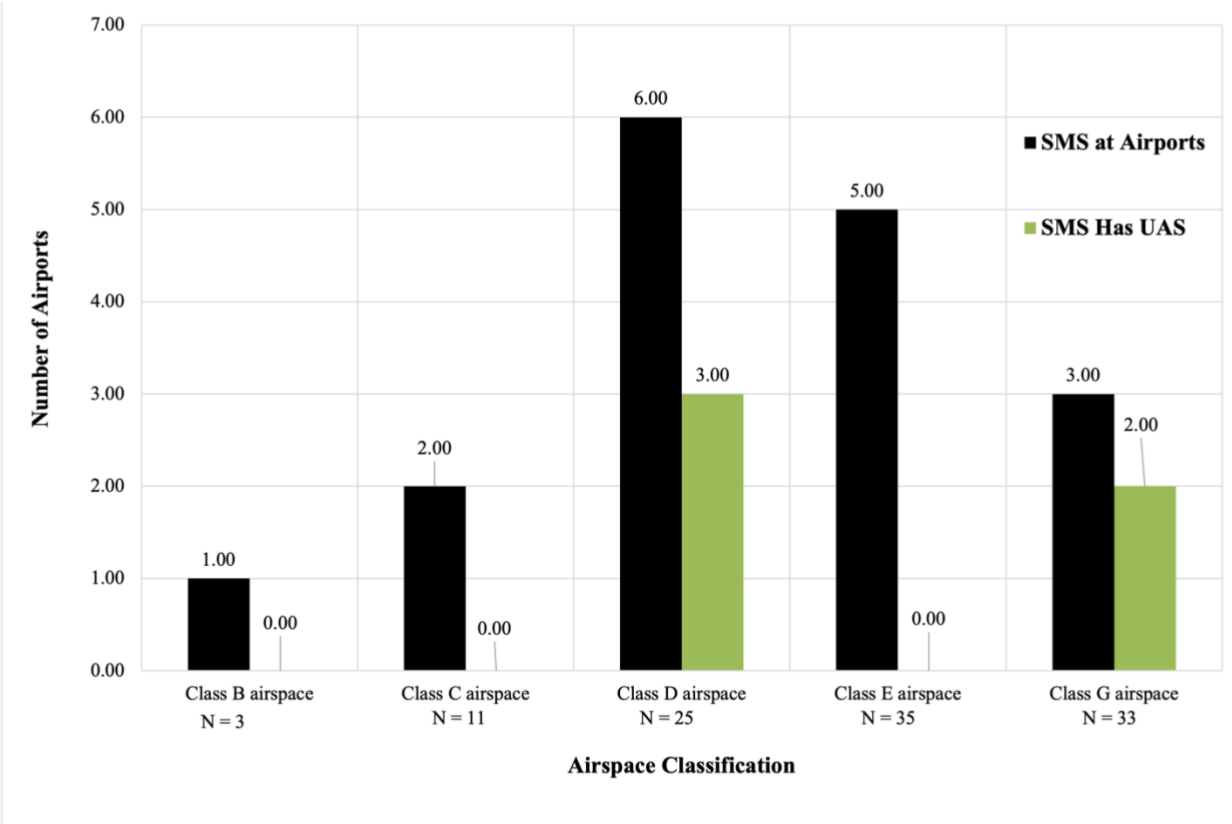
Level of Familiarity

Examining the *level of familiarity* of the 107 respondents that responded to this question, researchers found that 51.4% (n=55) said their level is "to a moderate extent" or "to a large extent." On the other hand, only 15.9% (n=17) indicated familiarity levels "to a little extent" or lower. It is important to note that for the responses about the level of familiarity, the following factors may affect the scoring

- *The level of familiarity* was purely based on the respondent self-assessing its organization's knowledge regarding regulations related to UAS.

- The researchers did not conduct any assessment to determine the respondent's level of familiarity.

Figure 1
SMS Adoption at Airports and those whose SMS includes UAS by Airspace Classification



Additional Guidance regarding UAS SRM

Further reviewing the complementing variable of *additional guidance regarding UAS SRM*, 64.5% (n=69) of respondents agreed or strongly agreed, whereas only 7.5% of the respondents disagreed or strongly disagreed with the need for additional guidance, which may suggest a gap in the participants' knowledge of UAS SRM as it applies to the AOA.

Level of Familiarity and Additional Guidance regarding UAS SRM

Researchers then cross-tabulated *familiarity with FAA regulations* and *additional guidance regarding UAS SRM* to explore inferences (see Table 2). When looking at familiarity, 90 respondents (84.1%) suggested that their familiarity levels ranged from "to some extent" to "to a large extent." Further investigating the familiarity and guidance crosstabulation, it was observed that 48.6% (n=52) of the respondents that felt their *familiarity with FAA regulations* was "to a moderate extent" or "to a large extent" also indicated a desire for additional guidance ("neither agree nor disagree", "agree", or "strongly agree"). Analyses of the cross-tabulated results found that stakeholders wanted additional guidance irrespective of their level of familiarity.

Table 2
Crosstabulation of Familiarity with Regulations and Need for Additional Guidance

	Level of Familiarity					
Additional Guidance	Not at all	To a little extent	To some extent	To a moderate extent	To a large extent	Total
Total	4	13	35	39	16	107
Strongly Disagree	0	0	1	1	0	2
Disagree	2	0	2	2	0	6
Neither Agree nor Disagree	0	6	8	11	5	30
Agree	2	6	19	18	7	52
Strongly Agree	0	1	5	7	4	17

Additional Education or Training regarding UAS Safety and Regulations

Researchers included a supplementary question in the survey to further explore the participant's desire for additional UAS/SMS guidance across different subject areas, such as regulations, airspace waivers and authorizations (LAANC), unmanned traffic management (UTM) (NASA, 2022), safety and risk management, and counter UAS technology. Survey respondents could choose multiple items. Even though 84.11% (n=90) of the respondents indicated their level of familiarity with UAS regulations was equal to or greater than "to some extent", a majority (87 of the 108 respondents) still indicated a desire for some type of "additional education or training" regarding UAS safety and regulations. Specifically, the results by category were 58.88% (n=63), indicating a need for more regulatory education and training, 49.53% (n=53) for airspace waivers and authorization, and 61.68% (n=66) for safety and risk management. The cross-tabulated distribution between "familiarity with UAS FAA regulations" and "additional guidance and training" is given in Table 3.

Furthermore, researchers found that with the increase in the number of off-the-shelf consumer UAS, large commercial airports were also experiencing an increase in UAS intrusions. These types of intrusions may have led many regulators to begin the adoption of UAS safety and risk management procedures as part of their SMS(ACI, 2016; FAA, 2007; FAA, 2015; FAA, 2022i; ICAO, 2007). Unauthorized UAS intrusions have resulted in major flight delays and financial losses, which in turn led to the realization of a need for more robust UAS SMS practices at airports (Rowlatt, 2019; The National Staff, 2016; Wendt et al., 2018). Similarly, two survey respondents indicated having experienced a hazardous UAS event and a high number of unauthorized UAS flights within their controlled airspace.

Table 3
Crosstabulation of Familiarity with FAA regulations and Additional Education and Training

	Level of Familiarity					
Additional Education and Training	Not at all	To a little extent	To some extent	To a moderate extent	To a large extent	Total
Regulations	2.0	10.0	22.0	20.0	9.0	63.0
Airspace waivers and authorization (LAANC)	1.0	5.0	19.0	18.0	10.0	53.0
Unmanned Traffic Management (UTM)	2.0	5.0	17.0	19.0	9.0	52.0
Safety and Risk Management	1.0	9.0	21.0	26.0	9.0	66.0
Counter UAS Technology	1.0	2.0	14.0	12.0	9.0	38.0
My organization is sufficiently trained	1.0	0.0	2.0	3.0	7.0	13.0
Other	1.0	0.0	2.0	1.0	0.0	4.0

Open-ended question responses

The survey included one open-ended question, which asked respondents if they had any other comments regarding SMS or UAS operations on or near airports. Overall, 14 people provided additional comments. Two of the respondents indicated their airport had experienced a hazardous event involving a UAS operating within the manned aircraft traffic pattern. One of these airports indicated they are using a UAS monitoring system and have recorded “an alarming number of illegal UAS flights” in their Class D airspace. Four respondents indicated a need for better UAS safety guidance and training that is tailored toward airports. Two respondents also expressed a need for better communication across the air traffic control community and frustration over the constant change in UAS policy. Three respondents from smaller airports located in Class G airspace voiced concern that an SMS regulation may be overly burdensome and must be scaled to smaller airports. Two respondents described a positive experience with UAS, having on occasion used UAS to conduct airport infrastructure inspections.

Discussion

This study’s main research purpose was to gain perspective on the state of SMS at airports. Initial inferences were derived from the review of the literature regarding SMS at airports. Further on, this study found a significant contrast between the implementation of SMS at airports, especially with regard to elements of SRM for UAS, given the increase in UAS operations in the NAS.

The following assertions may be derived from the literature and developed results,

- Documented SMS for airports is continuously being updated by aviation entities (organizations and regulatory agencies) as proactive safety practices evolve (ACI, 2016; FAA, 2007; FAA, 2015; FAA, 2022i; ICAO, 2007). The analyzed results gathered from the survey further suggest the need for additional guidance for SMS at airports as a lower percentage (15.3%) of airports had an SMS. Participant responses to the open-ended survey question further support this finding.
- Even though there has been an increase in commercial UAS operations in the AOA (FAA. 2022c; Pyrgies, 2019), survey results suggest SMS implementation at airports is behind. Initially, from the literature review of national and international regulatory guidance, researchers found that SMS for UAS was quite uncommon nor widely adopted. To further support findings from the literature review, results evaluated from survey responses found only 4.9% of airports include UAS elements in their SMS. The cumulative study of literature and results suggests a lack of guidance or understanding regarding commercial UAS operations in the AOA. This finding is further supported by the participant's responses, where a majority indicated the need for more education, training, and guidance regarding commercial UAS operations inside the AOA. Participant survey comments suggest a need for clearer policy guidance and education.
- A major component of any SMS is safety promotion (FAA, 2022d; ICAO, 2007). Communication of new and updated guidelines is an integral part of ensuring the latest safety practices in aviation are conveyed to all concerned aviation entities. Analysis of open-ended responses in the survey found that there may be a shortfall of communication that exists between the regulatory bodies and airport stakeholders.

Future Research

This research provides a perspective on the current state of SMS for airports. Based on the results, it is necessary for regulatory agencies to further develop guidance that assists airport stakeholders with safely addressing UAS and AAM operations. Additional regulatory guidance also requires effective education and communication between the regulatory body and airports. Future research may include comparing the airports' state of SMS from this research with the level of UAS activity within the airport's operating area.

Limitations

Many of the limitations of this study are related to sampling issues inherent to a convenience sample and by the timing of this study, which coincided with the COVID-19 pandemic. In terms of sampling issues, the survey was distributed widely via email to airport personnel for whom the researcher had contact information. The resulting responses (over 100) provide some insight into the perspective of airport operators but should not be considered representative of all airport personnel due to limitations inherent in non-probability sampling methods. The COVID-19 pandemic limited responses since researchers were unable to attend conferences to promote the research and limited the scope of the study since it was not practical to conduct in-person interviews or observations. COVID may also have impacted participation due to reduced staffing levels at many airport facilities, including larger and busier airports, such as those in Class A and B airspace. There may also be issues with self-selection since airport personnel who are not familiar with SMS and UAS topics may have been less likely to complete the survey. A final limitation is the use of email for the survey distribution; this methodology requires a strong database of current emails for airport personnel, it requires that the survey request make it through spam filters, it requires that the airport personnel click on a link, which some people are hesitant to do for security reasons.

Conclusion

With the advent of UAS commercial applications, the importance of SMS practices at airports is increasing. To ensure safety in the AOA as UAS operations further evolve, a formal SMS helps airports remain vigilant and proactive in addressing not only current threats but those that are not yet identified. As this study suggests, with the increase in commercial UAS operations in the AOA, there will arise an even greater need for airports to further develop robust safety practices. While many UAS opponents and media outlets or often of the opinion that UAS must remain clear of the AOA, UAS is slowly becoming an essential tool to assist airports in effectively managing operations, inspections, and maintenance practices (Hubbard et al., 2017; Mackie et al., 2019). Furthermore, UAS may improve efficiency at airports, aid organizations in safely conducting hazardous inspections, and reduce the completion time of various commercial applications as compared to traditional methods (Hubbard et al., 2017; Mackie et al., 2019). Looking ahead, the emergence of advanced air mobility, air taxis, and unmanned traffic management (UTM) (NASA, 2022) further supports the need for robust SMS at airports. Ultimately, this research suggests the importance of airports developing an SMS that addresses threats associated with commercial UAS operations. While this research describes the airport's current state of SMS processes related to commercial UAS operations, it highlights the need for further research into developing effective SMS processes that keep pace with emerging UAS technologies and use cases. This study may assist airport stakeholders, UAS operators, and regulators to further develop robust safety and risk management practices that support safe UAS operations within the airport operating area.

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Appendix

1. Please select the best description of your type of organization.
   - o Airport
   - o Fixed Base Operator at an airport
   - o Airport Air Traffic Control
   - o Air Passenger or Air Cargo Service
   - o Other____
2. Please select the FAA region associated with your airport.
   - o Alaskan Region
   - o Central Region
   - o Eastern Region
   - o Great Lakes Region
   - o Northwest Mountain Region
   - o Southern Region
   - o Southwest Region
   - o Western-Pacific Region
3. Which of the following categories best describes your airport's activity?
   - o Commercial Service - Large Hub
   - o Commercial Service - Medium Hub
   - o Commercial Service - Small Hub
   - o Commercial Service - Nonhub
   - o Non-Primary Commercial Service
   - o Reliever
   - o General Aviation
4. Which of the following airspace classifications is your airport located in?
   - o Class B airspace
   - o Class C airspace
   - o Class D airspace
   - o Class E airspace
   - o Class G airspace
   - o Special-use airspace (Restricted areas, military areas, etc.)
5. What is your position at the airport?
   - o CEO
   - o President
   - o Director
   - o Manager
   - o Assistant Manager
   - o Supervisor
   - o Other, please specify ____
6. Does your airport have a control tower?
   - o Yes
   - o No
   - o Don't know

7. Does your airport have a documented Safety Management System (SMS)?
   - o Yes
   - o No
   - o My airport is currently developing an SMS
   - o Don't know

If the answer to question 7 is Yes, then display this question:

8. Are UAS-related safety risks also a part of the Safety Management System (SMS)?
   - o Yes
   - o No
   - o Don't know

9. Does your airport have a UAS response plan?
   - o Yes
   - o No
   - o Don't know

10. What is the airport's level of familiarity with FAA regulations related to UAS?
    - o Not at all
    - o To a little extent
    - o To some extent
    - o To a moderate extent
    - o To a large extent

11. My airport would benefit from additional guidance regarding the Safety and Risk Management of UAS.
    - o Strongly Disagree
    - o Disagree
    - o Neither Agree nor Disagree
    - o Agree
    - o Strongly Agree

12. Do you feel your airport would benefit from additional education and training regarding UAS in the following subject areas (click all that apply)?
    - ▢ Regulations
    - ▢ Airspace waivers and authorization (LAANC)
    - ▢ Unmanned Traffic Management (UTM)
    - ▢ Safety and Risk Management
    - ▢ Counter UAS Technology
    - ▢ My organization is sufficiently trained
    - ▢ Other ____

13. Do you have any other comments regarding SMS or UAS operations on or near airports?____