Managing Unmanned Aircraft Systems in the Vicinity of Airports

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1 Introduction

1.1 Background

The rapid introduction of Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS) has far-reaching ramifications for its users of existing manned aircraft. Rapid and large-scale changes due to technological advances—if not done correctly—can result in costly mistakes related to aircraft and safety of people and property, delays in implementation, and ultimately loss of potential benefits to all stakeholders. Furthermore, the Federal Aviation Administration's (FAA) UAS integration efforts—including counter-UAS mechanisms, remote identification and tracking, and airspace authorization waivers—have direct implications for airport operators. Introduction of UAS will pose a wide range of new safety, economic, operational, regulatory, community, environmental, and infrastructure challenges to airports. These risks are further complicated by their dynamic and shifting nature. Experiences and lessons learned from recent major aviation system changes demonstrate the critical importance of ensuring that airports have the resources needed to avoid adverse impacts and maximize benefits as early as possible. This research effort—*Airports and UAS*—in support of the Transportation Research Board's (TRB's) Airport Cooperative Research Program (ACRP) will develop an initial set of these critical resources and tools for use by airport operators.

1.2 Overview of Airport Management of UAS Operations

The focus of this document is to provide guidance for airport operators and managers to manage UAS operations and related activities in and around airports. UAS operations that occur in the vicinity of airports may impact current and future airport operations and its stakeholders, on and off airports. The demand for commercial UAS may increase significantly once beyond visual line of sight (BVLOS)[1] operations and operations of multiple UAS by one pilot are allowed through broader regulatory frameworks. Understanding the nature of UAS operations, platforms, and uses is a topic of interest at most, if not all, airports in the aviation system. This includes the airports in the National Plan of Integrated Airport Systems (NPIAS) (federally funded commercial service primary, cargo, and reliever airports), general aviation airports (Assets 1 and 2 airports) and facilities such as seaplane bases and heliports. Some of these airports are already taking actions to better understand and tackle the challenges associated with managing UAS at their airports with varying degrees of success.

The rapidly evolving regulatory framework for integration of small UAS (sUAS) and counter UAS (cUAS) activities has resulted in the need for guidance to inform airport operators about managing UAS operations in the vicinity of their airports. For example, 14 *Code of Federal Regulations* (CFR), Part 107 (the sUAS Rule) allows, for the first time, broad commercial use of UAS in the United States. However, under the rule, UAS operations directly over people are still prohibited unless the operator has received special permission from the FAA. sUAS are defined as aircraft weighing less than 55 lbs, and include all elements of the system related to operation, such as ground control stations and communication networks. These aircraft may take many forms, including multi-rotor, fixed wing, and hybrid vertical take-off and landing with fixed wing forward flight vehicles. Some UAS operations near airports will require the ability to fly over populated areas and therefore will

[1] Currently, under the FAA's Part 107 rule, "the unmanned aircraft must remain within visual line of sight of the remote pilot in command and the person manipulating the flight controls of the small UAS. Alternatively, the unmanned aircraft must remain with visual line of sight of the visual observer" (FAA 2016).

require waivers to the sUAS rule. As a part of managing UAS operations, it will be important for airport operators to understand the regulatory requirements, framework, and ability to obtain waivers and exceptions. Additionally, airports could adopt UAS for the purposes of conducting airport operations. However, challenges exist with the cohabitation between UAS and manned aircraft.

1.3 Guidebook Audience and Format

The results of this guidance document represent a culmination of literature review and coordination interviews with aviation industry groups, government agencies, UAS manufacturers/dealers/sellers, advocacy groups, and users. The primary audiences for this guidebook are airport operators and managers.

This guidebook is organized by topics identified as relevant to UAS management by airports. It includes best practices related to airport coordination (Section 2), operational planning (Section 3), and contingency/emergency standards (Section 4). Additionally, it includes supporting tools, such as visual risk maps (Section 5) and a detailed table of authorities that delineates the roles and responsibilities of UAS management within airports.

Each of the previously mentioned Sections addresses an important component of UAS management around the airport vicinity. The tables, figures, and flowcharts were developed as quick reference tools to enable airport operators and managers to understand the basic context of UAS operations and provide further resources in case more information is required.

2 Airport Coordination Best Practices

Stakeholder coordination between agencies (state, local, and federal government), on-site air traffic control and operations, manned and unmanned users, as well as community members is key to safely integrating UAS into an airport environment. There are diverse concerns about coordination around safety, privacy, and security challenges surrounding UAS operations. This section provides an initial analysis of these issues based on the best practice recommendations outlined in *Voluntary Best Practices for UAS Privacy, Transparency, and Accountability*, May 18, 2016 (NTIA 2016) created by the National Telecommunications and Information Administration (NTIA). The level and type of coordination between UAS users and airport management is dependent upon several factors including, but not limited to:

- Airport users
- Zoning
- Land use
- Environmental factors, and
- Adjoining communities.

Section 2.1 provides an analysis of the airport types that exist in the NAS and how they may affect coordination with UAS. Section 2.2 evaluates the best practices currently employed to coordinate UAS operations in and around different airport environments.

2.1 Airport Type

The traffic and use of each airport type has an impact on the level of coordination required to successfully conduct UAS-integrated operations in the vicinity of these airports. Airports are referenced by the National Plan of Integrated Airport Systems (NPIAS) categories

To date, the majority UAS operations have occurred in and around reliever and general aviation (GA) airports (with the exception of some joint use facilities), but the potential for safety impact may be greater at larger airports because increased air traffic further complicates the cohabitation between UAS and manned aircraft. These airports are defined as shown in Figure 1 (FAA 2016). UAS-related activity and the subsequent required coordination will depend on the type/category of airport and the complexity of services provided. For example, airports that perform critical community access services will have more sensitive requirements around emergency procedures that will require more stringent coordination with UAS users operating within its vicinity.

Reliever Airports
Airports designated by the FAA to relieve congestion at Commercial Service Airports and to provide improved general aviation access to the overall community. These may be publicly or privately-owned.
General Aviation Airports
Public-use airports that do not have scheduled service or have less than 2,500 annual passenger boardings (49 USC 47102(8)). Approximately 88 percent of airports included in the NPIAS are general aviation

Figure 1: FAA definition of reliever and general aviation airports

Although the FAA uses all these factors to categorize airports within the United States' aviation system, changes to these criteria are anticipated in the near future. The expansion of light jet aircraft, sport pilot license, experimental aircraft (including UAS), development of new types of fuel, long-term forecast a decrease in piston engine aircraft, as well as requirements for decrease in engine noise and implementation of NextGen along with other technological and regulatory improvements is anticipated to change some of these airports roles within the U.S. Aviation System.

UAS development and use in the short and mid-term is likely in both GA and Joint Use Facilities. Although small UAS operations on airport facilities may be limited to inspections, data collection, flight training or other specialized use, a larger UAS fleet mix similar to aircraft already in production are also anticipated to be users of airport facilities. These aircraft do and will likely continue to support a variety of public, private and military operational missions. Use of smaller or less used airport infrastructure, including basic and public unclassified airports, may be the perfect testing and training ground for UAS integration.

The FAA and partner organizations have put safety guidance practices online at http://knowbeforeyoufly.org (FAA 2015), which are not sorted by airport type but have guidance for coordination activities. But even safe and fully coordinated flights may not be completely conflict-free. These guidelines are suggested and are voluntarily followed/implemented. Integration and coordination of UAS activity in and around the airport environment will require various agencies, organizations, users and public entities to establish standardized guidelines and practices for use and integration. The current system consists of a regulatory patchwork of federal, state and local regulations. Further, both the legislative and executive branches of the Federal Government have given different missions to different entities. This complicates the resolution of conflicts that arise during coordination activities.

While the FAA's official categorization of airports (NPIAS categories) is important, UAS operations may require operators to categorize risk by more nuanced characteristics such as numbers of operations, airfield configuration, traffic patterns, instrument approaches/minimums, controlled or uncontrolled airspace, low level helicopter operations or ultralight or other semi-unusual operations, flight paths including any low level non-straight in/out, towered/non-towered airports, and airspace categories. These specific details will be subject of subsequent research and guidance publications.

2.2 Coordination Best Practices of Selected Operations

Coordination between UAS operators, air traffic control and airport operations is dependent upon the type of operations that will be flying within and around the airport's airspace. Existing "Best Practices" are voluntary in nature. Therefore, changes to these practices and new regulatory requirements specially to address the patchwork of state and local regulatory criteria placed on UAS operations will continue for the foreseeable future. Recommended best practices associated with type of UAS use is outlined in the following sections.

2.2.1 Coordination with Local Air Traffic Control (ATC)

Airport coordination with ATC is necessary for the successful operation of UAS at or near airports. There are several elements to best practice coordination between an airport and ATC.

- Tactical Coordination: The airport's operations department or manager should maintain regular communication with ATC regarding UAS activity. This line of communication will be useful during anticipated UAS flights as well as when unanticipated UAS flights that are detected by either the airport or ATC. If possible, an airport UAS liaison with specific expertise in UAS detection and operations should communicate with ATC.

- Strategic Coordination: Airport managers and operations department/managers should coordinate on UAS planning with ATC as well. This includes considering a review of UAS incidents that can be part of Airport SMS or planned events in regular (weekly) briefings that occur between airports and ATC. Additionally, airport operations should notify ATC of Notices to Airmen (NOTAMs) that are filed with a planned UAS component.

These best practices for recreational UAS operators recommend that UAS users follow the safety guidelines outlined by the FAA and partner organizations located at http://knowbeforeyoufly.org (FAA 2015). This website outlines several coordination-related best practices to protect privacy which include those summarized in Figure 2. It is useful for airport operators and management to be familiar with this information that is being used to train UAS operators. See Section 3.2.1 Recreational/Educational Use for additional detail. NTIA also provided guidelines for neighborly drone use (Appendix A) of their stakeholders' report.

Guidelines for Neighborly Drone Use

1. Coordinate and ask for permission from affected neighbors early and often. "If you can, tell other people you'll be taking pictures or video of them before you do so."
2. Coordination may not be necessary if there are alternative flight paths. "Don't fly over other people's private property without permission if you can easily avoid doing so."
3. Maintain an open and clear dialog with affected neighbors. "If anyone raises privacy, security, or safety concerns with you, try and listen to what they have to say, as long as they're polite and reasonable about it."

Figure 2: Selected coordination-related best practices from the FAA's "Know Before You Fly" campaign

2.2.2 Governmental Operational Missions and Best Practices

Several federal organizations have been actively using and plan to continue to use UAS platforms to perform activities that may be hazardous to their personnel, require constant presence and may need to be conducted in areas which support native or threatened species. According to surveys and users, UAS operational missions are driven by improved safety, lower costs and improved data acquisition and management. Current federal users include but are not limited to the Department of the Interior (DOI), the National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), U.S. Forest Services in addition to the FAA. Other collaborative users include academia and private industry. Current common uses of UAS platforms include: law enforcement, firefighting, border patrol, disaster relief, search and rescue, military training, wildlife management, environmental monitoring, and other government *operational missions.*

2.3 Table of Authorities and Stakeholders

An important way to fully understand the roles and responsibilities for coordination between various stakeholders during UAS operations in the vicinity of an airport is to develop a specific table of authorities. There are five general categories of stakeholders: Industry Groups, Government Agencies, Manufacturers/Dealers, Advocacy Groups, and Users and Operators. They have specific coordination relationships between each other, as shown in Table 1. Examples of these groups are in the Appendix in Table 14.

Table 1: Cross-relational coordination needs between relevant groups of UAS stakeholders

	Users and Operators	Advocacy Groups	Manufacturers and Dealers	Government Agencies
Industry Groups	Industry groups and UAS users should coordinate together to determine the demand for technology and services.	Industry and advocacy groups work together to develop regulatory frameworks to present to policymakers and manufacturers.	Industry groups relay the state of UAS consumer demand to manufactures, who in turn develop new technologies to accommodate new needs.	Industry groups relay the state of UAS demand to government agencies, who in turn develop policies that meet consumer needs.
Government Agencies	Government agencies set rules that require input from UAS users. Coordination is important so that policies are fair and users buy in to standardized regulatory rules.	Advocacy groups are a medium through which government agencies determine the state of the UAS market and uses to develop rules.	Government agencies set rules that manufacturers must follow. Coordination ensures technical policies are fair and support innovative development.	
Manufacturers and Dealers	Manufacturers have to coordinate with users to understand and adapt to consumer demand.	Manufacturers and advocacy groups work together to understand the state of UAS policies and market demand to improve platforms and policies.		
Advocacy Groups	Users provide advocacy groups with input on existing UAS user challenges.			

Beyond these interactions, airports also have to coordinate between these groups at various levels in order to appropriately manage UAS in their vicinity, as described in Table 2. Of these groups, the most important coordination will likely occur for airports with users/operators, government agencies, and advocacy groups. These activities are varied by airport types but can be broadly summarized.

Table 2: Coordination relationship descriptions between airports and UAS stakeholder groups (with the responsible airport department or managers underlined)[2]

Relationship between Airports and	Users and Operators	Airport operations departments/managers and (if relevant) public relations liaisons should coordinate—both strategically and tactically—with UAS users in their vicinity. UAS users should also be expected to engage with airports. Airports should anticipate high demand UAS time periods (such as during a nearby high-traffic event) and proactively reach out to event organizers to provide clear guidelines on the appropriate use of UAS around their vicinity. For instance, Section 3.2 in this document provides guidance on how airports should handle and manage requests for UAS flights around their vicinity. Specifically, Figure 11 provides a decision flowchart that captures the relevant regulations and safety factors to be considered by an airport operations department/manager. Additionally, airports should plan for tactical management of UAS users that are unexpected by developing highly visible warning systems and open lines of communication with air traffic operators and law enforcement in case users pose an immediate threat.
	Government Agencies	In addition to coordination with government agencies such as air traffic operators and law enforcement, airports should strategically also participate in higher level rulemaking processes and as new UAS regulations are being developed. Early coordination by airport management executives reduces the probability of conflict or badly-planned rules to hamper efficient UAS integration in the future.
	Advocacy Groups	Airport operations departments/manager and public relations liaisons should solicit input from advocacy groups to understand surrounding community needs. Airports should not only engage with UAS-related groups, but also secondarily-affected groups, such as adjacent neighborhoods that may be in the path of planned UAS flights.
	Manufacturers and Dealers	Airport operations departments/managers should coordinate with manufacturers because it is important to understand the types of technologies that are available. This information can aid in the development of management methods or technologies, such as counter-UAS measures, which airports can develop. Airports may also wish to partner with manufacturers as UAS technologies advance that may be able to provide tenant leasing and potential revenue opportunities.
	Industry Groups	Similar to manufacturer coordination, airport operations departments/managers should coordinate with industry groups to understand the state of the market and technologies that may impact the management of UAS in their vicinity.

These coordination descriptions can be implemented in a template coordination table that is provided in Appendix 6.1.

3 Understanding the Requirements to Manage UAS Operations

This section will provide analyses on best practices for airport operators to better understand the requirements to operate a UAS and how to manage these operations at airports. It includes eight specific topics, as identified by the titles within Section 3.1 to Section 3.5.

The majority of UAS operations within the vicinity of airports will involve small UAS (i.e. less than 55 pounds MTOW operating at less than 100mph/87knots; note: see section 3.2.4 of this guidebook for more details on Title 14 Code of Federal Regulations Part 107 and the definition of sUAS and their operating limits).

3.1 Development of Concept of Operations

The concept of operations or CONOPS for UAS is a description of the nature of UAS operations and the consequent effects on relevant stakeholders and the environment in which it would be operating. This is the first step in effectively employing UAS in the airport environment and is key to the successful integration of UAS in the NAS. The goal of developing an CONOPS is to produce a document that defines the architecture of systems likely to be operated in the airport environments, the airworthiness requirements of the system, the operational requirements of such systems, the operational plan (e.g., intended missions and operational procedures), and the personnel certification requirements to support the operational plan within the target environment.

In this section, each of these aspects are discussed at a high-level and provides airport specific considerations. The section concludes with a list of resources to aid airport management in the development or analysis of UAS CONOPs for airports.

3.1.1 System Architecture

The description of the system architecture for a CONOP should define not only the UAS system, but also the environment it is intended to operate within. Table 3 describes each element of the system architecture that should be defined.

Table 3: Elements of the system architecture for a UAS CONOP

Element	Description
Goals and Objectives	At a minimum, the objective of CONOPS would include the seamless integration of the UAS system into the already existing CONOPS architecture at airports. To achieve this objective, emphasis should be placed on the primary use for the system, the method of operation, and the required crew and infrastructure necessary to operate the UAS. Further requirements are elaborated in Section 3.2. *Primary use for the system:* the operation of UAS within the NAS, and by extension, at airports requires prior approval and authorization by the FAA. This is currently achieved through the application and approval of a certificate of authorization (COA) to the operator of the system. Airports should review the contents of the COA which detail among other things, the use of the system, and the method of operation.

[2] Note that this is only a preliminary list of responsibilities, which will be expanded and improved as more results from Topic B (stakeholder coordination) are achieved.

<table>
<tr><th>Element</th><th>Description</th></tr>
<tr><td></td><td> Method of operation: The COA would also contain the method and manner in which the operator intends to use the system consistent with the manufacturer's guidelines and system certification from the FAA. Airports can expect UAS to operate primarily in two forms. Those requiring prepared take-off surfaces, and those not requiring such surfaces. It is important that the same level of care and concern given to manned aircraft is allotted UAS as the potential for mishaps and hazardous situations is very high. Required crew and infrastructure: UAS operations require a different kind of crew setup, placement and infrastructure to support operations (Valavanis, Vachtsevanos, 2015). At a minimum, the crew required for each UAS type should be identified, the communications methods and infrastructure including the datalink frequencies, voice communication techniques and frequencies, placement of crew and hardware to support the system operation and regulatory requirements and framework within which the system would be operated should be considered and identified. </td></tr>
<tr><td>Key components of the system</td><td> An assessment of the generic components necessary for the operation of a UAS within the vicinity of an airport provides the baseline for the efficient integration and consequent safe operation of the UAS within the airport framework. The concept of operations should define what components would be integrated into the system as well as those systems not needing integration, but rather impact the airport environment nonetheless. Some key components of UAS to be included are (Maddalon, Hayhurst, Koppen, Upcurch, Morris, & Verstynen, 2013): Remote pilot-in-command/operator of the system
Unmanned aircraft/platform
Ground control station
Ground data terminal
Airborne data terminal
Electromagnetic frequencies and communication facilities
Power source consideration
Hangar spaces/shelter for the system
Potential risk factors including line-of-sight obstructions</td></tr>
<tr><td>System Operation</td><td> The operation of the system would be a step-by-step process to give airport management a complete picture of the UAS operation. These elements should be documented by the airport operations department/manager in coordination with the FAA Airport District Office (ADO) and air traffic control (ATC). In outlining the system operation, certain key areas need to be addressed including: Airworthiness requirements
Airspace segregation
Flight routes and procedures</td></tr>
</table>

Element	Description
	• Intra-Crew and ATC briefing and communications • Datalink Frequency, bandwidth, and interference • Obstacle and line of sight (LOS) considerations • Contingency/emergency plans • Safety management systems • Regulatory requirements
Facility Management	Integrating UAS into the airport environment poses a challenge of modifying existing infrastructure to meet system requirements. Priority consideration should be given to the communications/navigational facilities, which should be prioritized. These include: • Command and control datalink • Voice communication equipment • Navigational Aid (NAVAID) utilization by UAS
Limitations of UAS Operations	The initial desire to treat UAS as normal aircraft exists, but the inability of UAS to meet most requirements and restrictions placed on manned aircraft is of particular concern to ATC and other airspace users. Integrating UAS operations in the context of manned operations require that an evaluation of certain procedures be taken into consideration. Some procedures needing assessment include: • Take-off and landing procedures • Arrival and departure procedures • See/sense/detect-and-avoid procedures • Lost communication procedures • Weather minimums (Instrument Flight Rules—IFR and Visual Flight Rules—VFR requirements) • NOTAMs

3.1.2 Operational Requirements

The operational requirements is a compilation of the tools to make the operation a reality. These requirements give meaning to the CONOP and is a direct assessment of the quality and detail contained in the guidance document to support UAS operations (Terwilliger, Ison, Robbins, & Vincenzi, 2017). Airports' specific requirements are the focus of this guidance and include the operational plan and the operational considerations.

3.1.3 Operational Plan

The dynamic nature of airport operations requires a plan that is well-thought out to suit the environment and is consistent with regulatory and safety requirements for operations. The operational plan is a description of how UAS operations will be conducted within the airport environment from the airport manager, operations department/manager, and ATC perspective. In future drafts of this guidebook, this section will provide guidance on UAS-specific planning tools to be considered prior to a UAS mission. At the minimum, airport UAS operations managers need to understand that any UAS planning tool will be specific to their airports and the unique unmanned system, but would contain guidance on a number of issues addressed including:

a. Process for initiating, developing, and maintaining the UAS operations system
b. Required human, infrastructural, and regulatory resources
c. Potential threats to the conduct of the UAS mission
d. Emergency plans
e. Process for retiring the system

Before each planned UAS flight, the airport operations manager, operations department/manager, and ATC must consider the operational environment elements factored into the operational plan. To ensure that most pertinent factors are considered, the following considerations are included:

a. Operational environment
b. Stakeholder coordination
c. Flight planning and execution
d. Regulatory guidance

Save for flight planning and execution, the other sections of the planned UAS flight document could be standard, needing revision periodically. The flight planning and execution section would eventually be unique for each mission flown and the overriding conditions peculiar to that flight. A checklist approach that identifies sections that must be addressed by all stakeholders prior to any flight could prove helpful and efficient to ensuring all relevant sections of the operational plan are addressed completely.

3.1.4 Personnel Certification Requirements

The integration of UAS operations in the vicinity of airports requires the support of personnel with an understanding of the systems (airport and UAS) operations and limitations. Airport personnel accustomed to working with manned aircraft would find that major differences exist between manned and unmanned systems.

Currently, no certification requirements exist for the airport personnel working with UAS in airports. However, the sUAS rules (Title 14 Code of Federal Regulation—CFR—Part 107; see Section 3.2.2.1) identifies the requirement for operations (Section B) and remote pilot certification (Section C). Part 107 could provide an initial set of guidelines and framework from which airport operators provide guidance to their personnel regarding the nature of UAS operations, what is and is not permissible, and other operational considerations.

Further airport training and guidance for airport operations personnel in charge of safety and security could provide additional value to its employees and ensure a culture of UAS safety. For instance, under the SMS, training of safety policy, procedures, and risk mitigations must be shared with the relevant employees. In general, the training should seek to introduce UAS systems types, operations, operational limitations, procedures (airport and UAS), and authorization and approval processes.

While FAA has developed minimum requirements for sUAS remote pilot certification, there is at present no consensus as to a standard training program for persons operating sUAS. As part of the certification requirement toward certifying remote pilots, the FAA has an online course found at their www.faasafety.gov website as well as the aeronautical knowledge test requirement, which applicants must undergo and pass to obtain a remote pilot certificate with an sUAS rating. This course and knowledge test provide prospective operators with a wide range of UAS knowledge including an introduction to small UAS, registration, operations and limitations, and best practices. The course is not meant to be all inclusive, but provides the operators with a very basic knowledge necessary to safely operate sUAS in the national airspace. Pilots may benefit from additional training and knowledge relating to specific types of operations and operating environments. To this end, airport operators could develop their training programs to meet their individual needs while referencing the FAA's online training materials. They could ensure their training program addresses the topics contained in the FAA's training course and knowledge test tailored to incorporate other areas of importance specific to the environment of their airport including its vicinity and its unique airport operations. This training could enhance the effectiveness and efficiency of sUAS operations around their airports while promoting a high culture and standard of aviation safety. Airport operators should also consider Part 107 certification for personnel directly responsible for interacting with UAS operators to ensure full knowledge of the dynamically changing regulatory environment.

3.1.5 Key Resources

The development of the appropriate CONOPs is defined in more detail in the following resources:

- Handbook of Unmanned Aircraft Vehicles (Valavanis, 2015)
- Perspectives on Unmanned Aircraft Classification for Civil Airworthiness Standards (Maddalon et al., 2013)
- Small Unmanned Aircraft Systems Guide: Exploring designs, operations, regulations, and economics of small unmanned aircraft systems (Terwilliger, Ison, Robbins, and Vincenzi, 2017; Chapter 5)

3.2 Authorization, Approval, and Notification

The majority of UAS operations in the U.S. require external review and approval, prior to operations. The type of approval is dependent on several factors, including location, aircraft attributes, and operational intent. The first level of authorization is at the federal level. While the FAA is responsible for most approval procedures, it is important for the airports to know about these policies.

3.2.1 Recreational/Educational Use

One area of authorization occurs for recreational uses as shown in Figure 3. Recreational uses are those without purposeful application in receipt of compensation (or for hire); these uses can include education and personal enjoyment purposes (FAA 2016a). The FAA (2016b) has identified guidance to coordinate operations (i.e., notify prior) within five statute miles of an airport, seaplane base, or heliport. These operations also must consider the safety to the broader NAS and cannot endanger the existing operations within the NAS and/or in the vicinity of an airport. Finally, any existing national community-based guidelines (e.g., Academy of Model Aeronautics [AMA]) should be considered as well. Note that in many cases, UAS are also referred to as "model aircraft" in connection to 14 CFR Part 101. Figure 4 depicts examples of Part 101 permissible (i.e., compliant) and non-compliant UAS operations.

Recreational

- Use of UAS for personal enjoyment (i.e., hobby) or for non-training, educational purposes and in accordance with 14 CFR, Part 101 (2017), subpart E and Section 336 of the FAA Modernization and Reform Act (FMRA) of 2012 (Public Law 112-95); not for purposeful application in receipt of compensation or for hire (FAA, 2016a)
- Requires coordination with airport operator and local ATC, if within five statute (SM) miles of an airport, seaplane base, or heliport
- Operation cannot endanger safety of the National Airspace System
- Conducted under community-based guidelines and within programming of a national community-based organization (CBO; 14 CFR § 101, 2017; FAA, 2016b)

Figure 3: Definition of recreational use of UAS; presented information adapted from 14 CFR §101 (2017); Section 336 (FMRA, 2012); and FAA (2016a; 2016b)

Flying for fun/education (under 14 CFR-Part 101)	
Permissible Uses	Non-compliant Uses
Personal enjoyment (fun)	Compensated (money, goods, services)
Competition (no compensation)	Competition (for prize or compensation)
Scale realism	Product Exhibition (for sales)
Exhibition	Faculty-led Data Collection/Research
Ed. design testing/ evaluation	UAS Flight Training
STEM outreach/ engagement	Data Collection for Business
Ed. skills development	Data Collection for Government

Figure 4: 14 CFR §101 Compliant and non-compliant UAS operations; note abbreviations of educational use (Ed.) and science, technology, engineering, and mathematics (STEM)

According to the FAA (2017a), an airport operator cannot deny (i.e., prohibit or prevent) such operations, but an objection can be noted and unsafe or suspected unauthorized use can be reported (FAA 2017a); see Section 3.2.3 Reporting Suspected Unauthorized Use.

The following represent resources that may assist airport operators in external cooperation/coordination with recreational/educational users in their community:

- FAA Memorandum, Educational Use of Unmanned Aircraft Systems (UAS): https://www.faa.gov/uas/resources/uas_regulations_policy/media/interpretation-educational-use-of-uas.pdf
- FAA, FAQ, Flying for Fun Under the Special Rule for Model Aircraft: https://www.faa.gov/uas/faqs/#ffr
- FAA, Interpretation of the Special Rule for Model Aircraft: https://www.faa.gov/uas/media/model_aircraft_spec_rule.pdf
- FAA, Advisory Circular 91-57a (2016), Model Aircraft Operating Standards: https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_91-57A_Ch_1.pdf

3.2.2 FAA UAS Operational Approval Mechanisms

The federal framework, managed by the FAA, provides for a series of operational approval mechanisms to gain access to the NAS in support of either public or civil flights. Each unique mechanism was created because of regulatory change and evolution, based on dynamic needs and technological capability enhancements to ensure "equivalent level of safety," among all users of the NAS. As the introduction of each mechanism resulted from development and adaptation over time, they were each affected by several influencing factors (e.g., review schedule, resource availability, and limiting conditions), which has resulted in a unique set of benefits and constraints to be fully considered, prior to pursuit and end use. Each of the current operational approval mechanisms for both public and civil operators, are depicted in Figure 5 and described in the following subsections.

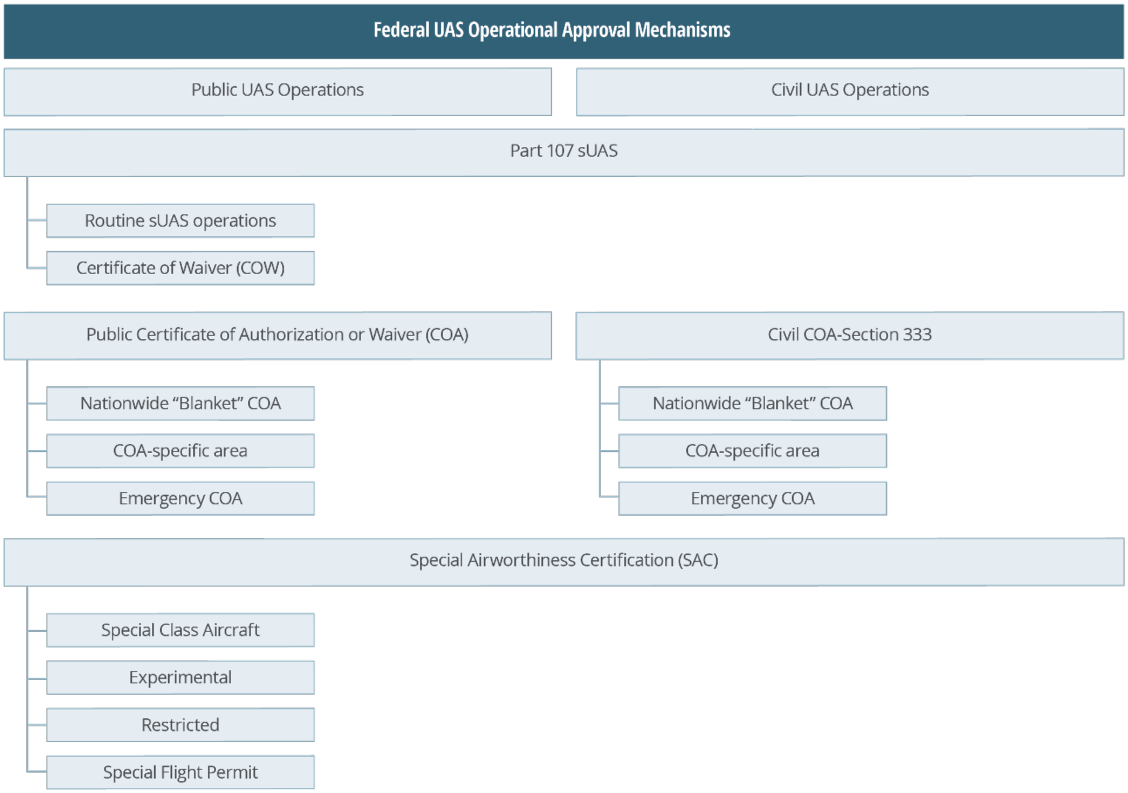

Figure 5: Federal UAS operational approval mechanisms

3.2.2.1 Part 107 sUAS

The majority of UAS operations within the NAS are anticipated to be conducted under the FAA's Part 107 rule for small UAS (sUAS). This regulation enables widespread and routine use of sUAS for those who meet specific operational, certification, registration, and system performance requirements, as depicted in Figure 6. Additionally, it is possible to operate beyond these rules, if the user applies for specific approval in the form of a certificate of waiver (COW) from the FAA, as described in Figure 7.

Part 107 Small Unmanned Aircraft Systems

OPERATIONS MUST BE CONDUCTED UNDER SERIES OF REQUIREMENTS:

- Aircraft-specifics
  - Registered
  - Under 55 pounds maximum takeoff weight (MTOW)
  - In condition permitting safe operation
  - Not to carry hazardous material
- Operational limitations
  - Under 400 feet above ground level (AGL) or within 400 feet radius of a structure
  - Under 100 miles per hour (mph)/87 knots
  - No flight over non-participants
  - Only within Class G airspace
  - 500 feet below and 2,000 feet away from clouds
  - Three SM visibility
  - Within visual line of sight (VLOS) of person manipulating controls Not from a moving aircraft; only from a moving vehicle, if in sparsely populated area and not for transportation of goods for compensation or hire
  - Limited to single unmanned aircraft at a time
  - Yield right of way to other aircraft
  - Daylight only
- Under supervision of a certified Remote Pilot in Command
  - At least 16 years of age
  - Successful completion of Unmanned Aircraft General examination or Part 61 certified and successful completion of initial training course
  - No known physical/mental impairment preventing safe operation
- Pre-flight familiarization and inspection of system

CERTIFICATE OF WAIVER (COW)

- Conditions that may be permitted, provided approval has been acquired from the FAA after review and determination of equivalent level of safety can be maintained
- Operation from a moving vehicle or aircraft, excluding carrying property for compensation or hire
- Daylight operation
- VLOS, excluding carrying property for compensation or hire
- Visual observer
- Operation of multiple sUAS
- Yielding right of way
- Operation over non-participants (people)
- Operation in Classes B–E airspace
- Operational limitations (14 CFR § 107, 2017; FAA, 2016b)

Figure 6: 14 CFR-Part 107 requirements and waiver procedures; presented information adapted from 14 CFR § 107, 2017; FAA, 2016b

The following resources may assist airport operators evaluate proposed operations within their vicinity, specifically related to Part 107:

- Part 107 Overviews
  - FAA, *Advisory Circular 107-2: Small Unmanned Aircraft Systems (sUAS)*: https://www.faa.gov/uas/media/AC_107-2_AFS-1_Signed.pdf
  - *FAA sUAS Part 107*: The Small UAS Rule: https://www.faa.gov/uas/media/faa-uas-part107-flyer.pdf
  - FAA, *Fact Sheet-Small Unmanned Aircraft Regulations (Part 107)*: https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=20516
  - FAA, *Summary of Small Unmanned Aircraft Rule (Part 107)*: https://www.faa.gov/uas/media/Part_107_Summary.pdf

- Part 107 Waiver Information
  - UAS remote pilots can apply for deviations from Part 107, as a COW online (expect a 90-day review and approval cycle, based on complexity of requested waiver): https://www.faa.gov/uas/request_waiver/
  - FAA, Waiver Application Instructions (2017): https://www.faa.gov/uas/request_waiver/media/waiver_application_instructions.pdf
  - FAA, Waiver Safety Explanation Guidelines for Part 107 Waiver Applications (2017): https://www.faa.gov/uas/request_waiver/waiver_safety_explanation_guidelines/

3.2.2.2 Certifications of Waiver or Authorizations (COAs)

Prior to the Part 107 sUAS rules (and subsequent certificates of waiver), authorizations for any public UAS operations were regulated through approvals of Certificates of Authorizations (COAs; public and civil). These approval mechanisms are still applicable for cases not covered by Part 107 including large UAS, those 55 lbs. or greater and the subsequent COW options. While Part 107 and COA approvals are beyond the authority of airport operators, it is important for airport managers and operations departments/managers to understand the requirements and processes that UAS operators are required to follow to operate a UAS. Furthermore, public airports operating UAS would also use similar public COA processes.

Public COA

The public COA process is summarized in Figure 7 and is specific to operators of public UAS by government agencies, organizations, or their vendors. These COAs still exist today for flights that do not meet requirements of the Part 107 rule or their specific waiver-able conditions. Generally, the COA procedure allows operation of a registered and market aircraft by a certified pilot within a specific geographic area, but also requires application and approval from the FAA Air Traffic Organization (ATO). The process is handled through an online system and approvals are provided to the applicant for two years (unless otherwise specified in the outcome of the application process), and include a nationwide "blanket" COA with similar requirements to the Part 107 rules (e.g., operation under 400 feet AGL).

Public Certificate of Waiver or Authorization

- Legacy approval mechanism, specific to public operators (e.g., government agencies and organizations)
- Enables operation of a registered and marked aircraft by a certified pilot within a defined operational boundary area; for operations not in conformance with Part 107 and applicable COW options (FAA, 2014a)
- Requires application to and approval from FAA Air Traffic Organization (ATO); submitted online using FAA COA Online System (FAA, 2017)
- Approval may include further requirements, specified by ATO to achieve equivalent level of safety
- Valid for two years, unless otherwise specified
- Includes "Blanket" Public COA up to 400 feet AGL nationwide with approval

Figure 7: Certificates of authorization process of for UAS operations before the Part 107 Rule; presented information adapted from FAA (2014a; 2017)

Emergency COA

COAs can also be approved on an emergency basis under special life-threatening or time-sensitive purpose. These details are provided in Figure 8.

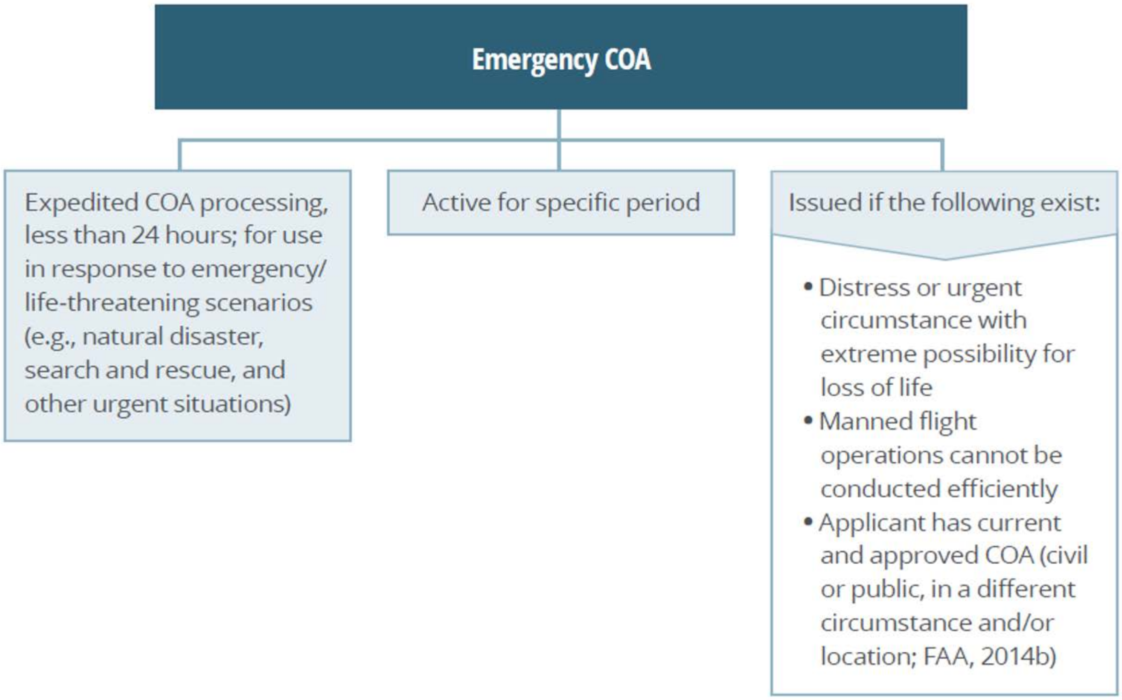

Figure 8: Emergency COA purpose and requirements; presented information adapted from FAA (2014b)

Section 333 Civil COA

Another method to obtain permission to operate UAS is through Section 333 of the FAA Modernization Act of 2012, which allows the Secretary of Transportation to determine if an airworthiness certificate is needed for a UAS operation (FAA 2017b, FAA 2014c). This provision was created prior to the Part 107 rule, but is still active. However, the Part 107 rule is generally meant to be the predominant method for UAS operational authorizations that meet its requirements. It is worth noting that for other UAS and operation types, Section 333 petitions can still apply; this is described in Figure 9. UAS operations under a COA must be preceded by a NOTAM (72 to 24 hours before) featuring the pilot's name and address, specified operational area (location and altitude), time and type of operation, and registration number of UAS (FAA 2016d). NOTAMs can be filed by contacting one of the following:

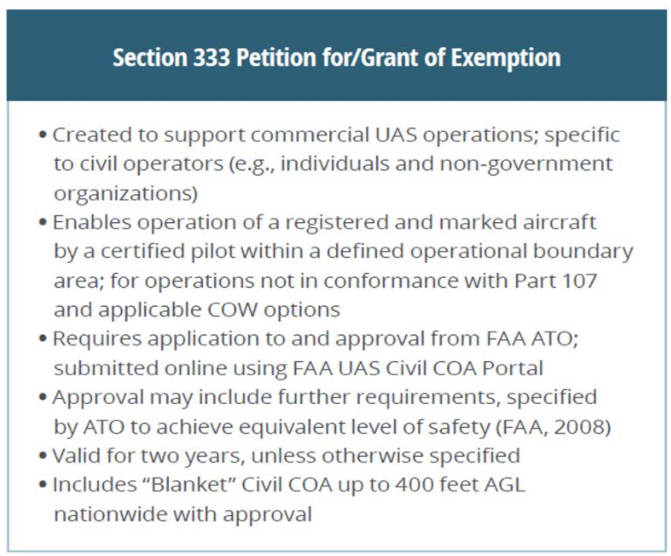

Figure 9: Description of the purpose of Section 333; presented information adapted from FAA (2008; 2014; 2017)

a) Local base operations or NOTAM issuing authority

b) NOTAM Flight Service Station at 1-877-4-US-NTMS (1-877-487- 6867)

Additionally, sample NOTAMs filed for Killian-Fort Hood Regional Airport and Southern California Logistics Airport is provided in Figure 10 (Neubauer 2015):

Robert Gray Aaf *(Killeen-Fort Hood Regional Airport)*

NOTAM #: L0187/15

Facility: GRK

Class: Military

Start Date: 13 Apr 2015 1400 UTC

End Date: 16 Apr 2015 2200 UTC

Status: Active

L0187/15 NOTAMN

Q) /QXXXX

A) KGRK KHLR

B) 201504131400

C) 201504162200

E) UAS OPERATIONS WITHIN THE ROBERT GRAY AAF CLASS D AIRSPACE, SURFACE TO 3500' MSL, AND WITHIN R-6302A, C, AND D, 5,500' MSL TO 10,500' MSL, CLASS 4 NON-EYE SAFE LASER OPS WITHIN THE RESTRICTED AREA, 1400Z (0900L) TO 2200Z (1700L) DAILY, 13 TO 16 APR 15.

Southern California Logistics

NOTAM #: 04/012

Facility: VCV

Class: Airspace

Start Date: 14 Apr 2015 1430 UTC

End Date: 17 Apr 2015 2359 UTC

Status: Active

!VCV 04/012 VCV AIRSPACE UNMANNED ACFT WITHIN AN AREA DEFINED AS 5NM RADIUS OF VCV SFC-5400FT DLY 1430-2359 1504141430-1504172359

Figure 10: Sample NOTAM issued for Killeen-Fort Hood Regional Airport and Southern California Logistics Airport (Neubauer 2015)

3.2.3 Reporting Suspected Unauthorized Use

There are several options that can be used to report suspected unauthorized use of UAS within the vicinity of an airport. These methods should be used for any suspicious, illegal, or unsanctioned operations creating unsafe conditions within the NAS or in violation of State/local laws and ordinances.

- FAA Hotline Reporting Form: https://hotline.faa.gov/
- Contact local Flight Standards District Office (FSDO): https://www.faa.gov/about/office_org/field_offices/fsdo/
- Contact State/local law enforcement (if state laws governing use of UAS/aircraft or operational personnel, including trespass, privacy, and/or operation of a vehicle; e.g., Florida State Statute 860.13, Operation of aircraft while intoxicated or in a careless or reckless manner; 2017); reference Law Enforcement engagement with Suspected Unauthorized UAS

Operations (FAA 2016e; https://www.faa.gov/uas/resources/law_enforcement/) in reporting

3.2.4 Airport Operator Review of UAS Operational Requests

Airport operators can expect to receive requests from those within their community to operate UAS in close proximity of a facility (i.e., within 5 statute miles). In such cases, a detailed analysis of the request may assist to uncover potential safety or liability risks associated with the request. Figure 11 represents a process to evaluate such requests and possible actions or decisions points, given the applicant provided information.

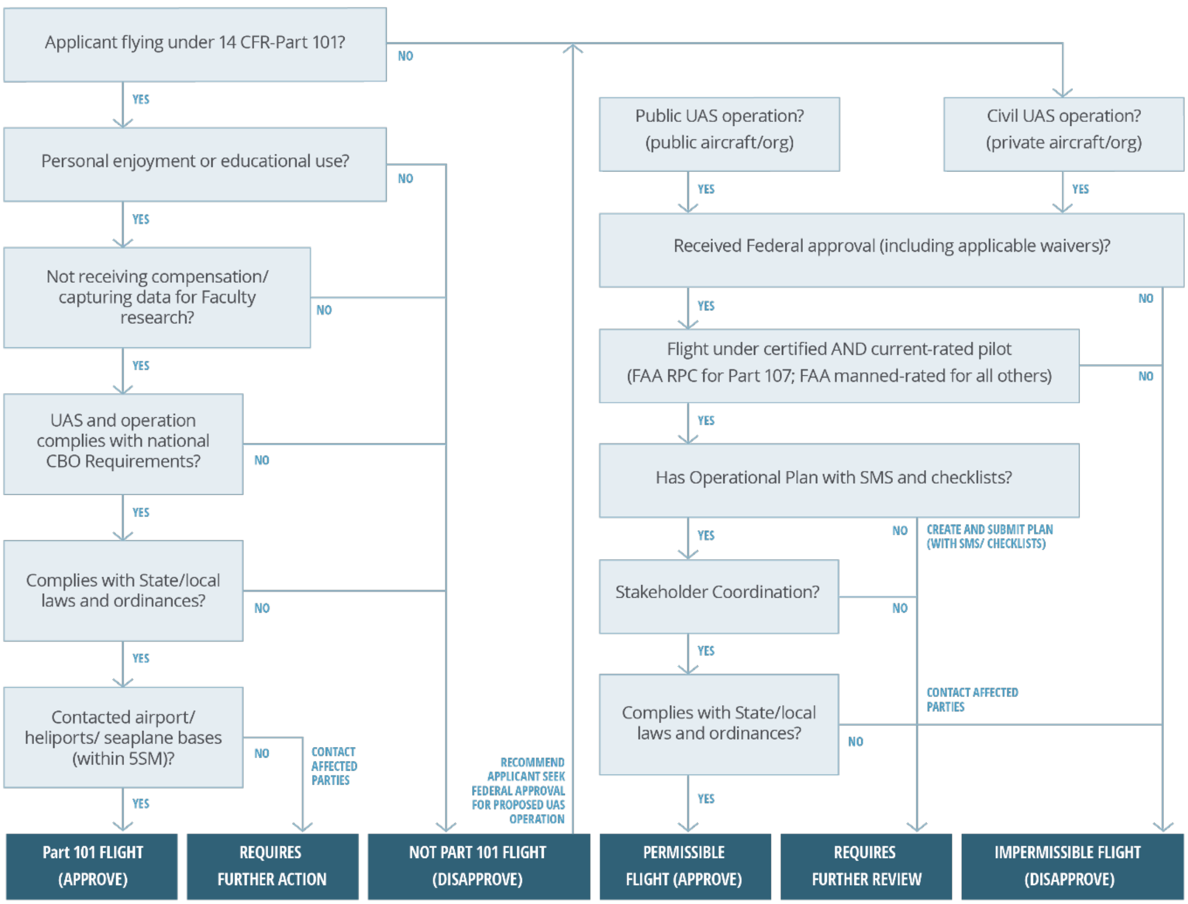

Figure 11: UAS operational approval evaluation flowchart

The following represents an overview of the linear review process:

1. *Is the request from a remote pilot seeking to fly under 14 CFR Part 101 (Subpart E, Special Rule for Model Aircraft)?* If yes, proceed to step A; if no, evaluate as a non-Part 101 UAS operation (proceed to step 2)

   NOTE: Items 1a-1e are considered best practices, as an airport operator cannot deny (i.e., prohibit or prevent) recreational (Part 101) UAS/model aircraft operations, but an objection can be noted and unsafe or suspected unauthorized use can be reported (FAA 2017, Flying for Fun Under the Special Rule for Model Aircraft)

a. *Is the proposed use for personal enjoyment or education use (e.g., evaluation of a UAS design or exhibition to promote STEM)?* If yes, proceed; if no, object, deny endorsement, and recommend user apply for appropriate Federal operational approval (e.g., Part 107, public/civil COA, or SAC)

b. *Confirm the user will not be receiving compensation (e.g., payment, goods, or services in kind) or they are not capturing data for a faculty-led research project.* If yes, proceed; if no, object, deny endorsement, and recommend user apply for appropriate Federal operational approval

c. *Does the proposed use (operation) and the specific UAS comply with the requirements of a national community based organization (CBO), such as the Academy of Model Aeronautics?* If yes, proceed; if no, object, deny endorsement, and recommend user either: 1) modify proposed use to comply with CBO requirements or 2) apply for appropriate Federal operational approval

d. *Does the proposed use comply with State and local laws governing such use (e.g., UAS, aircraft, or vehicles) in your area?* If yes, proceed; if no, request the user complies (revise Operational Plan to address specific requirements and exhibits proof of compliance), else object and, deny endorsement,

e. *Has the user contacted all airports, heliports, and seaplane bases within a 5SM radius of the proposed operational area?* (NOTE: check location using tool such as B4UFly). If yes, and all additional criteria has been satisfied, approve/support operations; if no, request the user complies and then exhibits proof of compliance, else object and deny endorsement.

2. *Is the user either a public (e.g., governmental organization or public school/college/university) or civil (all others) operator?* If yes, proceed to step A; if no, request further information

NOTE: Public COA holders are permitted to self-certify remote pilots.

a. *Has the user obtained appropriate Federal approval for operation in your area* (as defined below; FAA UAS operational requirement)*?* If yes, proceed; if no, deny approval/endorsement (such flight not permissible) until criteria met

    i. Under Part 107: in Class G airspace with a registered and marked sUAS conforming to weight and performance limits (e.g., less than 55 pounds maximum takeoff weight (MTOW), less than 100mph/87knots; see 3.2.2.1)

    ii. Under Part 107 with COW: in accordance with Part 107, except where allowable deviation is specified in approved COW

    iii. Under public/civil COA, within approved (defined) operational area or in under nationwide Blanket COA requirements: in Class G airspace with a registered and marked sUAS conforming to weight and performance limits (e.g., less than 55 pounds MTOW, less than 100mph/87knots); either case also requires pilot to file a NOTAM 24 to 72 hours before operation

    iv. Under SAC: within specified requirements of approval

b. *Will the flight be conducted under the authority of a certified and current pilot in command* (as defined below; FAA UAS operational requirement)*?* If yes, proceed; if no, deny approval/endorsement (such flight not permissible) until criteria met

i. Operations under Part 107: FAA certified Remote Pilot Certificate (RPC) operator (certified within last two years)

ii. Operations under Civil COA (333 Exception)/SAC: by current manned rated pilot (applicable certification current within last two years; e.g., any Part-61 certification except student pilot; includes sport, private, instrument, commercial, and airline transport pilot)

iii. Operations under a Public COA: organizations are permitted to self-certify remote pilots (confirm certification endorsement)

c. *Does the user have an Operational Plan, including appropriate SMS and checklists, specific to the UAS* (non-mandatory best practice, with exception of checklist which is a FAA UAS operational requirement)*?* If yes, and any additional criteria you deem necessary has been met, proceed; if no, deny approval/endorsement until criteria met (i.e., recommend they create and submit an appropriate Operational Plan addressing specific areas of concern or desired detail)

d. *Has the user contacted all applicable stakeholders that may be affected by operation* (e.g., , landowner[s], other government agencies, or other parties; non-mandatory best practice)*?* If yes, proceed; if no, deny approval/endorsement until criteria met (i.e., contact affected parties)

e. *Does the proposed use comply with State and local laws governing such use* (e.g., UAS, aircraft, or vehicles) *in your area* (FAA UAS operational requirement)*?* If yes, and all additional criteria you may have has been satisfied approve/support operations; if no, request the user complies (revise Operational Plan to address specific requirements and exhibits proof of compliance), else deny approval/endorsement.

3.2.5 Further Resources

The following represent resources that may assist airport operators in external cooperation/coordination with public and civil (i.e., commercial) UAS operators in their community:

- *Know Before You Fly* website: http://knowbeforeyoufly.org/
- Federal Aviation Administration
  - *UAS* webpage (including Getting Started, Beyond the Basics, Where to Fly, and FAQ): https://www.faa.gov/uas/
  - *UAS Sightings Report (November 2014-March 2017)*: https://www.faa.gov/uas/resources/uas_sightings_report/
  - *Law Enforcement engagement with Suspected Unauthorized UAS Operations*: https://www.faa.gov/uas/resources/law_enforcement/
  - *State and Local Regulation of Unmanned Aircraft Systems Fact Sheet:* https://www.faa.gov/uas/resources/uas_regulations_policy/media/uas_fact_sheet_final.pdf
- Academy of Model Aeronautics
  - *National Model Aircraft Safety Code:* https://www.modelaircraft.org/files/105.pdf

  - *sUAS Flight Safety Guide:* http://suas.modelaircraft.org/ama/images/sUAS_Safety_Program_web.pdf
- Online Aeronautical Charts (featuring UAS NOTAMs, i.e. DROTAMs; see "Layers-> Weather"): https://skyvector.com
- Example UAS Operational Checklists/Manuals
  - For Construction Use: https://business.libertymutualgroup.com/business-insurance/Documents/Unplaced/UASPreflightChecklist.pdf
  - Pre-flight: https://support.dronedeploy.com/v1/docs/pre-flight-checklist
  - General checklist: https://inside.mines.edu/UserFiles/File/PoGo/Compliance%26Ethics/UAS_Checklist_PrePostFlight_Draft2016Nov5.pdf
  - Commercial Best Practices: https://www.aig.com/content/dam/aig/america-canada/us/documents/business/specialty/guide-lrc-aero_business-uas-best-practices-sample-final.pdf
  - Pre/post- operation checklist: http://www.sbasite.com/media/sUAS%20Pre%20and%20Post%20Flight%20Checklist.pdf
  - Example Operations Manual: http://www.pipermountainaerial.com/uploads/1/0/2/0/102025336/piper-mountain-aerial_uas-operations-manual.pdf

3.3 Privacy and Data Considerations

This section briefly discusses privacy and data considerations for UAS operations in the vicinity of airports. It is not in the airport's authority to dictate or provide legal guidance regarding UAS privacy for those operating in the vicinity of their airport. However, there are some considerations worth noting so that airports can best inform these stakeholders. Additionally, when these operations are established under agreement with the airport, some additional privacy/considerations are established.

Public concerns related to privacy are commonly associated with UAS operations that collect data including videos and images that if disclosed could reveal private information of people and businesses that would otherwise have not been disclosed or required greater effort to obtain through other means. This concern is relevant for both Part 101 (hobbyist), public UAS operations (Certificate of Authorization [or waiver] and Part 107), and commercial UAS operations (Part 107 or Section 333 exemption). To mitigate these concerns, a number of government agencies, trade organizations (e.g. Association for Unmanned Vehicle Systems International—AUVSI), and hobbyist communities have established privacy best practices.

Additionally, if an airport enters into an agreement with a UAS operator—such as a routine permission to operate from the airport or its surrounding airspace or a tenant agreement to operate routinely from the airport—then privacy and data policy issues should be considered to maintain the appropriate level of privacy as necessary for the nature of those operations and the agreement. The most direct approach to addressing this concern would be the implementation of a non-disclosure agreement (NDA) between all parties involved in supporting the operation. Potential topics of disclosure include operator's clientele and business specific details regarding the operations performed under the agreement with the airport. An NDA would allow all parties to agree upon mutually what is ineligible for disclosure as well as the limits on the agreement.

Table 4: Guidance for airport privacy considerations

Privacy Considerations	Airport's Role
Unauthorized photography of people and property	Share best privacy and practice resources with operators inquiring about operating in vicinity of airport. Direct them to review any additional community or organizational standards applicable to the UAS operator.
Disclosure of sensitive information (under airport agreement with operator)	Agreements for routine operation with UAS operators should address any privacy concerns between the airport and the UAS operator (e.g. establishment of a non-disclosure agreement)

While privacy is an important consideration, it is not regulated by aviation entities. Neither the airport nor the FAA have the authority to regulate these considerations. Some additional resources for reference regarding privacy and community-based guidance on UAS best practices have been developed and are referenced below (AUVSI, 2012; Know Before You Fly, 2015; and NTIA, 2016).

The following resources listed below can be referenced for additional guidance on UAS privacy policy, best practice, and considerations.

- Voluntary Best Practices – NTIA (NTIA, 2016): This document addresses UAS guidance for privacy, transparency, and accountability for both private and commercial UAS use.
- Know Before You Fly, UAS Best Practices (Know Before You Fly, 2015): This website outlines several coordination-related best practices to protect privacy which include those summarized in Figure 2.
- AUVSI, Code of Conduct (AUVSI, 2012): This code provides best practices for "safe, non-intrusive" UAS operations in order to "accelerate public confidence in these systems". It provides a checklist that is categorized by guidance to achieve safety, professionalism, and respect in UAS operations.

3.4 Applicable Regulations, Laws, and Requirements

3.4.1 Federal Laws and Policies

The following section provides summaries of federal laws and policies relevant to UAS.

3.4.1.1 FAA issues fact sheet on state and local UAS laws (FAA 2015)

In light of the fact that many State and local governments, since 2013, have been creating their own UAS laws, despite federal preemption on the matter, the FAA decided to share a fact sheet on state and local regulation of UAS. This fact sheet provides information for states and municipalities considering creating laws addressing the use of UAS. The FAA outlines why, for safety reasons, they should maintain oversight of aviation and airspace. The fact sheet provides examples of state and local laws affecting UAS for which consultation with the FAA is recommended, such as "restrictions on flight altitude or flight paths, regulation of the navigable airspace, and mandating UAS-specific equipment or training." Furthermore, the fact sheet gives examples of UAS laws likely to fall within state and local police power, such as "requirements for police to obtain a warrant prior to using UAS for surveillance; prohibitions on the use of UAS for voyeurism; exclusions on using UAS for hunting or fishing, or harassing individuals engaged in those activities; and prohibitions on attaching firearms or other weapons to a UAS" (FAA 2015a).

3.4.1.2 14 CFR Part 107

All commercial operators not under Section 333 Exemptions must abide by the following rules. These rules in summary are as follows.

- The pilot must be at least 16 years old;
- Must pass an initial aeronautical knowledge test at an FAA-approved knowledge testing center; and
- Must be vetted by the Transportation Safety Administration (TSA). (FAA 2016c).

A person who already holds a pilot certificate under 14 CFR Part 61 and has successfully completed a flight review within the previous 24 months can complete a part 107 online training course at www.faasafety.gov to satisfy this requirement. Part 107 applies to aircraft that weigh less than 55 pounds and must be registered. (FAA 2016c).

Operating rules that may be waived by FAA permission, available through an online portal, include:

- Class G airspace;
- Must keep aircraft in visual line of sight;
- Must fly under 400 feet;
- Must fly during the day;
- Must fly at or below 100 mph;
- Must yield right of way to manned aircraft;
- Must NOT fly over people; and
- Must NOT fly from a moving vehicle. (FAA 2016c).

3.4.2 Hobby Regulations

There are several important regulations that relate to operations specifically by hobbyist. This section provides a brief summary of the applicable policies that hobbyists should consider. While not directly applicable to airport operators, this section can aid airports in providing guidance for hobbyists inquiring about UAS operations in the vicinity of airports.

3.4.2.1 FAA Special Rule for model aircraft 14 CFR Part 101

A hobbyist under the FAA safety guidelines must:

- (1) fly at or below 400 feet;
- (2) be aware of airspace requirements and restrictions;

- (3) keep the UAS within visual line of sight;
- (4) stay away from surrounding obstacles;
- (5) never fly near other aircraft, especially near airports;
- (6) never fly over groups of people;
- (7) never fly over stadiums or sports events;
- (8) never fly near emergency response efforts such as fires; and
- (9) never fly under the influence of drugs or alcohol.

The special rule for model aircraft (P.L. 112-95, section 336) provides the definition and operating rules for flying a model aircraft. Model aircraft operators that comply with ALL the following operational requirements during flight no longer have to register their UAS with the FAA." (FAA 2016b)

3.4.2.2 AC 91-57A with Change 1

Advisory Circulars (ACs) explain the regulations. This particular AC 91-57A provides explanations to hobby or recreation UAS pilots on ways to safely fly their aircraft in the NAS. Furthermore, this AC reiterates the federal definition of model aircraft as put forth in the FAA Modernizations and Reform Act (FMRA) of 2012, Section 336. (FAA 2016a).

3.4.2.3 Know Before You Fly

Know Before You Fly is an education campaign founded by the Association for Unmanned Vehicle Systems International (AUVSI) and the Academy of Model Aeronautics (AMA) in partnership with the FAA to educate prospective UAS users about the safe and responsible operation of their aircraft. (FAA 2015). This campaign is mainly aimed at providing guidance for operators. However, airport operations and public outreach liaisons may benefit from coordinating policies and strategic best practices with them.

3.5 Operational Coordination

FAA policy for UAS operations is that no person may operate a UAS, including tethered UAS, outside of active restricted, prohibited or warning areas in the NAS without specific authority, with the exception of a model aircraft flown for hobby or recreational purposes or an Optionally Piloted Aircraft that has a pilot onboard (FAA 2015). This section will provide guidance on required coordination with FAA, ATC, crew, and local community before, during, and after UAS operations in the vicinity of airports. The information here is primarily applicable to UAS users, but it is still important for airport operators and managers to understand the requirements from the pilots perspective in order to appropriately plan and manage UAS operations in their vicinity.

3.5.1 FAA Coordination

The specific authority for the operation of UAS in the NAS is the FAA and requires major coordination by the remote pilot operator before operations commence. The authority is issued only after the administrator deems that the operation can be conducted within certain stipulated legal and regulatory limits and does not pose hazards to the public. In coordinating with the FAA, the following should be considered:

- Responsibility for coordination is important for both the UAS operator and the airport management executives.
- Regulatory provisions based on nature of operation intended such as Part 107 option or certificate of waiver option.
- Type of mission/intended use of system.
- Operating altitudes.
- Flight crew qualifications and training requirements.
- Emergency procedures.

3.5.2 ATC Coordination

Prior to the operational conduct of a UAS flight, the coordination between the UAS flight crew and ATC personnel within the airspace of operation is necessary to ensure a safe flight. This section will identify will provide guidance on areas to consider in the coordination efforts between ATC and UAS flight crew:

- Responsibility for coordination.
- Pre-flight coordination including NOTAMs.
- Flight plan or mission details.
- Flight authorization/airspace waivers.
- Two-way communication techniques and procedures.
- Communication and Electromagnetic Spectrum issues:
- Normal Procedures
- Contingency plans
- Segregation plan in airspace with multiple UAS operations.
- Post-flight coordination.

3.5.3 Local Community Coordination

Informing the local community regarding the rules and best practices for operating within their vicinity can reduce the frequency of unauthorized or risky operations impacting airport operations, guide those seeking to perform authorized operations on the process for obtaining approval (when applicable), and mitigate the challenges associated with community-related complaints against such operations. It can also address the broader community regarding how to respond when unsafe UAS operations are witnessed.

This outreach and coordination effort applies to an airport management of hobbyist, civil, and public use of UAS. Each user type has the same potential to impact the local community and/or the safety of the airspace; therefore, local community engagement by airports' public outreach liaisons is important to ensure the long-term potential for future collaboration and coordination on current and anticipated uses of UAS.

Airport management could adopt the U.S. DOI approach to public and local community engagement before and during their operations. Being one of the most active users of UAS, the DOI uses scheduled public and town hall meetings and prepared information publications to describe the objectives and nature of operations (Neubauer, K. 2015). Airport managers can use the information provided in a certificate of authorization (or wavier) or 333 Exemption for a planned UAS activity to present this information to the local community. In addition, management and operators could address the following topics for a smoother operation of UAS in airports.

- Privacy considerations,
- Regulatory/legal guidance for use of airborne technology,
- Community engagement plan,
- Hobby users operating within 5 miles of the airport,
- Careful planning of UAS lost link (e.g. error in communications) and other contingency procedures,
- Compliance with city, county, state, and federal policies, ordinances and laws, and
- Reporting of unsafe or suspicious UAS activities.

Coordination and stakeholder outreach best practices are currently being develop concurrent to this research topic area. It is expected that the guidance from that research effort will provide insight into coordination best practices, including workshops and online outreach.

4 Safety and Emergency Management Best Practices

It is important for airport operators to understand how to deal with UAS accidents and incidents, including sightings of unauthorized UAS operations, and their potential ripple effect that can impact airport operations. This section will describe the best practices related to handling emergency situations due to UAS operations in the vicinity of an airport. In developing these topics, considered both tactical operations (reacting to a UAS incident) and strategic planning (guidance on anticipating UAS incidents) were considered. Specifically, the guidebook will cover the issues outlined in Sections 4.1 to 4.3.

4.1 Safety Management Systems

A safety management system (SMS) is a system established within an organization to address safety risks to people, property, and business needs through the declaration of an organizational safety policy, promotion of an overall culture of safety within the organization, safety risk management (SRM) to address and mitigate potential safety hazards, and a safety assurance policy to ensure long-term safety is maintained as it evolves. A relatively recent tool used by airports, an SMS document captures this system so that it can be disseminated to the appropriate stakeholders, defines clear instructions on the system and its execution, and can be shared with others as part of certification, operational approval, or demonstrating to others the organization's safety protections. Note that most smaller airports may not have an SMS in place. To date, a clear mandate for inclusion of UAS specific SMS sections or documents; however, it is a best practice to integrate UAS safety within its SMS program.

The ACRP's SMS guidance for airports (ACRP, 2007) defines an SMS and system safety as follows:

- "A safety management system (SMS) is a formal, top-down business-like approach to managing safety risk that is built on basic system safety principles" (ACRP, 2007).
- "System safety is the application of engineering and management principles, criteria, and techniques to achieve an acceptable level of safety throughout all phases of a system" (ACRP, 2007).

Additionally, the FAA's ATO has published its own Safety Risk Management System Manual (2017b) to provide SMS specific guidance its overall safety assurance of an evolving national airspace system. Additional guidance regarding SMS principles is contained in FAA Advisory Circular 120-92B.

4.1.1 UAS Considerations for an Airport SMS

A well-defined airport SMS could be sufficient to address the integration and approval needs of a UAS operations at the airport including operations within the vicinity of the airport, operations by airport tenants, operations from outside organizations, and operations performed by airport personnel in support of airport operations.

UAS Considerations for SMS Development or Revision: In Table 5, a number of special considerations for the SMS are provided for each major element of the SMS. Typically, safety and security considerations are handled by the airport operations department/managers of smaller airports that fall under Part 139 certification. Larger airports have a dedicated safety officer that oversees the development and management of SMS.

Table 5: UAS considerations for airport SMS

Element	SMS Considerations
Safety Policy	Policy statement should remain consistent so long as it is sufficiently broad and inclusive such that UAS operations addressed implicitly or explicitly. Organizational structure may wish to identify special safety personnel to oversee UAS operational safety.
Safety Risk Management (SRM)	Airport Safety Risk Management (SRM) should promote best practices in the assessment of UAS operations and systems integration within the SRM and Safety Assurance (SA) processes. For additional SRM factors please see Section 5 of this Guidebook below. It should account for safety risks both within the airport's control such as approval of public and commercial UAS operations in the vicinity of the airport. It should also consider safety risks resulting from potential nearby hobbyist activities such as those from nearby neighborhoods, parks, schools, etc. SRM should utilize tools such as UAS Facility Maps (FAA 2017e) and Geographic Risk Maps. Risk Mitigation strategies should consider at a minimum: Airport emergency planning Contingency management Issuance of NOTAMs Personnel training New infrastructure/resources
Safety Promotion	UAS tenants, operators, and maintainers should be consider integrated into the airport's safety culture. Training should include UAS tenants, operators, and maintainers and be conducted periodically. These training sessions can be conducted as workshops and webinars with updates and information shared through various mediums (e.g. websites, web application, flyers) developed to engage with the community. Safety changes resulting from UAS integration should be communicated to all appropriate employees. UAS safety lessons learned should be shared with airport employees, tenants, and other airport stakeholders.
Safety Assurance (SA)	Safety Assurance should include auditing (internal/external) to ensure UAS operations are adhering to the safety standards of the airport. UAS incident/accident reports should be shared with airport safety personnel to ensure lessons learned are captured and newly identified hazards are addressed by the SRA process. Corrective action should be taken to address new safety issues addressed by audits and data analysis.

Element	SMS Considerations
	Coordination with FAA and local law enforcement could help facilitate the identification of safety hazards from off-airport entities operating in the vicinity of and/or over airport property/airspace.

Utilization of SMS by Airport for Integration of UAS: The Safety Risk Management (SRM) safety risk assurance (SRA) process should be triggered with the integration of any related operational change including any new UAS system introduced within into the airport environment under an SMS.

For the integration of a new UAS into the airport environment, a SRM review an SRA will be required to examine identify and mitigate all potential hazards, prior to approval of operations, including, but not limited to the details of the operation, its contingency management strategies, personnel, airport access requirements, infrastructure requirements, and ATC coordination. For the integration of long-term infrastructure to support UAS operations, or the development of an environment for routine UAS operations and support, i.e. launch and recovery systems, control stations, communication systems, staging areas for runway takeoff and landing, the SRM SRA process is also required to determine the impact of these changes and mitigate risks to an acceptable level. Other uses of the SMS for support of UAS can vary based upon circumstances including the airport's other SMS requirements.

With airport operations, promotion of safety is also important. Given that UAS operators may not have an aviation background or their background is limited, it is important that fundamental SMS safety promotion and training is provided to those tenants/operators performing the UAS operation.

4.1.2 SMS Resources

Table 6 defines resources that provide more guidance and insight on SMS development. The resources in the first three topics (SMS Manuals, SRM/SA Guidance, and SMS for Airport Guidance and Resources) possess generic SMS information, while the resources in the last topic (SMS for UAS Operators Guidance) are specific to UAS. Future products from this research effort will provide UAS-specific SMS guidance.

Table 6: Safety Management System resources

Topic	Resources
SMS Manuals	FAA Safety Management Systems (web portal) (FAA 2017b) FAA Advisory Circular 120-92B FAA Air Traffic Organization Safety Management System Manual (FAA 2017d) ICAO Safety Management Manual (ICAO, 2017)
SRM/SASRA Guidance	FAA/Eurocontrol ATM Safety Techniques and Toolbox (FAA and Eurocontrol, 2007) System Safety Handbook (FAA 2017c)

Topic	Resources
SMS for Airports Guidance and Resources	FAA Order 5200.11: FAA Airports (ARP) Safety Management System (FAA 2010) AC 150/5200-37: Introduction to Safety Management Systems (SMS) for Airport Operators (FAA 2007) External SMS Efforts, Part 139 Rulemaking: Documentation from Airport SMS Pilot Studies (FAA 2017) ACRP Report 1: Safety Management Systems for Airports, Volume 1: Overview (ACRP, 2007) ACRP Report 1: Safety Management Systems for Airports, Volume 2: Guidebook (ACRP, 2009) ACRP Synthesis 37: Lessons Learned from Airport Safety Management Pilot Studies (ACRP, 2012)
SMS for UAS Operators Guidance	The Safety Risk Management of Unmanned Aircraft Systems (Clothier and Walker, 2014). Safety Risk Assessment for UAV Operation (Wackwitz and Boedecker, 2015)

4.1.3 Planned Toolkit Items

For future editions of this guidance material, the following resources are under consideration for inclusion in the future:

- Safety Management System Template
- Safety Risk Analysis Checklist
- Safety Management System Case Study Example
- Sample SRM Form and Checklist

4.2 UAS Contingency Management

Contingency management defines how the system and people should respond to common UAS in-flight hazards. For such hazards, a contingency management plan defines the system response and/or procedures that will execute upon detection of a contingency state. Table 7 presents several common UAS contingency types with a brief overview.

Despite the benefits of integrating UAS operations in and around airports, there are accompanying challenges and potential uncertainties impacting airport operations posed by routine UAS operation within its vicinity. To this end, airport managers need to be conversant with the possible contingency modes of UAS to better anticipate and mitigate the impact of UAS operating within a contingency mode. A general contingency plan could be written for UAS operations around an airport and the roles and responsibilities of the stakeholder involved such as the UAS operators, local air traffic control, etc.

However, the uniqueness of each unmanned system also requires that airport managers coordinate with the UAS crew on the plans of action that may not fit the general contingency plan. Such plans should be well articulated and distributed to appropriate stakeholders so that each has clear and concise roles, responsibilities, and courses of actions when such situations arise. This has the potential to mitigate the adverse effects of unplanned situations, or reduce their effects.

Table 7: Common UAS contingency event types

Contingency Events	High-Level Overview
Lost Link	Lost link procedures define the method of detection and response to a loss of positive control of the UAS as a result in an intermittent or full loss of radio frequency (RF) communication between the ground control station (GCS) and the UAS.
Lost Communications with ATC	Lost communications with ATC procedures define the pilot's response in the event that communication with ATC is lost. These procedures could include technical debugging of the appropriate systems, communication through alternative means (e.g., phone), transponder settings (if equipped), or initiating a return home.
Degraded or Lost GPS	Lost GPS procedures address the situation in which the quality of the GPS measurement of aircraft position and altitude are not sufficient to navigate and/or maintain safe operation. In addition to notifying ATC, the procedure must define procedures to safely land or terminate the UAS manually, since most automated operation relies upon GPS.
Engine Failure	An engine failure procedure must provide guidance on how to determine that the engine has failed or is failing based upon engine parameters, altitude loss, and audible cues. Typically, contingency management of an engine loss involves locating a suitable location within the power-off glide distance of the aircraft (unpopulated or sparsely populated), notification of ATC, and attempting to restart the engine (time permitting).
Loss of Electrical Power	Loss of electrical power represents a challenging contingency state as most flight controls reply upon electrical power to operate. Contingency procedures for a loss of electrical power would identify any diagnostics and guidance on suitable safety notifications.
Fly Away	A fly away is typically a more extreme case of a lost-link in which the aircraft not only has a loss of positive control from the PIC, but has also deviated from its pre-planned contingency route. To address fly away, procedures must exist to determine that the aircraft has deviated from its intended path, coordination with ATC regarding the emergency situation, and flight termination options when available.

Of the above, only lost link contingency planning is well-defined within FAA documents. FAA Order N Job Order (JO) 7110.724 (2016) guides air traffic controllers regarding how to handle UAS contingency management and their impact on the broader set of ATC procedures defined FAA

Order JO 7110.65W (2015). While geared towards ATC guidance, this document should be considered as part of the coordination between ATC and airport operations departments/managers who have to handle lost link procedures.

UAS contingency planning is unique to its operational environment, equipage, capabilities, and crew. This section will briefly define the elements required for a contingency plan. Next, the contingency planning considerations of lost-link procedures are described.

4.2.1 Elements of a Contingency Plan

This section defines the key elements of a UAS contingency plan that must be addressed.

Definition of Failure: UAS operations are still evolving and the potential for unpredictability during operations remains very high. A contingency plan is a series of actions to be taken in the event of an unforeseen or unpredictable event occurring during a planned mission (FAA 2006; Fern, Rorie, & Shiveley, 2014). This section generally describes steps to be taken in the event of such cases, and help prevent a hazardous condition from further developing into a dangerous or fatal situation. Some possible occurrences identified include loss of communication with ATC, engine failure, loss of electrical power, and navigation failures including lost link, GPS failure and fly away.

Method of Detection: The prompt identification of a potential situation requiring an activation of an alternative plan is key to minimizing the adverse effect of such a situation. Different methods of detection exist for emergency situation in UAS operations and the most effective means of detection would likely be a combination of these detection methods. Some methods of detection in UAS operation available to airport operators could include verbal communication from UAS flight crew, visual identification of UAS flight modes, electronic detection methods such as ATC radar displays. A combination of more than one of these modes would be an effective means to confirm a situation exists, and trigger appropriate response to meet the situation.

Action by relevant parties: Based on the nature of the situation, the following parties would respond:

- Unmanned Aircraft (UA)
- Remote PIC and crew
- ATC/Airport manager
- Others

In the contingency plan, the roles, responsibilities, and procedures of each must be defined as needed to ensure proper coordination among all relevant stakeholders.

4.2.2 Example: Lost Link Procedure Considerations

Lost link procedures are one of the most common types of contingency management procedures. A lost link situation occurs whenever the pilot loses positive control of the UA because of a full or partial interruption in RF communication between the GCS and the UA (Fern, Rorie, & Shiveley, 2014).

Requirements for UAS lost link procedures for systems operating under a certificate of authorization or 333 Exemption is provided in FAA Order N JO 7110.724 (2016) and have been incorporated into the latest revision of FAA Order 7110.65W (2015), ATC Procedures, in Section 5-2-9, “Lost Link Procedures.” Figure 12 describes the process for dealing with a lost link problem.

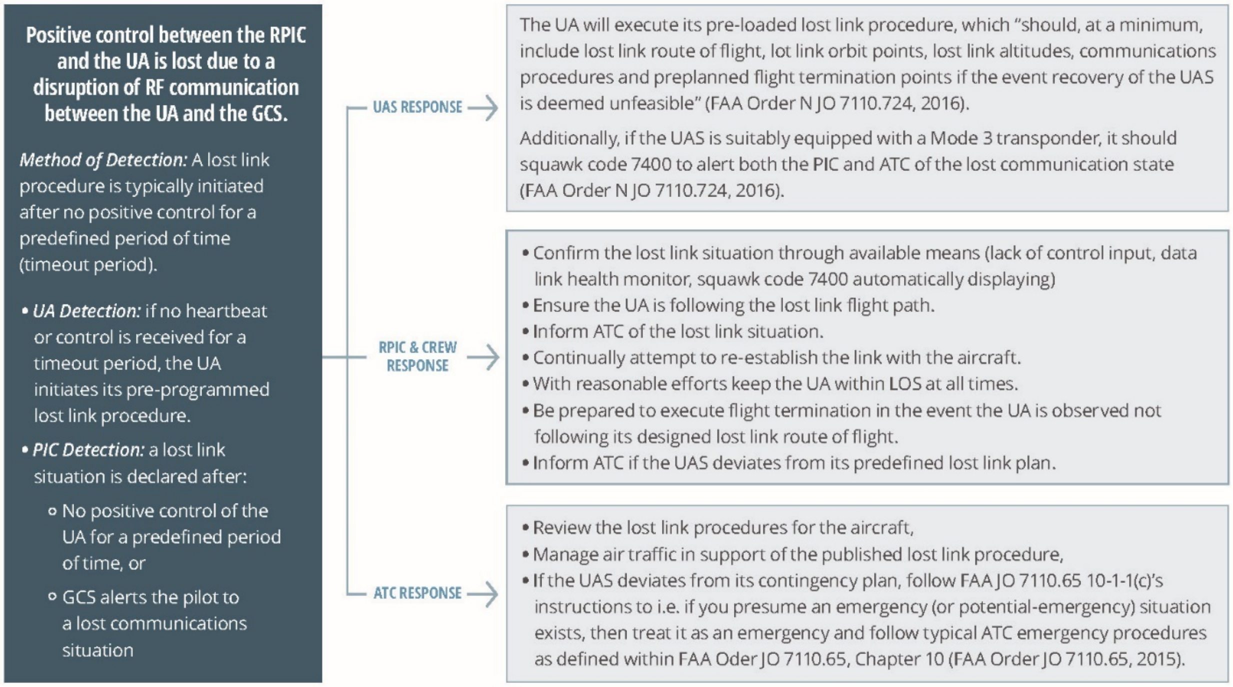

Figure 12: Roles and responsibilities for a lost link procedure

Other Responses: A lost link procedure could include additional support including the use of spotters to help locate the aircraft, emergency personnel to clear the scene near the rally/termination point, airport rescue and firefighting (ARFF) or other suitable firefighting/first responder organizations support to address any injury or fires resulting from an unsuccessful recovery.

4.2.3 Airport Considerations for Contingency Management

In general, UAS contingency management's purpose is to mitigate the risk of a UAS incident/accident by addressing common technical issues through pre-defined and pre-coordinated procedures. Some considerations for UAS contingency management that should be addressed by airports include, but are not limited to the following:

- Identify the person responsible for reviewing contingency management plans for UAS operations at the airport or in its vicinity.
- Identify hazards addressed by the contingency management plan, and determine if those hazards are sufficiently mitigated as per the SRA defined in the airport's SMS.
- Ensure that the contingency management plan does not produce secondary or tertiary hazards through its impact to the terminal airspace and airport surface operations.

Airport-specific contingency management plan factors should be developed by airport management in coordination with their operations department/manager as well as local ATC. Ensure that the UAS emergency plan and/or Airport Emergency Plan (AEP) sufficiently addresses preparation and response to the hazard produced by the contingency state and/or the results of a failure to return safely home.

4.3 Guidance for Emergency Plans for UAS Operations at Airports

This section provides guidance on developing an airport emergency plan for UAS operations at airports. The AEP provides guidance regarding:

- Preparation for an impending emergency
- Response to that emergency with a primary goal of public safety
- Recovery post-accident including investigation, clean-up, reporting, and restoration of airport services

An AEP is required for all airports certified under Title 14 CFR Part 139 § 325 (2017), which includes most non-general aviation airport categories supported by this guidance document. Airport operators should reference the FAA's guidance under FAA Advisory Circular (AC) 150-520-31C, "Airport Emergency Plan" (FAA 2009).

For all other airports, even if an AEP is not required, a standalone UAS Emergency Plan would improve the overall safety of routine UAS operation at the airport and promote a safety culture within the organization. The guidance provided herein should be applicable to either circumstance.

Additional references include in section 4.3.6 of this guidebook.

4.3.1 UAS Incident/Accident Procedures

The UAS emergency plan must define UAS incident/accident procedures, i.e. how the actors within the emergency plan respond to the emergency including pre-emergency and post-emergency response. An airport's AEP's hazard-specific appendix addressing aircraft accidents and incidents is a great resource to support the development of these procedures; however, UAS-specific considerations should also be addressed such as those highlighted in Table 8. The airport will follow a process similar to the one shown in Table 9 to develop their UAS specific incident/accident procedures.

Table 8: Considerations for UAS incident/accident procedure development

Examples of UAS-specific considerations for Emergency Plan Incident/Accident Procedures

• UAS type, size, and operational characteristics
• Procedures to mitigate risk identified by the airport's SMS for UAS operations for UAS incidents/accidents during:
    o Uncoordinated operations (e.g. hobbyist operations), and
    o Operator-Airport Coordinated operations;
• Procedures established by the UAS operator's SMS or emergency management plan;
• Air-to-air and air-to-ground collision incidents/accidents;
• Procedures for handling incidents/accidents involving unsafe use.

The following process could support the development of the UAS incident/accident procedures for a UAS emergency guide:

Table 9: Process for UAS incident/accident procedure development

Collect	❑ Current AEP or similar relevant emergency plans ❑ Emergency procedures from airport, local, state, and federal response agencies ❑ Existing SMS documents from airport and/or UAS operator(s) ❑ UAS contingency management plan(s) ❑ Associated UAS manuals and SOPs ❑ UAS -specific documents including material safety data sheets (MSDS) and recovery procedures
Analyze	❑ Identify gaps in current aircraft incident/accident procedures ❑ Identify UAS-specific hazards and procedures identified from collected materials
Develop	❑ Draft new UAS incident/accident procedures such that it o Addresses all identified gaps o Aligns with airport, local, state, and federal response agencies' procedures o Includes standard operating procedures for pre- and post- accident response

4.3.2 Communication Planning

The UAS Emergency Plan's communication planning section should address UAS-specific gaps in the existing communication plan specific to UAS operations.

The plan should consider the location of UAS personnel during their operation and their roles within the routine operation and emergency procedures. Assumptions also need to be made to identify off-airport resources including local police, firefighting, and rescue services and the communication infrastructures needed for the response to a UAS incident/accident.

The plan should include the flow of communication that includes appropriate UAS operations and support personnel. An example of this communication is provided in Figure 13. In it, the UAS operator (pilot-in-command) who could be on airport or off airport can communicate with airport operations via VHF radio on airport operations frequency regarding the details of the incident/accident, UAS specific information including hazardous materials (if relevant), identification and location of UAS crew (including visual observers), etc. A typical communication plan (as shown in FAA AC 150-520-31C, "Airport Emergency Plan" (FAA 2009) includes the declaration of communication frequencies between various emergency response organizations. Those elements are excluded to highlight the UAS PIC's relationship with the key response team entities.

When defining the *organization and assignment of responsibilities* section of the communication plan, the plan must incorporate the roles and responsibilities of all personnel tailored toward any UAS-specific needs. Furthermore, the section must identify and assign responsibilities to relevant personnel associated with UAS operation, which may vary between organization and operation, but could potentially include:

- Airport tenants providing UAS services
- UAS pilot-in-command
- UAS visual observers
- Other UAS-specific safety personnel and human resources

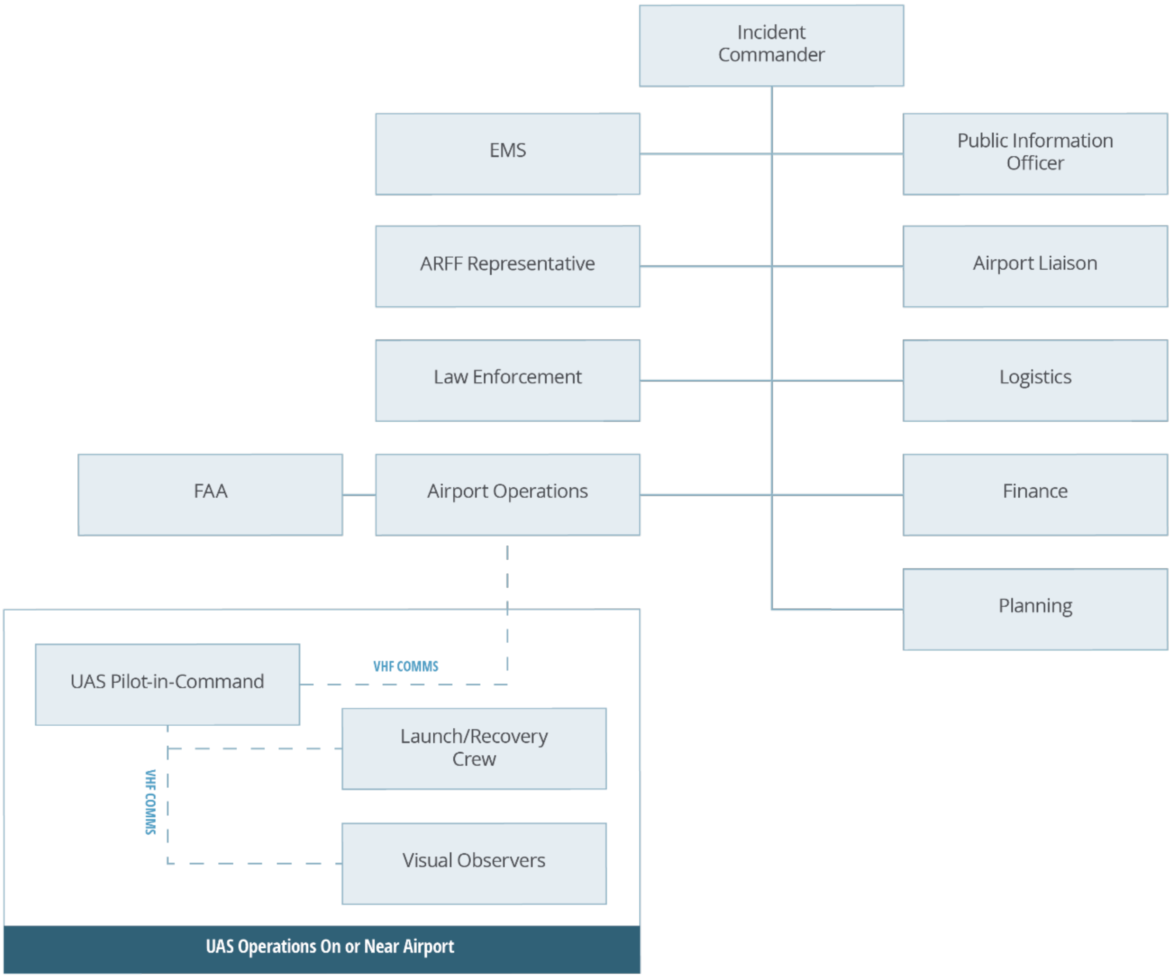

Figure 13: Example of a UAS integration into emergency management communication plan

4.3.3 Alerts and Notifications

An emergency plan's alerts and notifications function addresses the needs for alerting whose safety is potentially impacted by the UAS operation. For an UAS emergency plan, the authors must consider what UAS-specific warnings are relevant to their airport and its supported operations. Some considerations include:

- Purpose of the alert

- Individuals to be notified by the alert
- Mechanism for issuing alert and how individuals with special needs are accommodated
- Addressing system failures with the alerting mechanism
- Coordination of alerts across multiple jurisdictions (especially when considering off-airport emergencies)
- Pre-written alert messages and their variations

4.3.4 Local Media Coordination

FAA AC 150/520-31C (2009) provides guidance regarding coordination with local media in the event of an airport emergency to address the timely release of information relevant to public safety, notify families of those impacted, and address any misinformation. This task is typically delegated to a public information officer. In addressing UAS-related emergencies, much of this plan remains consistent with the reporting of all other airport emergencies as defined by the airport's emergency plan.

One consideration for local media coordination on UAS emergencies is the handling of sensitive and/or proprietary information. For instance, operation by a military or law enforcement agency may wish to limit the details of information release to avoid inadvertent disclosure to the nature of the operations being performed by the unmanned system. The terms of non-disclosure agreements and other arrangements must also be considered.

A greater sensitivity exists when addressing UAS emergencies to the media. There have been several examples in the past decade where misinformation related to UAS operations has had a potential adverse harm on the industry and/or the operations. Therefore, it is critical that information related to a UAS emergency is delivered in a timely manner to avoid excessive speculation with the utmost clarity.

A variety of communication modalities can be considered within the communication plan. Direct interaction with media includes interviews, press releases, and press conferences. Additionally, release of information to the public and media through social media is becoming more common. Social media provides one avenue for information release for public alerts and to directly share statements from the airport and/or responding entities, which provides additional modalities of information dissemination in a world where communication modalities is becoming increasingly varied.

4.3.5 Post-Emergency Reporting and Recovery Procedures

External reporting of aviation incidents and accidents are also required. Under Title 14 CFR Part 107 (14 CFR § 107, 2017), which regulates the operation of sUAS, within 10 days of an incident or accident that results in serious injury or damage to property (excluding the sUAS) so long as the repair costs or fair-market cost of a total loss of property exceeds $500. Reporting is handled either by phone with the operator's local FAA Regional Operations Center, or via an online form (14 CFR § 107, 2017; FAA, n.d.-b).

COA and Part 333 exempt UAS operations under the national blanket COA and have different reporting requirements, which are addressed using the COA online system. As per FAA Form 7711-1 (FAA n.d.), within 24 hours of an incident/accident, the FAA must be notified via email and an online form. Accidents/mishaps must be reported in the event that the incident/accident resulted in a loss of life resulting from the UAS operation within 30 days of the accident, serious injury, total unmanned aircraft loss, substantial aircraft damage, and damage to property other than the UAS (FAA n.d.). Incidents must be reported if one of several inflight system failures/emergencies occurred, if the incident was an airborne collision with another aircraft, deviations from the terms of the COA, ATC instruction, or other agreements; a fly away aircraft; or contingency plan execution for lost-link procedure (FAA n.d.)

As per Title 49 CFR Part 830.5 (49 CFR § 830.5), the UAS pilot-in-command must also report incidents and accidents to the National Transportation Safety Board (NTSB). This requirement holds regardless of the any COA Online incident/accident reports given the criteria of the regulation. The regulation is quoted directly in Appendix 6.7.

4.3.6 Emergency Planning Resources

Additional planning resources can be found in the following sources.

- Airport Emergency Planning Resources
  - AC 150/520-31C: Airport Emergency Plan (FAA 2009)
  - Airport Emergency Plan Checklist (FAA n.d.-c)
  - Airport Emergency Plan Template (NH.gov, 2017)
  - ACRP 04-19 Airport Emergency Planning Template: NIMS—Incident Command System Compliance (ACRP, n.d.) (project ending soon)
- UAS Incident/Accident Reporting Resources
  - FAA FORM 77-11 UAS: Blanket COA for any Operator issued a valid Section 333 Grant of Exception (FAA n.d-a)
  - FAA Reporting an Accident (Part 107) (FAA n.d.-b)
  - Title 49 CFR §830.5 Immediate Notification (49 CFR § 830.5, 2017)

5 Visual Risk Assessment Map and Factors

This section serves as a tool for developing visual risk assessment maps for airport operators. The method helps airport operators better understand and visualize geospatial risks that may exist in the context of UAS operations. Furthermore, this guidance helps airports with assessing risks as part of their risk management process. This section will describe the risk analysis approach (Section 5.1) and characterize the specific risk factors (Section 5.2). Using this approach and risk factors, Section 5.3 describes map elements and provides an example risk map. This tool can be used by airport operators to generate their own specific risk maps and improve risk management processes. The tool also helps provide a common framework for discussing risk among entities working with airports to manage and communicate risks.

5.1 Tools and Methods for Map Development

In this section, a method is described for map development using tools referred by FAA best practices and mitigation tools. The fundamentals of risk mitigations are introduced, as well as factors in leading to risk area categorization, which will help airport operators identify risk areas and mitigation strategies specific to their airports.

5.1.1 Development of Risk Factors

This section describes the approach to developing risk factors in the context of UAS operations for airports by defining key concepts such as risk matrix, factors, and management. This includes a description of a method for augmenting the FAA Safety Risk Management framework to incorporate UAS-related risks, leveraging literature from defense UAS programs and recent developments in commercial UAS testing and evaluation.

5.1.2 Defining Low-, Medium-, and High-Risk Areas

Likelihood \ Severity	No Safety Effect	Minor	Major	Hazardous	Catastrophic
Probable	Low	Medium	High	High	High
Remote	Low	Medium	Medium	High	High
Extremely Remote	Low	Low	Medium	Medium	High
Extremely Improbable	Low	Low	Low	Low	Med / High

Figure 14: FAA safety risk management criteria

Risk is described by likelihood and severity of an adverse event. While risk exists on a continuum, risk management frameworks categorize risk into discrete levels that represent risk management regimes. Risk level is determined on a case-by-case basis through an analysis of a scenario. The FAA has well established risk management criteria to determine the level of risk for manned flight, which is described herein. However, for UAS, risk management criteria are currently less well understood due to the relatively small amount of empirical evidence, as well as the dynamically changing nature of UAS operations as they are phased into the NAS, proliferate in number, advance in technology, and find new use-cases. This section identifies some common UAS risk criteria based on available information.

Figure 14 shows the FAA's Safety Risk Management Matrix (FAA 2013a) as a first consideration. As seen in the matrix, risk can be visualized as a table with columns that describe gradations of severity, and rows of likelihood. The grades of "Low," "Medium," and "High" are used to divide risk into three categories that trigger certain risk acceptance practices.

Definitions of likelihood of occurrence and severity of consequences can be observed from the FAA Risk Management Handbook 8083-2 (Flight Standards Service) (FAA 2013b) as shown in Table 10. These terms can be used to support the categorization of framework for a development of a risk map.

Table 10: FAA risk management criteria likelihood definitions (FAA 2013b)

Likelihood	Definition
Probable	**Qualitative:** Anticipated to occur one or more times during the entire system/operational life of an item. **Quantitative:** Probability of occurrence per operational hour is greater than 1×10^{-5}
Remote	**Qualitative:** Unlikely to occur to each item during its total life. May occur several times in the life of an entire system or fleet. **Quantitative:** Probability of occurrence per operational hour is less than 1×10^{-5}, but greater than 1×10^{-7}
Extremely Remote	**Qualitative:** Not anticipated to occur to each item during its total life. May occur a few times in the life of an entire system or fleet. **Quantitative:** Probability of occurrence per operational hour is less than 1×10^{-7} but greater than 1×10^{-9}
Extremely Improbable	**Qualitative:** So unlikely that it is not anticipated to occur during the entire operational life of an entire system or fleet. **Quantitative:** Probability of occurrence per operational hour is less than 1×10^{-9}

In addition to likelihood, it is also important to understand the severity of risks. The interplay between likelihood and severity constitute the total risk that is experienced by the UAS user and airport. Severity levels and definitions are provided in Table 11.

Table 11: FAA risk management criteria severity definitions

Severity	Definition
Catastrophic	Results in multiple fatalities and/or loss of the system
Hazardous	Reduces the capability of the system or the operator ability to cope with adverse conditions to the extent that there would be – Large reduction in safety margin or functional capability; Crew physical distress/excessive workload such that operators cannot be relied upon to perform required tasks accurately or completely; (1) Serious or fatal injury to small number of occupants of aircraft (except operators); Fatal injury to ground personnel and/or general public
Major	Reduces the capability of the system or the operators to cope with adverse operating condition to the extent that there would be – Significant reduction in safety margin or functional capability; Significant increase in operator workload; Conditions impairing operator efficiency or creating significant discomfort; Physical distress to occupants of aircraft (except operator) including injuries; Major occupational illness and/or major environmental damage, and/or major property damage

Severity	Definition
Minor	Does not significantly reduce system safety. Actions required by operators are well within their capabilities. Include: Slight reduction in safety margin or functional capabilities; Slight increase in workload such as routine flight plan changes; Some physical discomfort to occupants or aircraft (except operators); Minor occupational illness and/or minor environmental damage, and/or minor property damage
No Safety Effect	Has no effect on safety

Defining accurate risk levels is important for cost-effective accident prevention for operators and airports alike. The levels describe necessary approvals and approach to risk reduction and mitigation. System safety requirements must be consistent with other program requirements. Realistically, a certain degree of safety risk must be universally accepted to successfully operate UAS.

According to FAA Order 8040.4 (FAA 2012), the term hazard is defined as a "condition, event, or circumstance that could lead to or contribute to an unplanned or undesired event." UAS operations may be within an existing hazardous environment or cause a hazard for other operations. A single hazard may not necessarily cause an accident, but it can increase the likelihood and severity of an undesired event. Depending on the unique circumstances at each airport and for each operation, the defined risk may rank differently between low, medium, and high. Visual risks maps help understand hazards spatially, but not all hazards are easily represented visually. This chapter provides visual risk maps, as well as describing hazards that are not easily visualized, that can be used to define risk levels for specific scenarios.

Considering the FAA Risk Management Framework and literature on UAS risks, guidance for assessing high (Figure 15), medium (Figure 17), and low (Figure 16) levels are described here. They are provided as examples for how risk could be assessed. Because each unique circumstance at an airport will alter the risk assessments, these should not be considered blanket definitions, but rather example guidelines. These figures include examples of risk criteria and scenarios that characterize high, medium and low risk. The example risk criteria and scenarios were identified based on an analysis conducted by Bard College Center for the Study of the Drone on UAS incident reports (Gettinger 2015). The Bard analysis considers 921 incidents involving UAS from December 2013 to September 2015, and identifies common UAS sightings and close encounters.

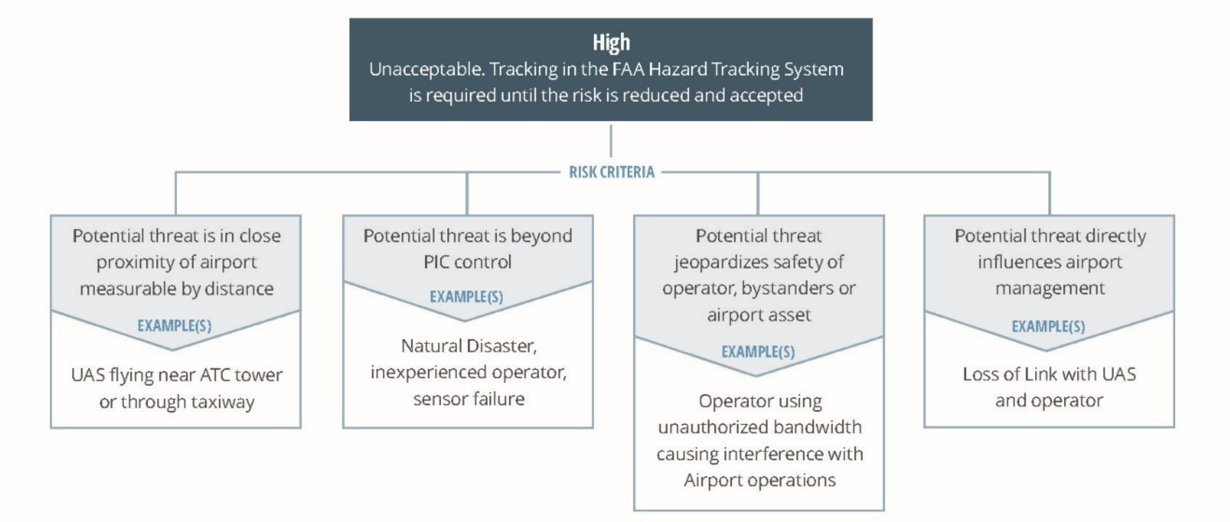

Figure 15: High risk level definition based on FAA Order 8040.4B. Four examples of common risk criteria are given based on research by Bard College Center for the Study of the Drone on UAS incident reports. These criteria demonstrate when a scenario may be considered high risk.

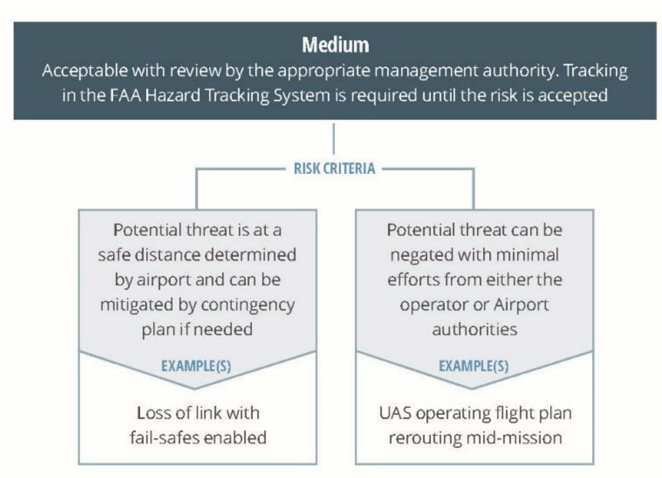

Figure 17: Medium risk level definition based on FAA Order 8040.4B. Two examples of common risk criteria are given based on research by Bard College Center for the Study of the Drone on UAS incident reports. These criteria demonstrate when a scenario may be considered medium risk.

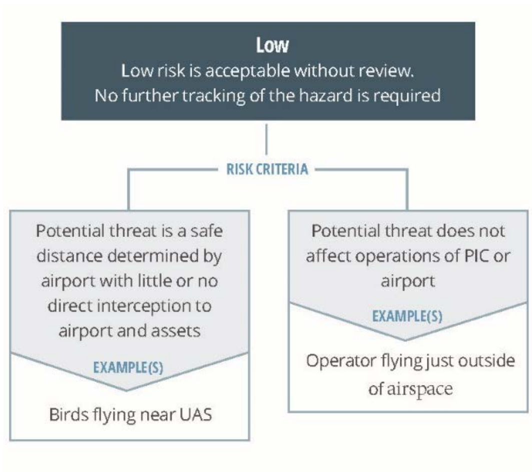

Figure 16: Low risk level definition based on Order FAA 8040.4B. Two examples of common risk criteria are given based on research by Bard College Center for the Study of the Drone on UAS incident reports. These criteria demonstrate when a scenario may be considered low risk.

5.2 Risk Factors

Risk factors can stem from system, operational, and environmental conditions. UAS operations around airports must consider the same risks as manned aircraft. New factors specific to UAS are defined in this Section. While these factors are most directly applicable to UAS operators, it is important for an airport operations department/manager to be familiar with them, especially as they relate to the management of UAS operations within the vicinity of existing manned aircraft around an airport. Table 12 describes risk factor definitions and guidance documents, which are based largely information from the FAA Risk Management Handbook 8083-2, FAA Low Altitude Authorization and Notification Capability (LAANC), FAA Part 107, 14 CFR 91, and AC 60-22.

Table 12: Risk factor definitions by category

Category	Risk Factor	Definition	Data Sources
Operational Factors	Separation	Separation may be achieved by reserving airspace, IFR/VFR	14 CFR 77: Standards and notification requirements for objects affecting navigable airspace
	Aircraft Capability	Aircraft complies with weight, payload, and airworthiness requirements	Part 107
	Line of Sight	Operation is conducted in visual line of sight, or extended/beyond VLOS with proper waivers or exemptions	Part 107
	Sensor Fidelity	Onboard sensors comply with general operating and flight rules	14 CFR 91: General Operating and Flight Rules
	System Integrity	System and operations comply using geofencing or waypoint navigation to avoid airspace, and demonstrate a secure operational reliability	AC 60-22
	Tracking and Identification	Tracking and ID systems can be ground based (e.g., radar) or part of the UAS (e.g., lighting, ADS-B, etc)	AC150/5300-13A: Airport Design Criteria
Pilot in Command	Operator Capability	PIC complies to Aeronautical Decision-Making Best Practices	14 CFR 91; AC 60-22
	Coordination with Airports	PIC complies with airport operations and recognizes critical pathways (e.g. runway approach and departure paths) to avoid	Part 107; Title 14 Part 77; AC150/5300-13A
	Operator Aptitude	Operator must hold a remote pilot airman certificate and demonstrate proficiency in operations	Part 107
Environment	Weather	Weather conditions during operations are dealt with in a reasonable manner; PIC must react accordingly to weather forecasts and communicate with airports under conditions	AC 60-22; 14 CFR 91

	Terrain Feature	Nearby terrain feature that influences flight plan (spot elevation, body of water, man-made road, etc.)	AC 60-22
	Local Infrastructure	Nearby buildings or sites; special permissions required when performing on-site operations within airports	AC 60-22; AC150/5300-13A
	Other Hazards	External factors not present during flight plan or initial operation (e.g., TFR)	AC 60-22

5.2.1 Operational

Recognizing the risks associated with UAS operations near airports, FAA has developed specific guidance based on airspace class and proximity to airports. Inside controlled airspace, special permission must be acquired via waiver from the FAA. More than 90% of airports in the United States have no control tower (Air Safety Institute, 2017).

Under Part 107, drone operators are not required to coordinate operations with or give notice to airports in Class G (uncontrolled) airspace. Part 101-E recreational users are only required to notify if an air traffic facility is present. The decree establishes a general rule for sUAS to avoid interference with manned aircraft, but does not include a provision recommending communication between aircraft, manned or unmanned, when approaching or departing from an uncontrolled airport. The FAA LAANC program is developing an automated Certificate of Authorization process for coordinating UAS traffic in Class G around airports.

System integrity and capability is critical in maintaining navigation, separation, and geospatial restrictions of UAS operations. Compromised system integrity could lead to hazardous risks, such as collision with a manned aircraft or people on the ground. UAS airworthiness and system integrity must constantly be checked and repaired for any operation to take place safely.

Operational factors can be challenging to depict geospatially, as they often relate to specific technology that is either onboard the vehicle or infrastructure provided by the airport and ATC. These capabilities can reduce the risks generated by certain UAS operations based on considerations such as range and performance of communications, perception systems, and the aircraft (e.g., in a lost link scenario).

5.2.2 Pilot in Command (PIC)

Pilot in Command (PIC) risk factors are described in AC 60-22, Part 107, and 14 CFR 77. These include capability, coordination, and aptitude. As the person in control of the UAS, the PIC must adhere to the Aeronautical Decision-Making Best Practices (FAA 2017a). The PIC is directly responsible for maintaining the flight path of the UAS, and coordinating with airports before and during operations. The PIC must also coordinate with a designated Visual Observer when conducting certain operations. A PIC operating under Part 107 must maintain a remote pilot airman certificate to demonstrate that they are a competent and knowledgeable pilot. Additional training may be appropriate based on the specific operation. In its current state, risk levels for PIC are challenging to illustrate in a Geospatial Risk map as it directly relates to the PIC's aptitude and merit.

5.2.3 Environment

An analysis and review of several FAA aviation documents, most notably AC 60-22, AC 150/5300-13A and 14 CFR 91, revealed many potential environmental factors to include on the UAS Risk Map. A prominent environmental risk factor is weather, which is a dynamic and localized factor that can quickly change operating risks in specific areas. High winds, precipitation, or icing conditions may be cause to alter or cease UAS operations or employ mitigation strategies. Concerns surrounding weather focus on both universal risks, such as precipitation or high barometric pressure, as well as those faced by only some airports, like coastal fog or strong cross winds.

A secondary environmental risk that can be visualized on a risk map is local infrastructure. Runways and taxiways within airports prove to be high-risk areas, especially if UAS operations occur concurrently with manned aircraft operations. Though runway and taxiway locations differ by airport, a generalized map will be able to denote these risks.

Other hazards that are difficult to include in a generalized risk map, but still present a risk to UAS operations, include undetectable terrain and wildlife strikes. Both are difficult to represent on a static map, but must be considered when implementing UAS operations. Wildlife risk can be mitigated on a map by denoting any open land surrounding an airport where birds or other animals may congregate.

5.3 Map Elements and Risk Management

A risk map captures the geospatial location of risk features (see Section 5.2) that are in proximity to an airport and drive risk for UAS operations. This section demonstrates how the risk factors translate into elements of a risk map. A sample risk map is developed for Pittsburgh International Airport (PIT) as an example of how to apply the concepts in this guidance.

5.3.1 Map Elements

The risk factors discussed in Section 5.2 are organized into three categories: operational, pilot in command, and environmental. Both operational and pilot in command risk factors can vary on a case-by-case basis, and do not lend themselves readily to geospatial representation. Environmental factors are more readily visualized geospatially. Environmental factors serve as the base layer for a visual risk map, and operational and pilot in command factors augment that base layer on a case-by-case basis.

PIT is used as an example to show how to identify and characterize potential risks. FAA represents the risk of UAS to ATC and facilities through UASFMs. The UASFM for PIT is shown in Figure 18, indicating altitudes below which Part 107 UAS operations require at a minimum further coordination with ATC. UAS operations above UASFM altitudes may still be permissible if risks can be addressed, for example through a waiver or COA approved by FAA. ATC and FAA are important stakeholder in UAS operations, but this document focuses on the perspective of an airport operator, whose concerns differ from ATC. For example, UASFMs are relatively coarse grids (about 1 minute of latitude by 1 minute of longitude, or 1 square mile), which is insufficient spatial resolution to appreciate some of the risks to airport facilities.

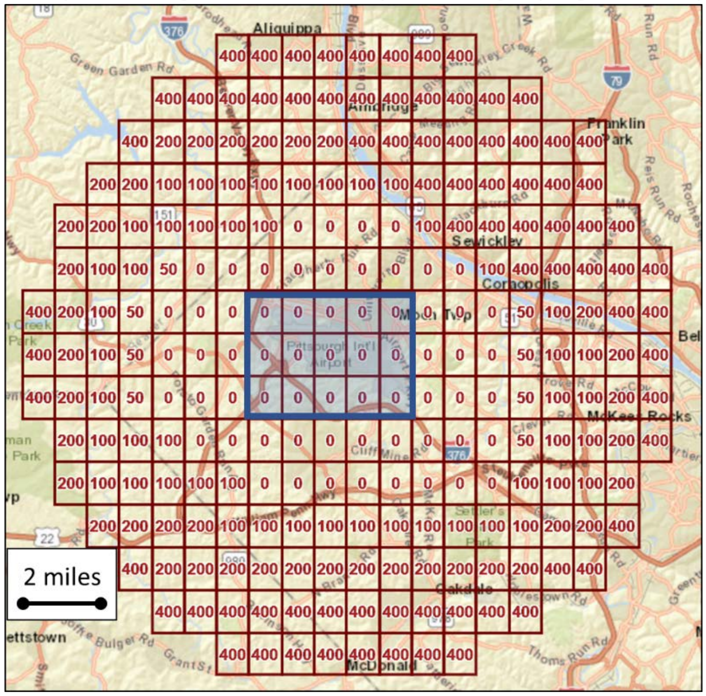

Figure 18:UASFM for PIT. Box indicates zoom area for risk map in Figure 19. Grid cell numbers indicate maximum ceiling of UAS operations permissible without further coordination with ATC.

Environmental risk factors include weather, terrain features, infrastructure and other hazards:

- Airport operators can track geospatial weather risk through weather data, such as the NextGen Weather Processor (NWP) data. Wind, precipitation, and icing forecasts are provided by National Weather Service Aviation Digital Data Service (ADDS) (www.aviationweather.gov). Icing can be visualized on NCAR's experimental online tool [http://www.rap.ucar.edu/icing/ip], shown in Figure 19. To our team's knowledge, no UAS-specific thresholds have been set for evaluating risk based on weather parameters. Weather may increase the likelihood of an incident, due to features such as smaller size and smaller control surfaces, but are also likely to carry less severity than manned craft.

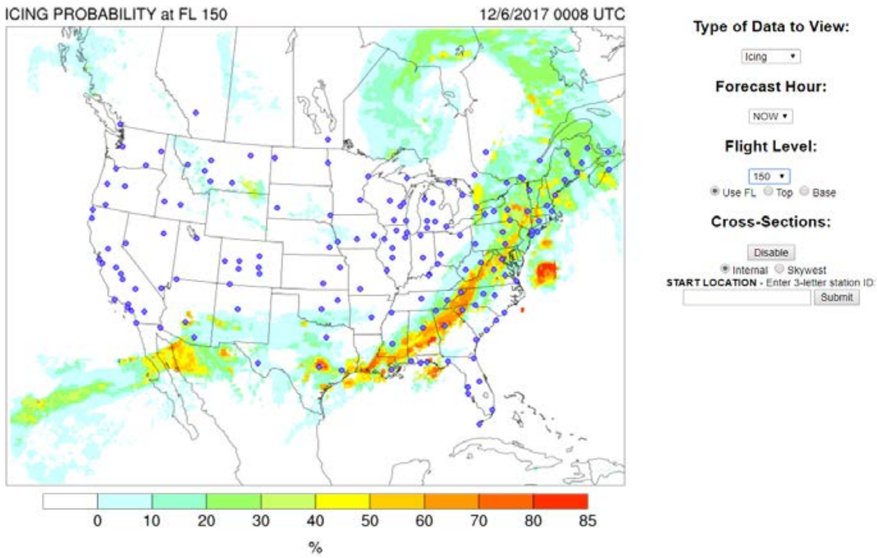

Figure 19: Probability of icing based on altitude and time [http://www.rap.ucar.edu/icing/ip/].

- Terrain features, infrastructure, and other hazards, are typically static, such as towers, parking lots, training facilities, etc. UAS may pose a threat to personal injury or property damage from collision due to loss of control, wind gusts, mechanical failure, or other unforeseen circumstances.

The major concerns for airport operators often occur in the immediate vicinity of the airport, where there are potential impacts to airport property, operations, or users. To help visualize airport specific considerations for assessing UAS risks near an airport, a sample risk map of PIT is shown in Figure 20. This map provides an overlay of the airport highlighting areas of increased risk, especially aircraft routes, surface hazards, and critical infrastructure. These risk areas are three-dimensional airspace volumes by nature. Top and side views help show the horizontal and vertical dimensions of these risks. Aircraft routes are clearly an area of higher risk due to concerns with separation, and these areas may vary depending on which runways are active. Only a single example runway operation configuration is shown, and several other configurations exist. Surface hazards, especially critical infrastructure like VORTAC towers, not only pose risk to the UAS, but also airport operations should a UAS disable certain functionality. Weather is an example of a time varying factor that heavily influences risks, and cannot be provided in a static map. Performance of UAVs, in particular small UAVs, typically degrades rapidly with higher winds, precipitation, and in icing conditions, and can result in UAVs being carried a significant distance. Weather conditions are in important layer of a risk map and risk evaluation.

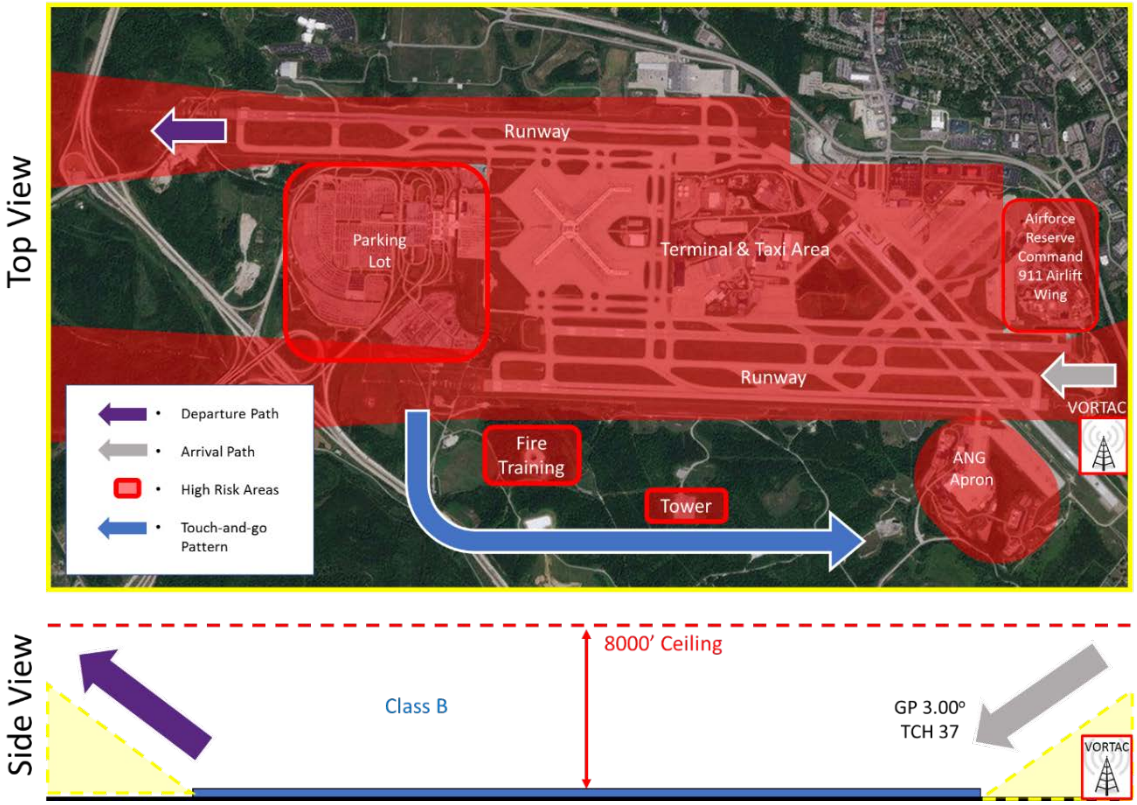

Figure 20: Sample risk map of PIT, Class B airspace, with Top and Side views. All UAS operations would be high risk in this area without a waiver or exemption. Specific geolocated features that further increase risk are identified, including surface hazards, critical infrastructure, and areas over people. It is possible to reduce the risk of a specific UAS operation to low risk, e.g., through a waiver or authorization that ensures a certain level of safety performance and mitigation measures.

5.3.2 Risk Management

What these maps do not show are certain operational and pilot in command factors that impact risk on a case-by-case basis. A flow chart in Figure 21 can be used to better understand these conditions. For example, if a UAS operation is being conducted in Class B airspace, it will require a waiver that addresses important risk reduction measure, such as how the UAS will coordinate with the airport and air traffic control.

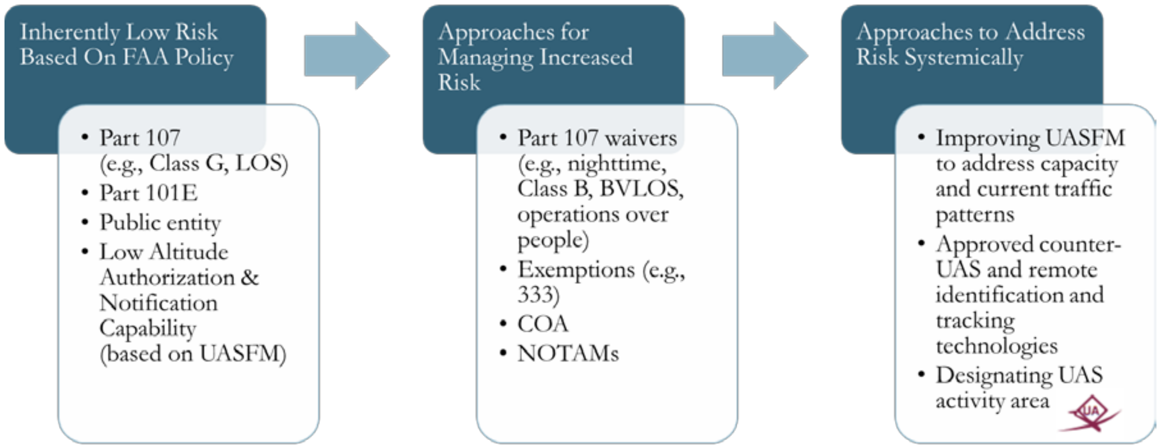

Figure 21: Flow chart describing policy and regulatory considerations for risk identification, reduction, and mitigation. Operations that are not inherently low risk may require case-by-case examination to evaluate potential risks to airports. Actions can be taken to systemically reduce risk of UAS operations around certain airports.

In augmenting the FAA Risk Management framework (FAA 2013b), it must be noted that sufficient data may not exist to clearly define the likelihood or severity of an adverse event, which is why Figure 21 only displays clear, high risk areas (red). Until such data exists, qualitative guidance on what criteria triggers other levels of risk is provided. In some cases, there is strong supporting documentation and data sources that describe how to evaluate risk. In other cases, more research and data is needed, and this framework may need to evolve as more information becomes available. Table 13 provides a summary of the risk factors to be considered as well as the potential sources for quantitative data for these factors.

Table 13: Risk factors categorized by likelihood and severity of adverse events

Category	Risk Factor	Risk Evaluation Guidance	Risk Guidance Sources
Operational Factor	Separation	Separation mostly relates to likelihood of an adverse event. It can be categorized into: Reserving airspace (e.g., TFR) = Extremely Remote IFR (e.g., ADS-B equipped) UAS flight corridors VFR (e.g., BNSF UAS corridors) Coordination with ATC (relationship between UAS operator and facility important)	UASFM
	Aircraft Capability	Weight mostly relates to the severity of an adverse event. It can be categorized into: <250 grams = No Safety Impact <55 lbs = Minor	Part 107, FAA Micro UAS Aviation Rulemaking Committee

Category	Risk Factor	Risk Evaluation Guidance	Risk Guidance Sources
		>55 lbs = Major Airworthiness mostly relates to likelihood of an adverse event. It can be categorized into: = Extremely Remote = Remote = Probable	
	Sensor Fidelity	Mostly relates to likelihood of an adverse event. It can be categorized into: Equipment certificate requirement = Extremely Remote Sensor output reliability threshold, lifespan, and accuracy	14 CFR 91, General Operating and Flight Rules
	System Integrity	Mitigation measures	14 CFR 77
	Tracking and Identification	Higher capability systems will result in lower likelihood of adverse events. For example, ADS-B equipped UAS can improve ability to separate, thus reducing risk. Systems and policy are still in development, but specific technologies can be categorized in a way that enables qualitatively assessment of likelihood, for example: High capability system (e.g., ADS-B, lighting, etc.) is most important when the application is extremely remote Low capability system (e.g., tail number, no electronic broadcast) = Increase probability	FAA UAS Remote ID and Tracking Aviation Rulemaking Committee
Pilot in Command	Operator Capability	Level of experience and flight knowledge	AC 60-22
	Coordination with Airports	Complies with CFR for notifying airports during operations	Part 107; 14 CFR 77
	Operator Aptitude	Level of experience and aptitude for flight knowledge	Part 107

Category	Risk Factor	Risk Evaluation Guidance	Risk Guidance Sources
Environment	Weather	Weather factors such as precipitation, humidity, visibility and barometric pressure	AC 60-22
	Terrain Feature	Visual features that affect flight operations based on vicinity of airport	GIS maps
	Local Infrastructure	Visual features that affect flight operations based on vicinity of airport	AC150/5300-13A
	Other Hazards	External factors that may affect operations such as wildlife or weather anomalies	Local broadcasts and warnings

6 Appendices

6.1 Table of Authorities

Table 14: Sample table of authorities to be used to coordinate for airports

Group	Specific Organization	Responsibility from the Organization	Responsibility to the Organization	Differences between NPIAS Airport Types
This is the general category of UAS stakeholder that may interact with an airport.	*These are examples of UAS organizations that may interact with an airport.*	*This describes the responsibility that "Specific*	*This describes the responsibility that the airport has*	*This describes any potential differences in*
Aviation Industry Group	ACI-NA – Ops & Tech Committee			
Aviation Industry Group	AAAE			
Aviation Industry Group	Commercial Drone Alliance			
Aviation Industry Group	ATCA			
Government Agency	ATC En-Route Centers			
Government Agency	Local Air Traffic Control Towers			
Government Agency	US Customs and Border Patrol			
Government Agency	DHS			
Government Agency	NASA			
Government Agency	State DOTs			
Government Agency	FAA			
Government Agency	ICAO			
Government Agency	NTIA			
Manufacturers, Dealers, and/or Sellers	PrecisionHawk			
Manufacturers, Dealers, and/or Sellers	3D Robotics			
Manufacturers, Dealers, and/or Sellers	Skyward			
Manufacturers, Dealers, and/or Sellers	Boeing/Insitu			
Manufacturers, Dealers, and/or Sellers	DJI			
Manufacturers, Dealers, and/or Sellers	Harris			
Manufacturers, Dealers, and/or Sellers	Airbus			
UAS Advocacy Group	DIY Drones			
UAS Advocacy Group	Drone Club of Central Florida			
UAS Advocacy Group	Academy of Model Aeronautics			
UAS Advocacy Group	AUVSI			
UAS Users	Utilities (power/electric)			
UAS Users	Consultants/Surveyors			
UAS Users	Construction Companies			
UAS Users	Insurance Companies			

6.2 Pre- to Post-Flight Actions

This Section describes factors that will be considered by the UAS operator. It is included in this appendix because it would be useful for an airport operations department/manager to familiarize themselves with these factors in order to better anticipate UAS operator procedures and planning. Conducting effective UAS application requires thorough review, planning, coordination, and inspection to ensure all operational requirements are sufficiently satisfied (American Bureau of Shipping, 2016; FAA, 2016b). An understanding of the steps and actions typically associated with operational preparation can assist airport operators with evaluating risks, benefits, and applicability of proposed UAS operations on or within the vicinity of their facility. Actions associated with effective UAS operations management can be categorized into those conducted prior to (pre) and after (post) application. The following subsections contain common steps and considerations associated with these two types of actions.

6.2.1 Pre-Flight Preparation

Pre-flight preparation entails the development, review, and revision of an initial operational concept. There should be a focus on an intended operational purpose (i.e., application). This operational concept, described in Section 0, is refined into a detailed operational plan that includes: a) identification and analysis of critical elements, b) assessment of past experience, c) operational definition, and d) evaluation of hypothetical scenarios. Identification of critical elements, including the high-level objective (purpose), threats, and available resources to support the operation, provides the base-level for determining the feasibility of a potential operation. Assessing past experience—through subject matter expert review and evaluation—can provide a clearer understanding of operational limitations and possible solutions (i.e., lessons learned; e.g., risk management options and plan revision).

Definition of the operation—including identification of specific goals and operational methods—provides an opportunity to categorize and prioritize tasks and functions. Evaluation of hypothetical scenarios allows for detailed review and consideration of possible risk events to create contingencies and controls, limiting and managing associated risk. The operational planning process can be made more efficient and effective, to support repeatable and expedited use, through development of a standard operating procedure (SOP; National Wildlife Coordinating Group [NWCG], 2016). Additionally, the development and implementation of a system risk management process (SRMP) can assist in decision making relating to several areas, including operation, financial commitment, and regulatory compliance (Clothier and Walker, 2014).

Pre-flight preparation commonly features the following tasks in Figure 22:

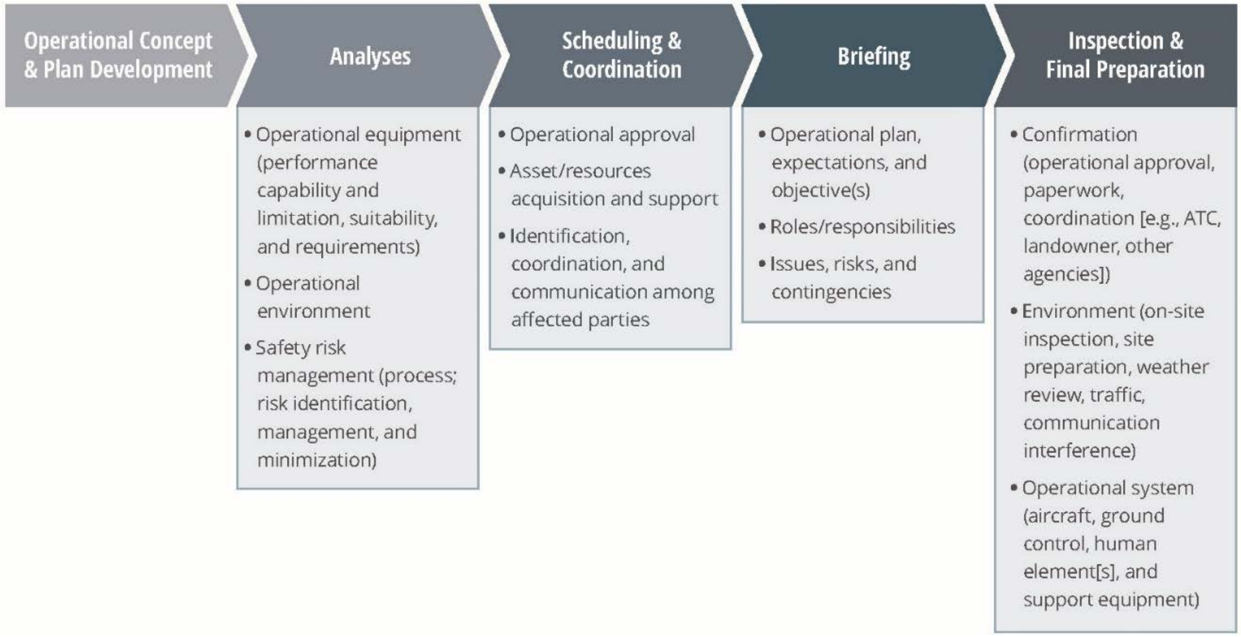

Figure 22: List of tasks required for pre-flight preparation

The following resources provide examples of common pre-flight activities, including planning, analysis, and safety management:

- Example pre-flight action checklist: http://ctemps.org/sites/ctemps.org/files/10_nias_pre_mission_coa_checklist_p2_generic.pdf
- Example sUAS Operational Plan document, featuring SMS (safety and risk assessment, control, and mitigation): https://assets.erau.edu/cm1/Assets/worldwide/data/erau-suas-consumer-guide-otp-srb-final-release.pdf
- Example operational procedures documentation: https://connect.ncdot.gov/resources/Aviation%20Resources%20Documents/NCDOT_Operational_Procedures_Template.docx

6.2.2 In-Flight Operations

The UAS operator/remote pilot in command is responsible for ensuring compliance with regulatory requirements and applying best-practices to ensure an "equivalent level of safety" is maintained within the operational area, including the following:

- Coordinating operations with applicable parties (e.g., airport operations department/manager and FAA ATC) to ensure awareness of UAS operations conducted in the vicinity; providing clear communication among team and applicable parties
- Positive positional reporting, command and control authority, and communication (verified positive control and signal receipt)
- Maintaining continuous visual line of sight and yielding right of way to other traffic

- Operating UAS within planned parameters (e.g., altitude, speed, boundaries, operational limitations) and performing appropriate response to emergency events, as specified in checklists, operational plan, and/or SMS
- Confirming appropriate separation distance from traffic, terrain, structures, non-participants, and weather (e.g., cloud ceiling)
- Cancellation of operation due to occurrence of actions/situations/events/conditions beyond specified tolerances, operational plan, and/or SMS

6.2.3 Post-Flight Actions

After an operation has concluded a series of actions remain to determine system state, confirm successful task completion (i.e., objectives met), assess and analyze operational observations, document findings, and share results among applicable stakeholders. The following represent typical tasks perform in support of post-flight action:

- Operational system inspection
- After-action review/briefing
- Post-data analysis
- Development and dissemination of results

Inclusion of the following materials and resources in the toolkit (to be included in subsequent update of document) can assist airport operators evaluate UAS operational proposals:

- Sample operational concept
- Sample SOP for runway inspection using a sUAS
  - Operational analysis
  - Schedule
  - Briefing
  - Pre/post-flight checklists
- Sample after-action briefing
- Sample flight data log and notes (post-flight)
- Sample data analysis
- Sample post-flight (finalized results) report (for results dissemination)

6.3 Aircraft Performance Requirements

Understanding inherent capabilities, limitations, and requirements associated with operational equipment used to conduct a UAS application represent a critical aspect of operational management. Identifying and analyzing applicable performance metrics, specific to the UAS and operational environment, enables the determination of system suitability to perform a given application. Figure 23 describes the performance considerations to enable review, evaluation, and assessment of system application feasibility:

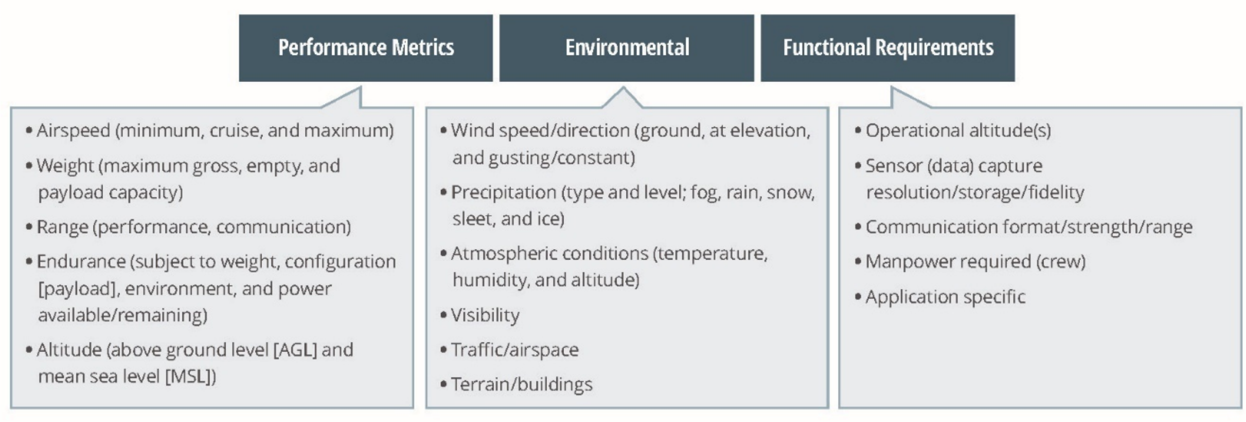

Figure 23: Aircraft performance requirements considerations to evaluate system application feasibility

Inclusion of the following materials and resources in the toolkit (to be included in subsequent update of document) can assist airport operators prepare to evaluate the applicability of specific UAS to operate on or in proximity to their facility, and in accordance with the proposed UAS operational plan:

- Aircraft performance tables
- Sample original equipment manufacturer (OEM) manual
- Sample airport diagrams/airspace charts
- Sample weather report

6.4 Special Airworthiness Certificates

The FAA provides for the application and approval of a special worthiness certificate, under several specific categories: special class, experimental, restricted, and special flight permit. Figure 24 contains the details of special airworthiness certificate requirements.

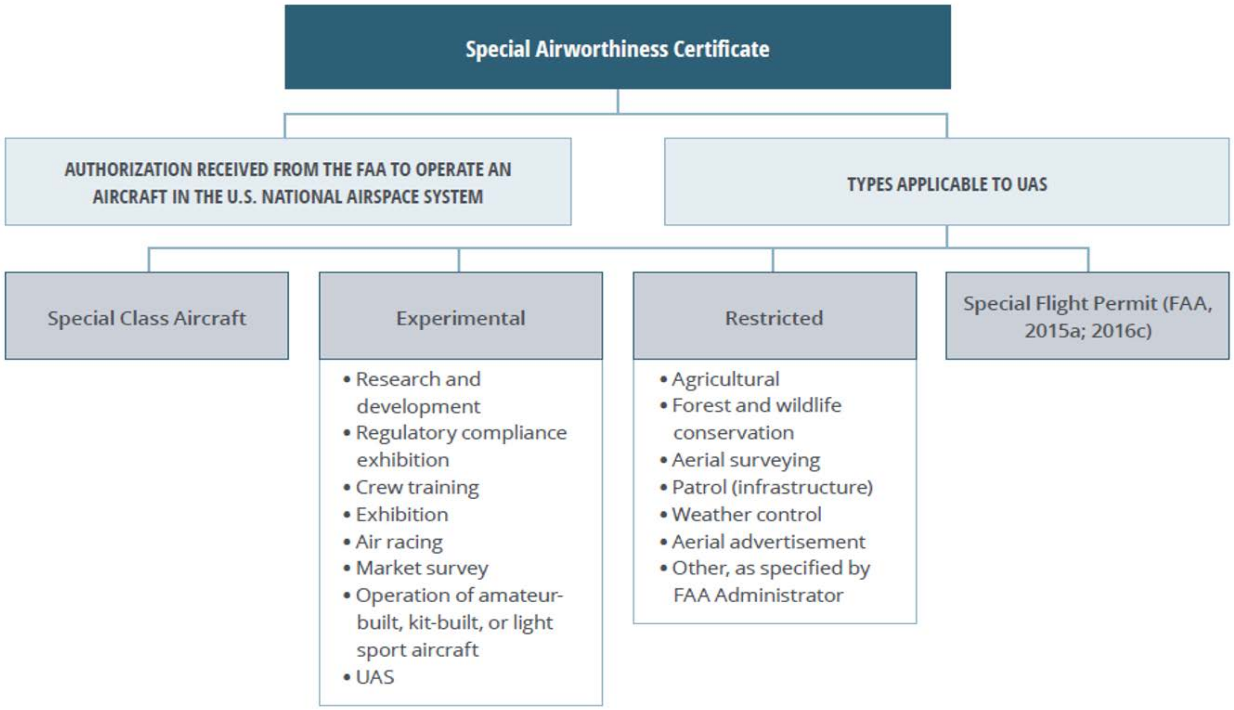

Figure 24: Special airworthiness certificate purpose and requirements; presented information adapted from FAA (2015a; 2016c)

6.5 Further Coordination

Beyond Part 107 and COAs at the U.S. federal government level, several other coordination and approval considerations apply, depending on the purpose and vicinity of the UAS operations. For instance, operations within sensitive DoD areas would be subject to the same airspace restrictions as normal manned-operations would. Sensitive infrastructure managed by the Department of Energy, Department of Transportation, National Park Service, and Department of Homeland Security would also be subject to the same security considerations, as well.

Other

- Federal approval and coordination (i.e., in conjunction with) other than FAA
- Department of Defense (DoD), operation within Restricted airspace controlled for military purposes
- Department of Energy (DOE), operation within vicinity or above critical infrastructure (e.g., power storage, generation, or transmission)
- Department of Transportation (DOT), operation within vicinity or above critical infrastructure (e.g., roadways, bridges, canals, or ports)
- National Park Service (NPS), operation within vicinity or above U.S. National Parks
- Department of Homeland Security (DHS)

Figure 25: Coordination with other U.S. agencies

Inclusion of the following materials and resources in the toolkit can assist airport operators prepare to confirm receipt of appropriate operational approvals, across the various levels applicable to their facility:

- Link to Academy of Model Aeronautics (AMA; i.e., national CBO) program
- Links to applicable federal regulations (e.g., 14 CFR parts)
- Sample COA application and approval
- Sample Section 333/civil COA application and approval
- Sample letter to landowner requesting permission to overfly property
- Sample local permit application and approval

Figure 26: Additional resources for UAS operational authorizations

6.6 Operational Environment Considerations

Conduct of UAS application, development of operational planning and coordination, and selection of appropriate equipment and crew necessitates investigation and analysis of the subject operational environment. Ensuring proposed operations have fully reviewed specifics details of the airport environment improves likelihood of risk identification and control, minimizes potential disruptions, and implementation of suitable operational scenarios and contingencies. The following represents major environmental elements for consideration:

- Review applicable maps/surveys (airspace, physical boundaries, geographic/topographical)
- Weather (common patterns, specific forecasts, cloud cover and separation)
- Time of day (visibility, light levels)
- FAA advisories/briefings (e.g., temporary flight restrictions [TFR]s, Notice to Airmen [NOTAM]s)
- Regulations (federal/state/local)
- Traffic and Activity
- Potential occlusion/interference (visual and radio propagation)
- Confirmation
    - Operational area type/format/requirements (airspace)
    - Distance measurement
    - Flight/path planning and trajectory analysis
    - Payload coverage
    - Environmental factors
    - Permissions/approval/coordination
    - Site inspection (visual)

Inclusion of the following materials and resources in the toolkit (to be included in subsequent update of document) can assist airport operators prepare to evaluate and document specifics of their operational environment:

- Sample maps/airspace charts
- Sample weather forecast
- Sample NOTAM
- Sample operational plan with analyses
- Sample landowner permission document (providing approval)
- Sample on-site checklist
- FAA B4UFly application (iOS and Android)

6.7 Pilot in Command Accident Response Procedure

This section can provide airports with an awareness of the procedures UAS pilots must follow in the event of an accident.

Table 15: Title 49 CFR §830.5 (49 CFR § 830.5, 2017)

§830.5 Immediate notification.
The operator of any civil aircraft, or any public aircraft not operated by the Armed Forces or an intelligence agency of the United States, or any foreign aircraft shall immediately, and by the most expeditious means available, notify the nearest National Transportation Safety Board (NTSB) office,[1] when:
[1]NTSB headquarters is located at 490 L'Enfant Plaza SW., Washington, DC 20594. Contact information for the NTSB's regional offices is available at http://www.ntsb.gov. To report an accident or incident, you may call the NTSB Response Operations Center, at 844-373-9922 or 202-314-6290.
(a) An aircraft accident or any of the following listed serious incidents occur:
(1) Flight control system malfunction or failure;
(2) Inability of any required flight crewmember to perform normal flight duties as a result of injury or illness;
(3) Failure of any internal turbine engine component that results in the escape of debris other than out the exhaust path;
(4) In-flight fire;
(5) Aircraft collision in flight;
(6) Damage to property, other than the aircraft, estimated to exceed $25,000 for repair (including materials and labor) or fair market value in the event of total loss, whichever is less.
(7) For large multiengine aircraft (more than 12,500 pounds maximum certificated takeoff weight):
(i) In-flight failure of electrical systems which requires the sustained use of an emergency bus powered by a back-up source such as a battery, auxiliary power unit, or air-driven generator to retain flight control or essential instruments;
(ii) In-flight failure of hydraulic systems that results in sustained reliance on the sole remaining hydraulic or mechanical system for movement of flight control surfaces;
(iii) Sustained loss of the power or thrust produced by two or more engines; and
(iv) An evacuation of an aircraft in which an emergency egress system is utilized.
(8) Release of all or a portion of a propeller blade from an aircraft, excluding release caused solely by ground contact;
(9) A complete loss of information, excluding flickering, from more than 50 percent of an aircraft's cockpit displays known as:
(i) Electronic Flight Instrument System (EFIS) displays;
(ii) Engine Indication and Crew Alerting System (EICAS) displays;

(iii) Electronic Centralized Aircraft Monitor (ECAM) displays; or

(iv) Other displays of this type, which generally include a primary flight display (PFD), primary navigation display (PND), and other integrated displays;

(10) Airborne Collision and Avoidance System (ACAS) resolution advisories issued when an aircraft is being operated on an instrument flight rules flight plan and compliance with the advisory is necessary to avert a substantial risk of collision between two or more aircraft.

(11) Damage to helicopter tail or main rotor blades, including ground damage, that requires major repair or replacement of the blades;

(12) Any event in which an operator, when operating an airplane as an air carrier at a public-use airport on land:

(i) Lands or departs on a taxiway, incorrect runway, or other area not designed as a runway; or

(ii) Experiences a runway incursion that requires the operator or the crew of another aircraft or vehicle to take immediate corrective action to avoid a collision.

(b) An aircraft is overdue and is believed to have been involved in an accident.

[53 FR 36982, Sept. 23, 1988, as amended at 60 FR 40113, Aug. 7, 1995; 75 FR 927, Jan. 7, 2010; 75 FR 35330, June 22, 2010; 80 FR 77587, Dec. 15, 2015]

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